DIOXIN 2026
13-18 SEPT
RIVA DEL GARDA
ITALY
46th International Symposium
on POPs and Related Pollutants

BFR 2026
RIVA DEL GARDA
12th International Symposium on Flame Retardants

Book of Abstracts

dioxin2026.org

Welcome Address

Dear colleagues and friends,

On behalf of the Local Organizing Committee, we want to warmly welcome you to Riva del Garda for the 46th International Symposium on Halogenated Persistent Organic Pollutants – Dioxin2026.

50 Years after the Seveso disaster the meeting will return to Italy and experts in the field of persistent organic pollutants, environmental chemistry, and toxicology can join and share their experiences with other colleagues. Let us learn from the past, analyse the present and move towards a future our grandchildren deserve to experience.

Dioxin2026 will be unique, not only from the beauty of the location, but also – because for the first time colleagues driving the Dioxin symposium series and colleagues driving the flame retardants symposium series (BFR) decided to act together for their 2026 editions. We are delighted that we are able to join our forces for what promises to be an excellent joint meeting in a wonderful venue. Together, we will even better globally address halogenated pollutant issues to more efficiently tackle current human health and environmental challenges. We are hopeful that sponsors will take advantage of meeting delegates from both communities and will take up the offer of providing the support that helps to make our meetings not only possible, but to be special and memorable occasions.

As expected, Dioxin/BFR 2026 will focus on the science of dioxins and BFRs, but also additional persistent organic pollutants (e.g. PFAS) and other persistent products such as micro/nanoplastics. Together we will share latest major advances in analytical determination, the understanding of emission, transport, fate, degradation, toxic behaviour, regulations, along with the growing attention in developing countries and global pollution issues.

For this 2026 edition, by the time of the printing of the booklet, close to 600 delegates have registered, representing 249 oral presentations and 257 posters, in up to 6 parallel sessions during 5 days.

In conjunction with the Symposia, there will be an exhibition involving instrumentation, chemical products, accessories, analytical companies, scientific journals, legal entities, research centres… The exhibition will form an integral part of the symposia and coffee breaks will be held in the exhibition area.

Surrounded by mountains and with some of the most picturesque views of Lake Garda, Riva del Garda brings together the best of Nordic hospitality with the Italian Riviera lifestyle. We will ensure that attendees enjoy the area of Riva del Garda and surroundings through multiple types of activities, whether cultural or gastronomic. Active wellness boosts productivity and creativity!

We hope that you will take advantage of this opportunity to be part of Dioxin/BFR 2026, and to gain from the interactions with students, academics, and science professionals from around the world.



Dr. Werner Tirler
Chair Dioxin 2026



Dr. Martin Rose
Chair BFR 2026

INFORMATION

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All abstracts listed in Dioxin2026 Symposium Book of Abstracts have been assigned a prefix for the type of presentation, and a sequential abstract number.

Oral Communication = Prefix based on session code and abstract number

Exemple : D2-789 ou BFR1-453

Poster = P

E.g. P-001

In the Book of Abstracts' section, you will first find the Oral Communications, listed by day, topic and time of presentation. You will then find the all the Posters, ordered by topic (alphabetically).

Index of Presenters

The Index of Presenters lists all abstract presenting authors in alphabetical order. To locate the page of the abstract, first take note of the abstract number and then locate the abstract, listed by type of presentation and in sequential order.

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INFORMATION

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Abdallah M.	D21-382	Tuesday	11:00 - 11:20	Garda A
Abdallah M.	D45-687	Thursday	14:00 - 14:20	Garda A
Abraham K.	D21-814	Tuesday	11:20 - 11:40	Garda A
Addink R.	D16-694	Tuesday	11:40 - 12:00	Dolomiti
Addink R.	P-697	Monday	17:00 - 18:00	Exhibition Area
Ademollo N.	D4-047	Monday	10:30 - 10:50	Riva
Aguirre-Martínez G.	P-741	Tuesday	17:00 - 18:00	Exhibition Area
Aha A.	BFR1-432	Wednesday	10:20 - 10:40	Riva
Aha A.	BFR1-450	Wednesday	10:40 - 11:00	Riva
Al-Abed S.	P-626	Tuesday	17:00 - 18:00	Exhibition Area
Ali A.	P-922	Tuesday	17:00 - 18:00	Exhibition Area
Alijagic A.	D18-120	Tuesday	11:20 - 11:40	Belevedere
Alke L.	D7-082	Monday	13:50 - 14:10	Garda A
Aloia R.	P-170	Tuesday	17:00 - 18:00	Exhibition Area
Alonso D.	D16-421	Tuesday	10:20 - 10:40	Dolomiti
Alonso D.	P-743	Tuesday	17:00 - 18:00	Exhibition Area
Altamirano J.	P-586	Thursday	13:00 - 14:00	Exhibition Area
Aminot Y.	D10-832	Monday	14:50 - 15:10	Garda B
Angeli A.	P-988	Monday	17:00 - 18:00	Exhibition Area
Aranda-Rodriguez R.	D7-098	Monday	14:10 - 14:30	Garda A
Araya-Piqué V.	BFR1-418	Wednesday	11:40 - 12:00	Riva
Arotcarena M.	P-979	Tuesday	17:00 - 18:00	Exhibition Area
Asakawa D.	P-060	Tuesday	17:00 - 18:00	Exhibition Area
Averina M.	P-136	Tuesday	17:00 - 18:00	Exhibition Area
Baessmann C.	D46-011	Thursday	16:10 - 16:30	Garda A

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Bagnuolo G.	P-593	Thursday	13:00 - 14:00	Exhibition Area
Balakrishna K.	D20-155	Tuesday	10:20 - 10:40	Riva
Balducci C.	P-447	Tuesday	17:00 - 18:00	Exhibition Area
Balducci C.	P-951	Tuesday	17:00 - 18:00	Exhibition Area
Balest L.	D37-664	Wednesday	11:40 - 12:00	Dolomiti
Balest L.	P-663	Thursday	13:00 - 14:00	Exhibition Area
Barber J.L.	D11-682	Monday	16:00 - 16:20	Garda A
Barbieri M.V.	D19-169	Tuesday	10:20 - 10:40	Garda B
Barola C.	P-373	Tuesday	17:00 - 18:00	Exhibition Area
Baycan N.	D30-182	Tuesday	15:40 - 16:00	Riva
Beggio M.	P-264	Tuesday	17:00 - 18:00	Exhibition Area
Ben Efraim R.	D42-096	Thursday	14:20 - 14:40	Dolomiti
Benedetti P.	D37-165	Wednesday	11:00 - 11:20	Dolomiti
Benoit N.	P-176	Tuesday	17:00 - 18:00	Exhibition Area
Bernhard A.	P-113	Tuesday	17:00 - 18:00	Exhibition Area
Beser M.I.	P-590	Monday	17:00 - 18:00	Exhibition Area
Bin Z.	P-388	Tuesday	17:00 - 18:00	Exhibition Area
Bonucci F.	P-507	Tuesday	17:00 - 18:00	Exhibition Area
Borga K.	D15-785	Monday	15:40 - 16:00	Belevedere
Bosomtwi A.	P-424	Monday	17:00 - 18:00	Exhibition Area
Brambilla G.	D15-930	Monday	16:40 - 17:00	Belevedere
Brandsma S.H.	D5-840	Monday	11:30 - 11:50	Belevedere
Brandsma S.H.	D38-852	Thursday	10:20 - 10:40	Belevedere
Bruvold A.	P-811	Monday	17:00 - 18:00	Exhibition Area
Buchmet A.	D31-786	Tuesday	16:20 - 16:40	Dolomiti

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Burgos Melo H.D.	BFR2-152	Wednesday	14:30 - 14:50	Riva
Burgos Melo H.D.	P-179	Monday	17:00 - 18:00	Exhibition Area
Burgos-Melo H.	P-009	Thursday	13:00 - 14:00	Exhibition Area
Butti L.	D6-884	Monday	13:30 - 13:50	Dolomiti
Buytaert J.	D22-441	Tuesday	13:50 - 14:10	Dolomiti
Cali' A.N.N.A.	P-457	Tuesday	17:00 - 18:00	Exhibition Area
Cali' A.N.N.A.	P-460	Thursday	13:00 - 14:00	Exhibition Area
Campaniello M.	P-380	Tuesday	17:00 - 18:00	Exhibition Area
Canzanella S.	P-436	Monday	17:00 - 18:00	Exhibition Area
Canzanella S.	P-439	Monday	17:00 - 18:00	Exhibition Area
Cao M.	D26-386	Tuesday	14:50 - 15:10	Riva
Cariou R.	D19-437	Tuesday	10:40 - 11:00	Garda B
Cariou R.	P-799	Tuesday	17:00 - 18:00	Exhibition Area
Carrer C.C.	P-339	Monday	17:00 - 18:00	Exhibition Area
Carrer C.C.	P-340	Monday	17:00 - 18:00	Exhibition Area
Castro-Jiménez J.	D13-121	Monday	16:00 - 16:20	Dolomiti
Ceccon E.	P-017	Thursday	13:00 - 14:00	Exhibition Area
Ceccon E.	P-048	Monday	17:00 - 18:00	Exhibition Area
Ceci R.	P-618	Thursday	13:00 - 14:00	Exhibition Area
Cerasa M.	D39-523	Thursday	10:00 - 10:20	Garda B
Cha Y.H.	P-725	Tuesday	17:00 - 18:00	Exhibition Area
Chang M.	P-451	Monday	17:00 - 18:00	Exhibition Area
Chang M.	P-448	Monday	17:00 - 18:00	Exhibition Area
Chen B.C.	D13-004	Monday	15:40 - 16:00	Dolomiti
Chen D.	P-882	Monday	17:00 - 18:00	Exhibition Area

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Chen S.	P-901	Monday	17:00 - 18:00	Exhibition Area
Cheng F.	P-200	Tuesday	17:00 - 18:00	Exhibition Area
Chiba S.	P-227	Thursday	13:00 - 14:00	Exhibition Area
Chung Y.J.	D21-036	Tuesday	11:40 - 12:00	Garda A
Cioni L.	D19-102	Tuesday	10:00 - 10:20	Garda B
Clarke B.	D43-628	Thursday	11:20 - 11:40	Garda B
Corami F.	D44-255	Thursday	14:00 - 14:20	Garda B
Costopoulou D.	P-390	Monday	17:00 - 18:00	Exhibition Area
Covaci A.	D2-518	Monday	10:50 - 11:10	Garda A
Currás-Collazo M.	D34-849	Wednesday	11:40 - 12:00	Garda A
D'antonio S.	P-643	Monday	17:00 - 18:00	Exhibition Area
D'onofrio F.	P-140	Tuesday	17:00 - 18:00	Exhibition Area
Dahlgren J.	D21-104	Tuesday	10:00 - 10:20	Garda A
Dai J.	P-555	Tuesday	17:00 - 18:00	Exhibition Area
Dan X.	P-759	Monday	17:00 - 18:00	Exhibition Area
Darina D.	P-174	Monday	17:00 - 18:00	Exhibition Area
De Boer J.	D29-551	Tuesday	15:40 - 16:00	Garda B
De La Torre A.	P-126	Monday	17:00 - 18:00	Exhibition Area
De La Torre A.	P-376	Tuesday	17:00 - 18:00	Exhibition Area
Dellatte E.	P-794	Thursday	13:00 - 14:00	Exhibition Area
Dervilly G.	D17-054	Tuesday	10:40 - 11:00	Limoni
Dervilly G.	P-053	Monday	17:00 - 18:00	Exhibition Area
Dhiman S.	P-891	Thursday	13:00 - 14:00	Exhibition Area
Di Bernardo G.	P-636	Thursday	13:00 - 14:00	Exhibition Area
Di Donatantonio G.	P-645	Thursday	13:00 - 14:00	Exhibition Area

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Di Mario M.	D5-576	Monday	11:50 - 12:10	Belevedere
Donegà M.	P-192	Tuesday	17:00 - 18:00	Exhibition Area
Dong D.C.X.	P-926	Tuesday	17:00 - 18:00	Exhibition Area
Dreyer A.	D9-966	Monday	14:30 - 14:50	Belevedere
Dumont G.	D39-304	Thursday	11:00 - 11:20	Garda B
Dvoršćak M.	P-375	Thursday	13:00 - 14:00	Exhibition Area
El Amraoui Aarab C.	D31-107	Tuesday	15:40 - 16:00	Dolomiti
Eppe G.	D41-577	Thursday	11:40 - 12:00	Garda A
Ericson Jogsten I.	P-816	Thursday	13:00 - 14:00	Exhibition Area
Ericson Jogsten I.	P-826	Tuesday	17:00 - 18:00	Exhibition Area
Eriksson V.	D35-016	Wednesday	11:00 - 11:20	Garda B
Eskes C.	D40-677	Thursday	11:00 - 11:20	Dolomiti
Esposito M.	D15-930	Monday	16:40 - 17:00	Belevedere
Eun H.	D41-391	Thursday	10:40 - 11:00	Garda A
Eun H.	P-395	Thursday	13:00 - 14:00	Exhibition Area
Ewers M.	P-213	Tuesday	17:00 - 18:00	Exhibition Area
Fang B.	D17-101	Tuesday	11:20 - 11:40	Limoni
Farre M.	D27-732	Tuesday	14:30 - 14:50	Garda A
Feng C.F.	P-093	Thursday	13:00 - 14:00	Exhibition Area
Feng Q.	P-086	Tuesday	17:00 - 18:00	Exhibition Area
Fernández-Arribas J.	D43-260	Thursday	14:20 - 14:40	Belevedere
Fiedler H.	D26-804	Tuesday	14:30 - 14:50	Riva
Focant J.	D1-583	Monday	11:30 - 11:50	Dolomiti
Fochi I.	P-942	Thursday	13:00 - 14:00	Exhibition Area
Formenton G.	D12-129	Monday	16:40 - 17:00	Garda B

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Franchina F.A.	D19-854	Tuesday	11:20 - 11:40	Garda B
Frantzen S.	P-972	Thursday	13:00 - 14:00	Exhibition Area
Frisario S.A.	P-539	Monday	17:00 - 18:00	Exhibition Area
Fu J.	P-907	Thursday	13:00 - 14:00	Exhibition Area
Fujii Y.	D3-801	Monday	11:50 - 12:10	Garda B
Fujii Y.	D28-788	Tuesday	16:40 - 17:00	Garda A
Fukuoka M.	P-156	Thursday	13:00 - 14:00	Exhibition Area
Gaddoni L.	P-007	Monday	17:00 - 18:00	Exhibition Area
Galarini R.	P-579	Monday	17:00 - 18:00	Exhibition Area
García-Mesa J.C.	D30-619	Tuesday	16:20 - 16:40	Riva
Gersthagen T.	P-464	Thursday	13:00 - 14:00	Exhibition Area
Giannelli Moneta B.	P-573	Monday	17:00 - 18:00	Exhibition Area
Gómez-Aburto V.	P-030	Monday	17:00 - 18:00	Exhibition Area
Goo N.	P-132	Tuesday	17:00 - 18:00	Exhibition Area
Gould D.	D4-073	Monday	11:50 - 12:10	Riva
Gould D.	P-254	Monday	17:00 - 18:00	Exhibition Area
Gould D.	P-065	Thursday	13:00 - 14:00	Exhibition Area
Gramblicka T.	P-293	Thursday	13:00 - 14:00	Exhibition Area
Granafei G.	P-491	Monday	17:00 - 18:00	Exhibition Area
Gravina F.G.	D31-130	Tuesday	16:00 - 16:20	Dolomiti
Gregoris E.	P-177	Tuesday	17:00 - 18:00	Exhibition Area
Groffen T.	D34-033	Wednesday	10:00 - 10:20	Garda A
Gruber L.	P-994	Thursday	13:00 - 14:00	Exhibition Area
Guo C.	P-057	Tuesday	17:00 - 18:00	Exhibition Area
Guo J.	D42-061	Thursday	15:20 - 15:40	Dolomiti

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Gütter L.	BFR5-377	Thursday	14:00 - 14:20	Riva
Hall T.	P-699	Thursday	13:00 - 14:00	Exhibition Area
Halse A.K.	P-992	Tuesday	17:00 - 18:00	Exhibition Area
Halvorsen H.L.	P-005	Monday	17:00 - 18:00	Exhibition Area
Halvorsen H.L.	P-003	Monday	17:00 - 18:00	Exhibition Area
Hammel S.	BFR1-611	Wednesday	11:00 - 11:20	Riva
Harju M.	P-661	Monday	17:00 - 18:00	Exhibition Area
Harner T.	D6-511	Monday	14:10 - 14:30	Dolomiti
Harner T.	D4-515	Monday	11:10 - 11:30	Riva
Hauschildt C.	D31-215	Tuesday	16:40 - 17:00	Dolomiti
Hebert Y.	P-010	Monday	17:00 - 18:00	Exhibition Area
Hebert Y.	P-079	Tuesday	17:00 - 18:00	Exhibition Area
Henry C.H.	P-570	Monday	17:00 - 18:00	Exhibition Area
Herkert N.	D23-709	Tuesday	14:30 - 14:50	Belevedere
Herkert N.	D29-708	Tuesday	16:20 - 16:40	Garda B
Herzke D.	D26-302	Tuesday	13:30 - 13:50	Riva
Herzke D.	D44-721	Thursday	14:40 - 15:00	Garda B
Herzke D.	BFR6-614	Thursday	16:30 - 16:50	Riva
Herzke D.	P-401	Tuesday	17:00 - 18:00	Exhibition Area
Hirato Y.	D42-063	Thursday	15:00 - 15:20	Dolomiti
Hoehn R.M.	D43-259	Thursday	14:00 - 14:20	Belevedere
Hofman D.R.	D12-207	Thursday	14:00 - 14:20	Garda A
Hofman J.	D20-410	Tuesday	11:00 - 11:20	Riva
Hogstrand C.	D40-673	Thursday	10:00 - 10:20	Dolomiti
Hollins H.	D2-023	Monday	11:50 - 12:10	Garda A

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Hoogenboom R.	D22-203	Tuesday	13:30 - 13:50	Dolomiti
Hoogenboom R.	D40-670	Thursday	10:40 - 11:00	Dolomiti
Hope K.	P-584	Monday	17:00 - 18:00	Exhibition Area
Horii Y.	P-731	Monday	17:00 - 18:00	Exhibition Area
Horii Y.	P-125	Tuesday	17:00 - 18:00	Exhibition Area
Hsu Y.S.	D20-300	Tuesday	10:40 - 11:00	Riva
Hu Y.	D34-379	Wednesday	11:20 - 11:40	Garda A
Huang W.	P-873	Monday	17:00 - 18:00	Exhibition Area
Huber S.	P-955	Thursday	13:00 - 14:00	Exhibition Area
Hussnain A.	D30-394	Tuesday	16:00 - 16:20	Riva
Huynh N.	D41-032	Thursday	11:00 - 11:20	Garda A
Huynh N.	P-077	Monday	17:00 - 18:00	Exhibition Area
Iannone A.	D3-247	Monday	10:30 - 10:50	Garda B
Idowu I.G.	D41-337	Thursday	10:20 - 10:40	Garda A
Igaku K.	P-365	Tuesday	17:00 - 18:00	Exhibition Area
Inaba K.	P-225	Thursday	13:00 - 14:00	Exhibition Area
Inui H.	P-110	Tuesday	17:00 - 18:00	Exhibition Area
Isobe T.	D46-284	Thursday	16:50 - 17:10	Garda A
Jain V.	D19-485	Tuesday	11:40 - 12:00	Garda B
Jansson S.	P-601	Monday	17:00 - 18:00	Exhibition Area
Jaspers V.	D11-354	Monday	16:40 - 17:00	Garda A
Jelínek N.	D5-070	Monday	10:30 - 10:50	Belevedere
Jelínek N.	P-103	Monday	17:00 - 18:00	Exhibition Area
Jeong Y.	P-797	Thursday	13:00 - 14:00	Exhibition Area
Jiménez B.	P-858	Tuesday	17:00 - 18:00	Exhibition Area

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Joly L.	D37-117	Wednesday	10:00 - 10:20	Dolomiti
Josefsson S.	D9-417	Monday	13:50 - 14:10	Belevedere
Juric A.	P-285	Thursday	13:00 - 14:00	Exhibition Area
Kajiwara N.	D8-745	Monday	14:10 - 14:30	Riva
Kajiwara N.	BFR4-781	Thursday	11:00 - 11:20	Riva
Kakinami M.	P-134	Tuesday	17:00 - 18:00	Exhibition Area
Kanai Y.	P-161	Tuesday	17:00 - 18:00	Exhibition Area
Kawabe Y.	P-372	Thursday	13:00 - 14:00	Exhibition Area
Kayan A.I.	P-769	Tuesday	17:00 - 18:00	Exhibition Area
Kazuhiro N.	P-031	Tuesday	17:00 - 18:00	Exhibition Area
Kim K.	P-078	Thursday	13:00 - 14:00	Exhibition Area
Kim S.D.	P-430	Tuesday	17:00 - 18:00	Exhibition Area
Klinčić D.	P-374	Thursday	13:00 - 14:00	Exhibition Area
Kok P.	P-038	Tuesday	17:00 - 18:00	Exhibition Area
Körner W.	BFR4-625	Thursday	10:20 - 10:40	Riva
Kozlova E.	D18-071	Tuesday	11:00 - 11:20	Belevedere
Krätschmer K.	D37-135	Wednesday	10:20 - 10:40	Dolomiti
Krätschmer K.	BFR3-137	Wednesday	16:00 - 16:20	Riva
Kucera P.	P-459	Thursday	13:00 - 14:00	Exhibition Area
Kuramochi H.	D23-524	Tuesday	14:10 - 14:30	Belevedere
Kuramochi H.	P-525	Monday	17:00 - 18:00	Exhibition Area
Kurt Karakuş P.B.	D17-112	Tuesday	11:40 - 12:00	Limoni
Kurt-Karakus P.B.	D14-111	Monday	15:40 - 16:00	Riva
La Mantia A.	P-985	Thursday	13:00 - 14:00	Exhibition Area
Lacomba I.	P-588	Monday	17:00 - 18:00	Exhibition Area

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Lasalle J.M.	D47-793	Thursday	16:50 - 17:10	Garda B
Lee Y.K.	D8-039	Monday	14:50 - 15:10	Riva
Lerch S.	D18-124	Tuesday	10:00 - 10:20	Belevedere
Lerch S.	D35-499	Wednesday	11:20 - 11:40	Garda B
Leshchenko V.	P-298	Monday	17:00 - 18:00	Exhibition Area
Leube P.	D12-012	Monday	15:40 - 16:00	Garda B
Leva M.	P-638	Tuesday	17:00 - 18:00	Exhibition Area
Levalier S.	D3-736	Monday	11:30 - 11:50	Garda B
Levalier S.	P-735	Monday	17:00 - 18:00	Exhibition Area
Li H.	P-363	Tuesday	17:00 - 18:00	Exhibition Area
Li H.L.	P-958	Tuesday	17:00 - 18:00	Exhibition Area
Liao C.	P-889	Monday	17:00 - 18:00	Exhibition Area
Lievens S.	D39-684	Thursday	10:40 - 11:00	Garda B
Lili Y.	P-876	Monday	17:00 - 18:00	Exhibition Area
Lili Y.	P-878	Monday	17:00 - 18:00	Exhibition Area
Liu G.	D23-885	Tuesday	14:50 - 15:10	Belevedere
Liu J.	D17-026	Tuesday	10:20 - 10:40	Limoni
Liu L.	P-085	Tuesday	17:00 - 18:00	Exhibition Area
Liu X.	P-871	Tuesday	17:00 - 18:00	Exhibition Area
Lodi R.	P-050	Monday	17:00 - 18:00	Exhibition Area
Lohrberg D.	P-913	Monday	17:00 - 18:00	Exhibition Area
Lomnicki S.	D23-580	Tuesday	13:50 - 14:10	Belevedere
Loyola-Sepulveda R.	D36-807	Wednesday	11:40 - 12:00	Belevedere
Lu C.W.	P-006	Tuesday	17:00 - 18:00	Exhibition Area
Luan T.	D15-895	Monday	16:00 - 16:20	Belevedere

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Lucidi E.	P-149	Monday	17:00 - 18:00	Exhibition Area
Luo J.J.	P-291	Thursday	13:00 - 14:00	Exhibition Area
Lymer J.	P-072	Tuesday	17:00 - 18:00	Exhibition Area
Machala M.	P-634	Tuesday	17:00 - 18:00	Exhibition Area
Mackinnon L.	BFR2-269	Wednesday	14:10 - 14:30	Riva
Marcus M.	P-474	Thursday	13:00 - 14:00	Exhibition Area
Marfil-Vega R.	P-962	Monday	17:00 - 18:00	Exhibition Area
Martín J.C.	D8-544	Monday	13:50 - 14:10	Riva
Martín J.C.	P-541	Monday	17:00 - 18:00	Exhibition Area
Matsukami H.	D8-704	Monday	14:30 - 14:50	Riva
Matsukami H.	P-758	Monday	17:00 - 18:00	Exhibition Area
Matsukami H.	P-533	Monday	17:00 - 18:00	Exhibition Area
Mavumengwana-Khanyile B.	P-397	Tuesday	17:00 - 18:00	Exhibition Area
Megson D.	D2-360	Monday	11:30 - 11:50	Garda A
Mehlmann H.	P-355	Thursday	13:00 - 14:00	Exhibition Area
Mikolajczyk S.	D22-067	Tuesday	14:50 - 15:10	Dolomiti
Mikolajczyk S.	P-069	Tuesday	17:00 - 18:00	Exhibition Area
Misselwitz M.	D21-324	Tuesday	10:40 - 11:00	Garda A
Miuchi M.	D35-297	Wednesday	10:20 - 10:40	Garda B
Mok S.	D30-752	Tuesday	16:40 - 17:00	Riva
Moon H.B.	P-059	Monday	17:00 - 18:00	Exhibition Area
Moreau S.	P-964	Monday	17:00 - 18:00	Exhibition Area
Moretti S.	D7-509	Monday	14:30 - 14:50	Garda A
Mosca S.	D35-147	Wednesday	10:40 - 11:00	Garda B

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Mueller V.	D20-151	Tuesday	10:00 - 10:20	Riva
Muir D.	D36-775	Wednesday	11:20 - 11:40	Belevedere
Muir D.	P-467	Monday	17:00 - 18:00	Exhibition Area
Müller M.	D29-740	Tuesday	16:40 - 17:00	Garda B
Muñoz-Arnanz J.	D44-621	Thursday	15:00 - 15:20	Garda B
Munschy C.	D17-003	Tuesday	10:00 - 10:20	Limoni
Murru L.	P-171	Monday	17:00 - 18:00	Exhibition Area
Nagoda C.	P-194	Monday	17:00 - 18:00	Exhibition Area
Nakano T.	D9-483	Monday	14:10 - 14:30	Belevedere
Nakano T.	D1-481	Monday	11:10 - 11:30	Dolomiti
Namura T.	D7-020	Monday	13:30 - 13:50	Garda A
Namura T.	P-750	Tuesday	17:00 - 18:00	Exhibition Area
Nauta W.	D36-187	Wednesday	10:40 - 11:00	Belevedere
Neugebauer F.	BFR6-456	Thursday	17:10 - 17:30	Riva
Ng B.H.	D25-320	Tuesday	14:10 - 14:30	Garda B
Nigon C.	BFR5-013	Thursday	14:40 - 15:00	Riva
Nigon C.	BFR5-014	Thursday	15:00 - 15:20	Riva
Nikiforov V.	D12-371	Monday	16:20 - 16:40	Garda B
Nikiforov V.	P-996	Monday	17:00 - 18:00	Exhibition Area
Nikiforov V.	P-990	Thursday	13:00 - 14:00	Exhibition Area
Nikiforov V.	P-795	Thursday	13:00 - 14:00	Exhibition Area
Niklas A.A.	D10-823	Monday	14:30 - 14:50	Garda B
Nilsen B.M.	P-974	Monday	17:00 - 18:00	Exhibition Area
Nilsson S.	D3-276	Monday	10:50 - 11:10	Garda B
Nilsson S.	D27-309	Tuesday	13:30 - 13:50	Garda A

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Nishijo M.	D1-251	Monday	10:30 - 10:50	Dolomiti
Nishijo M.	P-916	Thursday	13:00 - 14:00	Exhibition Area
Njuki N.	P-900	Thursday	13:00 - 14:00	Exhibition Area
Nomiyama K.	P-167	Tuesday	17:00 - 18:00	Exhibition Area
Nøstbakken O.J.	P-028	Tuesday	17:00 - 18:00	Exhibition Area
Numata J.	D25-115	Tuesday	13:50 - 14:10	Garda B
Numata J.	D40-701	Thursday	11:20 - 11:40	Dolomiti
Oh J.E.	P-041	Monday	17:00 - 18:00	Exhibition Area
Ohta C.	P-095	Tuesday	17:00 - 18:00	Exhibition Area
Oki H.	P-766	Monday	17:00 - 18:00	Exhibition Area
Okonkwo O.J.	P-114	Monday	17:00 - 18:00	Exhibition Area
Öman A.	P-088	Monday	17:00 - 18:00	Exhibition Area
Organtini K.	D41-025	Thursday	10:00 - 10:20	Garda A
Organtini K.	D46-024	Thursday	16:30 - 16:50	Garda A
Orr J.	D27-186	Tuesday	13:50 - 14:10	Garda A
Ortuño N.	P-420	Monday	17:00 - 18:00	Exhibition Area
Ortuño N.	P-423	Monday	17:00 - 18:00	Exhibition Area
Ozen E.Y.	P-729	Thursday	13:00 - 14:00	Exhibition Area
Paci F.P.	P-052	Tuesday	17:00 - 18:00	Exhibition Area
Padilha J.	D10-635	Monday	13:50 - 14:10	Garda B
Padilha J.	P-762	Tuesday	17:00 - 18:00	Exhibition Area
Pajurek M.	P-062	Monday	17:00 - 18:00	Exhibition Area
Pajurek M.	P-944	Tuesday	17:00 - 18:00	Exhibition Area
Palermo F.	P-496	Tuesday	17:00 - 18:00	Exhibition Area
Pamuk E.	D39-500	Thursday	10:20 - 10:40	Garda B

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Pan S.Y.	D23-042	Tuesday	13:30 - 13:50	Belevedere
Pardi F.	P-150	Thursday	13:00 - 14:00	Exhibition Area
Park Y.	P-650	Monday	17:00 - 18:00	Exhibition Area
Partington J.	D3-479	Monday	11:10 - 11:30	Garda B
Partington J.	D34-190	Wednesday	10:40 - 11:00	Garda A
Patel A.	P-726	Tuesday	17:00 - 18:00	Exhibition Area
Paz M.	D11-569	Monday	16:20 - 16:40	Garda A
Pellizzaro A.	D2-893	Monday	11:10 - 11:30	Garda A
Perra G.	P-221	Tuesday	17:00 - 18:00	Exhibition Area
Petrlik J.	D14-148	Monday	16:00 - 16:20	Riva
Petrlik J.	D14-469	Monday	16:40 - 17:00	Riva
Pham The T.	D1-288	Monday	10:50 - 11:10	Dolomiti
Pham-The P.H.A.M.T.	P-754	Monday	17:00 - 18:00	Exhibition Area
Phan V.S.	P-094	Tuesday	17:00 - 18:00	Exhibition Area
Philippart A.	P-982	Monday	17:00 - 18:00	Exhibition Area
Piazzi S.	P-075	Monday	17:00 - 18:00	Exhibition Area
Piechotta C.	P-949	Tuesday	17:00 - 18:00	Exhibition Area
Piersanti A.	D22-139	Tuesday	14:10 - 14:30	Dolomiti
Pirard C.	D27-349	Tuesday	14:10 - 14:30	Garda A
Poma G.	P-064	Monday	17:00 - 18:00	Exhibition Area
Pozo K.	P-222	Monday	17:00 - 18:00	Exhibition Area
Ragazzo A.	BFR2-083	Wednesday	13:50 - 14:10	Riva
Ramesh Kumar A.	D13-543	Monday	16:40 - 17:00	Dolomiti
Ramesh Kumar A.	D36-128	Wednesday	10:00 - 10:20	Belevedere
Resende G.	P-612	Tuesday	17:00 - 18:00	Exhibition Area

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Ricke E.	P-833	Tuesday	17:00 - 18:00	Exhibition Area
Riolo F.	D40-674	Thursday	10:20 - 10:40	Dolomiti
Rodrigues A.	D7-647	Monday	14:50 - 15:10	Garda A
Rodrigues A.	P-948	Tuesday	17:00 - 18:00	Exhibition Area
Roggeman M.	D5-689	Monday	11:10 - 11:30	Belevedere
Romagnoli M.	P-856	Thursday	13:00 - 14:00	Exhibition Area
Rosso B.	D4-244	Monday	10:50 - 11:10	Riva
Rosso B.	P-310	Monday	17:00 - 18:00	Exhibition Area
Rosso B.	P-312	Tuesday	17:00 - 18:00	Exhibition Area
Rottgen D.A.	D6-897	Monday	13:50 - 14:10	Dolomiti
Rund K.	D35-836	Wednesday	10:00 - 10:20	Garda B
Sadik O.	BFR4-472	Thursday	10:40 - 11:00	Riva
Sakatani K.	P-105	Tuesday	17:00 - 18:00	Exhibition Area
Salangad O.	D10-214	Monday	13:30 - 13:50	Garda B
Salangad O.	P-343	Monday	17:00 - 18:00	Exhibition Area
Sandanger T.M.	P-970	Monday	17:00 - 18:00	Exhibition Area
Sandau C.D.	P-690	Monday	17:00 - 18:00	Exhibition Area
Sanden M.	P-940	Thursday	13:00 - 14:00	Exhibition Area
Sanin F.D.	D43-587	Thursday	14:40 - 15:00	Belevedere
Sanin S.L.	D34-529	Wednesday	11:00 - 11:20	Garda A
Santoro S.	D6-675	Monday	14:50 - 15:10	Dolomiti
Sasano R.	P-838	Thursday	13:00 - 14:00	Exhibition Area
Scalabrin E.	D26-273	Tuesday	14:10 - 14:30	Riva
Scalabrin E.	P-272	Monday	17:00 - 18:00	Exhibition Area
Scheringer M.	D48-779	Thursday	16:50 - 17:10	Dolomiti

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Schinkel L.	P-405	Tuesday	17:00 - 18:00	Exhibition Area
Schneiders A.L.	D41-537	Thursday	11:20 - 11:40	Garda A
Schroeder H.	BFR5-828	Thursday	14:20 - 14:40	Riva
Schweizer S.	BFR1-839	Wednesday	11:20 - 11:40	Riva
Seltmann J.	P-968	Thursday	13:00 - 14:00	Exhibition Area
Semeraro M.D.R.	D48-581	Thursday	17:10 - 17:30	Dolomiti
Serafeim E.	BFR4-407	Thursday	11:40 - 12:00	Riva
Shotholo B.	D25-277	Tuesday	14:30 - 14:50	Garda B
Shukla V.	P-998	Thursday	13:00 - 14:00	Exhibition Area
Song Y.	P-549	Tuesday	17:00 - 18:00	Exhibition Area
Sørensen S.	P-776	Monday	17:00 - 18:00	Exhibition Area
Sousa A.C.	D28-415	Tuesday	16:00 - 16:20	Garda A
Sousa A.C.	P-001	Thursday	13:00 - 14:00	Exhibition Area
Stevanin C.	D42-106	Thursday	14:40 - 15:00	Dolomiti
Stramenga A.	P-181	Monday	17:00 - 18:00	Exhibition Area
Stroski K.	P-975	Thursday	13:00 - 14:00	Exhibition Area
Stubleski J.	P-099	Thursday	13:00 - 14:00	Exhibition Area
Su G.	D9-009	Monday	13:30 - 13:50	Belevedere
Sühring R.	D26-131	Tuesday	13:50 - 14:10	Riva
Sühring R.	D36-141	Wednesday	10:20 - 10:40	Belevedere
Sun H.	D17-100	Tuesday	11:00 - 11:20	Limoni
Sutter C.	D18-746	Tuesday	10:40 - 11:00	Belevedere
Suzuki M.	D18-127	Tuesday	10:20 - 10:40	Belevedere
Suzuki T.	P-428	Monday	17:00 - 18:00	Exhibition Area
Svobodova V.	P-246	Thursday	13:00 - 14:00	Exhibition Area

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Tabla Ruiz N.	D5-209	Monday	10:50 - 11:10	Belevedere
Tagawa E.	P-119	Monday	17:00 - 18:00	Exhibition Area
Takahara R.	P-705	Thursday	13:00 - 14:00	Exhibition Area
Takahashi A.	P-231	Tuesday	17:00 - 18:00	Exhibition Area
Takasuga T.	P-306	Monday	17:00 - 18:00	Exhibition Area
Takemine S.	D16-362	Tuesday	11:00 - 11:20	Dolomiti
Tani S.	D20-566	Tuesday	11:20 - 11:40	Riva
Tariba Lovakovic B.	P-236	Thursday	13:00 - 14:00	Exhibition Area
Tavoloni T.	P-138	Monday	17:00 - 18:00	Exhibition Area
Teiner M.	P-609	Tuesday	17:00 - 18:00	Exhibition Area
Teng Y.U.R.	D32-007	Tuesday	16:00 - 16:20	Belevedere
Tiercin A.	D32-084	Tuesday	16:20 - 16:40	Belevedere
Tiquet M.	P-097	Monday	17:00 - 18:00	Exhibition Area
Tirler W.	P-938	Thursday	13:00 - 14:00	Exhibition Area
Tiwari A.N.S.H.U.	P-434	Monday	17:00 - 18:00	Exhibition Area
Tobolková E.	D9-599	Monday	14:50 - 15:10	Belevedere
Tobolková E.	D14-412	Monday	16:20 - 16:40	Riva
Toborek M.	P-327	Tuesday	17:00 - 18:00	Exhibition Area
Tomasko J.	D37-035	Wednesday	11:20 - 11:40	Dolomiti
Torres M.	P-268	Monday	17:00 - 18:00	Exhibition Area
Trevisanato G.	D16-352	Tuesday	11:20 - 11:40	Dolomiti
Trinh Khac S.	P-045	Tuesday	17:00 - 18:00	Exhibition Area
Tsymbaliuk K.	P-527	Tuesday	17:00 - 18:00	Exhibition Area
Uçar Y.	P-531	Monday	17:00 - 18:00	Exhibition Area
Uhr L.U.	P-142	Tuesday	17:00 - 18:00	Exhibition Area

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Urbaniak M.	P-037	Tuesday	17:00 - 18:00	Exhibition Area
Urbaniak M.	P-903	Tuesday	17:00 - 18:00	Exhibition Area
Uwayezu J.N.	D42-080	Thursday	14:00 - 14:20	Dolomiti
Van Der Kroef I.	P-764	Monday	17:00 - 18:00	Exhibition Area
Van Der Veen I.	P-946	Monday	17:00 - 18:00	Exhibition Area
Van Engen I.	P-347	Tuesday	17:00 - 18:00	Exhibition Area
Van Leeuwen S.P.J.	D11-820	Monday	15:40 - 16:00	Garda A
Van Leeuwen S.P.J.	D22-830	Tuesday	14:30 - 14:50	Dolomiti
Vecchiato M.	P-381	Monday	17:00 - 18:00	Exhibition Area
Vecchiato M.	P-931	Monday	17:00 - 18:00	Exhibition Area
Venier M.	D45-476	Thursday	14:40 - 15:00	Garda A
Vénisseau A.	D16-553	Tuesday	10:40 - 11:00	Dolomiti
Verreault J.	D15-385	Monday	16:20 - 16:40	Belevedere
Verstraete F.	D40-773	Thursday	11:40 - 12:00	Dolomiti
Vestrucci L.	P-440	Tuesday	17:00 - 18:00	Exhibition Area
Vetter W.	BFR3-489	Thursday	11:40 - 12:00	Riva
Vetter W.	D38-487	Thursday	11:00 - 11:20	Belevedere
Vogel C.	P-005	Monday	17:00 - 18:00	Exhibition Area
Vogel C.	P-929	Thursday	13:00 - 14:00	Exhibition Area
Vollaro T.M.	P-145	Tuesday	17:00 - 18:00	Exhibition Area
Wang A.G.	P-869	Tuesday	17:00 - 18:00	Exhibition Area
Wang D.	P-368	Tuesday	17:00 - 18:00	Exhibition Area
Wang H.	P-924	Tuesday	17:00 - 18:00	Exhibition Area
Wang H.C.	P-018	Monday	17:00 - 18:00	Exhibition Area
Wang J.	P-953	Tuesday	17:00 - 18:00	Exhibition Area

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Wang Q.	D18-281	Tuesday	11:40 - 12:00	Belevedere
Warner N.	D37-162	Wednesday	10:40 - 11:00	Dolomiti
Weber R.	D21-305	Tuesday	10:20 - 10:40	Garda A
Weber R.	BFR6-315	Thursday	16:10 - 16:30	Riva
Weber W.	P-091	Monday	17:00 - 18:00	Exhibition Area
Webster T.F.	D32-331	Tuesday	15:40 - 16:00	Belevedere
Weiss J.	P-056	Thursday	13:00 - 14:00	Exhibition Area
Wise C.	D28-271	Tuesday	15:40 - 16:00	Garda A
Wise J.	P-219	Thursday	13:00 - 14:00	Exhibition Area
Wise Sr. J.P.	P-984	Tuesday	17:00 - 18:00	Exhibition Area
Woppowa L.	D38-547	Thursday	11:20 - 11:40	Belevedere
Wu F.	P-917	Tuesday	17:00 - 18:00	Exhibition Area
Wu Q.	D4-049	Monday	11:30 - 11:50	Riva
Wu Q.	D25-051	Tuesday	13:30 - 13:50	Garda B
Xiao Y.	D34-146	Wednesday	10:20 - 10:40	Garda A
Yabuki Y.	P-492	Monday	17:00 - 18:00	Exhibition Area
Yağar E.F.	D48-662	Thursday	16:10 - 16:30	Dolomiti
Yamamoto M.	P-191	Tuesday	17:00 - 18:00	Exhibition Area
Yang L.	D45-122	Thursday	14:20 - 14:40	Garda A
Yang L.	P-123	Tuesday	17:00 - 18:00	Exhibition Area
Yin S.	D43-378	Thursday	15:00 - 15:20	Belevedere
You J.	P-369	Thursday	13:00 - 14:00	Exhibition Area
Yu Z.	P-911	Monday	17:00 - 18:00	Exhibition Area
Yu Z.	P-716	Tuesday	17:00 - 18:00	Exhibition Area
Zanon A.	D2-066	Monday	10:30 - 10:50	Garda A

Index of **Presenters**

NAME	ABSTRACT	DAY	TIME	ROOM
Zapata-Corella P.	D13-319	Monday	16:20 - 16:40	Dolomiti
Zennegg M.	D20-403	Tuesday	11:40 - 12:00	Riva
Zhai J.	P-909	Tuesday	17:00 - 18:00	Exhibition Area
Zhang G.	D44-445	Thursday	14:20 - 14:40	Garda B
Zhang S.	P-055	Tuesday	17:00 - 18:00	Exhibition Area
Zhang Y.	P-021	Tuesday	17:00 - 18:00	Exhibition Area
Zhao D.	D27-074	Tuesday	14:50 - 15:10	Garda A
Zhao L.	D44-090	Thursday	15:20 - 15:40	Garda B
Zhao L.	P-157	Tuesday	17:00 - 18:00	Exhibition Area
Zhao M.	D38-333	Thursday	10:00 - 10:20	Belevedere
Zhao S.	D36-443	Wednesday	11:00 - 11:20	Belevedere
Zhou X.	P-034	Thursday	13:00 - 14:00	Exhibition Area
Zianni R.	P-046	Tuesday	17:00 - 18:00	Exhibition Area
Zhao D.	D27-074	Tuesday	14:50 - 15:10	Garda A
Zhao L.	D44-090	Thursday	15:20 - 15:40	Garda B
Zhao L.	P-157	Tuesday	17:00 - 18:00	Exhibition Area
Zhao M.	D38-333	Thursday	10:00 - 10:20	Belevedere
Zhao S.	D36-443	Wednesday	11:00 - 11:20	Belevedere
Zhou X.	P-034	Thursday	13:00 - 14:00	Exhibition Area
Zianni R.	P-046	Tuesday	17:00 - 18:00	Exhibition Area

DIOXIN 2026 13-18 SEPT RIVA DEL GARDA ITALY

BFR 2026 RIVA DEL GARDA
12th International Symposium on Flame Retardants



Dioxin 2026 - Book of Abstracts

Monday 14 September 2026

POPs Incidents Over the Years

M. Rose & R. Weber

D1-251 Increased autistic traits associated with perinatal dioxin exposure of 3-year-old children from birth cohorts in 3 areas in Vietnam

N.N. Tran[1], M. Nishijo[2], T. Pham-The[3], T.N. Pham[3], H.T. Vu[3], T.T.T. Luong[3], N. Yoshikazu[2], H. Nishijo[4]
[1]Hanoi University Of Public Health - Hanoi (Vietnam), [2]Kanazawa Medical University - Uchinada (Japan), [3]Vietnam Military Medical University - Hanoi (Vietnam), [4]University Of East Asia - Shimonoseki (Japan)

Introduction
Da Nang and Bien Hoa airbases remained contaminated with Agent Orange and other herbicides used during the Vietnam War. In 2008 to 2015, we recruited birth cohorts residing near these contaminated airbases and Hanoi (an unsprayed area). We collected milk samples from mothers of birth cohorts to measure dioxin levels of 17 congeners including 10 Polychlorinated Dibenzo-p-Dioxins (PCDDs) and 7 Polychlorinated Dibenzo-f-Furans (PCDFs) congeners by instrument methods and calculated their toxic equivalency (TEQ) levels as perinatal dioxin exposures indices. In each area, we followed-up children to investigate the effects of perinatal dioxin exposure on their neurodevelopment at 3 years of age using the Bayley Scales of Infant and Toddler Development, third edition (Bayley III) and Autism Spectrum Rating Scale (ASRS). In the current study, we combined data at 3 years of age of all birth cohorts and analyzed associations between ASRS scores and perinatal dioxin exposure in Vietnamese 3-year-old children to confirm our previous study results which reported that 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) was the most contributed congener to increasing autistic traits and that the effects were more remarkable in boys than girls.

Materials and Methods
A total of 486 children were included in the present analysis from a Da Nang birth cohort recruited in 2008 and 2009, a Bien Hoa birth cohort in 2012 and 2015, and a Hanoi birth cohort in 2014 were examined when they reached 3 years of age. General linear model was used to compare the means of ASRS scores, including DSM (Diagnostic and Statistical Manual of Mental Disorders Fourth Edition, Text Revision [DSM-IV-TR]), UB (Unusual Behaviors), SC (Social Communication), and TOT (Total) scores between higher and lower exposure levels of TEQ- PCDD/Fs, TEQ-non-TCDD (TEQ of PCDD/Fs congeners other than TCDD), and TCDD after adjusting for other covariates (gestational weeks and month age at the survey of children, and parity and education levels of mothers) according to sex. The cut-off levels were 11.5 (pg-TEQ/g lipid), 10.5 (pg-TEQ/g lipid), and 3.5 (pg/g lipid) for TEQ-PCDD/Fs, TEQ-non-TCDD, and TCDD, respectively. In addition, odds ratio for prevalence of children with elevated risk of ASD (autism spectrum disorders) defined as the DSM score more than 60 was analyzed between high and low groups of 3 dioxin markers using binary logistic regression model.

Results
In boys, only DSM scores were significantly higher indicating increased autistic traits in the high TEQ-PCDD/Fs group, compared with the low exposure group. Whereas, in girls, all ASRS scale scores were significantly higher in high TEQ-PCDD/Fs groups.
Girls also showed significantly higher scores of all ASRS scale scores in high TEQ-non-TCDD group. Also, boys showed significantly higher ASRS scores except SC scale scores in high TEQ-non-TCDD group. Although no significant different of mean ASRS scale scores was observed between high and low TCDD groups after adjusting confounding factors in both sexes, odds ratio of children with elevated ASD risk was
4.2 (95%CI: 1.4, 12.6) and significantly increased in high TCDD group compared with low exposure group in boys.

Discussion and Conclusion
In our previous analysis in Da Nang birth cohort1, we reported higher ASRS scores, particularly DSM scores, associated with higher TCDD in both sexes, with clearer dose-effect relationships in boys. However, in the current study, PCDD/Fs congeners other than TCDD indicated by TEQ-non-TCDD were suggested to increase autistic trait, particularly in girls. Whereas, in boys, increased risk of ASD was associated with high level of TCDD. These results suggest two types of effects on ASD symptoms; increasing autistic traits in both sexes for dioxin congeners other than TCDD and aggravating autistic symptoms to clinical levels in boys for TCDD.

References
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POPs Incidents Over the Years

M. Rose & R. Weber

D1-288 Effects of perinatal dioxin exposure on neurodevelopment of 3-year-old children from birth cohorts in 3 areas in Vietnam

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Introduction
Da Nang and Bien Hoa airbases remained contaminated with Agent Orange and other herbicides used during the Vietnam War. In 2008 to 2015, we started following birth cohorts residing near Da Nang and Bien Hoa airbases and Hanoi (an unsprayed area) and collected milk samples from mothers to measure dioxin levels of 10 congeners of Polychlorinated Dibenzo-p-Dioxins (PCDDs) including 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and 7 congeners of Polychlorinated Dibenzo-f-Furans (PCDFs) and calculated their toxic equivalency (TEQ) in the breast milk of mothers as the indices of perinatal dioxin exposures. In each area, we investigated the effects of perinatal dioxin exposure indicating by dioxins in maternal breast milk on child neurodevelopment from 4 or 6 months to 3 years of age using same test batteries such as the Bayley Scales of Infant and Toddler Development, third edition (Bayley III). In the current study, we combined all data at 3 years of age of birth cohorts and analyzed associations between Bayley III scores and perinatal dioxin exposure in Vietnamese children born more than 30 years after the end of Vietnam War.

Materials and Methods
The study area comprised two areas near Da Nang and Bien Hoa airbases and an unsprayed area in Hanoi, located in northern Vietnam. A total of 486 mother–infant pairs (96.0% of follow-up rate from the base line survey at birth) were included in the present analysis from a Da Nang birth cohort recruited in 2008 and 2009, a Bien Hoa birth cohort recruited in 2012 and 2015, and a Hanoi birth cohort recruited in 2014. General linear model was used to compare the means of neurodevelopmental indexes between higher and lower exposure levels of TEQ- PCDD/Fs, TEQ-non-TCDD (TEQ of PCDD/Fs congeners other than TCDD), and TCDD after adjusting for other covariates (gestational weeks and month age at the survey of children, and parity and education levels of mothers) according to sex. The cut-off levels were 17.5 (pg-TEQ/g lipid), 10.5 (pg-TEQ/g lipid), and 3.5 (pg/g lipid) for TEQ-PCDD/Fs, TEQ-non-TCDD, and TCDD, respectively.

Results
In boys, all Bayley III scores except cognitive scale, were significantly lower in the high TEQ-PCDD/Fs group, compared with the low exposure group. Whereas, in girls, no significant difference of any scale scores except gross motor subscale were found between high and low TEQ-PCDD/Fs groups. In high TEQ-non-TCDD groups, girls showed significantly lower scores of all neurodevelopmental scales, and boys showed significantly lower cognitive and language scale scores. However, no significant difference was observed between high and low TCDD groups after adjusting confounding factors in both sexes, although, only in girls, lower expressive language score in high TCDD group was found in the analysis without adjustment of confounding factors.

Discussion and Conclusion
In our previous analysis in each dioxin exposed area, we reported lower Bayley III scores associated with high TEQ-PCDD/Fs only in boys. However, in the current study, girls with high TEQ-non-TCDD showed significantly lower scores of all Bayley III scales, suggesting PCDD/Fs congeners other than TCDD may influence neurodevelopment in early childhood for girls. In conclusion, impacts of dioxin exposure originating from Agent Orange on neurodevelopment were significant in both sexes, but contribution of TCDD to the effects may varies by sex. For more analysis for dose-effect relationships is necessary in near future.

POPs Incidents Over the Years

M. Rose & R. Weber

D1-481 Kanemi Yusho Incident: Long-Term Health Effects of PCB and Dioxin Contamination

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Introduction
The Kanemi Yusho Incident was a major food contamination disaster in Japan caused by rice bran oil contaminated with polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), and related toxic compounds during the manufacturing process. Although initially regarded as PCB poisoning, subsequent investigations demonstrated that highly toxic dioxin-like compounds, particularly PCDFs and coplanar PCBs, were the principal contributors to the observed toxicity. The incident has become a landmark case in the study of persistent organic pollutants (POPs) and environmental health.

Materials and Methods
This report summarizes epidemiological, clinical, toxicological, and mechanistic studies conducted on Kanemi Yusho patients and their offspring. Particular attention was given to long-term health outcomes, developmental effects following prenatal exposure, and advances in understanding the molecular mechanisms underlying PCB- and dioxin-related toxicity.

Results
Affected individuals exhibited a wide range of symptoms, including chloracne, skin hyperpigmentation, fatigue, hepatic dysfunction, neurological disorders, ocular abnormalities, and immune dysfunction. Maternal exposure resulted in adverse birth outcomes, including low birth weight and developmental abnormalities in infants, commonly referred to as "dark-brown babies." Long-term follow-up studies revealed persistent health effects extending over several decades, including neurological impairment, endocrine disruption, chronic inflammation, metabolic disorders, and elevated cancer risk. Evidence also suggested adverse effects in offspring exposed in utero, raising concerns regarding transgenerational toxicity mediated through epigenetic mechanisms such as altered DNA methylation, microRNA expression, and dysregulated cellular signaling pathways.

Discussion and Conclusion
The Kanemi Yusho Incident fundamentally changed the understanding of PCB toxicity by demonstrating that toxicity cannot be explained solely by PCB concentrations. The findings contributed to the establishment of the toxic equivalency factor (TEF) and toxic equivalency (TEQ) concepts for dioxin-like compounds, while also highlighting their limitations. Non-dioxin-like PCBs exert toxicity through mechanisms independent of aryl hydrocarbon receptor (AhR) activation, including disruption of calcium signaling and neurodevelopmental processes. The incident remains a cornerstone in POPs research and emphasizes that PCB toxicity is highly complex, involving multiple mechanisms, life-stage susceptibilities, and potentially transgenerational effects.

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POPs Incidents Over the Years

M. Rose & R. Weber

D1-583 The 1999 Belgian Dioxin Crisis

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Introduction

The Belgian chicken incident started on May 29th 1999 when Belgian authorities announced the ban on the sale of chickens and eggs and immediate removal from store shelves. It became the Belgian Dioxin Crisis because of the chemical nature of the poisoning, the lack of proper crisis management, and the high public, agricultural and political impact. In fact, the contamination event took place in January 1999 when a transformer oil was mixed with recycled frying fat at a recycling center and later blended to animal fat intended for animal feed manufacture. The contaminated fat (±60-80 tons) was processed and the contaminated animal feed (±500 tons) was supplied to other manufacturers and then sold to egg, chicken, pork and dairy producers [1]. In February, the first problems of egg hatchability and increased mortality of chicks were reported in chicken farms.

Results

Histological examinations revealed similar lesions to what reported earlier for 'chick-oedema disease' in outbreaks of poultry poisoned by PCBs/dioxins during in the 1950s-70s, pointing out dioxins as the causative agent [2]. By the end of April, high levels of dioxins (> 10,000 pg TEQ/g fat) and PCBs (> 400 µg/g fat) were reported in the animal feed. Concentrations in poultry products had means of 0.84-8.2 µg /g fat and of 3.8-255 pg TEQ/g fat, for PCBs and dioxins, respectively [3]. The 2,3,7,8-substituted PCDD/F pattern (mainly PCDFs) was virtually identical to the one of the PCB contaminated rice oil of the 1968 Yusho incident [4]. Furthermore, all samples showed an Aroclor 1260-based PCB pattern at levels that correlated with PCDD/F levels. This supported the use the faster and cheaper PCB tests (seven 'marker PCBs' 28, 52, 101, 118, 138, 153, 180) to identify contaminated food products [5]. It took an extra month before the European Union (EU) was informed and the problem made public. EU countries and several non-EU countries temporarily banned imports of most Belgian agriculture products. An action that undoubtedly was implemented months after the real exposure period… It resulted in about 9,000,000 chickens and 60,000 pigs being preventively destroyed [6]. The EU prompted emergency testing for dioxins/PCBs (55,000 PCB analyses and 500 dioxin analyses were performed May-December 1999) [4]. In about 20,000 PCB samples originating from suspected farms, the PCB tolerance levels (0.1-0.2 µg/g fat) were exceeded in 11.1% of the cases [3]. This triggered calls for scientific opinions on food-feed maximum residue levels (MRLs), Tolerable Weekly Intakes (TWIs), and analytical methods for continuous longer-term monitoring.

Discussion and Conclusion

Regarding the impact on human health, some state that it is unlikely that adverse effects were inflicted in the Belgian population [3] while others suggest that neurotoxic/behavioural effects in neonates, together with an increase in cancer rates could be expected [1]. For the most exposed population, the maximum PCB/dioxin body burden would be similar to the levels of the 1980s (2-3 fold increase) or of those regularly eating contaminated seafood [5]. Overall, it was estimated that the contamination involved in total one gram TEQ of dioxins (90% furans) and 50 kilograms of PCBs. The Belgian government reported that the cost of the crisis to the food industry was US$1.54 billion. Even if no direct human health effects have been attributed to the crisis, it highlighted the importance of proper consideration of food safety and was at the origin of the effective and continuous EU monitoring strategy for the food chain, including systematic national monitoring of food of animal origin, which permitted much better management of smaller contamination episodes that have occurred in EU since 1999.

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PFAS Analysis 1

K. Fernie & N. Kajiwara

D2-066 PFAS: why there's no single silver bullet for capturing the full reality

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Introduction
The chemical landscape of Per- and Polyfluoroalkyl Substances (PFAS) has become an analytical minefield. With over 10,000 compounds, myriad industrial applications, and fragmented regulatory definitions, the scientific community must acknowledge a hard truth: the "single method = single truth" paradigm is fundamentally broken. This study asserts that relying on a solitary analytical technique is not just insufficient—it is professionally negligent in the face of the complex cross-matrix behavior of these "forever chemicals." The recent EU Regulation 2025/40 PPWR ban on PFAS in food packaging and ECHA restriction proposal underscores the urgency of this multi-matrix perspective. Consumer Products then become waste, leaching precursors into landfills and compost, eventually impacting water systems and the atmosphere.

Materials and Methods
To address this, we use both Target Analysis, TOP Assay, Alkaline hydrolysis and Suspect Screening. Discrepancies between these methods e.g. where TOP and aggregate methods frequently yield higher concentrations, as shown in 2024 comparative studies—are not "errors." Instead, they represent the "analytical gap" of unidentified precursors. The lack of harmonization in TOP assay parameters (pH, temperature, oxidant load) remains a critical bottleneck, complicating data comparability across laboratories and leading to dangerous underestimations of the total organofluorine burden.

Results
To demonstrate the practical application of the approach, a case study will be presented: a PE-based packaging containing 5% fluoropolymer. This known fluorine-contaminated system will be extensively investigated using all mentioned available analytical techniques to identify the molecules involved, determine their source, and characterize their degradation products.

Discussion and Conclusion
The shift toward a "cascade" evaluation—integrating TOF, AOF, EOF, and targeted methods—is now a regulatory necessity, benefiting not only consumers but also the entire value chain and supporting manufacturers in their investigative efforts. After all, how can substances be eliminated if they are not known? We must stop looking for a "silver bullet" method and instead adopt a sophisticated analytical toolkit that accounts for both direct contaminants and their indirect, degradable counterparts across all environmental compartments.

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PFAS Analysis 1

K. Fernie & N. Kajiwara

D2-518 Emerging PFAS screening in serum of residents living near a Belgian fluorochemical plant

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Introduction

Previous studies reported exceedingly high concentrations of legacy per- and polyfluoroalkyl substances (PFAS) across multiple environmental media (1-4) near a fluorochemical plant (FCP) close to Antwerp (Flanders), while non-target analysis (NTA) revealed additional PFAS in bird eggs (5) and soils (6). To better characterize human exposure, this study aimed to characterize PFAS in serum collected in 2021 from residents living within 3-km of the FCP using NTA based on high-resolution mass spectrometry (HRMS), to identify emerging PFAS. A subset of 20 serum samples with the highest PFAS levels, measured by targeted analysis, was selected.

Materials and Methods

Chromatographic separation and HRMS for NTA were performed using an Agilent 1290 Infinity UHPLC coupled to an Agilent 6530 QToFMS in ESI (-) mode. The acquisition and data processing methods have been described previously (5,6). Full-scan and data-dependent acquisition (DDA or "auto-MS/MS") prioritized the fragmentation of the most abundant precursor ions identified in the MS1 scan. Mass features were prioritized utilizing mass defect filtering and annotated against PFAS libraries (US EPA CompTox and PFASN-TREV19; >10,000 entries), then stratified into confidence levels (CLs). Concentrations of emerging PFAS were semi-quantified by normalization to structurally-similar target PFAS, based on molecular weight and retention time

Results

Chromatographic separation and HRMS for NTA were performed using by UHPLC-QToFMS in ESI (-) mode. The acquisition and data processing methods have been described previously (5,6). Full-scan and data-dependent acquisition (DDA or "auto-MS/MS") prioritized the fragmentation of the most abundant precursor ions identified in the MS1 scan. Mass features were prioritized using mass defect filtering and annotated against PFAS libraries (>10,000 entries), then stratified into confidence levels (CLs). Concentrations of emerging PFAS were semi-quantified by normalization to structurally-similar target PFAS. Overall, 42 PFAS from 13 classes were identified, notably long-chain pentafluorosulfanyl PFSA (SF5-PFSAs; C8-C10) reported for the first time in human samples. Regarding perfluoroalkanesulfonates (PFSAs) and related compounds, 10 classes were identified: PFSAs (10 homologues, C4 to C13), fluorotelomer sulfonates (8:2 FTS, 1 compound), SF5-PFSAs (3 homologues), ether-PFSAs (PFESA, 4 homologues), unsaturated-PFSAs (U-PFSA, 2 homologues), hydro-PFSA (H-PFSA, 2 homologues), hydro-unsaturated PFSA (H-U-PFSA, 2 homologues), and keto-PFSA (K-PFSA, 2 homologues). Within the perfluoroalkyl carboxylic acids (PFCAs) classes, three groups were identified, comprising PFCA (10 homologues, C4-C5, C7-C14), fluorotelomer unsaturated carboxylic acid (x:2 FTUCA, 1 compound), and hydro-PFCA (H-PFCAs, 1 compound). The remaining identified PFAS, primarily consisted of sulfonamides (FOSA, N-MeFOSA, and N-EtFOSA), and sulfonamidoacetic acids (N-MeFOSAA and N-EtFOSAA). Of the 26 PFAS with detection frequencies > 50%, 15 were legacy and 11 emerging PFAS. Legacy PFAS accounted for >94% of the ∑PFAS at concentrations one to two orders of magnitude higher than emerging PFAS. The most abundant legacy PFAS were PFOS (median: 300 ng/mL), PFHxS (18 ng/mL), PFOA (6 ng/mL), PFHpS (5 ng/mL), and PFNA (1.3 ng/mL). PFOS alone accounted for >85% of the mean ∑PFAS, reaching a maximum of 2900 ng/mL, among the highest concentrations worldwide found in humans.
Among emerging PFAS, PFOS structural analogues included PFEOS (median: 0.33 ng/mL), U-PFOS (0.28 ng/mL), and K-PFOS (0.10 ng/mL). Among SF5-PFSAs, SF5- PFNS exhibited the highest detection frequency (DF: 60%) and concentration (max: 0.57 ng/mL), consistent with widespread detection of SF5-PFSAs in bird eggs and soil from the same area (5,6)

Discussion and Conclusion

The results provided a critical, high-resolution snapshot of human PFAS exposure at a contaminated hotspot. Crucially, the application of HRMS-based screening shed light on a more complex exposure profile

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PFAS Analysis 1

K. Fernie & N. Kajiwara

D2-893 Per- and polyfluoroalkyl substances monitoring and removal: current challenges and future perspectives

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Introduction
Per- and polyfluoroalkyl acids (PFAS) are xenobiotic molecules belonging to the family of perfluoroalkyl substances. The strong C-F bond makes these molecules particularly resistant to hydrolysis, photolysis, and microbial degradation, and therefore particularly recalcitrant. PFAS are characterized by an amphiphilic nature that makes them water- and lipid-repellent and by low surface tension: thanks to these properties, since the 1950s they have been widely used as emulsifiers and surfactants in various products for cleaning carpets, leather, fabrics, floors, food containers, photographic films, and firefighting foams. PFAS are endocrine disruptors, difficult to biodegrade and therefore persistent in the environment and bioaccumulative. In Veneto, the main source of groundwater contamination is a fluorochemical plant that has been producing fluorinated compounds since the 1960s. PFAS have chemical and physical characteristics that give them good mobility in aqueous media, which, in the case of aquifer contamination, causes a very extensive "plume": the area affected by pollution is currently just over 150km2.

Materials and Methods
Acque del Chiampo Società Benefit manages the integrated water service in some areas affected by contamination. The current Legislative Decree 18/2023 and subsequent amendments, implementing Directive (EU) 2020/2184, provides for the verification of the parameters "Sum of PFAS" (with a parameter value of 0.10 µg/L), "Sum of 4 PFAS" (with a parameter value of 0.02 µg/L) and trifluoroacetic acid (TFA, with a parameter value of 10 µg/L) for a total of 31 compounds. The method developed in 2013 and continuously implemented, updated and currently applied in the Acque del Chiampo laboratory for the determination of PFAS refers to the validation and quality control specifications of the ISO 17025 accredited EPA 8327 method and involves analysis using the LC-MS/MS technique, using a high-performance liquid chromatograph (UHPLC) coupled with a triple quadrupole mass spectrometer.

Results
The protocol involves direct injection of the sample and, for most fluorinated compounds, allows a LoQ of 2 ng/L to be achieved and an extended relative percentage uncertainty (U%) associated with the final result of the individual compound to be declared from 35% to 50% in the measurement range 2–200 ng/L. The method applied also allows to improve the list of PFAS parameters, based on the detection of a compound in untreated water in accordance with the risk assessment and management of supply areas according to the Water Safety Plans (WSP) study carried out by the water operator. Indeed. the full scan acquisition with a high-resolution analyzer also made it possible to determine the m/z values of other fluorinated substances present; the potentially identified fluorinated substances were then confirmed or ruled out by analyzing a standard solution in terms of retention time and mass spectrum. In particular, PFBSA (perfluorobutane sulfonamide) was found in the activated carbon samples and subsequently in the groundwater samples.

Discussion and Conclusion
PFBSA is not included in the list of PFAS in Legislative Decree 18/2023 and subsequent amendments and additions; therefore, as required by the PSA approach, it has been included in the monitoring of groundwater intended for human consumption and in water treated with granular activated carbon intended for human consumption. The method is also applied for the determination of PFAS in other matrices such as wastewater, leachate, activated carbon, and plant biomass within research and development projects. These include the evaluation of bacterial biodegradation, the assessment of PFAS uptake by plants (phytoremediation, bioaccumulation and translocation in vegetable crops), PFAS mineralization through plasma technology and the development of specific sensors for continuous monitoring in aqueous matrices.

PFAS Analysis 1

K. Fernie & N. Kajiwara

D2-360 Environmental Forensics for PFAS

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Introduction

Per and polyfluoroalkyl substances (PFAS) are a group of over 7 million chemicals (Schymanski et al., 2023), thousands of which have now been detected in the environment (Megson et al., 2025). Work undertaken over the last few decades has helped us to understand that PFAS are ubiquitous environmental pollutants that pose a significant risk to environmental and human health. There has been an increase in the number of litigation cases involving PFAS which has driven the need for improved forensic tools to identify where PFAS pollution has originated. Targeted PFAS analysis and comparison against threshold values helps us establish a risk, but it is of limited use when trying to identify where the pollution has originated from. I will present a series of different case studies that we have undertaken to demonstrate the analytical and statistical tools we have at our disposal to perform PFAS forensics.

The first was applied to identify unusually high PFAS levels in residents in a UK town located near an AFFF manufacturer. This investigation formed part of a documentary (in our blood) shown on national TV in the UK (ITV, 2026). The investigation involved analysis of over 30 residents blood samples and comparison against the NHANES database. The results revealed over two thirds of participants would be above the 95% percentile for PFOA concentrations, indicating that that community has experienced an unusual PFAS exposure.

The second involved the use of non-targeted analysis to detect hundreds of PFAS in the vercinity of a fluorochemical plant. Levels of PFOA greatly exceeded proposed environmental quality standards. But this was just the tip of the iceberg, <17% of the total PFAS peak would have been detected if we relied on standard targeted PFAS monitoring (including a the most abundant PFAS that was directly linked to the chemical plant). (Megson et al., 2024),

The final case study involved the application of load-based measurements to identify the major sources of PFAS pollution in a river catchment. This investigation also utilised non-target analysis and identified the presence of a novel ultrashort PFAS from a currently unknown source.

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PFAS Analysis 1

K. Fernie & N. Kajiwara

D2-023 Identification of novel per-and polyfluoroalkyl substance (PFAS) isoform in textile using a multi-reflecting time-of-flight mass spectrometer technology

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Introduction

As awareness of the health risks associated with per- and polyfluoroalkyl substances (PFAS) grows, there is an increasing demand to determine total PFAS content to help reduce human exposure. Traditional targeted methods provide only a narrow insight of the PFAS content, making non-targeted screening with high-resolution mass spectrometry an effective approach to bridge quantitative analyses and discovery workflows.
In this study, high-resolution mass spectrometry (HRMS) combined with a
non-targeted screening (NTS) workflow was applied to characterize PFAS profiles in textiles. Textile reference material (LCG) was analyzed using data dependent (DDA) and processed with Pattern Analysis application within waters_connectTM Software Platform. Novel PFAS compounds, overlooked by the targeted methods, were identified with high confidence levels based on accurate mass measurement of the precursor and product ions.

Materials and Methods

Milled textile certified reference material (CRM) derived from outdoor clothing was used for analysis. PFAS were extracted from 0.5g of CRM was carried according to EN 17681-1:2025. Briefly, PFAS were extracted with alkaline methanol at 60°C for 1 hour, followed by centrifugation. The supernatant pH was then adjusted to 6-7. A 5 µL aliquot of both the CRM extracts and standards were analyzed using an ACQUITYTM Premier UPLCTM system coupled with the XevoTM MRT Mass Spectrometer in negative ionization mode. Data acquisition was performed using MSE (data-independent acquisition) and DDA (data-dependent acquisition). All data acquisition and processing were carried out on the waters_connect Software Platform, utilizing the UNIFITM Application and Pattern Analysis Applications for both quantitative analysis and non-targeted screening.

Results

The NTS workflow within the waters_connect Software Platform along with the PFAS libraries (in-house generated and an online version of the NIST PFAS library), enabled the identification and quantification of at least eighteen compounds with a mass measurement of <600 ppb RMS and mass resolution of >60,000 FWHM in the CRM samples. The tested CRM contained varying amounts of PFAS. For instance, 68 µg/Kg of PFOA and 40 µg/Kg were detected in CRM extracts.

Discussion and Conclusion

Further investigation using the Pattern Analysis Application, Mass defect filters and normalized mass defect tools enabled the identification of a novel PFAS compounds overlooked using traditional targeted methods. Whilst DDA acquisition mode increased identification confidence, using different modes of DDA enhanced the method selectivity by increasing the likelihood of triggering DDA on PFAS and PFAS like species.
This work shows the importance of NTS and HRMS for verifying the total PFAS content compared to conventional targeted approaches. HRMS gives a better understanding of PFAS content in the samples and help in understanding and mitigating the risks of human exposure.
The waters_connect Software Platform offers a one software solution for quantitative and NTS workflows. The screening workflow is based on accurate mass, fragment ion information, isotopic matching and mass defect, this coupled with high mass resolution, fast scan speeds and exceptional levels of mass precision of the Xevo MRT Mass Spectrometer significantly reduces false positives and enables rapid, confident assignment and identification of PFAS related compounds.

Human Exposure 1

S. Harrad & B. Le Bizec

D3-247 Analysis of Plastic Chemicals and Per-and Polyfluoroalkyl Substances in Medical Devices in Neonatal Units: a Source of Early-Life Chemical Exposure

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Introduction
Preterm neonates are especially vulnerable due to immature hepatic detoxification pathways, reduced renal clearance, and frequent prolonged exposure to plastic-containing medical devices (MDs) through invasive routes. The use of MDs in neonatal intensive care units (NICUs) may pose a potential health risk to preterm neonates due to the presence of chemicals of concern in these materials, including phthalates (PAEs), organophosphate esters (OPEs), alternative plasticizers (APs), and bisphenols (BPs). These compounds can be incorporated into polyvinyl chloride (PVC), a common synthetic polymer used in the manufacture of MDs to provide flexibility, softness, and durability [1]. An additional concern arises from per- and polyfluoroalkyl substances (PFAS), a class of synthetic chemicals used in both implantable and disposable MDs to provide chemical resistance and mechanical stability [2]. The potential risk associated with these substances is related to their endocrine-disrupting properties and their possible association with altered neurodevelopment, impaired lung maturation, and adverse metabolic programming during critical windows of development. This study aims to investigate, for the first time, the occurrence of multiple classes of compounds (i.e., OPEs, PAEs, APs, BPs, and PFAS) in MDs used in neonatal care.

Materials and Methods
A total of 26 MDs were analyzed. From these MDs, a total of 82 different parts were selected and cut into small pieces. Approximately 0.1 g of each sample was weighed and extracted twice using hexane:acetone (1:1, v/v), followed by methanol in an ultrasonic bath (15 min each). The extracts were filtered, combined and concentrated to 2 ml. Next, 200 µL of the final extract was taken and diluted with 800 µL of methanol to obtain a final volume of 1 mL. Prior to analysis, the samples were spiked with internal standards, filtered through a 0.25 µm PTFE syringe filter, and diluted with LC-MS grade water. The extracts were analyzed using LC-Orbitrap-HRMS.

Results
The analysis in positive ionisation mode revealed the presence of 13 OPEs, 5 PAEs, and 6 APs in MDs. The highest detection frequencies were observed for acetyl tributyl citrate (ATBC) (65%), di(2-ethylhexyl) (DEHA) (50%), tri-n-butyl phosphate (TNBP) (44%), and diethyl phthalate (DEP) (42%).The highest concentrations found in MDs were those of ∑APs (median: 0.97 µg/g; mean: 1,890 µg/g; range: <LOD–96,114 µg/g), followed by ∑PAEs (median: 4.87 µg/g; mean: 392 µg/g; range: <LOD–19,878µg/g) and ∑OPEs (median: 0.04 µg/g; mean: 19.9 µg/g, range: <LOD–1,110 µg/g). The analysis of BPs and PFAS was conducted in negative ionisation mode. Bisphenol A (BPA) was the only BPs detected (17% of samples) in the MDs, with concentrations ranging from <LOD to 43.7 µg/g (median: <LOD; mean: 1.12 µg/g). PFAS were also detected in some MDs.

Discussion and Conclusion
The findings of this study highlight the widespread presence of plastic chemicals in MDs used in neonatal care. Given the intensive and prolonged exposure in NICU settings, these materials may contribute to chemical exposure in preterm neonates through the migration of these substances into biological sites that come in contact with MDs. A further prioritisation is required to better understand the fate, toxicological profiles, and regulatory implications for the use of these substances in the manufacture of MDs intended for neonatal applications. Future studies will investigate the relationship between the use of specific MDs in NICU patients and the concentrations of metabolites measured in neonatal urine samples to identify potential exposure correlations.

Acknowledgment
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Human Exposure 1

S. Harrad & B. Le Bizec

D3-276 Cross sectional and temporal trends of extractable organofluorine (EOF) in pooled serum samples from Australia, 2002-2020

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Introduction
Targeted analysis of per- and polyfluoroalkyl substances (PFAS) in human serum has been widely conducted globally and a growing list of PFAS have also been identified by non-target analysis. However, this work has generally not explained all the extractable organofluorine (EOF) in human serum. Furthermore, there have been few studies of the time trends of EOF. The aim of this study was to determine the EOF and fraction of unidentified organofluorine (UOF) in the Australian population and assess temporal and cross-sectional trends.

Materials and Methods
A total of 48 pooled deidentified surplus pathology serum samples, stratified by age (<5, 5-15, 16-30, 31-45, 46-60 and >60 yrs), sex, and collection year (2002-03 and 2020-21), as well as biennial samples from females (31-45 yr) from 2002-03 to 2020-21, were analysed for EOF and 50 targeted PFAS. UOF was determined as EOF minus total measured targeted PFAS (expressed as F equivalents).

Results
Out of the 48 samples of pooled serum analysed in this study, 66% had EOF concentrations above the MDL (34 ng/mL F), ranging up to 370 ng/mL F. EOF concentrations and detection frequencies (DFs) were higher in 2002-03 than 2020-21 (median 69 ng/mL F (DF 100%) vs 29 ng/mL F (DF 42%)), with biennial samples showing an overall decline of 6.8±1.8 %/yr. Despite declining EOF, the proportion of UOF increased over time (~3.2%/yr) among the biennial samples, with median % UOF compromising 63% and 86% of EOF in 2002-03 and 2020-21, respectively. EOF and UOF concentrations were not significantly different between males and females but were higher in the >60 age group in 2002-03.

Discussion and Conclusion
Serum EOF concentrations and temporal trends in the Australian population were similar to those reported internationally e.g. 1, 2. The significant decline in EOF over time is consistent with reduced exposure to legacy PFAS following regulatory restrictions3; however, UOF constituted a large and increasing fraction of EOF, reflecting declining contributions from targeted PFAS and highlights the growing importance of unmonitored fluorinated substances not captured by current targeted analyses.

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Human Exposure 1

S. Harrad & B. Le Bizec

D3-479 Microsampling for PFAS analysis: Cheap high-resolution biomonitoring

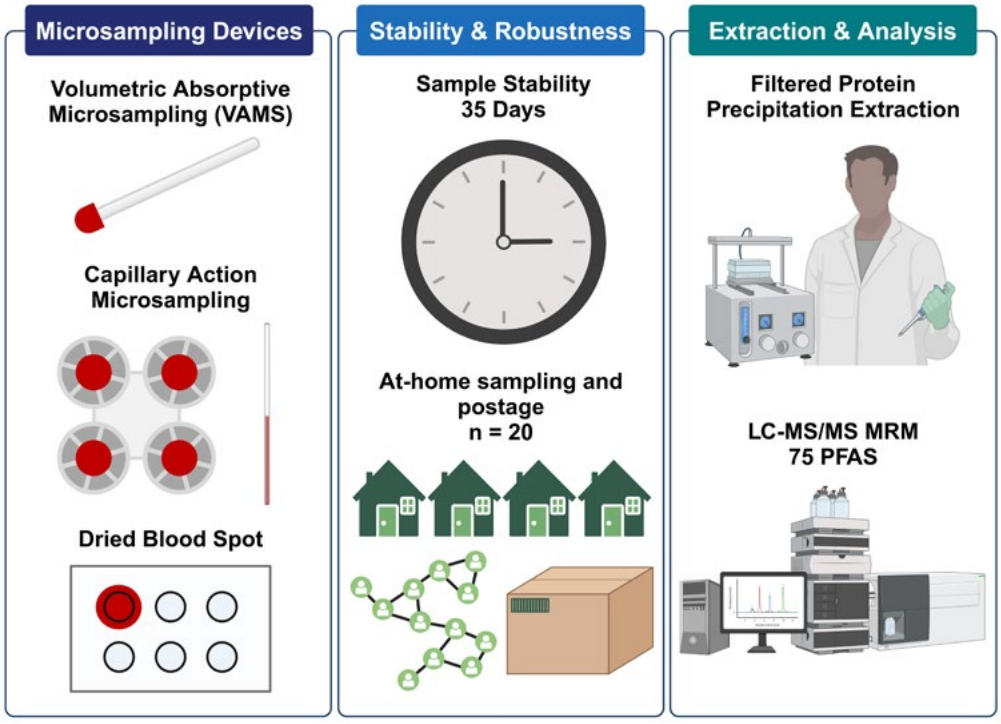
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Introduction

Per- and polyfluoroalkyl substances (PFAS) are present in the blood of over 99% of the general population, and exposure to elevated concentrations of PFAS has been associated with multiple negative health outcomes. Despite international concern, PFAS blood testing is generally inaccessible and expensive. Microsampling is an emerging technology that promises high-resolution PFAS biomonitoring data through self-collection of participant samples. This study develops a cheap, robust methodology for the extraction of PFAS from dried blood matrices and tests various microsampling technologies for their suitability to at-home sampling for blood PFAS.

Materials and Methods

Five extraction methodologies were evaluated for their extraction efficiency of 75 PFAS from capillary action dried blood spots (CDBS) collected (sample volume – 10.96 µL ± 5%) at 5 ng/mL. Two different protein precipitation methods (centrifugation (PPTc) and filtration via positive pressure manifold (PPTf)), an acid-base (liquid-liquid) extraction, a protease digestion with protein precipitation (centrifuged), and weak anion exchange solid-phase extraction were investigated. The optimal extraction method was then validated on a range of control and donor CDBS samples with blood PFAS concentrations ranging from 0.5-50 ng/mL. Sample analysis was performed using an optimized LC-MS/MS method for 75 PFAS. To determine the at-home suitability of microsampling for blood PFAS sampling, dried blood spots (DBS) (Whatman 903) (collected via spotting), volumetric absorptive microsampling (VAMS) (Neoteryx Mitra) and CDBS (Neoteryx hemaPEN) were compared for sample stability, reproducibility, and susceptibility to contamination in the home sampling environment and postage. Only 49 PFAS were considered for these comparisons, as DBS collected via spotting were observed to have unacceptably high variance for many of the 75 PFAS originally tested. Firstly, a 35-day time-point experiment was carried out, with sample stability evaluated by monitoring the change in recovery of PFAS over time. Following the time-point experiment, participants (n = 20) collected blood samples at home. A 'blank' and 'spiked' (5 ng/mL) blood sample was collected with each device by each participant (n = 120) and sent by post to the Australian Laboratory for Emerging Contaminants.



Human Exposure 1

S. Harrad & B. Le Bizec

D3-479 Microsampling for PFAS analysis: Cheap high-resolution biomonitoring

Results

Of the extraction methods tested, PPTf was most efficient, recovering 62 out of 75 PFAS within 70-130% (at 5 ng/mL), with a relative standard deviation less than 20% for 73 PFAS. PPTf was then used to extract samples for both the time-point and at-home sample collection experiments comparing the three microsampling technologies. After 35 days, the change in PFAS recovery was greater than 10% for five PFAS by CDBS, four by DBS and zero by VAMS. Throughout the at-home sample collection experiment, no contamination of blank samples was observed.
Furthermore, VAMS and CBDS respectively retained 45 and 37 of the 49 PFAS within 70-130% recovery when sampled at home, whereas DBS only retained 16 PFAS.

Discussion and Conclusion

The comparisons of the methods undertaken confidently identify PPTf as the most accurate and consistent extraction methodology for a wide range of PFAS from dried blood microsamples. Furthermore, VAMS was consistently the microsampling technology most suited to at-home sample collection for blood PFAS analysis, demonstrating; 1) consistent sample stability for periods exceeding one month at room temperature, 2) no measurable susceptibility to sample contamination, and 3) retaining the most PFAS within the sample throughout sampling and postage. The combination of at-home self-sampling via VAMS and confident PFAS extraction via PPTf presents a powerful workflow for cheap, accessible and high-resolution biomonitoring.

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Human Exposure 1

S. Harrad & B. Le Bizec

D3-736 Perfluoropropionic acid exposure through drinking water and serum elimination half-life in humans

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Introduction
Perfluoropropionic acid (PFPrA) has few reported direct uses but is known to be an unintentional by-product in the production of other PFAS, as well as a degradation-, thermolysis-, and oxidation product of precursor compounds. PFPrA contamination has been reported in humans and the environment, e.g. in surface water, drinking water, and human blood [1-2].
In 2025, PFPrA-contaminated wastewater was discovered in a small Swedish community after the municipality included ultrashort-chain PFAS in the monitoring. Further sampling also revealed contaminated drinking water, with concentrations reaching 7 000 ng/L. The water supply was replaced, and a rapid response study was initiated to investigate exposure among the affected population.

Materials and Methods
Residents voluntarily donated blood (n=25) and urine (n=10) samples. A control group (n=11) was recruited from another area. Repeated sampling was performed for ten of the 25 participants. Seven sampling occasions took place, starting 1-5 days after exposure via drinking water had ceased. During this period, the contaminated water was thoroughly replaced, resulting in PFPrA concentrations ranging from <3.0 to 6.7 ng/L. PFPrA and selected PFAS were analyzed in serum and urine using 100 µL sample to which 13C-PFPrA and 26 additional labeled PFAS were added. Acetonitrile was used for extraction and protein precipitation, and the analysis was performed using both supercritical fluid chromatography tandem mass spectrometry (SFC-MS/MS) and ultra-performance liquid chromatography-MS/MS (UPLC-MS/MS). Half-life was estimated based on the regression coefficient for time in a linear mixed-effects model with random intercept. Values below the limit of detection (<3.0 ng/mL) were imputation with LOD/$\sqrt{2}$ and concentrations were log-transformed (natural logarithm).

Results
PFPrA was detected in 88% of the residents (<3.0-75 ng/ml) with a median of 16 ng/mL while the detection frequency was 9% for the controls (<3.0-3.1 ng/ml). Concentrations of other PFAS were comparable between the residents and the control group with PFOS showing the highest (second for the residents) median concentration of 5.2 and 5.8 ng/mL, respectively. PFPrA was also detected in urine from the exposed residents, with a median concentration of 3.4 ng/mL (<2.0-7.8 ng/ml).
Serum elimination was studied over a 153 day period. PFPrA concentrations decreased over time, and at the last time point, four participants still had detectable serum concentrations with a median of 5.5 ng/mL. One participant was excluded due to only <LOD values and one due to an unexplained increase in PFPrA. The estimated time coefficient for PFPrA based on remaining eight participants was $\hat{\beta}_1 = -0.013$ (SE = 0.001), corresponding to a half-life of $t_1/_2$ = 53.7 days (95% CI: 45.178–62.729). The observed half-life was considerably longer than anticipated, and it remains unclear if toxicokinetic differences or uncontrolled exposure sources influenced the PFPrA elimination in the present study.

Acknowledgment
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Human Exposure 1

S. Harrad & B. Le Bizec

D3-801 Tissue-specific distribution of perfluoroalkyl carboxylic acids in seafood

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are organic fluorinated compounds of concern because of their environmental persistence and bioaccumulation potential. In our previous study, we investigated PFAS concentrations in edible seafood distributed in Japan and neighboring regions and showed that some seafood species may contribute to dietary PFAS exposure1,2). We have also reported body-part-specific distribution of PFAS in dolphins, indicating that PFAS accumulation patterns differ among tissues and body parts3). Edible seafood consists of multiple parts, such as muscle, liver, head, and shell, and the edible portions differ depending on species and processing practices. However, limited information is available on which parts of edible seafood contain higher levels of PFAS and how PFAS are distributed among different tissues or body parts. Therefore, this study aimed to clarify the distribution and accumulation characteristics of PFAS in edible seafood by analyzing different tissues and body parts.

Materials and Methods

Commercially available edible seafood samples in Japan were analyzed. Samples were dissected into muscle, liver, and/or other relevant tissues or body parts, depending on the species, and each fraction was analyzed separately. Based on previous findings that perfluoroundecanoic acid (PFUnDA), a C11 perfluoroalkyl carboxylic acid (PFCA), was frequently detected at relatively high levels in Pacific cod1)and shrimp2), C8–C14 PFCAs were selected as target compounds. Differences in PFCA concentrations, tissue or body-part concentration ratios, and PFCA profiles were compared among tissues, body parts, and species. In this abstract, we present the results obtained for crustacean samples.

Results

In crustacean samples, PFCA concentrations differed among body parts. Concentrations tended to be higher in the head than in the muscle. This finding is likely related to the presence of the hepatopancreas, also known as the midgut gland, in the head region. The hepatopancreas is considered functionally comparable to the mammalian liver and may play an important role in PFCA accumulation in crustaceans.
The head-to-muscle concentration ratio differed among crustacean species. Overall, the head-to-muscle concentration ratio decreased with increasing PFCA chain length, suggesting that longer-chain PFCAs (C9<) may be relatively more distributed to muscle tissue than PFOA (C8). Regarding PFCA composition, long-chain PFCAs, particularly C11 and C13 PFCAs, were dominant in muscle tissues.

Discussion and Conclusion

These findings suggest that body-part-specific distribution should be considered when estimating dietary PFAS exposure from seafood. Since edible portions differ depending on species, processing practices, and consumption habits, tissue- and body-part-specific PFCA data are important for more accurate assessment of PFAS intake from seafood.

Acknowledgment

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POPs in Polar Regions

B. Jiménez & R. Suehring

D4-047 Climate-change induced processes driving persistent and emerging contaminants in High Arctic fjords: insights from surface sediments and the historical record

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Introduction
Arctic fjords such as Kongsfjorden and Krossfjorden (Svalbard, ~79°N) lie at the intersection of terrestrial, cryospheric, and oceanic systems, making them highly sensitive to climate-driven change. Accelerated glacier retreat enhances meltwater discharge and sediment fluxes, promoting remobilisation of anthropogenic contaminants, while Atlantic water inflow via the West Spitsbergen Current further alters transport pathways (1).These long-range inputs interact with local emissions and secondary emissions from glacial and terrestrial reservoirs, creating complex spatial and temporal patterns. This study investigates these processes using surface sediments from key depositional areas and a ^{210}Pb-dated sediment core to provide both spatial and historical perspective. We focus on a broad suite of persistent and emerging compounds includingpolychlorinated biphenyls (PCBs), brominated flame retardants (BFRs), organochlorine compounds (OCs), per- and polyfluoroalkyl substances (PFAS), polycyclic aromatic hydrocarbons (PAHs), bisphenols, benzothiazoles, and UV filters.

Materials and Methods
Surface sediments (n = 43 stations) were collected across Kongsfjorden and Krossfjorden during field campaigns in September 2023 and August 2024. In parallel, a sediment core (NYA20-C11) retrieved from central Kongsfjorden was used to reconstruct the historical contamination record; chronology was established by ^{210}Pb CRS modelling, with accumulation rates ranging from 0.06 to >4 cm yr^{-1}, and supplemented by retene (a PAH coal-combustion proxy). All analyses were conducted following validated multi-residue methods with appropriate QA/QC protocols and blank corrections.

Results
Contaminants were ubiquitously detected, with distributions primarily governed by sediment accumulation dynamics. ΣPFAS ranged from 0.034 to 0.320 ng/g d.w., decreasing with distance from glacier fronts. ΣPCBs (0.056–0.371 ng/g d.w.) were dominated by 5- and 6-chlorine congeners, consistent with long-range atmospheric transport. PBDE-209 reached up to 0.233 ng/g d.w.; HCB was the most ubiquitous OCP (up to 0.45 ng/g d.w.). PAHs were the most abundant contaminant class (ΣPAH_{19} up to 1072 ng/g d.w.), closely tracking TOC and sedimentation patterns. BTH reached up to 93 ng/g d.w. The sediment core recorded PCB deposition onset around World War II and PFAS appearance in the 1960s; elevated retene levels reflect historical coal mining.

Discussion and Conclusion
Contaminant distributions reflect a complex interplay of long-range atmospheric transport, cryospheric remobilisation, and local contributions, all modulated by climate-driven processes. The predominance of n-PFOS and PFNA is consistent with global transport patterns, while glacial meltwater represents an increasingly important PFAS source expected to intensify under Arctic warming. Intermediate-chlorination PCB congeners (5–6 Cl) indicate long-range atmospheric transport as the primary delivery mechanism, with higher concentrations near glacier fronts suggesting accelerating melt releases of legacy compounds (2). Elevated PBDE-209 at deep outer-fjord stations may reflect glaciogenic particle-bound transport, and the DDE/DDT ratio (>5) confirms historical DDT inputs. PAHs show a mixed pyrogenic–terrigenous origin; the retene signal, linked to local coal-combustion history in the sediment core, highlights PAHs as both contaminant tracers and process indicators. Down-core trends reveal distinct source behaviours: OCPs and PCBs reflect secondary release from terrestrial and glacial reservoirs, while PFAS are linked to sustained oceanic transport. BTH and transformation products were detected at concentrations comparable to or exceeding those of legacy POPs. Together, these findings demonstrate that climate-change-induced processes, accelerating glacier retreat, enhanced meltwater discharge, and progressive Atlantification, are active drivers shaping contaminant distribution and temporal variability in Arctic fjords, establishing a critical baseline for risk assessment and international regulatory frameworks including the Stockholm Convention and the Global Framework on Chemicals.

Acknowledgment
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POPs in Polar Regions

B. Jiménez & R. Suehring

D4-244 Plasticene Archives: small microplastics and plastic additives preserved in a sediment core from the Svalbards

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Introduction
The Arctic, once considered a remote and pristine environment, may serve as an efficient sink for long-range-transported contaminants of emerging concern (CEOCs), including microplastics (MPs) and plastic additives. Sediment cores provide time-resolved archives that can constrain the onset, accumulation rates, and potential sources of these emerging pollutants. Here, we present an integrated approach to investigate small MPs (<100 µm; SMPs), plastic additives, and other microlitter components (MLCs) in a 210Pb-dated sediment core collected in the Svalbard archipelago, with the aim of gaining crucial insights into historical inputs and environmental drivers of SMPs and MLCs.

Materials and Methods
The sediment core was subsampled at defined depth intervals in a plastic-free ISO 7 clean room (under contamination-controlled conditions). The aliquoted subsamples underwent a mild pretreatment, namely oleo-extraction, followed by purification and filtration. This allows the simultaneous extraction of SMPs and MLCs. Chemical characterization and simultaneous quantification (via microscopic counting) were performed using Micro-FTIR (Particles analysis), with several reference libraries to ensure the optimal identification of each particle. All the analyses were performed in duplicate. Since the analysis via vibrational spectroscopy is non-destructive, a multi-technical approach was used: selected filters were also analyzed via Pyr/GC-MS. The QA/QC protocol was rigorous to detect potential contamination at each step; reagent blanks and procedural blanks were analyzed as samples. The method's yield was also tested; it was optimal (> 90%).

Results
Micro-FTIR particle analysis (applied to all depth intervals) revealed SMPs and MLCs along the core profile, except in the deepest layers dated before the 20th century (pre-dating the widespread production and use of synthetic polymers). The vertical distribution shows depth-dependent variations consistent with changing inputs over time and/or post-depositional mixing; Py-GC/MS measurements on selected filters provided complementary confirmation of the dominant polymer classes.

Discussion and Conclusion
The combined polymer–additive dataset enables more robust discrimination between potential sources (local activities vs. long-range transport) and constrains the timing of enhanced deposition of plastic-related contaminants in the Svalbard region.

Acknowledgment
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This work has benefited from the infrastructural support of the Centre for Trace Analysis (CeTrA) of Ca' Foscari University through the project IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System, funded by EU - Next Generation EU, PNRR- Mission 4 "Education and Research" - Component 2: "From research to business" - Investment 3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures" The authors also thank Elga Lab Water, High Wycombe, UK, for the pure water system used in this study.

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POPs in Polar Regions

B. Jiménez & R. Suehring

D4-515 Contaminants in Air at Polar GAPS Network Sites: Distinguishing Local Sources vs Long-Range Transport

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Introduction

The Global Atmospheric Passive Sampling (GAPS) Network has operated since 2004 to generate global contaminant data for persistent organic pollutants (POPs) and contaminants of emerging environmental concern (CEECs), with a focus on background and remote regions (Schuster et al., 2021). For these locations, a critical challenge is ensuring that monitoring data represent regional or global atmospheric burdens rather than contamination from local infrastructure, activities, or materials - the "halo effect" (Stow et al., 2005). Such local influences can bias long-term trend assessments, spatial comparisons, and data used for chemical management and Stockholm Convention Effectiveness Evaluation.
Several GAPS initiatives have investigated this issue, including the following studies being highlighted here:

- Spatial mapping of POPs at the Alert station (2004–2005), and
- A pilot program initiated in 2023 with AMAP and INTERACT to assess site representativeness at Arctic research stations

Materials and Methods

Across all studies, polyurethane foam (PUF) disk passive air samplers were used following established GAPS protocols (Schuster et al., 2021). Samplers were pre-cleaned, deployed for months-long periods, and analyzed at ECCC laboratories for targeted POPs/CEECs and, where applicable, by non-target screening. Field blanks and sampling-rate adjustments ensured robust concentration estimates.

Results

At Alert, spatial mapping showed homogenous air concentrations for PCBs and organochlorine pesticides across the 10-site grid, confirming the absence of local contamination. In contrast, elevated PBDEs were detected near a newly constructed research building, attributed to off-gassing from PBDE-containing materials - a clear but localized halo effect. In the Arctic pilot sites, paired "on-station" and "remote" samplers were deployed to detect possible local influences. Preliminary targeted analysis results (Figure 1) show generally good agreement between sites, indicating minimal local impacts. However, at one sub-Arctic station substantially higher PCB levels - and an enrichment in higher molecular weight congeners - were observed at the on-station location, demonstrating the diagnostic value of congener profiles for identifying point-source contributions.
These studies highlight that halo effects are chemical-class specific and may influence only certain POPs or CEECs at a given station.
We propose a practical framework for evaluating new or existing remote monitoring locations, including the strategic use of two or more samplers initially to test for local sources, chemical fingerprinting, and integration of emerging indicators such as air microbiome (eDNA) metrics and health-related assays as additional forensic tools.

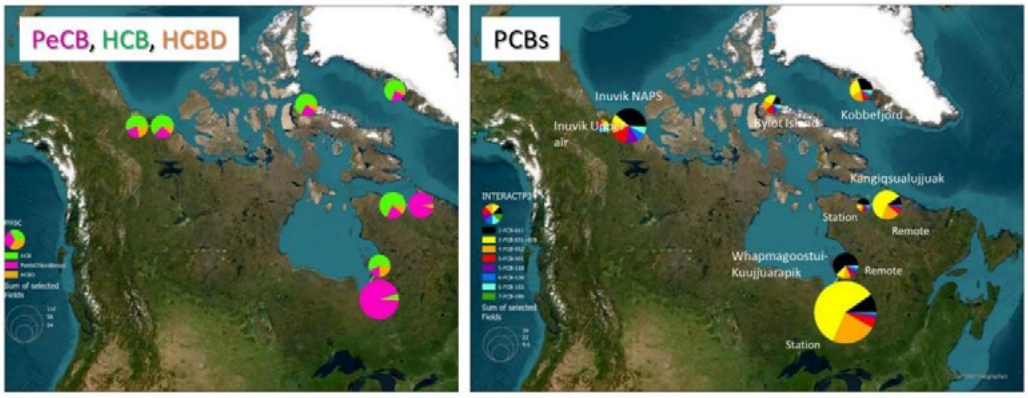


Figure 1. Concentrations in air for selected POPs at passive sampling sites. PeCB-Pentachlorobenzene; HCB-Hexachlorobenzene; HCBD-Hexachlorobutadiene; PCB-Polychlorinated biphenyls.

POPs in Polar Regions

B. Jiménez & R. Suehring

D4-515 Contaminants in Air at Polar GAPS Network Sites: Distinguishing Local Sources vs Long-Range Transport

Acknowledgment

We acknowledge funding support for the GAPS Network provided by the Chemicals Management Plan, Northern Contaminants Program, and UNEP. The study also benefitted from support from INTERACT and AMAP.

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POPs in Polar Regions

B. Jiménez & R. Suehring

D4-049 Occurrence of POPs-like Halogenated Natural Products in Antarctic Sponges

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Introduction

More than 8,000 halogenated natural products (HNPs) have been discovered and documented, among which approximately 10 classes exhibit chemical structures similar to persistent organic pollutants (POPs) and are both persistent and bioaccumulative. HNPs are primarily produced by certain lower marine organisms, such as sponges and seaweeds. Our previous studies revealed that the marine sponge Hyrtios proteus is a potential producer of the typical HNPs 2′ -MeO-BDE 68 (BC-2) and 6-MeO-BDE 47 (BC-3), and that the red seaweed Plocamium serves as a natural producer of (1R,2S,4R,5R,1′ E)-2-bromo-1-bromomethyl-1,4-dichloro-5-(2′ -chloroethenyl)-5-methylcyclohexane (MHC-1). However, for certain HNPs such as 2,3,3′ ,4,4′ ,5,5′ -heptachloro-1′ -methyl-1,2′ -bipyrrole (Q1), the natural producers remain unclear. Notably, high quantities of these HNPs are often detected in marine biota living near such producer organisms. In this study, we aim to characterize the occurrence of HNPs in a variety of Antarctic sponges and to determine whether they serve as natural producers of specific HNPs.

Materials and Methods

Ten marine sponges were sampled in Theys Bay and Adélie Cove in the Ross Sea, Antarctica. The samples were freeze-dried, ground into powder, and lipids were extracted with cyclohexane/ethyl acetate (46:54, w/w) using accelerated solvent extraction. Subsequently, the extracts were sequentially purified by gel permeation chromatography and adsorption chromatography with deactivated silica gel. HNPs (mainly BC-2, BC-3, 2,6-DBP, 2,4-DBP, 2,4,6-TBP, 2,4,6-TBA, Q1, and MHC-1) were
quantified using GC-ECNI-MS in selected ion monitoring mode. An Optima 5 MS column was used in the GC oven.

Results

Quantification data showed that 2,4,6-TBP was the predominant halogenated natural product (HNP) in all sponge species, accounting for over 90% of the total quantified HNPs in eight of the ten samples (Fig.1). Notably, the amount of 2,4,6-TBP
in Haliclona (Gellius) rudis (Topsent, 1901) from Adélie Cove and Haliclona (Rhizoniera) dancoi (Topsent, 1913) from Theys Bay each accounted for approximately 70% of the total quantified HNPs, while 2,6-DBP accounted for about 28% in both species (Fig.1).

Additional investigation of unquantified HNPs was conducted using full scan and low-mass SIM (m/z 79 and m/z 35) by GC-ECNI-MS, leading to the detection of five halogenated phenols (denoted as #1 to #5).

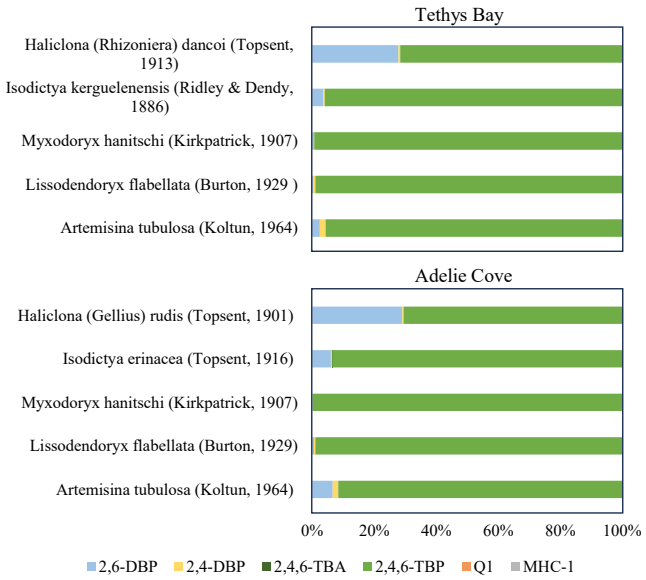


Fig. 1. Major HNPs detected in various Antarctic sponges from the Tethys Bay and Adelie Cove.

POPs in Polar Regions

B. Jiménez & R. Suehring

D4-049 Occurrence of POPs-like Halogenated Natural Products in Antarctic Sponges

The molecular ions of these five compounds were monitored, and their isotopic patterns suggested that they are trichlorophenol (#1, $C_6H_3Cl_3O$), two isomers of dichlorobromophenol (#2 and #3, $C_6H_3Cl_2BrO$), and two isomers of chlorodibromophenol (#4 and #5, $C_6H_3ClBr_2O$) (Fig.2).

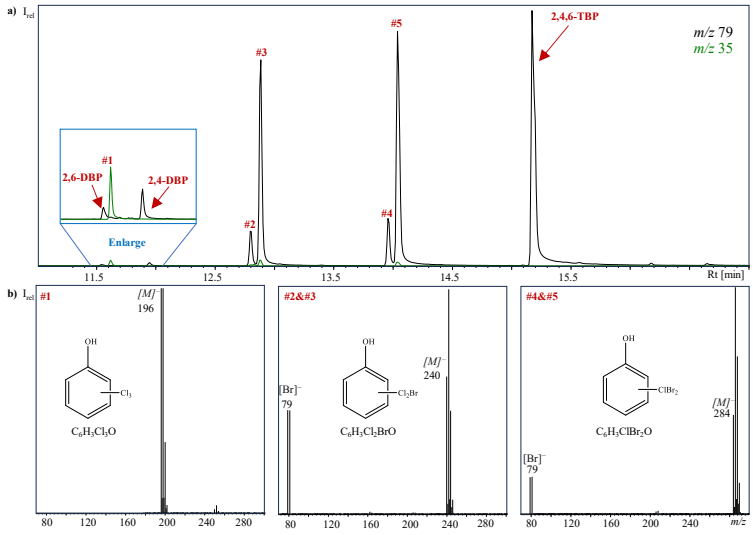


Fig. 2. Detection of bromophenols or chlorophenols in *Lissodendoryx flabellata (Burton, 1929)* using GC-ECNI-MS-SIM (*m/z* 79 or 35) .

Discussion and Conclusion

Previous studies have reported that the distribution of HNPs is highly geographically dependent; however, this was not the case in the present study. Specifically, marine sponges from the same genus but sampled from different bays exhibited similar HNP patterns. These findings suggest that the distribution of HNPs in Antarctic sponges is species-dependent rather than geographically dependent.

In summary, analysis of HNPs in various Antarctic sponge species from Theys Bay and Adélie Cove revealed that 2,4,6-TBP predominated, followed by 2,6-DBP and 2,4-DBP. The distribution of HNPs in the same sponge species appeared to be stable, even when sampled from different locations. In addition, five rarely reported halogenated phenols were preliminarily characterized as trichlorophenol or mixed chlorinated/brominated phenols.

Acknowledgment

Natural Science Foundation of China (32402251), Liaoning Provincial Science and Technology Plan Joint Program (2025-MSLH-047) and Dalian Polytechnic University Research Start-up Project for Introduced Talents (LJBKY2025062).

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POPs in Polar Regions

B. Jiménez & R. Suehring

D4-073 Modernizing Flame Retardant Analysis: Conversion of Helium Carrier Gas EI GC HRMS to Nitrogen Carrier Gas GC-APCI MS/MS

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Introduction
Because the analysis of polybrominated diphenyl ether (PBDE) flame retardants is often performed to ensure compliance with national regulations and international treaties, data specificity and confidence in the performance of the analytical technique are vital. In the past this led to the use of magnetic sector-based GC HRMS with electron ionization (EI). However, both EI and magnetic sectors impose limitations to the modernization of PBDE analysis due to incompatibility with alternative carrier gas types to helium combined with slow acquisition rates. Gas chromatography atmospheric pressure chemical ionization (GC-APCI) is readily adaptable to the use of nitrogen carrier gas at high flowrates and when combined with tandem quadrupole MS/MS opens the opportunity for faster acquisition rates and the prospect of combining PBDEs with the analysis of other halogenated flame retardants.

Materials and Methods
An EI GC HRMS reference method was first reproduced using helium carrier gas and then adapted to nitrogen carrier gas on the same GC-APCI QqQ system. Conversion of He carrier gas methods to N2 often requires the scaling of column dimensions. For this method though, no commercially available scaled column was found, and so, the N2 carrier method was implemented on the same column as is used with He.
Through the use of carrier gas flow ramping the N2 method was able to maintain the separation of the critical isomeric pair of BDE 49 and BDE 71 while also keeping the total runtime of 27 minutes the same. The last eluting analyte, BDE 209, had a RT of
21.8 min for the N2 method versus 24.7 min for the He reference method.

Results
Extracted samples, QCs and standards were analyzed to evaluate method performance. The main performance criteria evaluated were sensitivity, precision, accuracy and linearity. The GC-APCI MS/MS method met or exceeded all performance requirements. Data will be presented that includes an average r2 value of 0.999885 for the 25 analytes across greater than three orders of magnitude; <10% RSDs for all four EIS and <2% for all six IS; and a reporting limit for BDE 209 of 0.25 ppb.

Discussion and Conclusion
An all-nitrogen configuration GC-APCI QqQ system was applied to the analysis of PBDEs in environmental matrices by adapting a reference method previously used on magnetic sector EI GC-HRMS systems. Performance criteria was equal-to or better-than EI magnetic sector and helps demonstrate the feasibility of GC-APCI MS/MS as a an alternative for the most stringent regulatory and standard analytical methods.
The change to tandem quadrupole MS from high resolution MS allows access to improved performance measures such as higher acquisition speeds and high specificity MS/MS while also requiring reduced training time and expertise.

Acknowledgment
The authors would like to thank the Quebec Laboratory for Environmental Testing (QLET) at Environment and Climate Change Canada for providing the reference methods and samples for this study.

Environmental and Human Exposure to Consumer Products 1

V. Esposito & I. İmamoğlu

D5-070 Unsafe by Design: Hazardous Chemicals in Kenyan Consumer Products

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Introduction

Plastic products contain over 16,000 chemical additives, many not chemically bound to the polymer matrix and capable of migrating into food or direct skin contact. Three plastic-associated chemicals alone—BPA, DEHP, and PBDEs—were linked to 5.4 million cases of ischemic heart disease and loss of 11.7 million IQ points due to prenatal exposure. Children are particularly vulnerable due to their smaller body size, developing organ systems, and mouthing behaviors. Kenya lacks national chemical safety regulations and systematic market surveillance, allowing hazardous products to reach consumers undetected.

Materials and Methods

Fifty-five plastic products were collected from the Kenyan market across nine categories: pencil cases, sunglasses, sport bottles, coffee cups, infant bottles, toys, kitchen utensils, microwave lids, and snack containers. All samples were screened using X-ray fluorescence to determine bromine and heavy metal content. Based on XRF results, 31 samples were selected for detailed analysis at the University of Chemistry and Technology, Prague. Four black plastic samples were analyzed for PBDEs, novel brominated flame retardants (BTBPE, DBDPE, HBBz, OBIND, PBEB, PBT), Dechlorane Plus, HBCDD, and TBBPA using GC-MS-NICI and UHPLC-MS/MS. Twenty-seven food-contact samples were analyzed for bisphenols using UHPLC-MS/MS.

Results

All four black plastic products contained PBDEs ranging from 17.2–47.9 mg/kg, dominated by BDE-209 (87–95% of total). Novel brominated flame retardants (nBFRs) exceeded PBDEs in all samples, totaling 37.9–106.9 mg/kg. Decabromodiphenylethane (DBDPE) was the primary contributor to this group, with concentrations reaching up to 103,449 ng/g, confirming its role as a major substitute for DecaBDE. Dechlorane Plus, listed under the Stockholm Convention in 2023, was detected in all four samples at 269–911 ng/g—representing, to our knowledge, among the first reported detections of this compound in toys and kitchen utensils globally. One toy arrow sample approached the forthcoming EU limit of 1,000 ng/g for unintentional trace contamination, which will be effective from April 2028. Additionally, tetrabromobisphenol A (TBBPA) reached its highest concentration in the Rubik's cube sample at 32,927 ng/g, illustrating significant contamination from recycled electronic waste. BPA was found in all 27 food-contact samples at 1.12–48,764 ng/g. Four sport bottles showed extreme concentrations (13,812–48,764 ng/g). Critically, four infant bottles marketed as "BPA-free" contained BPA at 6.2–19.1 ng/g, including the highest concentration recorded in this product category. BPS, promoted as a BPA replacement, was detected in 25 of 27 samples, illustrating "regrettable substitution" where one endocrine disruptor replaces another. The highest BPS levels (up to 15.7 ng/g) were recorded in microwave lids, a pattern consistent with its use in heat-resistant applications where high temperatures further accelerate chemical migration. XRF screening further revealed a range of toxic metals — including cadmium, lead, and antimony — across toys, pencil cases, and an infant bottle teat, with several values exceeding EU limits.

Discussion and Conclusion

Recycled e-waste (BDE-209) and "regrettable substitutions" (nBFRs) are primary contamination sources in Kenyan plastics. Failures in labeling ("BPA-free") and monitoring (Dechlorane Plus), alongside cadmium levels eightfold over EU limits, expose children to a "toxic cocktail". Addressing this requires enforceable national standards, border testing, and a Global Plastics Treaty with binding chemical restrictions. Ultimately, hazardous additives must be removed from production altogether to ensure safety.

Acknowledgment

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Environmental and Human Exposure to Consumer Products 1

V. Esposito & I. İmamoğlu

D5-209 Plastic additives in consumer products: assessing dermal migration under simulated exposure conditions

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Introduction
Menstrual products have been identified as a source of exposure to plastic additives such as phthalates (PAEs), organophosphate esters (OPEs), and alternative plasticizers (APs) [1]. These products are used in direct contact with vulvar and vaginal tissues, which are highly permeable and may facilitate chemical absorption. Despite increasing evidence of plastic additives occurrence in menstrual products, dermal exposure remains poorly characterized. In particular, the influence of biological fluids on plastic additives release has not been investigated. Therefore, this study aimed to measure the transfer of plastic additives from menstrual products to the skin using dermal migration experiments under simulated use conditions, focusing on the influence of sweat and sebum (SS) and vaginal/menstrual fluids (VF/MF).

Materials and Methods
Dermal migration experiments were performed adapting a previously published experimental setup [2]. Polydimethylsiloxane (PDMS) sheets were used as a skin surrogate to assess the transfer of plastic additives. The experiments were performed with and without synthetic biological fluids, including SS and VF/VM. Contact time and temperature were controlled to simulate realistic exposure.
The easily releasable fraction (ERF) is defined as the fraction of a chemical released from a product that reaches the skin. After exposure with menstrual products, PDMS sheets were extracted using a hexane:acetone (1:1, v/v) mixture assisted by ultrasonication. Extracts were cleaned using Florisil SPE cartridges and analyzed for PAEs, OPEs, and APs by LC-MS/MS. Using the most realistic exposure conditions (including SS and VF/MF), dermal migration experiments were performed with non-spiked samples of 5 sanitary pads, 5 panty liners and 5 tampons.

Results
Sanitary pads were used to evaluate the influence of biological fluids and to determine the ERF of a wider range of plastic additives in spiked experiments. ERFs showed a dependence on exposure conditions, ranging between <LOD-56% without fluids, and decreasing to <LOD-10% with all biological fluids. Depending on the compound, different behaviours were observed going from experiments without to experiments with all fluids: TPrP decreased from 56% to <LOD; BBzP increased from
<LOD to 32%; ATBC had comparable values (1-3%).
Experiments under the most realistic exposure conditions were further extended to non-spiked products (sanitary pads, panty liners, and tampons). Migration of OPEs was consistently observed across all product types, while APs showed higher variability. Migration of PAEs was not observed in non-spiked products. Different products showed distinct ERFs. For example, ATBC ERFs in sanitary pads and panty liners (1–7%) were lower than in tampons (up to 43%).

Discussion and Conclusion
The results show that biological fluids can significantly influence the release of plastic additives from menstrual products. Dermal migration experiments under the most realistic exposure conditions show that the release of plastic additives is dependent on the specific compound and the type of menstrual product, with compounds showing contrasting behaviours across matrices and exposure conditions. These findings highlight the need to further investigate the use of menstrual products as a potential exposure pathway.

Acknowledgment
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Environmental and Human Exposure to Consumer Products 1

V. Esposito & I. İmamoğlu

D5-689 Plastic by design, exposure by default: synthetic antioxidants in plastics and household dust

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Introduction

Synthetic antioxidants (AOX) are widely used in consumer products such as plastics, food contact materials (FCMs), and personal care products to prevent oxidative degradation and extend the product lifetime. As these compounds are not chemically bound to product matrices, they can migrate into food, indoor environments, and ultimately the human body, raising concerns about human exposure. This study investigated two types of AOX, the synthetic phenolic antioxidants (SPAs) such as Irganox 1010, and the organophosphite antioxidants such as Irgafos 168. The occurrence of these AOX was identified in plastic materials and quantified in indoor dust, thereby providing a comprehensive evaluation of human exposure pathways, with a specific focus on exposure to toddlers as a vulnerable population.

Results

First, the occurrence of AOX in plastic toys (n = 22) and FCMs (n = 43) was investigated using a suspect screening approach with HPLC-QTOF-MS. This resulted in the identification of 15 AOX. In more than 50% of samples, multiple AOX were detected, with up to four antioxidants present in a single sample. This co-occurrence likely reflects synergistic use of different antioxidant types, mixing of plastic matrices, and/or recycling processes. These findings highlight plastics as a significant and complex source of exposure, while also revealing important knowledge gaps for less-studied compounds.

Secondly, AOX in indoor dust was quantified as another important exposure pathway, particularly for vulnerable populations, such as toddlers. A validated LC–MS/MS method enabled the quantification of 10 AOX and 3 transformation products in 80 dust samples collected from Belgium, China, Greece, Spain, and Thailand. Seven AOX showed detection frequencies above 50%, with concentrations ranging from ng/g to µg/g, with the highest concentrations for AO245 (Triethylene glycol bis(3-tert-butyl-4-hydroxy-5-methylphenyl)propionate), indicating their consistent presence. In addition, regional variability was observed across countries.

Exposure scenarios for dust ingestion were evaluated using both average and high (95th percentile) exposure estimates. Overall, risk estimates were below concern thresholds; however, the high-exposure scenario for toddlers indicated potential risks. First, in one Greek household, the hazard quotient exceeded 1 for BHT-COOH (3,5-di-tert-butyl-4-hydroxybenzoic acid), suggesting that health risks cannot be excluded. Second, TCEP (tris(2-chloroethyl) phosphate) exceeded the hazard quotient of 1 in at least one sample per country, and in approximately 40% of samples from student dormitories in China. It should be noted that TCEP was measured here as a transformation product of the antioxidant TCEPi ((tris(2-chloroethyl) phosphite), although it is widely used as an independent phosphate flame retardant.

Discussion and Conclusion

In conclusion, AOX are ubiquitous in indoor environments, and exposure via indoor dust is evident. While overall risk estimates remained below concern levels, elevated exposure scenarios suggest that potential health risks cannot be excluded in specific cases, particularly for toddlers.

Environmental and Human Exposure to Consumer Products 1

V. Esposito & I. İmamoğlu

D5-840 Screening of plastic chemicals in consumer products using LC- and DART-timsTOF-MS

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Introduction
Plastic products contain a wide range of additives, including flame retardants, plasticizers, antioxidants, and biocides, which are intentionally incorporated to improve material performance. Despite existing European regulations targeting substances such as polybrominated diphenyl ethers (PBDEs), phthalates, and bisphenol A (BPA), these compounds can still be present in consumer products due to legacy recycling streams, imported materials, and regulatory gaps in manufacturing regions [1,2]. Comprehensive and high-throughput analytical approaches are therefore needed to support enforcement and enable screening of both regulated and emerging substances.

Materials and Methods
Grinded or finely cut consumer product samples (25 mg) were subjected to a two-step extraction using dichloromethane (DCM) followed by toluene. Chemical analysis was performed using reversed-phase liquid chromatography coupled to trapped ion mobility spectrometry–time-of-flight mass spectrometry (LC-timsTOF-MS) and a high-throughput direct analysis in real time (DART)-timsTOF-MS workflow. Suspect screening lists were compiled from relevant EU regulations (General Product Safety Directive, Toy Safety Directive, Substances of Very High Concern (SVHC), RoHS), the PlastChem database, and validated spectral libraries (MassBank and NIST).

Results
The DCM–toluene extraction provided broad chemical coverage, while additional extraction steps indicated the presence of more polar compounds not efficiently recovered by non-polar solvents. LC-timsTOF-MS enabled the detection of a wide range of plastic additives, including flame retardants, plasticizers, antioxidants, and biocides. Trapped ion mobility spectrometry improved the separation of complex mixtures and supported differentiation of isomeric compounds, including selected phthalates. DART-timsTOF-MS successfully detected regulated phthalates, bisphenols, and brominated flame retardants. Calibration experiments demonstrated good linearity for representative compound classes, supporting quantitative potential.

Discussion and Conclusion
DART-timsTOF-MS provided rapid, direct analysis without chromatographic separation, enabling high-throughput screening of up to 12 samples within two minutes and significantly reducing solvent consumption. In contrast, LC-timsTOF-MS provided higher separation power and broader compound coverage. Together, both approaches are complementary: LC enables detailed characterization of complex mixtures, while DART supports rapid screening and potential regulatory applications. The combined use of LC-timsTOF-MS and DART-timsTOF-MS enables both comprehensive profiling and high-throughput screening of plastic additives in consumer products. This integrated approach supports a more efficient chemical risk.

Acknowledgment
Acknowledgement – This study was funded by the European Partnership for the Assessment of Risks from Chemicals. Grant agreement No. 101057014

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Environmental and Human Exposure to Consumer Products 1

V. Esposito & I. İmamoğlu

D5-576 Toward a Circular Economy: Are Reusable Food Contact Materials Safe for Consumers?

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Introduction

The transition from disposable to reusable systems has become a central pillar of European environmental policy. Under the framework of the European Green Deal, the European Union has committed to achieving climate neutrality by 2050 while decoupling economic growth from resource use. Within this agenda, plastics and packaging have been identified as priority areas due to their significant contribution to greenhouse gas emissions, resource depletion, and environmental pollution. The adoption of the Single-Use Plastics Directive (EU) 2019/904) marked a decisive regulatory step, restricting or banning a range of single-use plastic products and promoting preventive measures, reuse systems, and extended producer responsibility schemes.

While recycling has long been promoted as a key mitigation strategy, its practical limitations remain substantial. Recycling rates across Europe vary considerably by material type and application, and not all food contact materials (FCMs) are technically or economically recyclable. Moreover, recycling infrastructure is unevenly developed across Member States, and closed-loop systems for food-grade applications remain limited. As a result, many single-use food contact articles, despite being theoretically recyclable, are in practice incinerated, landfilled, or exported, thereby undermining circular economy objectives.

In this context, reusable food contact materials have emerged as a primary and immediate strategy to reduce environmental impacts associated with disposable products. Unlike recycling, which addresses waste post-consumption, reuse models aim to prevent waste generation at the source. By extending product lifetimes and distributing environmental burdens across multiple use cycles, reusable systems have the potential to significantly lower material throughput, reduce greenhouse gas emissions, and decrease littering, provided that adequate collection, washing, and redistribution infrastructures are in place.

Environmental impact is an important consideration; however, consumer safety remains paramount. Indeed, sustainability does not automatically guarantee safety. It is essential to ensure that these materials do not release hazardous substances into food under foreseeable conditions of use. Therefore, alongside environmental considerations, chemical safety assessment remains a fundamental requirement.

To date, the most significant shift from single-use items to reusable alternatives is occurring in the takeaway sector, as well as at large-scale events such as festivals, concert halls etc.

To this end, this study aims to investigate the (potential) migration of substances from reusable plastic articles intended for takeaway or large events.

From Science to Policy

F. Pecoraro & W. Tirler

D6-884 Environmental legislation in the post-Seveso era

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Introduction

Facilities that process or store specified quantities of hazardous substances are subject to the regulatory framework established by the European Seveso Directives - most recently, Directive 2012/18/EU - and by the corresponding national implementing legislation (in Italy, Legislative Decree No. 105/2015).

Member States are required to periodically report to the European Commission on the implementation of the Directive. The reporting format has recently been updated through Commission Implementing Decision (EU) 2025/113.

The management of major-accident risks, together with their potentially significant environmental, occupational, and public safety consequences, lies at the heart of the Seveso regime. Effective risk management requires acknowledging the existence of risk, recognizing that its complete elimination is often impossible, and adopting all technically feasible measures to reduce both the likelihood of accidents and the severity of their consequences should they occur.

Materials and Methods

For environmental practitioners, it is important to note that, although the Seveso Directives do not apply to waste landfills or underground storage sites, they must be taken into account for all other waste-management activities, as clarified in the European Commission Communication of 9 April 2018 on waste classification.

The regulatory framework is built around three key principles: prevention, transparency, and mitigation. Prevention is pursued through the preparation of core management documents, including the Major-Accident Prevention Policy and the Safety Management System implementation program. Transparency is ensured through mandatory notifications, self-certifications submitted to the competent authorities, and, where required, the Safety Report. Mitigation is addressed through internal and external emergency plans prepared in accordance with specific guidelines, as well as through the provision of information to the public.

The Seveso framework does not assess hazardous installations in isolation. It also addresses situations in which the consequences of a major accident may be amplified by geographical location, the proximity of multiple establishments, and the hazardous substances present within them—the so-called domino effect.

Results

The presentation will conclude with three practical case studies.

The first concerns the Seveso disaster (1976), the most serious chemical accident in Italian history. A valve failure at the ICMESA plant in Meda/Seveso released a cloud of TCDD dioxin that contaminated the surrounding area. The disaster led directly to the adoption of the first Seveso Directive (82/501/EEC). Particular attention will be devoted to the concept of panic damage, which was recognized for the first time by the Italian Supreme Court even in relation to residents who, after years of medical monitoring, were ultimately found to have suffered no physical injury.

The second case study examines the Viareggio railway disaster (2009). Although the accident involved the transportation of hazardous substances rather than a fixed industrial installation, its dynamics closely mirrored the major-accident scenarios addressed by the Seveso legislation, involving a gas-cloud explosion. The event prompted a comprehensive revision of safety regulations governing the transport of dangerous goods through urban areas.

Discussion and Conclusion

The third case concerns the Calenzano explosion (2024), a recent accident that caused multiple fatalities. Preliminary findings suggest that the incident was linked not to the plant's production process itself but to interference from external maintenance activities. An accidental gasoline release reportedly vaporized, forming a flammable cloud that was ignited by the heat generated by the engine of a mobile elevating work platform (MEWP), triggering the initial explosion and the subsequent chain of explosions.

From Science to Policy

F. Pecoraro & W. Tirler

D6-897 The evolution of the Seveso Directive: between historical memory and future challenges.

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Introduction
The evolution of the Seveso Directive: between historical memory and future challenges.

Materials and Methods
In the first part, the presentation will analyze the evolution of the Seveso Directive from the 1976 disaster to the present day, summarizing the regulatory developments leading up to the current Seveso III Directive. The first part focuses on historical memory as a driver of legislative change, highlighting how successive reforms have progressively raised industrial safety standards and improved major accident hazard management. In the second part, the analysis will focus on the future prospects for the evolution of legislation.

Results
Tomorrow's legislation has the crucial task of regulating these elements without stifling competitiveness and research. The report will analyze the current state of affairs and the prospects ahead.

Discussion and Conclusion
In the future, the Seveso legislation will have to address the challenges arising from the ongoing industrial transformation.
The challenges relate to future regulatory updates aligning ecological transition goals with emerging risks from new technological (i.e. digital transition) and geopolitical scenarios and ensuring the safety of advanced industrial plants without hindering innovation and sustainability.
European decarbonization targets are introducing innovative energy carriers, such as hydrogen, and new large-scale energy storage systems into industrial complexes. These technologies are seen as tools for sustainability. At the same time, they present potential risks in terms of energy density, reactivity and their chemical-physical behavior. In addition to new materials, we must acknowledge the mass digitalization of plants, which exposes high-risk sites to threats of cybersecurity breaches and cyber sabotage. Last but not least, the climate crisis could lead to more frequent NaTech (Natural Hazards Triggering Technological Accidents) phenomena such as floods, extreme temperatures or other meteorological events that can trigger chain reactions of industrial accidents.

From Science to Policy

F. Pecoraro & W. Tirler

D6-511 New Developments under Stockholm Convention's Global Monitoring Plan

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Introduction

The Global Monitoring Plan (GMP) of the Stockholm Convention on Persistent Organic Pollutants (POPs) is a cornerstone of the Convention's Effectiveness Evaluation under Article 16. GMP provides a global framework for collecting comparable POPs monitoring data in the core media across the five UN regions namely Africa, Asia-Pacific, Eastern Europe, Group of Latin American and Caribbean Countries region, GRULAC, and Western Europe and Other Groups region, WEOG (Figure 1). The first, second and third phases of GMP were completed in 2009, 2015 and 2021 (UNEP, 2023). Regional reporting is currently underway for the fourth phase of the GMP, providing baseline data and assessing temporal trends for nearly 40 listed POPs, with additional substances under consideration for listing.

Results

This presentation will summarize recent progress in GMP reporting across core environmental media, including air, human tissues, and water (for per- and polyfluoroalkyl substances, PFASs). Key challenges will also be discussed, such as persistent data gaps, capacity limitations, and the growing disconnect between the pace of chemical policy development and the ability of monitoring programs to respond.
Finally, emerging strategies and cross-cutting themes relevant to the future evolution of the GMP will be highlighted (UNEP, 2024). These include approaches to chemical mixtures, efforts to better link environmental concentrations to human exposure and health, biodiversity loss, and climate change. The presentation will also explore opportunities to strengthen regional and global collaboration under the GMP framework, including through enhanced engagement with academic research communities, regional monitoring networks, the POPs Review Committee under the Stockholm Convention, and the newly established Intergovernmental Science-Policy Panel on Chemicals, Waste and Pollution, with a view to enhancing the relevance, responsiveness and scientific robustness of the GMP.

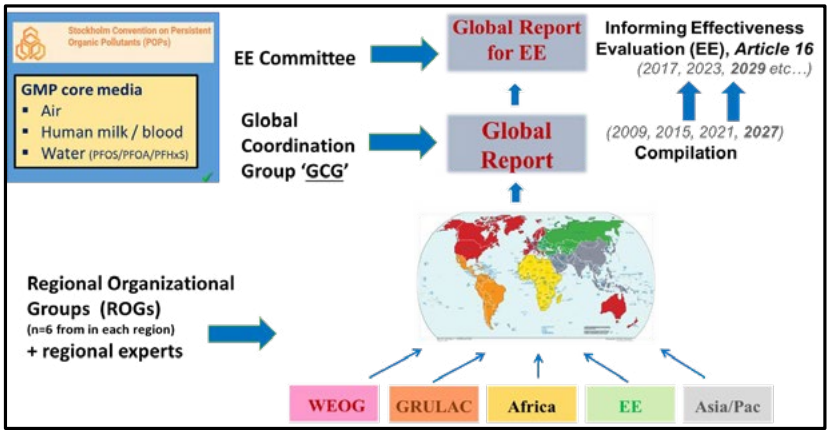


Figure 1. Regional reporting structure for the Global Monitoring Plan of the Stockholm Convention on POPs.

Acknowledgment

We acknowledge the contribution of lead drafters for the 3rd Global Monitoring Plan report as well as UNEP support for the report on Enhancing POPs monitoring and air and water. These include: Sara Broomhall, Hayley Hung, Yasuyuki Shibata, Katarina Sebkova, Derek Muir, Luc Miaz, Ramon Guardans, Katrine Borga, Matt MacLeod, Gerhard Lammel, Alexei Gusev, Ana Maria Wit and Victor Hugo Estellano.

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From Science to Policy

F. Pecoraro & W. Tirler

D6-249 Strategic technology and service needs for Micro/Nanoplastics and Bioplastics Research in food, environment and health domain

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Introduction

The increasing prevalence of micro/nanoplastics (MNPs) and the accelerated adoption of bioplastics in food systems pose substantial risks to public health, ecosystems, and environmental sustainability. The FHERITALE project (Food, Health and Environment Research Infrastructures to Tackle Emerging Priorities) addresses these urgent challenges by fostering collaboration among European research infrastructures, industries, and policymakers. This initiative aligns closely with the European Commission's goals to bridge current knowledge gaps and improve regulatory frameworks regarding MNPs, ultimately supporting informed policymaking and effective mitigation strategies. The ultimate goal of FHERITALE is to establish a robust and harmonized research framework focused on building a collaborative network of research infrastructures, industries, and policymakers to advance knowledge, improve monitoring, and devise mitigation strategies for MNPs and bioplastics' impacts on food, health, and the environment. A key step to achieve this is the systematic identification, categorization, and mapping of existing technologies and analytical methods utilized in the study of MNPs and bioplastics, as well as the assessment of technological gaps and needs for these materials in the field of food, health, and environment.

Materials and Methods

The development of the comprehensive inventory was conducted through a systematic methodology, by data collection and data extraction. AI-powered literature analysis tool, was employed to efficiently manage and analyze extensive curated literature data (815 documents from peer-reviewed literature, EU-funded project outputs, and institutional reports from EU and international bodies).
Optimized queries specifically targeting technological needs, coupled with manual controls and checks for ensuring soundness, facilitated accurate data extraction. Data were rigorously validated through literature consultation, categorized, and then reviewed.

Results

Result of the identification, extraction and classification of strategic technology and service needs have been compiled in a comprehensive database found on Zenodo (Vankoningsloo et al., 2026).
The thematic analysis highlights key priority areas for advancing research and management of micro- and nanoplastics. Major needs include improved detection of smaller particles, optimized analytical workflows, and the development of harmonized methods and realistic reference materials to ensure data comparability. Strong emphasis is also placed on environmental monitoring and modelling of particle fate, as well as more ecologically relevant impact assessments. In human health, understanding toxicokinetics and leveraging advanced in vitro and omics approaches are critical. Regulatory progress requires MNP-specific risk assessment frameworks and standardized thresholds, while growing data complexity calls for advanced modelling and AI-based tools. Finally, the development of sustainable alternatives and improved wastewater treatment solutions remains essential for effective mitigation and prevention.

Acknowledgment

This work is a part of FHERITALE and is funded by the European Union. Grant Agreement No. 101131588
Method and study design: Renier N. (Sciensano)

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From Science to Policy

F. Pecoraro & W. Tirler

D6-675 Shaping the science-policy interface on chemicals, waste and pollution: the role of the new ISP-CWP

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Introduction

The formal establishment of the Intergovernmental Science-Policy Panel on Chemicals, Waste and Pollution (ISP-CWP) on 20 June 2025 in Punta del Este (Uruguay) represents a significant milestone in global environmental governance. Mandated by UNEA Resolution 5/8 (2022), the Panel is the first intergovernmental science-policy body specifically dedicated to strengthening the interface between knowledge production and decision-making on chemicals, waste, and pollution, complementing existing bodies addressing climate change and biodiversity.

Emerging within a governance landscape characterized by multiple frameworks and diverse institutional actors, the ISP-CWP seeks to provide a more integrated approach to pollution prevention and the sound management of chemicals and waste. The rapid growth in global chemical production, expanding waste streams, and the persistent impacts of pollution on human health and ecosystems underline the relevance of such an initiative. In this context, the Panel aims to reinforce the evidence base of policymaking while ensuring policy relevance and maintaining a non-prescriptive role.

This contribution examines both the establishment process and the institutional features that may shape the Panel's effectiveness. Its governance structure includes a Plenary as the main decision-making body, supported by a Bureau and an Interdisciplinary Expert Committee (IEC) responsible for providing scientific and technical expertise. A voluntary trust fund is foreseen to support its activities. The Panel also emphasizes the integration of diverse knowledge systems, including Indigenous and local knowledge, in order to broaden participation and diversify its knowledge base.

Among its core functions, the ISP-CWP is expected to carry out horizon scanning to identify emerging issues, produce policy-relevant assessments, and support capacity building, particularly in low resource countries. It also promotes the
accessibility and transparency of data through practices aligned with FAIR principles. These elements reflect an effort to combine methodological robustness with responsiveness to policy needs.

The process leading to the establishment of the ISP-CWP, conducted through multiple sessions of ad hoc Open-Ended Working Group, reflects the complexity of building consensus in a multilateral setting. While broad agreement was achieved on the overall structure and mandate, some aspects—such as participation modalities, social inclusion considerations, and elements of the conflict-of-interest framework—will continue to evolve as the Panel becomes operational.

Overall, the design of the ISP-CWP incorporates many lessons from existing science-policy interfaces while adapting them to the specific challenges of chemicals, waste, and pollution governance. Its long-term effectiveness will depend on its ability
to maintain scientific rigor, foster trust among stakeholders, support evidence-based decision-making, and translate knowledge into actionable policy support at both national and international levels.

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PFAS Analysis 2

S. Harrad & R. Suehring

D7-020 Comprehensive analysis of novel per-and polyfluoroalkyl substances in anti-fog agents

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Introduction
Per- and polyfluoroalkyl substances (PFAS) have been widely used in industrial and consumer products because of their unique properties. However, PFAS have received worldwide attention because of their environmental persistence and toxicity. The Conference of the Parties of the Stockholm Convention on Persistent Organic Pollutants listed PFOA and PFOA-related compounds in Annex A in May 2019. Anti-fog agents are one of the consumer products known to contain PFAS. A recent study has reported the presence of novel PFAS and unidentified fluorinated compounds in anti-fog agents manufactured in China and the United States [1]; however, available information remains limited. Comprehensive investigations of PFAS in anti-fog agents are therefore needed. In this study, we determined the concentrations of individual PFAS in anti-fog agents sold in Japan and estimated the structures of unidentified fluorinated compounds in the anti-fog agents.

Materials and Methods
Seven anti-fog agents sold from 2007 to 2018 were purchased in Japan. The concentrations of 119 target PFAS in these products were determined by LC-MS/MS and GC-MS/MS. Concurrently, the concentration of total fluorine (TF) was determined by combustion ion chromatography. Alkaline hydrolysis of these products was then applied. One mL of 1 M sodium hydroxide solutions was added to these products; reacted at 50 °C for 24 h, followed by individual PFAS analysis. Oxidative decomposition using the total oxidizable precursor (TOP) assay was also applied to these products. Ten mL of 150 mM $K_2S_2O_8$ and 400 mM NaOH solutions were added and combined with these products. The mixtures were reacted at 85 °C for over 6 h, followed by individual PFAS analysis. Screening analyses for unknown compounds were conducted by GC-MS and LC-Orbitrap-MS to identify the chemical structures of the unidentified PFAS detected in this study. Furthermore, the chemical structures of unidentified PFAS were estimated by using an in silico-type chemical-structure estimation tool (MetFrag [2]).

Results
The concentrations of 6:2 fluorotelomer alcohol (6:2 FTOH) ranged from 0.224 to 137 mg/kg in all products. The concentrations of 6:3 FTOH ranged from 1.62 to 20.9 mg/kg in three products. The concentrations of TF in the anti-fog agents ranged from 5,000 to 16,000 mg-F/kg in all products. The concentrations of individual PFAS were up to 1% of TF concentrations. There was no difference in the concentrations of FTOHs before and after alkaline hydrolysis. For all products, the C5–C7 PFCAs accounted for the majority of the total PFCA concentrations after the TOP assay. The chemical structures were estimated from the precise masses of the peaks obtained by LC-Orbitrap-MS. The candidate compounds were estimated using MetFrag [2].

Discussion and Conclusion
Dominant compounds identified by target PFAS analysis were 6:2- and 6:3 FTOH. 6:3 FTOH was detected in consumer products for the first time. The low contribution of identified PFAS to the TF concentration suggests that the major fluorinated components in the anti-fog agents were unidentified PFAS. In addition, the compounds detected by target analysis could be derived from impurities and degradation products during the manufacturing process. Alkaline hydrolysis and TOP assay partially elucidated the structures of unidentified PFAS in the anti-fog agents. The structures of primary PFAS were further estimated using a chemical-structure estimation tool based on high-resolution mass spectrometry data. The estimated candidate structures were consistent with the results obtained from target PFAS analysis, alkaline hydrolysis, and TOP assay. These findings indicate that the comprehensive analysis enabled the identification of previously unknown PFAS in anti-fog agents.

Acknowledgment
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PFAS Analysis 2

S. Harrad & R. Suehring

D7-082 Determination of unknown Per- and Polyfluoroalkyl Substance Precursors in Plant Based Foods via the Total Oxidizable Precursor Assay

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Introduction

Per- and polyfluoroalkyl substances (PFAS) comprise a vast class of over 10,000 synthetic chemicals, widely used for their water-, grease-, and dirt-repellent properties. Owing to their structural heterogeneity, analytical sum methods such as the total oxidizable precursor (TOP) assay are indispensable for detecting PFAS precursor compounds capable of transforming into perfluoroalkyl acids (PFAAs) through oxidation or environmental processes. While the TOP assay has been applied to various matrices [1], its use in plant-based foods remains unexplored, despite documented PFAS accumulation in edible plant tissues. This gap limits comprehensive exposure assessment, as unknown PFAS precursors cannot be quantified by target analysis due the lack of reference standards. This study adapts the TOP assay for plant food matrices to detect previously unaccounted PFAS precursors in fruits and vegetables available on the retail market, thereby improving dietary exposure assessment.

Materials and Methods

The method for determining PFAS (target analysis) in plant food was adapted from Aßhoff et al. [2] with modifications. Briefly, 10 g of homogenized sample spiked with isotopically labelled standards was extracted with 0.1% NH3 in acetonitrile. After centrifugation, the extract was evaporated, redissolved in water, and subjected to solid-phase extraction (SPE) using a cartridge containing graphitized carbon black and weak anion-exchange material. For the TOP assay, a parallel sample preparation underwent oxidation: after evaporation, sodium persulfate and sodium hydroxide were added. An isotopically labelled PFAS precursor with a known endpoint was added before evaporation as a reverse surrogate. It serves as a process control to verify complete precursor oxidation; its recovery (> 85%) confirms that oxidation conditions are sufficient to convert the precursors to their PFAA endpoints. Oxidation was performed at pH > 12 and 85 °C, followed by cooling, pH adjustment and SPE. Final analysis was conducted using high-performance liquid chromatography-tandem mass spectrometry. Method validation was performed via a spiking experiment. For the TOP assay, recovery of the isotopically labelled internal standards (< 70% postTOP) was used as criteria for complete oxidation without loss of the analytes.

Results

This method enables the detection of unknown PFAS precursors in plant-based foods at limits of quantification (LOQs) for individual PFAA endpoints (post-TOP assay) ranging from 1 to 5 ng/kg, depending on the matrix. Complete precursor oxidation was verified using a reverse surrogate standard, allowing reagent amounts to be adjusted according to matrix-specific requirements. The method covers perfluorocarboxylic acids (PFCAs) with perfluorinated alkyl chains ranging from C3 to C13 and perfluorosulfonic acids (PFSAs) with perfluorinated alkyl chains from C3 to C12, ensuring a comprehensive spectrum of oxidation endpoints. The method was applied to a representative selection of fruits and vegetables available on the German retail market, addressing critical gaps in exposure data for unknown precursors.

Discussion and Conclusion

The adaptation of the TOP assay to plant food matrices enables the identification of previously undetected PFAS precursors in fruits and vegetables. In conclusion, the TOP assay complements target analysis, offering a comprehensive approach to PFAS precursor determination in these key plant-based food groups. The analysis of diverse plant foods will further strengthen exposure data and risk evaluation.

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PFAS Analysis 2

S. Harrad & R. Suehring

D7-098 Characterization of Fluoropolymers and Nonstick Cookware Coatings by Neutron Activation Analysis, Raman, and FTIR Spectroscopy

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Introduction

Fluoropolymers are a subgroup of polymeric per- and polyfluoroalkyl substances (PFAS), known for repelling water and oil, resisting heat and chemicals, and exhibiting low friction and inertness. These properties enable their application in aerospace, consumer products, and cosmetics. During manufacturing, PFAS processing aids such as Gen X (HFPO-DA) and 4,8-dioxa-3H-pefluorononanoate (Adona) are used as alternatives to phased-out legacy PFAS, and may be released during the manufacture, use, and disposal of fluoropolymer containing products. In addition to these aids, other PFAS—including residual reactants, monomers, oligomers, aqueous residues, and volatiles—may be emitted throughout the fluoropolymer lifecycle. To address potential concerns associated with these releases, this study aims to support the risk assessment of fluoropolymers. Specifically, this presentation focuses on the characterisation of fluoropolymer standards, nonstick cookware coatings and products emitted at different temperatures.

Materials and Methods

Fluoropolymer standards, including PTFE, PCTFE, PVDF, PVDF-HFP, FEP, ECTFE, PFA, THP, THV, and FPO, were obtained from multiple suppliers. Additionally, 13 nonstick frying pans (NS-FP), 2 air-fryers and 1 waffle maker were procured from various local and online vendors in Canada.
The total fluorine content of fluoropolymer standards and NS-FP coatings was analyzed using neutron activation analysis (NAA). NS-FP coatings were manually removed using a carbide scraper and chisel, with care taken to avoid damaging the metal substrate.
To complement the NAA results, Raman spectroscopy and mid-infrared reflectance Fourier-transform infrared (FTIR) spectroscopy were used to characterise both fluoropolymer standards and NS-FP surfaces. NS-FP surfaces were analysed directly using Raman and mid-infrared reflectance techniques. For FTIR analysis, approximately 1 cm^2 sections were cut from flat regions of the pans. These sections were used for attenuated total reflection (ATR) measurements or FTIR imaging with a microscope. Further characterisation will be conducted using pyrolysis–gas chromatography–mass spectrometry (pyrolysis-GC-MS).

Results

The total fluorine mass percent in the fluoropolymer standards ranged from 39% to 81%. NS-FP samples exhibited fluorine contents ranging from 37% to 72%, except for one NS-FP and the small appliances in which fluorine content were below the detection limit (<1%). In addition, fluoropolymer standards displayed distinctive ATR-FTIR and Raman spectra. There were no observable PTFE spectral signature from NS-FP coating samples with a total fluorine content below 1%, while the remaining samples contained PTFE.

Discussion and Conclusion

Only THV had its fluorine content reported in the certificate of analysis (CoA). Of the 15 nonstick cookware items, 7 indicated PTFE coatings, with one also specifying FEP. NAA produced reproducible total fluorine measurements (RSD < 4%) for all standards, except THV, which had higher variability (RSD = 14%) and an error of –9.1% relative to the CoA.
Surface characterisation of NS-FP using Raman and ATR-FTIR spectroscopy confirmed PTFE signatures in fluorine-rich coatings. In contrast, NS-FP coatings with no detectable fluorine exhibited spectral features consistent with silica, likely originating from sol–gel coatings used in ceramic cookware. Additionally, small electric appliances displayed graphitic carbon spectra, indicating the presence of carbon-based surface coatings.
Infrared reflectance spectroscopy results aligned with total fluorine measurements, with the strongest PTFE signatures observed in NS-FP coating containing the highest measured fluorine levels. IR and Raman spectra also showed vibrational features beyond those of PTFE, likely due to other polymeric components present in the multilayer coatings.
Overall, the analytical techniques employed provided consistent and complementary characterisation of nonstick cookware. In most cases, findings matched product labelling; cookware marketed as PFAS-free showed fluorine levels below the detection limits. However, some products did not specify the type of coating.

Acknowledgment

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PFAS Analysis 2

S. Harrad & R. Suehring

D7-509 Suspect Screening of Emerging PFAS in Terrestrial Biota of Alimentary Interest: An Interlaboratory Exercise

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Introduction
Suspect Screening (SS) and Untargeted (UT) Analysis are techniques to screen and identify the presence of legacy and emerging organic chemicals, such are those belonging to the per- and polyfluoroalkyl substances (PFAS) family. This PFAS SS Interlaboratory Study (PFAS-SSIS) was designed and administered to experienced labs to understand the sources of variability first in the SS and optionally in the UT analysis, considering a complex matrix as wild boar liver, of relevance both for the food safety and the environmental quality.

Materials and Methods
Participating laboratories from Europe have been asked to analyze two samples: a) an extract from a pool of 28 wild boar livers hunted in Italy containing varying amounts of known and unknown PFAS and other chemicals; b) an extract from a procedural blank. The laboratories reported the identified PFAS in each of the samples, according to a proposed annotation grid. The laboratories reported on their methods (chromatography, mass spec platforms, software and databases), and the initial results of the study. All results are evaluated and reported without disclosing the laboratory identities.

Results
Thirteen labs reported results (out of 16 invited). They used mostly Q-Orbitrap based technology, but four labs also employed Q-ToF instruments. Gradient runtimes varied from short steep runs (<10 min) to longer runs (27 min). 43 PFAS were reported at confidence level (CL) 1a/1b, incl well-known compounds like PFOS & PFOA. 52 additional PFAS were reported at CL 2 (incl 2a-2c). Additional features were reported at levels 3-5. High variability was observed between participating labs. In terms of compound classes, 60 legacy PFAS were reported, 24 Cl- or H-substituted legacy PFAS and 27 emerging PFAS.

Discussion and Conclusion
Generally, the majority of the laboratories identified the legacy PFAS present in sample A, although there was a wide variability between the total number of PFAS reported in each sample among the different laboratories. Some labs with extensive PFAS HRMS experience identified more compounds than others, possibly because they avail over a larger range of chemical reference standards, needed for a level 1 identification. As regards the 'PFAS dark matter', in this frame grouped as level 3-5, up to 157 substances were reported, showing that there is a large potential of substances present in the wild boar sample that are awaiting identification and confirmation. This study demonstrates that laboratory reports may vary substantially in terms of reported PFAS and CLs when applying SS and UT analysis on a wild boar extract.

PFAS Analysis 2

S. Harrad & R. Suehring

D7-647 Two-Dimensional Gas Chromatography Coupled with Low- and High-Resolution Mass Spectrometry for PFAS Suspect Screening Analysis in Water Samples

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Introduction

Persistent organic contaminants include a broad and evolving group of chemicals that can occur at trace levels across environmental compartments, particularly in water systems. Among these, per- and polyfluoroalkyl substances (PFAS) are of increasing concern due to their persistence, mobility, and potential adverse health effects. Water samples present significant analytical challenges, as contaminants are often found at ultra-trace concentrations within complex chemical backgrounds.

This work describes a generic analytical framework based on comprehensive two-dimensional gas chromatography coupled with both high- and low-resolution time-of-flight mass spectrometry (GC×GC-HR/LR-TOFMS) for broad-scope screening of environmental contaminants in water samples. This approach supports both targeted and non-target investigations, with particular emphasis on the role of high-resolution TOFMS in confident compound annotation, interference reduction, and the use of mass defect plots for PFAS suspect screening.

Materials and Methods

Water samples were analysed using a direct immersion solid-phase microextraction Arrow (DI-SPME Arrow) approach prior to GC×GC analysis. This extraction technique provides enhanced sensitivity compared to conventional SPME while minimizing solvent consumption and sample preparation steps. In addition to PFAS-related compounds, the DI-SPME Arrow methodology is also suitable for the extraction and screening of other environmental contaminants, including pesticides and semi-volatile organic pollutants.

A GC×GC configuration combining non-polar and polar stationary phases was employed to maximize chromatographic peak capacity and resolve structurally related compounds. This enhanced separation is especially beneficial for environmental water analysis where co-elution and matrix effects are common.

High-resolution mass spectrometry (R > 25,000) using multiple ionization modes enabled accurate mass measurements and identification. Multiple ionization modes, including electron ionization (EI) and chemical ionization in both positive and negative modes (PCI/ECNI), were applied to expand compound coverage and improve molecular ion detection. Negative chemical ionization proved particularly effective for fluorinated analytes.

GC×GC low-resolution TOFMS data were also collected to assess the applicability of the method in a routine environment where downscaling from complex to simple data is often desirable. Calibration procedures were successfully implemented, and different extraction Arrow Fibers were tested to optimize analyte recovery and analytical performance across a range of PFAS-related compounds.

Results

This GC×GC-(HR)TOFMS workflow demonstrated strong capability for detecting trace-level fluorinated contaminants in water samples at low concentration levels. The combination of structured chromatographic separation and high-resolution mass spectrometry enabled reliable non-target and suspect screening, including PFAS-related compounds lacking reference standards. Their detection was further enhanced by using mass defect plots and mass defect series. The DI-SPME Arrow extraction approach provided efficient enrichment of fluorinated compounds while maintaining compatibility with a broad range of environmental contaminants, demonstrating its versatility for multi-residue screening applications. Furthermore, the low-resolution TOFMS approach showed promising performance for routine applications, demonstrating that benchtop instrumentation can provide valuable screening information when combined with optimized chromatographic separation and appropriate calibration strategies.

Discussion and Conclusion

Overall, GC×GC coupled with both high- and low-resolution TOFMS, together with DI-SPME Arrow extraction, represents a versatile and future-ready platform for comprehensive monitoring of PFAS and other environmental contaminants in water samples.

Waste Management of POPs

M. C. Cristofori & S. Sakai

D8-544 Towards safer recycled LDPE: removal of PCDD/Fs and dl-PCBs using green extraction agents

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Introduction

Some recycled plastic may contain high levels of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and dioxin-like polychlorinated biphenyls (dl-PCBs) [1]. The degradation of plastics into microplastics allows their release into the environment, where human exposure may constitute a potential threat to health [2]. At present, the decontamination techniques used for polyolefins in mechanical recycling are not adequate to efficiently remove organic contaminants that may compromise the safe use of recycled plastics.
In this context, the present study evaluated different treatments for reducing polychlorinated contaminants, including PCDD/Fs and dl-PCBs, in recycled LDPE using natural deep eutectic solvents (NADES), ionic liquids (ILs), and vegetable oils as extraction media.

Materials and Methods

Post-consumer recycled black LDPE processed by a local recycling facility was used in this study. The material underwent a standard industrial cleaning process involving hot-water washing performed by company. The sample was specifically selected due to the high total PCDD/F (40 pg/g) and dl-PCB (1370 pg/g) concentration, previously identified during quantitative analysis. Mixtures of thymol-camphor (1:1 v/v), choline chloride-oxalic acid (1:1 v/v), 1-butyl-3-methylimidazolium trifluoromethanesulfonate [BMIM][Otf], and sunflower oil were selected as green extraction agents for removing PCDD/Fs and dl-PCBs. In autoclave reactors, five 10 mL fractions of various removal agents were prepared, each containing 1 g of plastic material (limited by the autoclave capacity). Treatments were performed for 2 hours at 50, 100, and 150 °C, respectively. After washing, the mixture was vacuum filtered to collect the plastic material for subsequent analysis. For the extraction of PCDD/Fs and dl-PCBs, 2 g of shredded recycled plastic sample were stirred with 30 mL of toluene during 24 h at room temperature. Purification of PCDD/Fs and dl-PCBs was carried out using Power-Prep™ automated cleanup equipment. Identification and quantification of PCDD/Fs and dl-PCBs were carried out by gas chromatography coupled to triple quadrupole mass spectrometry (Agilent 7890B/7010B, GC-MS/QQQ) using isotope-labelled internal standards.

Results

The use of thymol-camphor at 100 °C was the most effective treatment, achieving toxicity reduction rates of approximately 60 % and 95 % for PCDD/Fs and dl-PCBs respectively. In addition, total concentrations decreased from 40 to 8 pg/g for PCDD/Fs and from 1370 to 40 pg/g for dl-PCBs. Notably, sunflower oil at 50 °C achieved total toxicity removal efficiencies close to 59 % for PCDD/Fs and 95 % for dl-PCBs, also ranking among the most effective treatments. In contrast, treatment with choline chloride-oxalic acid at the temperatures studied yielded the poorest results in terms of PCDD/Fs and dl-PCBs removal, and even increased toxicity compared to untreated LDPE (from 0.6 up to a maximum of 1.5 pg WHO-TEQ/g), due to the marked increase in PCB-77 content as temperature increased. This may be attributed to congener redistribution phenomena in the presence of excess chlorine derived from the extractant. Regarding [BMIM][Otf], the reduction in toxicity was 30-60 % for PCBs and up to 40 % for PCDD/Fs.

Discussion and Conclusion

Two of the extraction media evaluated in this study proved to be promising alternatives for reducing PCDD/F and dl-PCB contamination in recycled LDPE. Among the evaluated treatments, thymol-camphor (1:1 v/v) at 100 °C showed the best overall performance. Although additional optimization and scale-up studies are still required, the evaluated treatments showed considerable potential for reducing chlorinated organic contaminants in recycled LDPE and developing safer recycling routes within a circular plastics economy.

Acknowledgment

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Waste Management of POPs

M. C. Cristofori & S. Sakai

D8-745 Occurrence of Plastic-Associated Compounds in Japan's Plastic Circular System: Part 1 — Targeted Analysis Results

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Introduction

A wide range of chemicals, including additives and processing aids, are used in plastic materials and products. Depending on the polymer type and application, these chemicals enhance polymer stability and provide additional functions such as flame retardancy, UV resistance, and flexibility. Because chemicals contained in plastics can be released into the environment during use, recycling, and disposal, their potential impacts on human health and ecosystems have attracted increasing scientific and public attention in recent years. In addition to controlling new uses of substances of concern, it is important to identify the chemicals entering plastic circular system and understand their sources and distribution during recycling processes. In this study, we collected a wide range of recycled plastic pellets produced in Japan and investigated the occurrence and concentration levels of plastic-associated compounds, including persistent organic pollutants (POPs), present in domestic plastic circular streams.

Materials and Methods

A total of 127 recycled plastic pellet samples produced in Japan between 2021 and 2026 were collected from a wide range of feedstocks, including electrical and electronic equipment, containers and packaging, automobiles, agricultural plastics, and industrial waste. Seven polymer types were included in this study: polypropylene (PP), acrylonitrile–butadiene–styrene, polyethylene (PE), PP/PE mixtures, polystyrene, polyvinyl chloride (PVC), and polyamide. For targeted analysis, substance groups considered to have a particularly high potential to enter the plastic circular system were selected, including 17 halogenated flame retardants, chlorinated paraffins, 11 benzotriazole ultraviolet stabilizers, perfluoroalkyl carboxylic acids (PFCAs), 15 phosphate ester flame retardants/plasticizers, and 25 phthalate and non-phthalate plasticizers. Br and Cl concentrations in the samples were also measured.

Results

Overall, when categorized by additive functional group, plasticizers showed the highest concentrations and detection frequencies, followed by flame retardants and ultraviolet absorbers. The maximum concentrations of substances classified as POPs found in recycled pellets were as follows: PBDEs (up to 85 mg/kg), HBCD (up to 6.7 mg/kg), chlorinated paraffins (up to 29 mg/kg), UV-328 (up to 3.4 mg/kg), Dechlorane Plus (up to 1.6 mg/kg), and PFCAs (<0.0001 mg/kg). Decabromodiphenyl ethane (DBDPE), a candidate POP, was detected more frequently and at higher concentrations than PBDEs, with a maximum concentration of 510 mg/kg. For samples with particularly high Br contents, the BFRs included in the targeted analysis could not fully explain the observed Br concentrations. Among the plasticizers, non-phthalate alternative plasticizers showed higher concentrations than conventional phthalate plasticizers, particularly in materials derived from packaging waste, and their concentrations were positively correlated with Cl levels.

Discussion and Conclusion

Although the concentrations of POP-related plastic additives evaluated in this study were generally low in recycled pellets and none exceeded the low POP content limits established under the Basel Convention, DBDPE, a candidate POP, was detected at relatively high concentrations and with a high detection frequency, highlighting the need for continued monitoring. Given that Br concentration is no longer a reliable indicator of POP-BFR content, and that DBDPE and bis(2-ethylhexyl) tetrabromophthalate (BEH-TEBP)—both candidate POPs—may be designated as POPs in the near future, there remains a need to develop a management framework that effectively balances plastic circularity with chemical safety management. The elevated concentrations of alternative plasticizers in pellets derived from containers and packaging were likely attributable to the inadvertent incorporation of small amounts of chlorinated polymers, such as PVC and vinylidene chloride, during the recycling process. More broadly, this finding suggests that even small amounts of non-target polymers inadvertently incorporated into the recycling stream can influence the occurrence of plastic-associated additives in recycled materials.

Acknowledgment

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Waste Management of POPs

M. C. Cristofori & S. Sakai

D8-704 Occurrence of Plastic-Associated Compounds in Japan's Plastic Circular System: Part 2 — Database-Driven Suspect Screening Analysis Results

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Introduction
Information on chemical substances in recycled plastics is essential for understanding the occurrence of plastic-associated compounds in the plastic circular system and for developing measures to mitigate their potential adverse effects. Given that over 10,000 chemical substances may be used in or present in plastics [1], a comprehensive assessment requires an integrated analytical approach combining highly sensitive targeted analysis with screening methods. Here, we developed a database-driven suspect screening method specifically optimized for plastic-associated compounds and applied it to investigate their occurrence in recycled plastic pellets collected from Japan's plastic circular system.

Materials and Methods
We analyzed 102 recycled plastic pellet samples collected in Japan between 2021 and 2024. Toluene extracts were analyzed by LC-ESI/HRMS/MS and GC-APCI/HRMS/MS. For suspect screening, five chemical databases available in the CompTox Chemicals Dashboard—ECHAPLASTICS (659 substances) [2], CPPDBLISTA (2,144 substances) [3], CPPDBLISTB (238 substances) [4], CSSEXTRACTS (1,063 substances) [5], and PLASTICMAP (7,352 substances) [1]—were integrated to build an in-house compound database library. Substances unlikely to be detected by these analytical methods, such as inorganic compounds, inorganic salts, complexes, organic salts, and polymeric compounds, were removed, yielding a final library of more than 5,000 plastic-associated compounds.

Results
The database-driven suspect screening approach optimized for plastic-associated compounds enabled the identification of additional regulated and unregulated compounds beyond those detected by targeted analysis. Among the regulated chemicals, bisphenol A (BPA), methylenedianiline (MDA), and tris(xylyl) phosphate (TXP), all classified as substances of very high concern under the European REACH Regulation, were identified. Only a limited range of regulated chemicals was detected in recycled plastics. BPA, MDA, and TXP were found in 48, 41, and 22 of the 102 samples, respectively, with concentration ranges of <5–3,800 mg/kg, <1–300 mg/kg, and <0.5–20 mg/kg. Among the unregulated chemicals, AOX-168 was the most frequently detected, followed by AOX-1076, UV-770, DLTDP, and AOX-1010. The highest concentrations were observed for AOX-168, BDP, AOX-1010, DMTDP, and UV-2908, with concentration ranges of <2–5,400, <1–4,000, <40–3,400, <5–1,800, and <2–990 mg/kg, respectively. In addition to 10 brominated flame retardants detected by targeted analysis, tetrabromobisphenol A diglycidyl ether (TBBPA-bGE), a derivative of TBBPA, was also identified at concentrations ranging from <5 to 56 mg/kg.

Discussion and Conclusion
The results indicated that recycled plastic pellets composed of polyethylene (PE), polypropylene (PP), PE/PP mixtures, and polyamide were unlikely to contain BPA, MDA, or TXP. Similarly, recycled plastic pellets derived from waste containers and packaging were unlikely to contain these compounds at concentrations indicative of intentional additive use. By contrast, recycled acrylonitrile–butadiene–styrene derived from household appliances might require management measures, including prevention of cross-contamination or restrictions on use where appropriate. This study also identified unregulated chemicals in recycled plastic pellets, such as antioxidants and light stabilizers. As the occurrence of these compounds in recycled plastic pellets has not previously been systematically investigated, these findings provided novel insights into unregulated chemicals present in the plastic circular system.

Acknowledgment
This research was supported by the Environment Research and Technology Development Fund [JPMEERF20233001] of the Environmental Restoration and Conservation Agency provided by Ministry of the Environment of Japan.

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Waste Management of POPs

M. C. Cristofori & S. Sakai

D8-039 Characteristics of PCDDs/DFs Emissions from Cremators in South Korea

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Introduction

The cremation rate in Korea has rapidly increased, surpassing 90% for the first time in 2021 and reaching 91.7% in 2022 with a total of 342,128 cremations performed. In 2009, the Ministry of Climate, Energy and Environment added cremation facilities to the list of air pollutant emission facilities and established emission standards for dust, CO, SOx, and NOx in crematory emissions. However, there are no specific standards for dioxins. The government has added crematoria to the emission source list and is estimating annual emissions. This study aims to understand the characteristics of dioxin emissions from crematoria.

Materials and Methods

Sampling was conducted at the final emission outlet of the cremator exhaust gas, timed to align with the cremation process, and lasted for approximately one hour. The sampling volume ranged from 0.8 to 1.5 Sm^3 (corrected to 0°C and 1 atm). The measurements were calculated using the International Toxic Equivalency Factor (TEF-I) standard without correcting for oxygen concentration. The dioxin emission factors and emission quantities calculation method followed the Residual Pollutants Emission Estimation Method and Procedure announced by the National Institute of Environmental Research, and the calculations were based on data measured over the past five years.

Results

Five facilities were measured, and subsequently, eight cremators were measured annually, resulting in a total of 37 cremators being measured for dioxins over the past five years. The arithmetic mean concentration of the 37 cremators is 0.732 ng-TEQ/Sm^3, with a median of 0.115 ng-TEQ/Sm^3, and a standard deviation of 1.295 ng-TEQ/Sm^3. The minimum concentration is 0.000 ng-TEQ/Sm^3, and the maximum concentration is 5.262 ng-TEQ/Sm^3. The 37 cremators have a total of 10 different combinations of prevention equipment. The most commonly used combination, employed by 14 cremators, is CY-BF-SCR. The second most common combination is SNCR-BF-SCR. The average concentration of the most frequently installed prevention equipment combination, CY-BF-SCR, is 0.667 ng-TEQ/Sm^3, which is lower than the overall average.

Discussion and Conclusion

This study identified the dioxin emission characteristics from cremation facilities nationwide. The PCDDs/DFs concentrations measured from 37 cremators showed variations, ranging from 0.000 to 5.262 ng-TEQ/Sm^3.

The emission characteristics of PCDDs/DFs from cremators were analyzed according to different prevention equipment. The concentration of dioxins emitted varies among cremators. This variation indicates that while some facilities effectively control dioxin emissions, others have lower control levels.

Concerns about dioxin emissions from cremation facilities persist, but there are currently no specific guidelines for dioxin emissions from these facilities in South Korea. To reduce national dioxin emissions and implement effective dioxin management, it is necessary to consider establishing guidelines and regulations for dioxin emissions from cremation facilities.

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Formation, Sources, Control 1

G. Hunt & T. Nakano

D9-009 Effects of Industrial Solid Waste on the generation of PCDD/Fs, dl-PCBs and unknown pollutants during engineering co-combustion

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Introduction
Co-combustion of municipal solid waste (MSW) and industrial solid waste (ISW) has become a globally prevalent solid waste disposal technology for its high disposal efficiency and energy recovery potential. However, previous studies have predominantly focused on targeted conventional pollutants, while the correlation between complex ISW components and the generation of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), dioxin-like polychlorinated biphenyls (dl-PCBs), and non-target unknown toxic contaminants remains poorly understood. Most existing studies were also conducted in laboratory-scale tests, which cannot fully reflect the actual pollutant generation characteristics in engineering-scale incinerators. To address these gaps, this study aims to quantitatively reveal the influence of ISW co-combustion on multi-class toxic pollutants, and identify the key waste components driving pollutant formation via a pseudo-component matrix model, to provide scientific support for clean and safe co-combustion operation.

Materials and Methods
In this study, based on a 650 t/d incinerator and a tube furnace simulation platform, co-combustion experiments of ISW, like biomass and plastic, are designed and conducted, with blending ratios ranging from 0% to 30%. A pseudo-component matrix model was developed to represent complex waste compositions using nine representative components (biomass- and plastic-derived fractions). Target pollutants (PCDD/Fs, dl-PCBs, and PAHs) were quantified by HRGC/HRMS and GC-MS, while non-target contaminants were characterized using FT-ICR MS and GC/Q-TOF MS combined with toxicity screening based on the US EPA ToxCast database.
Correlation analysis was applied to identify key components influencing pollutant formation.

Results
Plastic-rich ISW significantly increased the formation of toxic pollutants, whereas biomass components showed limited effects. For non-target contaminants, plastic co-combustion promoted the formation of unsaturated and highly unsaturated compounds (DBE ≥15) and cyclic species by 17%–49%. High polyester conditions uniquely generated multiple high-toxicity compounds, increasing the number of toxic species by 25 compared to raw MSW. For target pollutants, co-combustion increased PCDD/Fs and dl-PCBs by up to sixfold, with maximum TEQs of 843 ng/kg and 68.1 ng/kg, respectively, while PAHs remained relatively stable. Correlation analysis identified PET, PVC, and cellulose as key contributors to PCDD/F and dl-PCB formation, with PET/cellulose acting as aromatic precursors and PVC as the primary chlorine source.

Discussion and Conclusion
This study established a quantitative relationship between complex waste components and multi-class toxic pollutant generation during engineering co-combustion via the pseudo-component matrix model. High-proportion plastic (especially PET and PVC) ISW co-combustion is the dominant factor promoting the formation of highly toxic PCDD/Fs, dl-PCBs and unique unknown toxic contaminants. Blending of waste plastics, polyester textiles, artificial leather and waste paper should be strictly regulated to achieve source control of high-risk pollutants. The findings provide fundamental data and practical guidance for optimizing the co-combustion process and mitigating the environmental risk of MSW and ISW co-incineration.

Acknowledgment
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Formation, Sources, Control 1

G. Hunt & T. Nakano

D9-417 Source tracing of PCDD/Fs in Lake Vättern, Sweden, and comparison of modelling approaches

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Introduction
PCDD/Fs are legacy pollutants that still present environmental challenges, despite decades of mitigation efforts. To be able to apply measures for further reductions in levels, it is necessary to identify and quantify sources. One approach is Positive Matrix Factorization, PMF. In previous work in Sweden, a PMF model published by the US EPA was used for source tracing and apportionment of PCDD/Fs in sediment. In the project TRACED, we aim to compare this model with two models that allow missing data and focus on the most important congeners, respectively. Here we show the results of the source tracing of PCDD/Fs in Sweden's second largest lake, Vättern, using the EPA-PMF model, and comparing it to preliminary results from the missing data model.

Materials and Methods
Sediment was sampled in Lake Vättern and smaller lakes upstream. A total of 54 samples were selected for full-congener analysis using GC-HRMS at Umeå University, Sweden. GC peaks that coeluted were merged into one peak, and peaks that were below the limit of detection (LOD) in more than 50% of the samples were excluded. In total, 81 peaks corresponding to one or several PCDD/F congeners were included in the statistical analysis. The analysis was carried out using the US EPA model PMF 5.0.

Results
The best output from the PMF model was obtained presuming 5 PCDD/F factors. Based on the congener profiles, the factors were matched to previously measured and modelled source profiles. In short, factor 1 was dominated by OCDD and HpCDDs and resembled a profile for remote atmospheric deposition, although it was also similar to the profile for PCDD/F contamination in pentachlorophenol products. Factor 2 consisted of many different PCDD/Fs and mostly resembled a source profile for incineration. In factor 3, HpCDFs and OCDF dominated, and it was strikingly similar to a profile for tetrachlorophenol-contaminated soil. Factor 4 contained many different PCDD/Fs and was most similar to a previously measured profile for atmospheric deposition in southern Sweden (i.e., different from the background pattern seen in factor 1). And finally, factor 5 had a very characteristic profile dominated by HxCDD, PeCDD and TCDD, which matches profiles from sulphate pulp mills.
In the most contaminated samples, tetrachlorophenol and sulphate pulp mill contamination dominated. They represented two point sources, one in the south of Lake Vättern and one in the north. In the offshore sediment surface samples, on the other hand, the atmospheric sources (atmospheric deposition in Southern Sweden and remote deposition) dominated, and the pattern was very consistent. The factor representing incineration was not common in the samples, but it became the dominating factor in samples taken deeper down in sediment cores, i.e., representing older time periods.

Discussion and Conclusion
The study in Lake Vättern demonstrated the importance of similar PCDD/F sources as previously shown along the Swedish coast of the Baltic Sea. From a toxicological perspective, the PCDD/F profile deriving from sulphate pulp mills is more problematic as it contains more of the less chlorinated, more toxic congeners. The US EPA PMF model provided what appears to be logical results. The PMF model allowing missing data, developed within the TRACED project, gave similar results, with an interesting feature – the factor representing atmospheric deposition in Southern Sweden decreased in importance. This was a profile containing many different PCDD/Fs, and it seems that it might erroneously increase in importance when replacing missing data with e.g. ½ LOD. The project work continues with refining existing models and developing a model favouring sparsity.

Acknowledgment
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Formation, Sources, Control 1

G. Hunt & T. Nakano

D9-483 Congener-Specific Analysis of Low-Chlorinated PCDD/Fs Using a DB-Dioxin Column

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Introduction
Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) substituted at the 2,3,7,8-positions are highly toxic, and extensive attention has therefore been devoted to the congener-specific analysis of tetra- to octachlorinated PCDD/Fs. Because only congeners fully substituted at all four 2,3,7,8-positions exhibit dioxin-like toxicity, lower-chlorinated congeners have not been assigned toxic equivalency (TEQ) values and have received comparatively little attention. However, analysis of low-chlorinated congeners is important for understanding PCDD/F formation mechanisms and for evaluating their potential use as surrogate indicators for estimating TEQ values in on-line emission monitoring systems. In addition, congener distribution patterns of low-chlorinated PCDD/Fs provide valuable information for source apportionment studies. While extensive data are available for tetra- to octachlorinated congeners, information on mono- to trichlorinated PCDD/Fs remains limited. In previous studies, we achieved complete congener assignment of MCDD/F–T3CDD/F on an SP-2331 column and MCDF–T3CDF on a DB-5MS column. The present study investigates the applicability of a DB-Dioxin column for isomer-specific analysis of low-chlorinated PCDD/Fs.

Materials and Methods
A total of 74 congeners of MCDD–T3CDD and MCDF–T3CDF were synthesized by pyrolysis of chlorophenols and chlorobiphenyls. In addition, 23 commercially available standards were analyzed for cross-validation of congener assignments. GC/MS analysis was performed using an HP 5890 II gas chromatograph coupled with a JMS-700 high-resolution mass spectrometer operated at a resolution greater than 10,000. Separation characteristics and analytical performance of the DB-Dioxin column were evaluated and compared with those of previously reported columns.

Results
The DB-Dioxin column enabled isomer-specific analysis of low-chlorinated PCDD/F congeners. Although its lower polarity resulted in slightly reduced isomer separation compared with the highly polar SP-2331 column, satisfactory resolution of individual congeners was achieved. Furthermore, the DB-Dioxin column effectively separated PCDD homolog groups, reducing the number of ions monitored simultaneously in selected ion monitoring (SIM) mode and thereby increasing analytical sensitivity. Combined with the inherently higher sensitivity of mid-polar columns, these characteristics resulted in improved overall GC/MS performance for the analysis of low-chlorinated PCDD/Fs.

Discussion and Conclusion
The DB-Dioxin column provides a practical and sensitive approach for congener-specific analysis of mono- to trichlorinated PCDD/Fs. The improved homolog separation and analytical sensitivity make it suitable for detailed investigations of PCDD/F formation mechanisms, source apportionment, and surrogate-based TEQ estimation. In future work, we aim to develop an AI-assisted method for predicting the retention behavior and elution order of individual PCDD/F isomers using molecular descriptors derived from molecular dynamics simulations and quantum chemical calculations. Such an approach may facilitate congener identification and enhance the reliability of comprehensive PCDD/F analysis.

Formation, Sources, Control 1

G. Hunt & T. Nakano

D9-966 Towards a German Standard on the determination of PFAS in emission

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are a large group of more than 10000 compounds widely used in industrial processes and consumer products. Many PFAS were intentionally produced, however, among PFAS, there are also products of incomplete destruction. Their persistence in the environment, potential for long-range transport and bioaccumulation as well as associated health risks have made many PFAS a major focus of environmental and public health concerns.

Consequently, PFAS have become an important focus of research, monitoring, and regulatory efforts worldwide. In contrast to (drinking) water (DIN EN 17892, ISO 21675) or solid matrices (DIN EN ISO 25652), there is no European standard on the determination of PFAS in air, particularly in emission. Therefore, several European countries implemented national reference methods, e.g. Belgium (LUC/VI/003) or France (XP X43-126). Similarly, Germany is working on a reference method on PFAS in emission. This approach is to be presented at DIOXIN 2026 and will be published soon. Generally, the German reference method (VDI Expert Recommendation VDI EE 3499 Part 5 / VDI Guideline VDI 3499 Part 5 (www.vdi.de/3499)) describes a standardized determination of perfluoroalkyl carboxylic acids, perfluoroalkyl sulfonic acids, polyfluorinated fluorotelomer sulfonic acids, and per- and polyfluorinated oxocarboxylic acids with at least four carbon atoms in flue gas or exhaust gas from stationary emission sources. The standard is created as a minimum-requirement-approach specifying two strategies of PFAS emission stack sampling: 1st, on the basis of sampling with a cooled probe and 2nd, on the basis of sampling with a heated probe. Sampling is carried out isokinetically in accordance with DIN EN 1948-1. A volume of at least 2 m^3 is collected. PFAS are accumulated in (alkaline) water followed by adsorbent resins (e.g. XAD-2). Probe as well as glass equipment is to be rinsed with methanol/methanolic solution which become part of the sample. In both methods, several sub-samples are obtained, which are combined into a single analytical solution during the analytical procedure. Instrumental detection is performed by LC-MS/MS.

Minimum requirements are:

- Isokinetic sampling
- Method quantification limits of ≤ 0,3 ng/m3 for individual PFAS
- Implementation of at least 5 mass-labelled PFAS-sampling standards and documentations of their recovery rates
- Implementation of mass-labelled PFAS internal standard for the analytical process (for as many target PFAS as possible) and documentation of their recovery rates
- Quantification using the isotope dilution method
- Implementation and documentation of field blank measurements

Acknowledgment

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Formation, Sources, Control 1

G. Hunt & T. Nakano

D9-599 POPs and Heavy Metals in Cement Produced by Solid Waste Co-processing

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Introduction
Cement production is a major industrial sector, responsible for approximately 7% of anthropogenic CO_2 emissions. To reduce fossil fuel use and divert waste from landfills, cement kilns co-process waste as alternative fuels or raw materials, including refuse-derived fuel (RDF)1. While this practice is often presented as a climate mitigation strategy, RDF is a heterogeneous, largely non-recyclable and fossil-based mixture, and its use may not lead to actual emission reductions but rather to accounting shifts2. Co-processing raises concerns regarding the formation of toxic substances, including persistent organic pollutants (POPs) and heavy metals.

Materials and Methods
Nine cement samples were collected from cement plants in Taiwan (n = 3), Colombia (n = 2), and the Czech Republic (n = 4), representing facilities with varying degrees of waste co-processing. Samples were analysed for heavy metals (Hg, Pb, Cd, As), PCDD/Fs, dioxin-like (dl) and indicator PCBs, BFRs, chlorinated paraffins, OCPs, and PFAS. PCBs, OCPs, HCBD, and HCB were analysed using GC-MS/MS, while BFRs and chlorinated paraffins were determined by GC-MS (NICI). HBCD isomers and TBBPA were measured using UHPLC-MS/MS, and PFAS were analysed using UHPLC-MS/MS. PCDD/Fs and dl PCBs were quantified by HRGC-HRMS. Heavy metals (As, Cd, Pb) were determined using ICP-MS, while mercury was analysed by AAS (AMA).

Results
Heavy metals were detected in all samples, with the highest concentrations observed in Taiwanese cement: lead up to 49 mg/kg, cadmium up to 2.72 mg/kg, and arsenic up to 36.6 mg/kg, while mercury remained low (≤0.07 mg/kg). PCDD/F concentrations were below detection limits in most samples, except for two Czech samples from Prachovice (0.158 pg WHO-TEQ/g) and Mokrá (0.123 pg WHO-TEQ/g). Dioxin-like PCBs were consistently detected at very low levels (0.007–0.031 pg WHO-TEQ/g). Most brominated flame retardants, PFAS, and organochlorine pesticides were below detection limits. Chlorinated paraffins were the most prevalent organic contaminants, with SCCPs up to 45.7 ng/g and MCCPs up to 113 ng/g.

Discussion and Conclusion
The co-processing of diverse wastes may introduce contaminants into cement, including metals from rubber and industrial residues and chlorinated additives from plastics. Higher heavy metal levels observed in Taiwanese samples, compared to values reported for cement produced without contaminated inputs, suggest that waste co-processing may contribute to elevated trace metal contents3. Concentrations of SCCPs and MCCPs were within environmental background levels and substantially lower than those reported for highly contaminated sites. PCDD/Fs were detected in two Czech samples from the Prachovice and Mokrá cement plants. Estimated cement-bound PCDD/F flows (~1.9×10^8 and ~1.7×10^8 ng/year), based on measured concentrations and nominal capacities, were approximately seven and nearly three times higher than reported 2024 air emissions, respectively. This suggests that cement may represent an overlooked reservoir of PCDD/Fs, with part of the contaminant load retained in the final product. At the scale of global cement production (~4 billion tonnes annually), even low concentrations may correspond to notable cumulative amounts, including tens of thousands of tonnes of heavy metals and tens of tonnes of chlorinated paraffins. This indicates that cement may act as a long-term reservoir of hazardous substances, with potential release during demolition, recycling or weathering, and exposure risks for users handling cement dust. These findings highlight the need for further research on waste co-processing.

Acknowledgment
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POPs in Wildlife

K. Fernie & V. Jaspers

D10-214 Multi-matrix suspect and non-target PFAS profiling in great tits (Parus major) reveals complementary bioindicator roles of plasma, feathers, and faeces

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are globally distributed, highly persistent contaminants posing substantial ecological and human health risks. Despite evidence of PFAS biomagnification in terrestrial food webs,1 data coverage on the matrix-specific fate of emerging and novel PFAS in wildlife remains limited. Moreover, the utility of complementary, non-invasive matrices for detecting novel PFAS classes is still largely unexplored. Great tits (Parus major) are well-established integrative bioindicators capable of reflecting multi-pathway environmental exposure.2 Therefore, this study aimed to characterise the occurrence and partitioning patterns of PFAS, providing insights into the matrix-specific fate and bioaccumulation of novel and emerging PFAS across plasma, feathers, and faeces of great tits sampled near the 3M fluorochemical plant in Flanders, Belgium.

Materials and Methods
Combined targeted and suspect/non-target screening (SS/NTS) using high-resolution mass spectrometry (HRMS) enabled the identification of over 100 individual PFAS across 16 classes, from the bird matrices.

Results
Results were compared with previously reported soil concentrations (ΣPFAS up to 118 µg/g) measured from the same site.3 Matrix type was identified as the dominant factor driving compositional variability, with each matrix exhibiting distinct PFAS profiles. Plasma was enriched in long-chain carboxylic acids (PFCAs), sulfonamidoacetic acids (FASAAs), ether-carboxylic acids (PFECAs), and ether-sulfonic acids (PFESAs). Feathers were characterised by long-chain sulfonic acids (PFSAs), PFCAs, sulfonamides (FASAs), and pentafluorosulfide sulfonic acids (SF5-PFSAs), whereas faeces showed exclusive detection of the C4-sulfinic acid, FBSI. In contrast, soil samples were enriched in perfluorophosphoric diesters (PFPDEs), hydrogen-substituted sulfonates (H-PFSAs), phosphinic acids (PFPiAs), and individual PFAS (i.e., PFHxSAm and FOSE).

Discussion and Conclusion
Multivariate statistics confirmed matrix-dependent PFAS differentiation, showing a distinct cluster for soil and a separate but partially overlapping ordination space for plasma, faeces, and feathers (non-metric multidimensional scaling). Univariate tests identified significant matrix effects for 98 PFAS, with asymmetric pairwise differentiation across matrix pairs (Kruskal-Wallis). Soil–plasma comparisons identified 55 PFAS with significantly elevated long-chain PFCAs, PFSAs, and unsaturated ether-carboxylates (dPFECAs) in plasma (10–50× above soil). Soil–feather comparisons (41 PFAS) showed enrichment of short-chain PFCAs in feathers and depletion of long-chain PFSAs, while soil–faeces comparisons (27 PFAS) showed elevated FASAs in faeces, alongside depletion of long-chain PFSAs.
Matrix correlation analyses showed structure-dependent bioavailability, with significant soil–plasma correlations on 7 classes and 20 individual PFAS, indicating that soil profiles may predict plasma exposure only for a selective subset of classes and compounds. The absence of significant plasma–feather correlations at the class level but correlations at the site level (ρ = 0.47–0.77) suggests that feathers integrate exposure over longer temporal scales rather than directly reflecting circulating plasma concentrations. Selective plasma–faeces correlations observed for ether-carboxylates (PFECAs and dPFECAs) indicate preferential faecal elimination for these classes.
Although plasma (which reflects recent internal exposure) captured the widest PFAS spectrum among the biological samples, complementary matrices, such as feathers (long-term accumulation) and faeces (elimination), further add biological context beyond non-invasive monitoring. Our results collectively suggest that extending analytical coverage through SS/NTS may substantially advance PFAS environmental (bio)monitoring, enabling a more comprehensive characterisation of legacy, emerging, and novel PFAS in terrestrial wildlife systems.

Acknowledgment
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POPs in Wildlife

K. Fernie & V. Jaspers

D10-635 PFAS occurrence in Atlantic puffins stranded after storm events on the Portuguese coast

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Introduction
Storm events can increase seabird mortality by affecting flight capacity, foraging success, and energetic balance. The Atlantic puffin, Fratercula arctica, is a wide-ranging pelagic and migratory seabird of the Northeast Atlantic, listed as Endangered in Europe, and may be exposed to persistent and bioaccumulative contaminants across different marine regions. Per- and polyfluoroalkyl substances (PFAS) are of particular concern due to their environmental persistence, trophic transfer potential, and harmful physiological effects in wildlife. Despite the ecological and conservational importance of this species, little is known about its exposure to PFAS and other organic and inorganic contaminants.

Materials and Methods
Therefore, in this study, we assessed PFAS contamination in liver samples from 30 Atlantic puffins found dead along the Portuguese coast in February 2026 after storm events. Liver tissue was analysed for a suite of PFAS compounds, including perfluoroalkyl carboxylic acids and perfluoroalkyl sulfonates, following the adapted methodology of Lu et al. (2024, Environmental Pollution 362, 125025).

Results
Preliminary results showed that the most frequently found contaminants were PFOS, followed closely by long-chain perfluoroalkyl carboxylic acids, with odd-numbered chains predominating, especially PFTrDA and PFUnDA. Other long-chain PFCAs, including PFNA, PFDA, PFDoDA, PFTeDA, and PFHxDA, were also detected, although generally at lower levels than PFTrDA and PFUnDA, whereas PFOcDA was not detected in the first analysed set. In contrast, the remaining PFAS, including PFHxS, PFHpS, PFDS, PFOA, and FOSA, were absent or occurred only at low levels. Overall, the observed profile, PFOS > PFTrDA > PFUnDA > PFNA ~ PFDA ~ PFDoDA ~ PFTeDA > PFHxDA > PFOcDA, is consistent with patterns previously reported in the livers of migratory seabirds and other marine top predators.

Discussion and Conclusion
This pattern may be related to the high persistence and bioaccumulative potential of PFOS and long-chain PFAS in marine food webs. To our knowledge, this is the first assessment of PFAS in the liver of Atlantic puffins and the first report of PFHxDA in this species. The predominance of PFOS and long-chain carboxylated compounds suggests exposure through diet, likely reflecting trophic transfer from marine prey consumed during the non-breeding period or during movements along the Northeast Atlantic. Although the mortality event was associated with storms, contaminant exposure may represent an additional physiological stressor, potentially interacting with poor body condition, food limitation, or increased energetic demands during extreme weather events. Further studies integrating contaminant concentrations with body condition, stable isotopes, diet information, and pathological assessment would help clarify the role of PFAS exposure in seabird health and vulnerability to storm-related mortality. Moreover, evaluating stranded individuals may improve our understanding of how persistent contaminants accumulated in pelagic food webs can be transported from marine systems to coastal and terrestrial environments during episodic mortality events. In fact, because puffins are highly mobile seabirds that forage at sea but may strand, breed, moult, or deposit biological material in coastal and terrestrial environments, they may contribute to the movement of marine-derived contaminants across ecosystem boundaries. Overall, this study contributes to the understanding of PFAS occurrence in Atlantic pelagic seabirds and highlights the relevance of stranded birds as sentinels of chemical contamination in marine ecosystems.

Acknowledgment
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POPs in Wildlife

K. Fernie & V. Jaspers

D10-823 Occurrence of per and polyfluorinated alkyl substances (PFAS) in Danish terrestrial game species

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Introduction
Per- and polyfluoroalkyl substances (PFAS) comprise a large group of synthetic chemicals characterized by their environmental persistence, bioaccumulative properties, and potential adverse health effects. The European Food Safety Authority (EFSA) identified food consumption as the primary source of PFAS exposure for most European populations and established a tolerable weekly intake (TWI) of 4.4 ng/kg body weight for the sum of PFOS, PFOA, PFNA, and PFHxS (Schrenk et al., 2020).
Concerns have been raised regarding PFAS contamination in wild game species consumed by hunters and the general public. However, knowledge of PFAS occurrence in terrestrial game animals in Denmark remains limited. This study investigates the occurrence and distribution of PFAS in Danish terrestrial game species, including European hare (Lepus europaeus), deer, pheasants, rooks, and woodcock, and evaluates their potential contribution to human dietary exposure.

Materials and Methods
Samples were collected from game species originating from multiple locations across Denmark. The current dataset comprises 100 hare liver samples, 50 deer liver samples, and approximately 100 bird samples (pheasant, rook, and woodcock), for which both liver and muscle tissues were analysed. Samples were screened for a broad range of legacy and emerging PFAS, including perfluoroalkyl carboxylic acids (PFCAs), perfluoroalkyl sulfonic acids (PFSAs), fluorotelomer sulfonates (FTSs), fluorotelomer carboxylic acids (FTCAs), fluorotelomer unsaturated carboxylic acids (FTUCAs), and selected PFAS alternatives. Extraction was performed using a QuEChERS-based method followed by liquid chromatography–high-resolution mass spectrometry (LC–HRMS, Orbitrap). In addition to targeted analysis, non-target and suspect screening workflows are ongoing to identify previously unmonitored PFAS and transformation products.

Results
Targeted analysis of hare liver samples showed PFOS to be the predominant PFAS and the only compound detected in all samples. PFOS concentrations ranged from 0.30 to 24.5 ng/g wet weight. PFNA and 6:2 FTS were also frequently detected, whereas FTCAs, FTUCAs, GenX, and DONA were not detected in any hare samples. Spatial differences in PFAS occurrence were observed across Denmark. The highest ΣPFAS concentrations (5.4–26.4 ng/g wet weight) and PFOS levels (7.1–24.5 ng/g wet weight) were measured in hares collected from the Skælskør area in southwestern Zealand, where PFHxS and PFNA were also consistently detected. Targeted analyses of deer and bird samples are currently being completed, and these results will be presented at the conference. Non-target and suspect screening analyses are ongoing.

Discussion and Conclusion
This study provides new insight into PFAS occurrence and geographical distribution in Danish terrestrial game species. Results from European hare indicate widespread exposure and substantial spatial variation. Ongoing analyses of deer and birds, combined with non-target screening, will improve understanding of PFAS contamination in terrestrial wildlife and its potential contribution to human exposure through game meat consumption.

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POPs in Wildlife

K. Fernie & V. Jaspers

D10-832 PFAS contamination in the common dolphin (Delphinus delphis) from the NE Atlantic: precursors, biological drivers, and temporal trends

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Introduction
Ubiquitous in the marine environment, PFAS accumulate in marine organisms such as the common dolphin (Delphinus delphis), a protected species of key ecological importance. As long-living top predators with a food consumption nearing 3 kg d-1 of small pelagic fish, they are particularly exposed to biomagnifying pollutants and as such, are recognised as sentinel species to evaluate the health of the oceans' ecosystem. Since high concentrations of PFOS were reported in marine mammals in the early 2000s, 43 published articles have reported PFAS concentrations in marine dolphins worldwide, including 8 in European waters. Despite being the most common cetacean in the world, common dolphin was only studied for PFAS twice in European waters, revealing high hepatic levels of PFOS and PFCAs. In this context, this study explores PFAS contamination in tissues of the common dolphin from the Bay of Biscay, NE Atlantic Ocean, examining over 70 adult individuals collected between 1990 and 2023 through the French Stranding Network.

Materials and Methods
Individual carcasses were collected along the Bay of Biscay coastline as part of the French Stranding Network led by the Pelagis observatory (La Rochelle, France), where they were necropsied to identify the cause of death (bycatch or others), measured, aged, sexed and dissected. Male adults were selected (n=66) for the main study, with an additional 5 females in recent individuals. Liver was studied for all individuals, also blubber (n=26) and muscle (n=5) in recent individuals. Preys (anchovy, sprat, sardine, n=6) were also analysed. After extraction and clean-up, 36 PFAS including precursors were targeted by LC-MSMS using validated methods.

Results
The high occurrence of PFAS in livers of the common dolphin was revealed, with 24 of the 36 monitored PFAS found in over half of the recent samples. PFOS prevailed, constituting on average 64% of the PFAS fingerprint (mean: 201 ± 88 ng g-1 wet weight). The often-overlooked precursors FASAs and FTCAs were found at higher or similar levels to PFCA's. The concentrations were comparable to those reported in the literature in Delphinidae worldwide, indicating that the Bay of Biscay is neither a pristine reference site nor a hotspot for PFAS contamination. The levels in liver were an order of magnitude higher than those in muscle and blubber, with generally similar contamination profiles across tissues. No relationship between length or age and PFAS hepatic concentrations was evidenced, but contamination profiles depended on the cause of death, and likely, the dolphin's nutritional status. This trend was not observed in blubber, reflecting the lower turnover rate of this tissue. Female were relatively less contaminated than male in the shorter chain PFAS, suggesting potential elimination of the most mobile compounds by maternal transfer. PFAS showed decreasing concentrations between 2005-2010 and 2020-2023 and a shift of contamination profiles from longer to shorter-chains. Marked increase for all PFAS (but FTCAs) in liver between preys and dolphin confirmed their biomagnification.

Discussion and Conclusion
PFAS contamination is widespread in Bay of Biscay common dolphins, with profiles dominated by PFOS, followed by FASAs, PFCAs, and FTCAs. The evolving temporal trends generally reflected regulatory phase-outs and industrial chemistry shifts. Focusing on different tissues provided insights into the dynamics of PFAS in common dolphin.

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Levels and Trends (Biota, Food and Feed) 1

R. Ceci & R. Malisch

D11-820 Long term monitoring of POPs in eel from Dutch rivers: what can we learn?

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Introduction
Since late 1970s, eel (Anguilla anguilla) is employed for monitoring pollutants in Dutch freshwaters. Eel is representing the local pollution status. While initially OCPs, heavy metals, PCBs and dioxins were monitored, at later stages also BFRs and PFASs were added. The monitoring provides insights in the status of the local environment and, from a food safety perspective, if the eel is safe for human consumption.

Materials and Methods
Every year 20-25 locations were selected for monitoring, of which 7 locations are monitored yearly to establish time-trend series. Eels were caught by electrical fishing (53-76 cm range since 2016, smaller sizes before). The selected eels were characterized (size, weight) and fillets were pooled into composite samples per location. These were analysed for the POPs mentioned above.

Results
For the 7 locations, trendlines could be established for dioxins and dioxin-like PCBs (on a TEQ basis) and also for PFASs. The dioxin/PCB-TEQ trendlines showed variation from year-to-year, but this highly correlated with the fat content of the samples.
Highest concentrations were found in the major rivers (Rhine, Meuse, Waal, IJssel) and their sedimentation areas, whereas lower levels were observed in eel from surface waters that are not connected to the major rivers. For PFASs, levels varied between 10-30 ng/g (sum of 4 PFASs) with some locations showing higher levels (up to 58 ng/g). PFOS was the dominant congener (50-80% of the sum), followed by long-chain perfluorinated carboxylic acids (PFDA-PFTeDA).

Discussion and Conclusion
There are several key learnings from this >45-year monitoring study. In the initial years (1980-1990s), strong decreases were observed in the levels of several OCPs and non-dioxin-like PCBs. Dioxin/PCB-TEQ levels exceeded the Maximum Levels (MLs) in the majority of the main rivers, where commercial fishing is not allowed. Remote areas or those not connected to main rivers showed (substantially) lower levels.
Dioxin/PCB-TEQ trends on a fat weight basis are stable, meaning that the local environmental pollution does not change substantially over time. Dioxin-TEQ contributed only for 5-10% to the sum-TEQ, specific dioxin-contaminated sites excluded. This contribution changes somewhat when the new 2022 TEFs are applied. Analysis of PFAS levels, available since 2017, shows that levels are stable at most locations. PFOS is the major contributor, as observed in other studies on aquatic species. Long-term monitoring provides valuable insights in the development of pollutant levels over time.

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Levels and Trends (Biota, Food and Feed) 1

R. Ceci & R. Malisch

D11-682 Trifluoroacetic acid (TFA) is a significant contributor to PFAS concentrations in estuarine biota

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Introduction
As part of the UK's National PFAS plan, surveys of sediment and biota PFAS concentrations were conducted in two UK estuaries, the Thames and Mersey. Samples were collected over the period September 2025-February 2026 by Environment Agency staff and chemical analysis was performed at Cefas.

Materials and Methods
Sediment samples (25 per estuary) were collected using hand grabs higher up the estuaries and day grabs lower down the estuaries. Fish were collected using otter trawls at three locations in the Mersey and two locations in the Thames. Eleven species of fish were collected in the Thames (dab, herring, flounder, smelt, whiting, common sole, sea bass, pouting, plaice, tub gurnard and red mullet) and seven species of fish were collected in the Mersey (dab, herring, whiting, flounder, plaice, sea bass and common sole). Bycatch species caught during the Mersey fishing,

including brown shrimp, flying crab, common starfish and rayed trough shell (clams), were also collected. Additionally, Pacific oysters, Asian freshwater clams, grey mullet and lugworms were sampled from the shore in the Thames and blue mussels were collected from two sites in the Mersey. Where catches allowed, samples were analysed as pools of multiple individuals, homogenised as whole organisms (minus shells/exoskeleton), with the exception of two grey mullets, which were dissected to obtain liver and muscle samples.
A total of 96 biota samples and 50 sediment samples were analysed for a suite of 60 PFAS and 5 ultra-short chain PFAS. Samples were spiked with a mixture of 25 isotopically mass-labelled internal standards (including TFA), extracted using sonication and cleaned up dispersively using graphitised carbon. Instrumental analysis was carried out using a Vanquish Flex UHPLC coupled with an Orbitrap Exploris TM 120 mass spectrometer (Thermo Scientific, Massachusetts, United States). Separation of 'normal' PFAS was carried out with an Acclaim RSLC C18 analytical column (2.2µm particles, 100 mm x 2.1 mm, from Dionex, Thermo Scientific, Massachusetts, United States) and separation of ultra short chain PFAS was with a Shodex HILICpack VT-5 column (150 mm x 2.0 um, 5 um)(Resonac America Inc.). All analyses were carried out under full analytical quality control procedures that included the analysis of a certified reference material and a blank sample with every batch of 10 samples. Reference materials used were NMCAG-RM1 (spiked mussel homogenate; in house reference material produced by QUASIMEME) and SETOC-779 (Marine sediment: WEPAL, Wageningen).

Results
∑65PFAS concentrations in sediments ranged from 0.14-14.5 (average 3.3) µg/kg dw in the Thames, and from 0.084-2.5 (average 1.3) µg/kg dw in the Mersey, with averages of 11 PFAS positively detected in the Thames (range 3-17) and 7 PFAS positively detected in the Mersey (range 1-11). 6:2FTAB and PFOS were the predominant PFAS in both estuaries, usually making up more than half of the
∑65PFAS concentrations between them, and TFA was below LOQ in all samples.
∑65PFAS concentrations in biota samples ranged from 1.29-59.1 (average 23.0) µg/kg ww in the Thames, and from 4.6-142 (average 22.9) µg/kg ww in the Mersey, with averages of 15 PFAS positively detected in the Thames (range 4-25) and 14 PFAS positively detected in the Mersey (range 3-21). Highest concentrations were found for TFA, followed by PFOS, PFOSA, PFBSA and 6:2 FTAB, (averages 11.7, 6.1, 1.5, 1.3 and 0.60 µg/kg ww in the Thames and 14.4, 3.0, 1.9, 0.72 and 1.3 µg/kg ww in the Mersey, respectively).

Discussion and Conclusion
TFA made a greater contribution to ∑65PFAS in invertebrate samples, on average 81% in the Thames and 64% in the Mersey, compared with 16% in the Thames and 35% in the Mersey in fish. The consequences of failing to include TFA in methods for biota monitoring will be discussed.

Levels and Trends (Biota, Food and Feed) 1

R. Ceci & R. Malisch

D11-569 Toxicological profiles of North Atlantic mesopelagic species: from raw materials to by-products

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Introduction
Mesopelagic species such as Calanus finmarchicus, Benthosema glaciale, and Meganyctiphanes norvegica are emerging as sustainable resources for food and feed production, but data on contaminant occurrence remain limited. This screening study provides a broad assessment of legacy and emerging pollutants, including POPs, BFRs, PFAS, and trace metals, in raw biomasses and processed fractions. In addition, the influence of industrial processing on contaminant partitioning is explored. Such screening-level data are essential for identifying potential risks, evaluating regulatory compliance, and guiding further investigations to support safe and sustainable utilization of marine resources.

Materials and Methods
Samples were collected during summertime trawl hauls on five research expeditions in the Northeast Atlantic between 2021 and 2023. Portions of the biomass were processed by thermal separation, enzymatic hydrolysis, or silage, yielding oil, soluble protein, and sedimentation fractions. Both raw materials (RM) and processed fractions were screened for POPs. 26 polychlorinated biphenyls (PCBs), 22 organochlorine pesticides (OCPs), and 11 brominated flame retardants (BFRs) were extracted using a multicomponent liquid–liquid extraction with acetone and cyclohexane, followed by gel permeation chromatography cleanup and analysis by GC-MS and GC-MS/MS. Lipid content was determined gravimetrically from 1-mL of the fat extract. RMs were additionally analyzed for toxic metals and 35 PFAS. Metals were quantified following acid digestion with ultrapure HNO_3 and HCl and analysis by triple-quadrupole ICP-MS. For PFAS, methanol extraction followed by WAX-SPE and graphitized carbon cleanup was applied, with quantification by UHPLC-MS/MS.

Results
For RM, all contaminants were under the EU maximum limit (ML) for food and feed ingredients for all matrices except arsenic with a concentration of 30mg kg^{-1} (ML 25mg kg^{-1} [1]) in B. glaciale, and cadmium, which had a mean concentration of 2.32mg kg^{-1} but a median of 1.58mg kg^{-1} ML 2.0mg kg^{-1} [1]) in C. finmarchicus. The sediment fraction of C. finmarchicus had also high levels of cadmium (median of 4.04mg kg^{-1}). No BRFs, OCPs or PCBs were detected in any of the soluble protein fractions. Sum of chlordane was highest in M. norvegica and B. glaciale for all matrices, but 1.7 times under ML [1] for M. norvegica oil. Highest concentration of DDTs was in M. norvegica oil (0.045mg kg^{-1}), 11 times under ML [1]. No DDTs were detected in C. finmarchicus RM or sediment. ICES-6PCBs were under ML for all matrices, the highest being M. norvegica oil (87.07µg kg^{-1}). The highest lipid-normalized concentrations of both ΣBDEs (28, 47, 99, 100, 153 and 154) and ΣNBFRs (PBT, PBEB, DPTE and HBB) were observed in C. finmarchicus sediment, reaching 24.66 and 17.48 ng g^{-1} lw, respectively.

Discussion and Conclusion
All species contained low levels of legacy and emerging contaminants and were largely compliant with EU regulatory limits. Exceptions included elevated arsenic in B. glaciale and cadmium in C. finmarchicus RM, consistent with known metal accumulation in zooplankton. Processing strongly influenced contaminant distribution, with no detectable PBDEs, NBFRs, OCPs, or PCBs in soluble protein fractions, indicating efficient partitioning of hydrophobic compounds into lipid-rich and solid matrices. Overall, marine biomasses and derived products appear safe regarding organic contaminants, while metal accumulation in specific fractions shows the need for matrix-specific assessment. The enrichment of ΣBDEs and ΣNBFRs in sediment fractions reflects their affinity for particulate and lipid-rich materials but remains within expected environmental ranges. These findings support the potential for optimized processing to produce low-contaminant ingredients for food and feed applications.

Acknowledgment
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Levels and Trends (Biota, Food and Feed) 1

R. Ceci & R. Malisch

D11-354 PFAS plasma levels in common eiders (Somateria mollissima) from the Oslo fjord: Influence of breeding site, diet and migration pattern

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Introduction
Populations of marine birds in the Oslofjord are declining. Marine birds are under significant pressure from multiple stressors, such as climate change and pollution. Per-and polyfluoroalkyl substances (PFAS) are of growing concern due to being toxic, bioaccumulative, and extremely persistent. More information is needed on PFAS in the Oslofjord, and the different factors determining exposure to the Oslofjord marine birds. In this study the aim was to investigate how breeding site, diet and migratory behavior affect PFAS exposure in common eiders breeding in the Oslofjord.

Materials and Methods
Blood samples, back and breast feathers, as well as spatial data from global location sensors, were collected from breeding female common eiders, at two breeding colonies in the first week of May in 2022, 2023 and 2024. One colony was located in the inner Oslofjord (Nesodden), and one in the outer Oslofjord (Hvaler). The PFAS concentrations in the blood plasma (n=63) were determined using target analysis with ultra performance liquidchromatography-tandem mass spectrometry (UPLC-MS/MS). Stable isotope ratios (δ15N and δ13C) were determined in the blood (n=62) and feathers (n=63). The median latitude measured in the month of January was used as a proxy for overwintering site, and was used as a covariate in the statistical analysis.

Results
Common eiders breeding in the inner Oslofjord at Nesodden had higher PFAS plasma concentrations. At Nesodden, the sum of the most 5 prevalent PFAS (∑5PFAS including PFOS, PFHxS, PFUnA, PFNA and PFDA) ranged from 7.69–79.6 ng/mL, while the ∑5PFAS range was 5.52- 38.8 ng/mL at Hvaler.
In addition, 6:2 FTS stood out by having the highest individual measured plasma concentrations of any of the PFAS in the study (129.2 and 126.1 ng/mL, at Hvaler in 2024 and Nesodden in 2022, respectively). However, no samples in 2023 from any of the two colonies had 6:2 FTS plasma concentrations >LOD.
The dietary niche was found to be similar between the two colonies, but the inner Oslofjord common eiders had more dietary variation as a group. The common eiders in the outer Oslofjord were found to have a higher δ15N in their blood, indicating a higher trophic position. However, δ15N was not found to affect PFAS exposure. δ13C in back feathers had a negative effect on PFAS concentrations. The common eiders' median latitude in January was not found to have a significant effect on PFAS exposure.

Discussion and Conclusion
The higher concentrations in Nesodden compared to Hvaler can be explained by the eiders at Nesodden breeding and feeding closer to the city of Oslo. The source for the 6.2-FTS is currently unknown, but it is alarming since a study from 2020 on eiders in the Oslofjord did not find any detectable levels of 6:2 FTS1.
The higher dietary variation observed in the inner Oslofjord common eiders could possibly be due to having less of their preferred prey available in that area, which needs to be confirmed in the future.
The negative influence of δ13C in back feathers on PFAS concentrations, indicates a more pelagic or offshore diet to be associated with higher PFAS exposure. The back feathers relate to the food ingested during the previous year's summer which interestingly seems to affect the circulating PFAS concentrations during the following breeding season.
It was concluded that both proximity to Oslo and the common eiders' diet affected their PFAS exposure, with a more pelagic or offshore diet leading to a higher exposure. The difference in trophic positions between the colonies was not found to affect PFAS exposure.

Acknowledgment
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Determination of PFAS in Emissions and Ambient Air

S. Maggi & W. Tirler

D12-012 Learning from real case scenarios: Full-scale incineration of a fluorinated aqueous film-forming foam

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Introduction

Certain per- and polyfluoroalkyl substance (PFAS) show unique surfactant properties and have been used in aqueous film-forming foams (AFFF) for extinguishing fires of flammable liquids. The restriction on the continued use of PFAS, based on concerns of high environmental persistence of the fluorinated chain and potential impact of PFAS on the environment and human health, resulted in a phase out of AFFFs in numerous countries [1,2]. The remaining stocks must now be safely destroyed.

Although thermal treatment currently offers the highest potential for PFAS waste destruction, there are concerns about products of incomplete destruction (PIDs) formed under insufficient combustion conditions.

Here, we present the results of our first incineration campaign of the project, Investigating the Thermal Decomposition of PFAS in a Full-Scale Commercial Hazardous Waste Incinerator" funded by the U.S. Department of War's Strategic Environmental Research and Development Program (SERDP) [3]. We investigated the incineration of a contemporary fluorotelomer-based AFFF under varying temperatures and AFFF mass flows at a commercial full-scale hazardous waste incineration plant in Germany. Our goal was to evaluate the completeness of PFAS destruction and the potential formation of PIDs for each set of treatment conditions.

Materials and Methods

Three incineration conditions sets were tested: (1) 250 kg/h AFFF at 1050 °C, (2) 250 kg/h AFFF at 950 °C, and (3) 1500 kg/h at 950 °C. Flue gas was sampled using equipment according to Other Test Methods (OTM-) 45 and OTM-50 behind the secondary combustion chamber (SCC) as well as at the stack. However, a more comprehensive perspective was achieved by taking solid samples (slag, boiler ash and ash from the electrostatic precipitator, short E-filter) and liquid samples (wet slag remover water and scrubber water). In addition to targeted analysis of extracts according to U.S. EPA Method 1633 and OTM-45/-50, non-targeted screening was performed to test for PIDs that had not been targeted in the analyte lists of these methods.

Results

Analysis of the OTM-50 samples showed that the concentrations of all nonpolar volatile analytes were below their respective method detection limits under all test conditions and at both sampling points. This includes tetrafluoromethane (CF4), a highly persistent PID and potent greenhouse gas. No fluorinated unknowns were detectable via non-targeted screening, too. In both, slag and the wet slag remover water, major AFFF-components were detectable after the first day of AFFF incineration. These detections, however, were most likely due to the cleaning procedure of the kiln injection lines after the completion of an incineration experiment. Boiler and E-filter ashes were free from AFFF components under all test conditions and only low amounts (ng/kg) of perfluoroalkyl carboxylic acids were detected sporadically. Results of the OTM-45 and scrubber samples are currently under review.

Discussion and Conclusion

Our study demonstrates that AFFF can be destroyed by hazardous waste incineration without the formation of CF4 and other nonpolar volatile PIDs. Furthermore, with appropriate operation, mixing and waste stream composition, a temperature of 950 °C in the SCC is likely to be sufficient to achieve a satisfactory destruction efficiency.

Acknowledgment

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Determination of PFAS in Emissions and Ambient Air

S. Maggi & W. Tirler

D12-371 Pseudo-PFAS: Adaptive monitoring of perfluorotributylamine and related chemicals in air of Svalbard and mainland Norway, 2017 – 2025

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Introduction

Perfluorotributylamine(PFTBA) is an inert colorless volatile liquid with boiling point of 178 °C used mainly as perfectly inert coolant. Apparently, it is so non-toxic that it can be used as blood substituent or for liquid breathing. It is a well-known calibrant for mass-spectrometers. It was monitored by NILU by appointment of the Norwegian Environment Agency after initial finding in a screening project in 2017[1,2].

Materials and Methods

Main sampling points were NILU air monitoring stations Zeppelin(Svalbard), Birkenes(rural, southern Norway) and Sofienbergparken(urban, Oslo). Air(40-100 m3) was sampled at 1 m3/h on in-house made SPE cartridges containing 250mg of ABN+(Biotage AS, Sweden). Cartridges were eluted with 4 mL of hexane (pentane, ethylacetate, MTBE were also used). d18-Diisopropylbenzene was added as internal standard, and extracts analyzed on Q Exactive GC equipped with a polar TG-200 or similar column in full-scan mode and in some instances in T-SIM mode as well.

Results

PFTBA, perfluorotripentylamine(PFTPeA), perfluoroperhydrophenanthrene(PFPHP) and perfluorotetrachlorobutane(PFTCB) were found in majority of air samples in all three locations(except experimental failures) with average levels of ca 2, ca 0.1, ca 0.05 and ca 0.02-0.2 ng/m3, respectively. Only PFTCB showed high seasonal and geographical variation. Due to interannual improvements in campaign design, sampling, workup and analysis it is not possible to conclude on long-term trends. Perfluorotripropylamine(PFTPrA) was detected but not monitored(lower levels and technical limitations).

Discussion and Conclusion

PFTBA was found to be one of the major organohalogen components of air along bromoform, hexachlorobutadiene, hexachloroethane, di-/trichlorobenzenes and dichlorotoluenes.

PFTBA as greenhouse gas: this contribution is negligible because, despite its high GWP and predicted long atmospheric lifetime, its levels(2ng/m3 or 0.015 ppt(v/v)) are ca 30 times lower than those of C6-C8 perfluorocarbons[3], ca100000 times lower than combined level of fluorinated gases(1.5 ppb) and ca 2500 times lower than the pre-historical natural level of carbon tetrafluoride(35-40 ppt).

PFTBA as precursor of PFAAs: this contribution is negligible, because, despite higher levels – 100000 higher than PFOS, 50-500 higher than fluorotelomer precursors of PFAAs[2], PFTBA cannot be a precursor of traditional PFAAs longer than PFBA which will not bioaccumulate. The maximum amount of TFA that can be formed upon degradation of PTFBA is ca 4000 tons, which is > 10000 times lower than presence of TFA in deep ocean(56-200 million tons)[4]. A hypothetical risk is a theoretical possibility of formation of azaperfluoroacids of formula (C4F9)2N(CF2)nCOOH, n = 1-3, similar in properties to C10-C13 PFCAs. The theoretical yield can reach 8000 tons, but with possible atmospheric lifetime of PFTBA of, say, 1000 years the annual emission wouldn't exceed 8 tons, which is hardly detectable without a focused effort.

MDL: The broad method was proved to detect contaminants at 0.1pg/m3, or 400kg/atmosphere. Pre-concentration of samples, use of NCI and advanced SIM can drive MDL down to kilograms/planet.

DATASET: A complete reported dataset is available from NILU as well as full-scan Orbitrap(NTS) files on a polar GC column. Additionally, full-scan files from siloxane monitoring (similar samples on low-polar TG-5MS column) complement full record(> 1000 files) of air composition in the past decade.

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Determination of PFAS in Emissions and Ambient Air

S. Maggi & W. Tirler

D12-129 Determination of PFAS in stationary source emissions: validation of a simplified method

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Introduction

The monitoring of per- and polyfluoroalkyl substances (PFAS) in atmospheric emissions is critical for assessing the environmental impact of industrial activities, yet standardized methods for stack monitoring remain limited. This work aims to develop and field-validate a simplified and robust method for PFAS stack emissions.
The study presents a validated method developed by ARPAV for the quantification of 26 PFAS compounds, including legacy carboxylates, sulfonates, and emerging alternatives like GenX (HFPO-DA), ADONA, and cC604.

Materials and Methods

The sampling train is designed to capture both particulate-bound and volatile PFAS using a heated probe, a quartz fiber filter, and a series of impingers (NaOH 0.1 N and methanol). Analysis is performed by LC-MS/MS using isotopic dilution.
A rigorous quality control system was implemented by differentiating the use of isotopically labeled standards. 13C-labeled compounds are added directly to the filter before the start of sampling to identify and quantify any potential losses occurring during the field operations. Additional labeled standards are added in the laboratory prior to extraction to account for matrix effects and analytical recoveries.
A key strength of this work is the field validation conducted at a thermal regeneration plant for granular activated carbon (GAC). The plant processes carbons used in the purification of drinking water contaminated by PFAS, representing a challenging high-temperature matrix.

Results

The method demonstrated high sensitivity (LOQ <0.5 ng/m3 with 200 Nl of sampling volume) and robustness. Validation trials at the regeneration facility showed that the sampling train effectively handles high-moisture and high-temperature effluents.
Recoveries of sampling standards (added to the filter prior to sampling) consistently exceeded 77%, and native compounds recoveries at the LOQ level ranged from 91% to 133%, ensuring high accuracy even in the presence of complex combustion by-products.

Discussion and Conclusion

The method aligns with the principles of US EPA OTM-45[1], it offers significant advantages for public and routine laboratories as procedural simplicity: the extraction and clean-up phases are streamlined (using basic methanol/water mixtures), reducing processing time and solvent consumption compared to the more elaborate OTM-45 requirements. The method simplifies the sampling train and avoids the use of XAD resins, which are often prone to contamination and require complex preparation and extraction.

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Levels and Trends (Abiotic)

S. Raccanelli & M. Venier

D13-004 Characterizing PCDD/F and PCB emissions from wood-fired boilers in Taiwan

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Introduction

Taiwan has committed to achieving carbon neutrality by 2050, with several municipalities also pledging to phase out coal use. As an island nation with limited domestic energy resources, Taiwan increasingly relies on alternative fuels (AF), including waste wood and solid recovered fuel (SRF). Compared with conventional fuels, the chlorine content in these AF is generally higher and waste wood contains lignin, both of which contribute to an increased likelihood of PCDD/F formation.

Consequently, waste wood boilers have emerged as one of the most frequently cited non-compliant emission source categories in Taiwan over the past five years. In response, the Ministry of Environment (MOENV) enacted a more stringent PCDD/F emission standard for SRF and waste-derived fuels effective on January 1st 2026, tightening the limit from 0.5 to 0.1 ng I-TEQ/Nm^3.

Materials and Methods

Annual PCDD/F emission quantities from AF boilers were estimated using emission factors derived from stack test results and annual activity data. PCDD/F emission data from 126 AF boilers for the period 2021 to 2025 were analyzed. 10 wood-fired boilers (including 2 wood-pellet-fired and 8 waste-wood-fired units) and 9 steelmaking electric arc furnace (EAF) stacks were further investigated following standard methods (NIEA A809 11B) established by the National Environmental Research Academy (NERA) of MOENV.

Results

The annual PCDD/F emission from AF boilers in 2023 was 2.037 g I-TEQ, accounting for only 5% of total domestic emissions. However, stack emission concentrations from 2021 to 2025 ranged widely from <0.001 to 179.410 ng I-TEQ/Nm^3 (n = 819), with 31 and 223 samples exceeding 0.5 and 0.1 ng I-TEQ/Nm^3, respectively. Exceedances were predominantly observed in wood-fired boiler stacks. Detailed investigation of 10 high-emission wood-fired boiler stacks yielded an average concentration of 0.787 ng I-TEQ/Nm^3 and a PCDF-to-PCDD ratio of 2.912. Wood-pellet-fired boilers exhibited higher emission concentrations than waste-wood-fired boilers due to the absence of PCDD/F removal devices. A PCDF-to-PCDD ratio greater than 1 was commonly observed in high-emission wood-fired boilers. This phenomenon has conventionally been attributed to de novo synthesis. However, greater particulate mass on filters did not necessarily correspond to higher emissions. Wood-fired boilers exhibited lower PCB concentrations relative to PCDD/Fs, whereas EAFs showed the opposite pattern, with a positive correlation between PCDD/F and PCB emissions. A regulatory compliance surveillance test conducted in 2025 revealed marked differences in total emission quantities across filter samples with varying particulate loadings, but no significant differences in congener distribution. These findings are inconsistent with the de novo pathway mechanism, which would result in elevated chlorination levels and higher PCDD/F concentrations on particulate matter through heterogeneous reactions and the Deacon reaction.

Discussion and Conclusion

The adoption of wood-based fuels in Taiwan is expected to increase. These findings suggest that emission reduction strategies for wood-fired boilers should not only focus on flue gas temperature management but also on precursor reduction. Low metal oxide content in wood pellets and waste wood may account for the absence of elevated concentrations of PCDD/Fs and higher-chlorinated PCDD/Fs on particulate matter.

Acknowledgment

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Levels and Trends (Abiotic)

S. Raccanelli & M. Venier

D13-121 Organophosphate ester (OPEs) plastic additives in marine sediment across Europe

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Introduction

Organophosphate esters (OPEs) flame retardants and plasticizers are among the most widely distributed plastic additives in the marine environment. Nowadays, OPEs reach marine coastal areas at high rates due to non-stop emissions, raising high global concern because of their hazardous properties [1]. These chemicals, particularly the more hydrophobic compounds, have the ability to eventually accumulate in marine sediments, which constitute an effective storage compartment of OPEs [1] [2]. Marine sediments may then be a key integrative matrix to monitor these contaminants in coastal areas. Typically, sediment sampling campaigns focus on a few specific sites, offering a limited geographical distribution. The Traversing European Coastlines (TREC) expedition was a pan-European survey that allowed coordinated coastal marine sediment sampling (among other matrices). The overall objective of this study was to investigate the OPE occurrence and hotspot across Europe using the surface sediments collected by the TREC expedition.

Materials and Methods

Twenty-four sampling stations encompassing coastal areas in the North-east Atlantic and Mediterranean Sea, were sampled (2023-2024). Various sampling replicates, within a few meters each other, were considered for each station (70 samples in total). OPEs were analysed using a previously validated method [2]. Briefly, 1 g dw of sediment was spiked with the corresponding OPE labelled standards (surrogates) and sonicated twice with a mixture of ethyl acetate/cyclohexane (80/20). The resulting extract was cleaned-up with SPE-NH2 columns, which were first eluted with ethyl acetate/cyclohexane (1:4, v/v) and then acetate/cyclohexane (1:1, v/v) solvent mixtures. The two fractions were separately quantified by isotopic dilution LC-ESI-MS/MS. The entire analytical procedures were conducted in clean laboratories (ISO 8 class), under a low-dust atmosphere and positive pressure. Procedural blanks (n=18) were performed, and median values ranged from non-detected (nd) to 554 pg, depending on the compound. All concentrations were blank corrected. The method limits of quantification varied from 1 to 296 pg/g dw, depending on the compound and sample. The median method recoveries (n=70) of labelled surrogates ranged from 50 to 103%. Ancillary parameters such as total organic carbon content (TOC) and granulometry were also analysed on the same samples.

Results

The most frequently detected OPE was the aliphatic compound tris(2-ethylhexyl) phosphate (TEHP), with an overall median detection frequency (DF) of 87 % across sites. Tris(2-butoxyethyl) phosphate (TBOEP) and the chlorinated compound, tris(2-chloroethyl) phosphate (TCEP), were the second most detected OPEs, with a DF=71%. Only six of out of nineteen target OPEs were never detected. sumOPEs concentrations expanded over 3 orders of magnitude across European coasts, ranging from 0.02 to 47 ng/g dw, and different OPE fingerprints were found across the studied stations. The influence of TOC in the OPE special distribution is under investigation and will be also discussed

Discussion and Conclusion

Our results revealed the ubiquitous presence of OPE in the sedimentary compartment across Europe. The fact that TEHP reached the highest DF in not surprising due to its high hydrophobicity (log Kow > 9), favouring it accumulation in the sedimentary compartment. The large variability of the measured concentrations and the different fingerprints observed, point to heterogeneous pollution patterns across Europe. Results still under evaluation but, likely, the combination of site-specific sources and the differences in sediment composition and environmental processing across European areas may play an important role on the final accumulation of OPEs in coastal sites.

Acknowledgment

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Levels and Trends (Abiotic)

S. Raccanelli & M. Venier

D13-319 Occurrence of organophosphate esters and other CECs in seawater and sediments from offshore wind farm areas of the North Sea

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Introduction
The transition toward clean energy sources in Europe is changing the energy production system. In this context, the development, installation and operation of new offshore wind farms (OWFs) is being increased during last years and is expected to keep growing during next decades, specially in the North Sea, which has been planned as the main power hub for clean energy production in Europe (Hamburg Declaration, 2026). Some environmental effects associated with OWF installations such as the production of underwater noises and electromagnetic fields or the reef effect have been described during recent years but chemical emissions have been largely disregarded.

Materials and Methods
We analyzed 45 seawater and sediment samples from 4 OWF areas of the North Sea (Germany and Belgium) and 3 types of reference areas. Ultrasound assisted extraction (sediment) and SPE clean up (seawater) were optimized to ensure simple, reproducible and effective workflows. Chromatographic separation coupled to tandem mass spectrometry was used to determine the occurrence of 19 organophosphate triesters (tri-OPEs) and 6 organophosphate diesters (di-OPEs) along with other pollutants potentially emitted by OWF such as phenols and benzotriazoles (Hengstmann et al., 2025).

Results
Chlorinated tri-OPEs and TEP were dominant in seawater pollution profiles from Germany. Frequenly detected compounds (>85%) included 8 tri-OPEs (TBOEP, TEP, TnBP, TiBP, TCEP, TCIPP, TDCIPP, TPhP), 4 di-OPEs (DMPP, DPhP, DBPs and BEHP), 1H-benzotriazole (BTR) and 4-methyl-1H-benzotriazole(4MeBTR), with concentrations ranging from <MQL to 29 ng/L. Sediments from Germany showed pollution profiles dominated by phenolic compounds such as 4-nonylphenol, bisphenol A, bisphenol F and 4-dodecylphenol at concentrations of up to 11.1 ng/g dw. In seawater from Belgium, widespread compounds included TEP, TBOEP, TPhP, BTR, DBPs, DPhP, DMPP, TnBP, TiBP, TDCIPP, IDDPP, 3TBPDPP and 4MeBTR, with individual concentrations between <MQL and 3.2 ng/L. Total concentrations in sediments from Belgium ranged from nd to 28.1 ng/g dw and showed averaged profiles with high contribution of phenolic compounds, particularly bisphenol A. The highest detection frequency was found for 4-dodecylphenol (80%).

Discussion and Conclusion
A differential distribution and pollution profile of studied compounds in seawater was found in OWFs from Germany and Belgium while pollution profiles in sediments were usually dominated by phenols in both countries. In seawater, two arylic tri-OPEs, IDDPP and 3TBPDPP, were just sporadically detected in Germany but widespread in Belgium (<MQL - 3.24 ng/L) while chlorinated triOPEs such as TCEP and TCIPP, were nearly ubiquitous in Germany but detected in only close to seashore in Belgium. The most polluted sample was collected in the Elbe plume influence area, pointing to riverine discharges as the main pollution source in Germany. Further oceanic dilution in the North Sea was showed by the statistically significant correlation of concentration with salinity for the following compounds: TCEP, TCIPP, TDCIPP, TEP, TnBP, TiBP, BTR, 4MeBTR, BEHP, DBP and DMPP. In Belgium, BTR and 4MeBTR also showed statistically significant correlation with salinity. Even though higher DMPP concentrations were found in OWF B than OWF A water samples, both located in Belgium, possibly indicating a specific emission source in that installation, none of the studied compounds can be crearly associated to offshore wind farm emissions and found pollution fingerprints result from a multisource scenario in a highly anthropized semiclosed sea basin like the North Sea.

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Levels and Trends (Abiotic)

S. Raccanelli & M. Venier

D13-543 Are Unreported Technical Polychlorinated Biphenyl Formulations used in Legacy Building Materials Threatening Indoor Environments of a Central Indian City Despite the Ban?

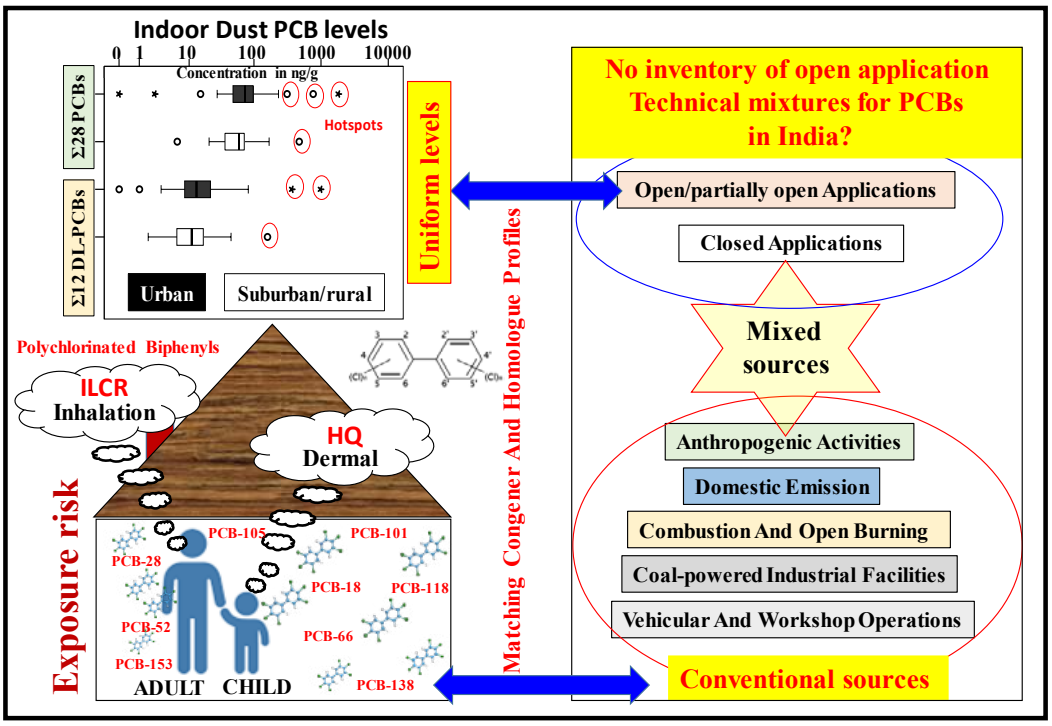
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Introduction

The continued detection of PCBs in the Indian environment decades after their ban presents a paradox that cannot be explained solely by legacy closed-system uses and unintentional emission sources. This gap reflects a fundamental limitation in how PCB inventories have been conceptualized and regulated in India, with a predominant focus on closed applications while implicitly assuming that open and partially open uses were considered negligible. However, open and partially open applications such as plasticizers, sealants, paints, inks, adhesives, and floor finishes have largely been excluded from national inventories due to challenges in identification, quantification, and regulation. These applications, by design, facilitate continuous emissions through volatilization, abrasion, and partitioning into indoor air and settled dust, particularly within residential environments. The present study evaluates whether unreported open and partially open applications, legacy closed applications, and anthropogenic emissions sources continue to influence indoor environmental PCB levels and human exposure.

Materials and Methods

Settled household dust samples were collected from ninety residences from Nagpur city, Maharashtra, central India. Samples were sieved through a 500 µm stainless-steel sieve, transferred to amber-coloured glass containers and stored at –20 °C until analysis. A certified standard mixture comprising 28 PCB congeners, and isotope-labelled surrogate standards were procured from AccuStandard (USA). Anhydrous sodium sulfate and chromatography-grade silica gel were obtained from Sigma-Aldrich Chemicals Pvt. Ltd. Pesticide-residue-grade solvents (acetone, hexane, and dichloromethane) were purchased from Honeywell (Germany). PCBs were extracted from dust samples using microwave-assisted extraction (MAE) system with hexane:acetone (1:1, v/v). For cleanup, the concentrated extracts were subjected column clean up using a florisil and acidified silica column. The extracts were quantitatively loaded, and PCBs were eluted with hexane:dichloromethane (3:2, v/v). PCBs were quantified using GC–MS/MS (Agilent 7000D GC/TQ).



Levels and Trends (Abiotic)

S. Raccanelli & M. Venier

D13-543 Are Unreported Technical Polychlorinated Biphenyl Formulations used in Legacy Building Materials Threatening Indoor Environments of a Central Indian City Despite the Ban?

Results

The Σ28 PCB concentrations ranged from BDL to 1819.4 ng/g, with a mean (± SD) of 103.3 ± 206.8 ng/g. The Σ12 DL-PCBs ranged from BDL to 990.2 ng/g (mean: 30.7 ± 110.5 ng/g). Σ12 DL-PCBs constituted 30% of Σ28 PCBs. Detection frequencies varied from non-detectable (PCB-169) to 99%. Lower-chlorinated congeners (di- to tetra-chlorinated PCBs) dominated the congener profile, with PCB-8, -18, -28, -44, -52, and -66 detected in 93–97% of samples. PCB-118 exhibited the highest detection frequency (99%) among the 12 DL-PCBs. The overall PCB homologue distribution in indoor dust followed the order: penta-PCBs (28.8%) > tri-PCBs (26.4%) > hexa-PCBs (18.9%) > tetra-PCBs (16.8%) > hepta-PCBs (5.1%), with negligible contributions from octa-, nona-, and deca-PCBs.

Discussion and Conclusion

About 75% of sampling sites were dominated (>50%) by low-chlorinated homologues (di–tetra PCBs), particularly tri- and tetra-PCBs. Such homologue patterns closely resemble the compositional profiles of low- to mid-chlorinated technical PCB mixtures such as Aroclor 1016, Aroclor-1221, -1232,-1242-1248, Clophen A30, Kanechlor -,300,-400, Delor 103, and Sovol formulations. In contrast, only 27% of sampling sites exhibited dominance (>50%) of higher chlorinated homologues, primarily penta-, hexa-, and hepta-PCBs.). These houses are likely impacted by near-by sources indicating localized influences rather than widespread regional contamination. Further, the homologue patterns are consistent with closed or partially closed application sources, including transformers, capacitors, and industrial hydraulic systems. Correlation analysis revealed strong positive associations between the indoor dust PCB homologue profile and several technical PCB formulations, such as Aroclor 1248 ($r = 0.858$, $p < 0.01$), Kanechlor 400 ($r = 0.808$, $p < 0.01$), Clophen A50 ($r = 0.849$, $p < 0.01$), Kanechlor 500 ($r = 0.836$, $p < 0.01$), and Pyralene DP-3 ($r = 0.841$, $p < 0.01$), indicating mixed-source contributions from products historically used in open, partially open, and closed applications. Few urban sites showed exceedances of hazard index (HI > 1), and ILCR (>1×10-4) implying long-term carcinogenic and non- carcinogenic risk for adults and children.

POPs in Developing Countries

O. Okonkwo & K. Pozo Gallardo

D14-111 Vehicle Cabins as Microenvironments of OPFR Exposure in Türkiye

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Introduction

Organophosphate flame retardants (OPFRs) have been widely used in vehicle interior materials as an alternative to polybrominated diphenyl ethers (PBDEs). However, as OPFRs are applied as additives to various materials to confer flame retardant properties and since they do not chemically bond to the materials they are released into the environment over time, causing continuous exposure through dust and airborne particles in indoor environments including enclosed vehicle cabins. The literature indicates that they are commonly found in indoor dust and are significant pollutants in vehicle microenvironments (Svobodová et al., 2025; Tokumura et al., 2017). Current study investigates the presence of selected OPFRs in interior dust collected from vehicles in Türkiye and evaluates the profiles according to model years before and after 2004.

Materials and Methods

Dust samples were collected from a total of 93 vehicles spanning model years from 1985 to 2022. Sampling was performed using a vacuum cleaner system equipped with glass fiber filters. The compounds analyzed included the isomers of Triethyl Phosphate (TEP), Tri-n-butyl Phosphate (TnBP), Tris(2-chloroethyl) Phosphate (TCEP), Tris(1-chloro-2-propyl) Phosphate (TCiPP1-2), Tris(1,3-dichloro-2-propyl) Phosphate (TDCiPP), Tris(2-butoxyethyl) Phosphate (TBOEP), Triphenyl Phosphate (TPHP), 2-Ethylhexyl Diphenyl Phosphate (EHDPP), Tris(2-ethylhexyl) Phosphate (TEHP), Tris(2-isopropylphenyl) Phosphate (T2iPPP). Ultrasonic extraction was done using 30 mL of acetone:hexane (1:1) mixture, followed by purification by solid-phase extraction (Agilent, bond elute mega BE-SI 5 mg 20 ml) and elution was done using 25 mL of hexane followed by 25 mL of acetone. Both fractions were combined, sample volume was reduced to 1 mL in iso-octane. Chemical analyses were performed using gas chromatography-mass spectrometry (GC-MS).

Results

The OPFR levels in vehicle interior dust samples varied over a wide range (0.9–5.47×10^5 ng/g) and showed high heterogeneity; mean values ranged from 13.1–3.56×10^4 ng/g. The most dominant compounds were TCEP, TDCiPP, TCiPP isomers, and TBOEP. In comparisons based on model year, significant increases ($p<0.05$) were detected for TDCiPP, TBOEP, TCEP, TPHP, TCiPP1-2, EHDPP, and TEHP in vehicles manufactured after 2004, while no significant difference was found for TEP, TnBP, and T2iPPP. Overall, average OPFR levels differed by a factor of 0.108–6.64 between vehicles produced before and after 2004, with a notably stronger upward trend observed in the post-2004 period.

Discussion and Conclusion

The findings indicate that OPFR compounds are prevalent and present in higher concentrations in vehicle interiors, with chlorinated species (TDCiPP, TCiPP, TCEP) being predominant, and that their use as flame retardants is quite widespread (Cequier et al., 2014). The high measured values reveal that vehicle interior microenvironments might act as a significant source of exposure pathway for humans, while the increase in vehicles after 2004 is thought to be due to the rise in OPFR use following the restrictions on brominated flame retardants. In conclusion, vehicle interiors represent a significant source of OPFR exposure, and given the potentially higher accumulation—particularly in newer vehicles—further detailed investigation into the environmental and health impacts of these compounds and their alternatives is warranted.

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POPs in Developing Countries

O. Okonkwo & K. Pozo Gallardo

D14-148 POPs in Free-Range Chicken Eggs from Rustavi, Georgia

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Introduction
Free-range chicken eggs are recognized as sensitive bioindicators of environmental contamination by persistent organic pollutants (POPs), particularly in areas affected by industrial and agricultural activities. Rustavi (Georgia) represents a potentially contaminated environment due to historical pesticide use and ongoing industrial emissions. This study assessed POP levels in eggs from Rustavi and Tazakendi and evaluated potential human exposure risks. It is based on a broader report published by Arnika in 2025.[1]

Materials and Methods
Pooled samples of free-range chicken eggs (2–5 eggs per sample) were collected from households in Rustavi and Tazakendi. Samples were homogenized and analyzed in accredited laboratories. Target analytes included PCDD/Fs, dioxin-like PCBs (dl-PCBs), indicator PCBs, organochlorine pesticides (DDTs, HCHs), and brominated flame retardants (PBDEs, HBCD). Analytical methods involved GC-HRMS, GC-MS/MS, and DR CALUX bioassays. Results were expressed on a lipid basis and compared with EU regulatory limits.

Results
Egg samples from Rustavi and Tazakendi showed elevated concentrations of several POP groups. PCDD/F levels ranged from 1.4 to 3.7 pg WHO-TEQ/g fat, while combined PCDD/F + dl-PCB concentrations reached up to 18.9 pg WHO-TEQ/g fat, exceeding the EU limit of 5 pg WHO-TEQ/g fat. Organochlorine pesticides were detected at high levels, with ∑DDT concentrations up to 7,120 ng/g fat. The p,p'-DDT/p,p'-DDE ratios approached or exceeded 0.5 in some samples, suggesting relatively recent inputs. HCH isomers were generally lower, although one sample showed elevated β-HCH. PBDE concentrations were mostly low, except for one sample with an extremely high level (1,231 ng/g fat), indicating a localized contamination source.[2]

Discussion and Conclusion
Comparison with other industrial and metallurgical hot spots in the region (Table 1) showed that ∑DDT concentrations in eggs from Rustavi and Tazakendi (15–7,226 ng/g fat) exceeded levels reported from Zenica in Bosnia and Herzegovina (4–341 ng/g fat) and Alaverdi in Armenia (78–599 ng/g fat). The upper range also exceeded concentrations measured in Arjut, Armenia (312–2,579 ng/g fat), a locality affected by obsolete pesticide contamination. Concentrations of six indicator PCB congeners (11–107 ng/g fat) were also higher than those reported from Zenica and Alaverdi. PCDD/Fs and dl-PCBs reached levels comparable to other metallurgical hot spots. Elevated DDT and PCB concentrations in soils from Rustavi and Tazakendi further support the presence of industrial and historical pesticide contamination, with ∑DDT levels reaching up to 235 ng/g dry matter (dm) in general soil samples and 1,087 ng/g dm in soils from children's playgrounds, while seven indicator PCBs reached up to 459 ng/g dm and 24.3 ng/g dm, respectively.[1]

Table 1: Comparison of concentrations of ∑DDT (ng/g fat), six indicator PCB congeners (ng/g fat), and PCDD/Fs/dl-PCBs (pg WHO-TEQ/g fat) in free-range chicken eggs from industrial hot spots. Sources: 1,3-5

POP chemicals	Rustavi and Tazakendi (Georgia)	Arjut (Armenia)	Zenica (Bosnia and Herzegovina	Alaverdi (Armenia)
∑DDT	15-7,226	312-2,579	4-341	78-599
6 indicator PCBs	11-107	37-48	2.3-13	8.3-16
PCDD/Fs/dlPCBs	6.7-36.7	18.9-35.4	3.95-8.7	5-40.1

The results indicate significant contamination of eggs from Rustavi and Tazakendi by POPs, particularly DDTs and dioxin-like compounds, raising concerns about dietary exposure of local populations, especially children.

POPs in Developing Countries

O. Okonkwo & K. Pozo Gallardo

D14-148 POPs in Free-Range Chicken Eggs from Rustavi, Georgia

Acknowledgment
Authors acknowledge financial support from the Transition Programme of the Czech Ministry of Foreign Affairs, and the Government of Sweden through IPEN.

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POPs in Developing Countries

O. Okonkwo & K. Pozo Gallardo

D14-412 Environmental and egg contamination by POPs in a waste-affected community: Arjut, Armenia

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Introduction
Burning of landfill sites and open waste burning are recognized sources of unintentionally produced persistent organic pollutants (UPOPs), including polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), and are listed as source categories in Annex C of the Stockholm Convention1. These compounds are characterized by persistence, bioaccumulation potential, and toxicity, and are formed during incomplete combustion of heterogeneous waste streams containing chlorinated and brominated materials2. Rural communities near unmanaged or overburdened landfills may face elevated exposure risks due to multiple pathways. This study investigates the occurrence and distribution of POPs in environmental matrices and free-range eggs from Arjut, a village in northern Armenia affected by long-term landfill-related pollution and open burning activities.

Materials and Methods
A total of nine samples were collected in Arjut (Armenia) in 2025, including five outdoor dust samples, two waste samples (cable burning residue and TV casing material), and two pooled free-range egg samples. Dust samples were analysed for indicator PCBs, organochlorine pesticides (OCPs: HCHs, DDTs), brominated flame retardants (PBDEs, HBCD, nBFRs), TBBPA, Dechlorane Plus (DP), PFAS, and chlorinated benzenes (PeCB, HCB, HCBD). Waste samples were analysed for PCBs, brominated flame retardants (PBDEs, HBCD, nBFRs), TBBPA and DP. PFAS, PCDD/Fs and dl-PCBs were determined in the TV casing waste sample, while selected chlorinated benzenes were determined in the cable burning residue. Egg samples were analysed for PCDD/Fs and dl-PCBs, indicator PCBs, OCPs (HCHs, DDTs), BFRs, chlorinated benzenes and UV stabilizers. PCBs, OCPs, chlorinated benzenes and DP were analysed by GC-MS/MS (EI), PBDEs and nBFRs by GC-MS (NICI), HBCD, TBBPA, PFAS and UV stabilizers by UHPLC-MS/MS, and PCDD/Fs and dl-PCBs by HRGC-HRMS, with results expressed as WHO-TEQ.

Results
Waste samples differed markedly. The cable burning residue (ARM-ARJ-W-1/25) contained high concentrations of brominated flame retardants (∑PBDEs up to 5,725 ng/g dm; ∑nBFRs up to 2,340 ng/g dm) and elevated PCB levels. The TV casing waste sample (ARM-ARJ-W-2/25) showed lower concentrations overall, but contained a combined PCDD/F and dl-PCB level of 24.1 pg WHO-TEQ/g. Dust samples showed heterogeneous contamination, with ∑7PCBs up to 4.115 ng/g dm and ∑DDT up to 8.822 ng/g dm. Egg samples showed the highest contamination. The sample collected further from the landfill contained extremely high concentrations of OCPs (∑HCH 195,170 ng/g fat; ∑DDT 2,579 ng/g fat) and elevated PCB levels. The second sample showed lower pesticide concentrations but detectable PCBs. Combined PCDD/F and dl-PCB reached 35.4 and 18.9 pg WHO-TEQ/g fat, exceeding the EU maximum level for eggs (5.0 pg WHO-TEQ/g fat)3 by approximately seven- and four-fold. PCDD/F levels in eggs ranged from 4.17 to 8.08 pg WHO-TEQ/g fat, exceeding the EU maximum level of 2.5 pg WHO-TEQ/g fat.

Discussion and Conclusion
The results indicate that open waste burning and inadequate landfill management are important sources of POPs. High concentrations of brominated flame retardants and elevated TEQ values indicate informal waste treatment as a key emission source. Elevated TEQ levels in eggs demonstrate transfer into the food chain and potential risks to human health. Differences between egg samples suggest that feed contributes to exposure, with higher pesticide concentrations observed in the sample associated with purchased feed. Overall, the findings highlight the combined role of local pollution sources and agricultural practices in shaping exposure patterns.

Acknowledgment
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POPs in Developing Countries

O. Okonkwo & K. Pozo Gallardo

D14-469 POPs and Mercury in Fish from Rustavi Area (Mtkvari River Basin)

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Introduction
Fish represent one of major pathways of human exposure to persistent organic pollutants (POPs) and mercury, particularly in industrially contaminated regions. The Mtkvari River and associated aquatic systems near Rustavi (Georgia) are affected by industrial discharges and legacy pollution. This study investigates POPs and mercury in fish species from the area and evaluates spatial and species-specific contamination patterns. The study is based on a broader report published by Arnika in 2025. 1

Materials and Methods
A total of 12 pooled fish samples representing seven species were collected from the Mtkvari River and a nearby lake. Fish were grouped by species, size, and location.
Fillet samples with skin were analyzed following standardized protocols. Target analytes included PCBs, DDTs, HCHs, pentachlorobenzene, hexachlorobenzene, hexachlorobutadiene, mercury, and other heavy metals. Chemical analyses were performed using GC-MS/MS and atomic spectrometry methods. Results were compared with EU food safety limits.

Results
All fish samples contained detectable levels of POPs. PCB concentrations reached up to 20.9 ng/g fresh weight, while ∑DDT concentrations ranged up to 86 ng/g fresh weight, exceeding or approaching the EU limit of 50 ng/g in several samples. Higher contamination levels were generally observed in fish collected downstream of wastewater discharge point.

Discussion and Conclusion
Compared with freshwater fish from other industrial regions (Table 1), fish from the Mtkvari River showed relatively high DDT concentrations, exceeding levels reported from the Nura River and Balkhash Lake in Kazakhstan. 2,3 PCB concentrations were lower than those reported from heavily industrialized sections of the Odra River in Czechia 4 and within the range observed in the Sava River in Serbia. 5 These findings indicate combined impacts of industrial pollution and both historical and current pesticide use in Rustavi.

Table 1: Comparison of concentrations of ∑DDT and six indicator PCB congeners (ng/g wet weight) in freshwater fish samples from industrialized regions.

POP chemicals	Mtkvari River (Georgia)	Odra River (Czechia)[4]	Sava River (Serbia)[5]	Nura RIver (Kazakhstan)[2]	Balkhash Lake (Kazakhstan)[3]
∑DDT	12.8-86	NA	NA	2.53-6.78	0.08-3.43
6 indicator PCBs	2.7-18	27-70	2.0-168	1.11-3.05	0.13-3.7

Mercury concentrations ranged from 0.013 to 0.187 mg/kg fresh weight, remaining below the EU limit of 0.5 mg/kg. However, higher concentrations were observed in predatory species such as wels catfish, indicating bioaccumulation. Other POPs, including HCB and HCH isomers, were detected at lower concentrations.
The findings confirm widespread contamination of fish in the study area with both legacy POPs and mercury. Spatial patterns suggest that wastewater treatment plant effluents may contribute to contamination hotspots in the Mtkvari River. Although mercury levels remained below regulatory thresholds, trophic transfer in predatory fish may represent a long-term exposure risk.
The combined presence of POPs and mercury raises concerns regarding cumulative dietary exposure for local communities and highlights the need for regular monitoring and measures to reduce pollutant releases from metallurgical industry.

POPs in Developing Countries

O. Okonkwo & K. Pozo Gallardo

D14-469 POPs and Mercury in Fish from Rustavi Area (Mtkvari River Basin)

Acknowledgment

Authors acknowledge financial support from the Transition Programme of the Czech Ministry of Foreign Affairs, the Sigrid Rausing Trust, the Global Greengrants Fund, and the Government of Sweden through IPEN.

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Ecotoxicology

E. Benfenati & B. Jiménez

D15-785 Comparing polychlorinated n-alkane occurrence with other contaminants in a killer whale food web - contribution to effects on killer whale steroid hormones in low and high tourism seasons

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Introduction

Long lived apex predators such as killer whales (Orcinus orca) are exposed to multiple stressors throughout their lifetime, environmental pollutants being one of these, exceeding thresholds of negative effects for legacy contaminants such as PCBs (Andvik et al., 2021; Desforges et al., 2018). Of replacement chemicals for regulated chemicals, polychlorinated n- alkanes (PCAs) are the largest component of the commercial product chlorinated paraffins, and have been used globally in increasing amounts. Food web biomagnification potential of PCAs compared to legacy contaminants is still inconclusive, with limited data for PCAs with carbon chain length ≤ 9 and ≥ 18. Killer whales are increasingly popular for whale-watching tourism, without knowing how this affects the whales stress, as indicated by steroid hormones that can also be affected by contaminant load (Galligan et al., 2019).

Materials and Methods

In biopsies of killer whales from northern Norway, we analysed organic contaminants and steroid hormones in the blubber, and dietary markers (stable isotopes) in the skin. In addition, tissue from a range of fish and marine mammal species from the same coastal marine food web were analysed and compared for PCAs of different carbon chain length (very-short: PCAsC6-9 [vSCCPs], short: PCAsC10-13 [SCCPs], medium: PCAsC14-17 [MCCPs], and long: PCAsC18- 24 [LCCPs]), 57 legacy chlorinated or brominated contaminants such as PCB, DDT, Chlordanes, PBDE, and new brominated flame retardants. For killer whales, the periods of COVID-19 travel restrictions were used as a contrast to high whale-watching tourism seasons, and various steroid hormones were measured in the biopsies (Dulgheriua et al., 2026).

Results

Legacy organic contaminants dominated the occurrence in marine mammals (54–87%), whereas PCAs dominated in fishes (58–98%). Poikilotherm and homeotherms had similar and low trophic magnification factors (TMFs) of shorter chained PCAsC6-9, PCAsC10-13, and PCB-28 with a TMFs range 1.9-2.4. For PCAsC14-17 and PCAsC18-24, the TMFs were high in poikilotherms (4.8 and 4.6, respectively) and no significant trophic magnification in homeotherms (1.0 [0.5–2.3] and 1.0 [0.4–2.8], respectively). For contaminants with known high biomagnification potential such as PCB-153 and p,p'DDE, the TMFs of 5.7 and 5.3, respectively in homeotherms were comparable to the mid and long carbon chain length PCAs TMFs in poikilotherms. However, both PCB-153 and p,p'-DDE had non-significant food web magnification in poikilotherms (TMF 0.67 [0.1–3-1] and 1.9 [0.9–3.9], respectively. Killer whales had higher steroid hormone levels during periods of high whale watching activity after accounting for inter-individual variation. Cortisol levels increased with pollutant levels in males, as well as a subtle but significant synergistic effect with whale watching activity, and an apparent antagonistic effect of nutritional status. Reproductive steroid hormone levels decreased with increasing PCA levels, indicating adrenal effects. We demonstrate the urgent need to understand effects of multiple stressors in marine mammals and other wildlife

Discussion and Conclusion

The physiological group of a species (homeotherm or poikilotherm) influenced the food web magnification of several contaminants, and neglecting to identify this would underestimate PCAs TMFs and overestimate TMFs for legacy contaminants such as PCB-153 and p,p'-DDE if unaccounted for. Our results indicate higher PCA concentrations and biomagnification potential in poikilotherms than homeotherms, which is likely due to fishes lower biotransformation and elimination ability. The steroid hormones were higher in periods of high tourism activity and increased with pollutant levels in males.

Acknowledgment

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Ecotoxicology

E. Benfenati & B. Jiménez

D15-895 2,3,7,8-TCDD induced immunotoxicity and disrupted alternative splicing networks in THP-1-derived macrophages

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Introduction
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) is a persistent environmental contaminant with well-known immunosuppressive effects, yet the detailed molecular mechanisms, particularly those beyond the aryl hydrocarbon receptor (AhR), remain incompletely understood.

Materials and Methods
Using human THP-1-derived macrophages as an in vitro model, we investigated TCDD-induced immunotoxicity across a range of concentrations (1–50 nM, including environmentally relevant levels). RNA-sequencing coupled with weighted gene co-expression network analysis (WGCNA) was performed. For alternative splicing analysis, six human cell lines (liver, skin, reproductive, and immune origins) were exposed to 0.1–10 nM TCDD, and AS events were identified using rMATS.

Results
A battery of high-throughput assays revealed that TCDD significantly reduced cell adhesion and the expression of adhesion molecules (ICAM-1, VCAM-1, CD11b), decreased the number of pseudopodia and F-actin content, and altered the secretion of multiple cytokines/chemokines. Notably, TCDD promoted a pro-inflammatory state by up-regulating TNF-α and down-regulating IL-10, while also disrupting chemokines involved in granulocyte and T-cell regulation (e.g., MIP-1b, IL-8, G-CSF, IL-2, IL-7). RNA-sequencing coupled with WGCNA identified ten hub genes (TNF, SRC, FGF2, PTGS2, CDH2, GNG11, BDNF, WNT5A, CXCR5, RUNX2) that correlated strongly with the observed immune phenotypes. AhR was not among the top hub genes, suggesting the involvement of alternative pathways. While analyzing the transcriptomic data from the above THP-1 macrophage experiments, we unexpectedly observed that TCDD markedly suppressed alternative splicing events, a regulatory layer not previously linked to its immunotoxicity. This finding prompted us to systematically investigate AS changes across six human cell lines. At 0.1–10 nM TCDD, all five AS event types (especially skipped exon and mutually exclusive exon) were significantly suppressed, leading to reduced transcript diversity. Among the six lines, THP-1 cells showed the highest sensitivity, with marked inhibition of AS events and decreased average transcript isoforms per gene. Mechanistically, TCDD altered the expression and splicing patterns of multiple splicing factors, particularly hnRNP family members (e.g., HNRNPA2B1, HNRNPH1), and disrupted spliceosome components (DDX5, EFTUD2, PUF60, RBM25, SRSF1) in a cell-type-specific manner. Overlapping differentially alternatively spliced genes across all six cell types were enriched in immune-related pathways, including NOD-like receptor signaling and glyoxylate/dicarboxylate metabolism.

Discussion and Conclusion
Collectively, our findings demonstrate that environmentally relevant TCDD concentrations impair macrophage immune functions (adhesion, morphology, cytokine secretion) and globally suppress alternative splicing, with THP-1 macrophages being particularly vulnerable. These results expand the mechanistic understanding of TCDD immunotoxicity beyond classical AhR signaling and highlight alternative splicing disruption as a novel, sensitive endpoint for dioxin risk assessment.

Acknowledgment
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Ecotoxicology

E. Benfenati & B. Jiménez

D15-385 Body condition, contaminants, and mortality: A comparative study of at-risk St. Lawrence Estuary belugas and Northwest Atlantic harbour porpoises

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Introduction

Marine mammals in the Estuary and Gulf of St. Lawrence (Canada) face cumulative stressors, including chronic contaminant exposure. The St. Lawrence Estuary (SLE) beluga is a long-lived, resident population with extensive blubber reserves, while the Northwest Atlantic (NWA) harbour porpoise is a seasonal visitor in the SLE that has a high metabolic rate with minimal lipid storage. In 2022, summering porpoise strandings in the SLE spiked by 399% above average, primarily due to emaciation. Elevated contaminant exposure has been hypothesized as a primary factor in the SLE beluga population's lack of recovery, potentially contributing to severe systemic pathologies, which historically included high rates of cancer, and, more recently, infectious diseases as well as gestation- or parturition-related complications (Lair et al., 2016). Contaminants determined at occasionally high levels in SLE belugas include the halogenated flame retardants (HFRs), per- and polyfluoroalkyl substances (PFAS) and trace elements, which were reported to perturb energetic metabolism and accelerate the depletion of lipid reserves in marine mammals (Bernier-Graveline et al., 2021). However, very limited information is known for the NWA harbour porpoise.
The objective of this study was to comparatively investigate the associations between tissue (blubber or liver) HFR, PFAS and trace element levels, body condition (using the scaled mass index, SMI), and causes of mortality in SLE beluga and NWA harbour porpoise carcasses.

Materials and Methods

We analyzed a comprehensive suite of HFRs (34 PBDE congeners and 14 other HFRs) by GC/MS-ECNI, PFAS (33 compounds) by UHPLC-HRMS, and trace elements (49) by ICP-MS/MS in blubber or liver of 46 SLE beluga and 25 NWA harbour porpoise carcasses recovered between 2016 and 2024 in the SLE.

Results

Results revealed distinct carcass contaminant profiles; SLE belugas were characterized by higher blubber HFR and liver PFAS concentrations, while NWA harbour porpoises were dominated by trace elements. The SMI of SLE belugas declined with increasing liver PFAS and total mercury (THg) concentrations, and over the study period. In NWA harbour porpoises, lower SMI was primarily driven by age (calves) and liver THg concentrations. We identified a significant temporal increase in liver THg levels specifically within the calf cohort over the study period. Mortality caused by infectious disease in NWA harbour porpoises clustered with higher liver THg, Se, and Zn concentrations. In SLE belugas, the highest liver PFAS levels were found in calves, all of which died of parturition-related complications.

Discussion and Conclusion

This study provides a critical comparative assessment of two at-risk cetaceans by exploring the associations between body condition (SMI), contaminant exposure, and mortality. Despite the divergent species-specific contaminant profiles, higher liver THg emerged as a consistent predictor of lower SMI across both species, alongside a specific association with liver PFAS in the SLE beluga, suggesting that contaminant exposure may contribute to declining body condition. Furthermore, we highlighted a shifting St. Lawrence chemical landscape: while legacy HFRs (PBDEs) and selected PFAS precursors (FTCAs) in SLE belugas are declining following industry phase-out and/or regulations, the linear increase of THg in liver and non-PBDE HFRs in blubber of NWA harbour porpoise calves signals heightened toxicological risks in critical early-life stages.

Acknowledgment

This work was primarily supported by the Fisheries and Oceans Canada's Canada Nature Fund for Aquatic Species at Risk (CNFASAR) program.

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Ecotoxicology

E. Benfenati & B. Jiménez

D15-930 Prenatal exposure to legacy and emerging PFAS in a stranded Cuvier's beaked whale (Ziphius cavirostris)

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Introduction

The Cuvier's beaked whale (Ziphius cavirostris G. Cuvier, 1823) is the only beaked whale commonly found in the Mediterranean Sea and inhabits deep offshore waters, making it particularly difficult to study. This species is listed as Data Deficient (DD) on the IUCN Red List due to its elusive, deep-diving nature, making population estimates challenging (1). As a long-lived apex predator, it is highly susceptible to the bioaccumulation of persistent contaminants such per- and polyfluoroalkyl substances (PFAS), a class of emerging pollutants of growing concern due to their persistence and toxicity. In December 2025, an adult pregnant female specimen of Ziphius stranded along the Southern Tyrrhenian coast of Italy (FAO marine area 37.1.3) was subjected to necropsy.

Materials and Methods

Samples of liver, muscle, and kidney from both the adult and fetus, and blubber from the adult, were analysed for PFAS. Samples were extracted and purified using established procedures and analysed in LC-HRMS, under target and suspect screening approaches for C4-C18 PFCAs, C4-C12 PFSAs, Cl-PFECAs as perfluoropolyether carboxylates, also known as ADV or Mono Functional Surfactants and their degradation products H-PFECAs, Fomblin® Bi-Functional Surfactants (BFS), N-MeFOSAA, 9Cl-PF3ONS,11Cl-PF3OudS, GenX, ADONA, and C604. Limit of quantification ranged from 10 to 50 ng/kg fresh weight for the considered analytes (2).

Results

Generally, measured PFAS showed higher total concentrations in fetal tissues than those recorded in adult (Fig.1). On fresh weight, in liver ∑PFAS reached 192.7 ng/kg in the fetus and 114.3 ng/kg in the adult; in kidney, 122.2 ng/kg (fetus) and 60.1 ng/kg (adult); and in muscle, 69.2 ng/kg (fetus) and 9.3 ng/kg (adult), respectively. In blubber, ∑PFAS concentration was 8.7 ng/kg. Both legacy and emerging PFAS were detected in all samples. PFNA was the predominant compound in most tissues, whereas PFOS was the main PFAS in blubber. PFOA as already known, showed a better transfer rate to foetus than PFOS and other PFAS (Fig.1) (3).

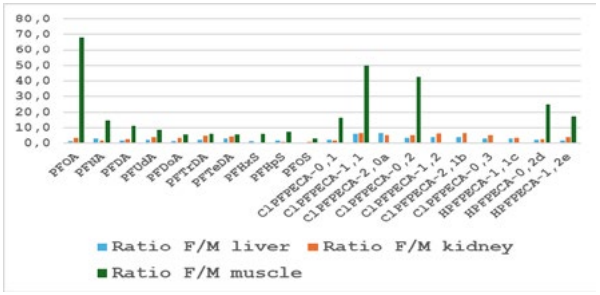


Fig 1. Foetus vs Mother selected PFAS concentration ratio in liver, kidney and muscle, respectively.

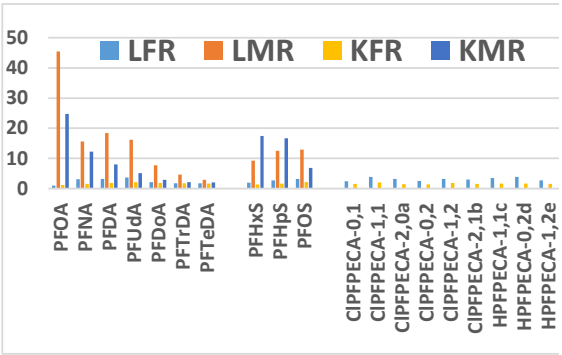


Fig. 2. Muscle-to-Liver (L) and to-Kidney (K) in Foetus (F) and Mother (M) Ratio (R) of selected PFAS.

Discussion and Conclusion

Notably, we could evaluate in a mammalian species the prenatal exposure to Cl-PFECAs, a data missed in the available toxicological file for ADV authorization as fluoropolymerisation aid (4). Taking muscle PFAS concentration as proxy of those present in the blood, it seems the foetal liver and kidney immaturity prevents a higher bioaccumulation of PFAS in such organs, as seen in the mother (Fig.2). PFAS profile is consistent with that recorded in Ziphius preys, such as squids and cephalopods of the Mediterranean Sea (5). These preliminary prenatal evidences integrate PFAS perinatal intake assessment in marine mammals (6), and stress the relevance of observational study in supporting New Approach Methodologies to assess PFAS prenatal exposure in mammals.

Ecotoxicology

E. Benfenati & B. Jiménez

D15-930 Prenatal exposure to legacy and emerging PFAS in a stranded Cuvier's beaked whale (Ziphius cavirostris)

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Non-Polar POPs: Advanced Analytical Workflows

C. Carrer & H. Fiedler

D16-421 The untargeted characterization of lake sediment using enhanced chromatography and high-resolution time-of-flight mass spectrometry

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Introduction
Hamilton Harbour, located at the western end of Lake Ontario, has been designated an Area of Concern since 1985 because of extensive sediment contamination by heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and other industrial pollutants. This contamination has contributed to degraded water quality, declines in fish and wildlife populations, and loss of wetland habitat. Exposure to these contaminants may also cause deformities and reproductive impairment in aquatic organisms and pose potential risks to human health. To address these concerns, the Hamilton Harbour Remedial Action Plan initiated construction of an engineered containment facility in 2015 to isolate the most highly contaminated sediments and treat associated contaminated water; project completion is anticipated in 2027.
In this study, comprehensive two-dimensional gas chromatography coupled with high-resolution time-of-flight mass spectrometry, and a Multi-Mode Source (MMS) was applied to characterize Hamilton Harbour sediments. The analytical approach targeted known contaminants, including PCBs and PAHs, while also enabling nontargeted screening for additional classes of persistent organic pollutants through advanced data processing and spectral interpretation.

Materials and Methods
Sediment samples were collected in duplicate from Hamilton Harbour in 2014, 2017, and 2018. Samples were extracted by accelerated solvent extraction (ASE) using dichloromethane:ethyl acetate, followed by cleanup with silica/alumina and copper.
The sediment samples and a standard mixture containing 120 polycyclic aromatic compounds were analyzed using comprehensive two-dimensional gas chromatography coupled with high-resolution-time-of-flight mass spectrometry. The mass spectrometer was equipped with next generation multi-mode source that enabled the acquisition of complementary electron ionization, positive chemical ionization, and negative chemical ionization high-resolution accurate mass data. Data were processed using untargeted peak-finding with deconvolution, database searches, and formula determinations for fragment, molecular, and adduct ions. Restrospective analysis of the data for trace components was carried out using spectral analysis tools and targeted analyte finding.

Results
The combination of enhanced chromatographic separation and high-resolution mass spectrometry significantly increased the number of annotated pollutants. Non-targeted data processing facilitated the characterization of multiple hazardous chemical classes, including phenols, polycyclic aromatic compounds, polychlorinated biphenyls, heteroatom-containing polycyclic aromatics (oxygen , nitrogen , and sulfur substituted), chlorinated and brominated phenols, and linear alkyl benzenes. Compound annotation integrated spectral library searching with elemental formula assignment based on high-resolution, accurate mass measurements of fragment, molecular, and adduct ions (average mass accuracy ≤ 1 ppm; isotopic fidelity scores > 900/1000). Retention index filtering and the integration of soft ionization with electron ionization spectra improved confidence in compound annotations. Combining spectral analysis tools and target analyte finding increased the total number of pollutants characterized in the sediment.

Discussion and Conclusion
The analytical methodology enabled confident annotation of multiple classes of both legacy and emerging pollutants in complex sediment matrices. Legacy pollutants were detected at trace levels, requiring the enhanced sensitivity of negative chemical ionization in combination with high-resolution time-of-flight mass spectrometry for reliable characterization. Overall, the integration of multi-modal ionization techniques with high-resolution detection provides a robust and comprehensive framework for the untargeted analysis of diverse contaminant classes in complex environmental samples.

Non-Polar POPs: Advanced Analytical Workflows

C. Carrer & H. Fiedler

D16-553 Is GC-MS/MS ready for monitoring of PCDD/F and PCBs in food and feed, given the prospect of lower regulatory limits (future TEFs' implementation)?

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Introduction

Gas chromatograph coupled to high-resolution mass spectrometer based on an electromagnetic field and electron ionisation, i.e. GC-(EI)-HRMS, has long been considered the reference technique for dioxins and PCBs analysis. Its high resolving power enables efficient separation of isomers, while the mass defect of halogenated compounds provides a high level of specificity. This combination allows accurate quantification at the lowest regulatory levels even in highly complex samples such as food and feed. However, GC-HRMS systems need higher resources than routine triple quadrupole benchtop GC-MS/MS systems. They require highly skilled operators for calibration and maintenance as well as substantial energy consumption due to the use of a magnet and ultrahigh vacuum. Moreover, support from several instrument providers is gradually being discontinued. The introduction of GC-MS/MS into European regulation in 2014 for dioxins and PCB official control (Commission Regulation (EU) 2014/589 repealed by Commission Regulation (EU) 2017/644), encourages laboratories to explore alternative approaches to replace these legacy systems. Over the past decade, significant advancements have been achieved in mass spectrometry from ionisation sources to detection technologies. These developments now support the perspective of meeting even more stringent future regulatory limits using GC-MS/MS systems.

Materials and Methods

In this study, we considered the assessment of two different GC-MS/MS systems using either electron ionisation (EI) or atmospheric pression chemical ionisation (APCI) to cover the two main benchtop solutions currently available on the market. EI was selected which is comparable to that used in GC-HRMS. In this case, method development mainly consisted of optimizing and selecting appropriate transitions, with ion ratios differing between isomers due to variations in chlorine substitution patterns affecting the product ions. By contrast, APCI provides a softer ionization process, favouring the preservation of the M+. molecular ion which typically appears as the predominant and often unique ion under dry conditions. Therefore, APCI offers enhanced sensitivity in MS/MS mode, with M+. ion serving as both the most informative and intense precursor ion.

Discussion and Conclusion

The aim of our study was to determine the suitability of both GC-MS/MS systems for Dioxin and PCB determination in official control. Indeed, the analytical performances listed into the 2017/771 EU regulation must first be fulfilled on several regulated food and feed matrices. Then, there remains the question of the robustness of this GC-MS/MS devices compared to GC-HRMS systems, particularly when used for various food and feed monitoring activities. A wide range of samples was analysed in parallel using both GC-MS/MS and GC-HRMS systems. These included fat from pork, bovine and sheep species, poultry muscle, eggs, seafood and milk samples, but also feed supplement samples and environmental samples such as grass and soil samples. The quality controls were consistently monitored and confirmed the good suitability of both systems, demonstrating satisfactory performances even after several weeks without any maintenance of the MS source. However, our observation indicate that these instruments should be preferably dedicated to POPs analysis and operated under stable and consistent GC-MS conditions ensuring their robustness. Overall, the results obtained suggest that future, more stringent regulatory limits could be achieved and reliably controlled using such GC-MS/MS instrumentations in the coming years.

References

Commission Regulation (EU) 2017/644 of 5 April 2017 laying down methods of sampling and analysis for the control of levels of dioxins, dioxin-like PCBs and non-dioxin-like PCBs in certain foodstuffs and repealing Regulation (EU) No 589/2014.
Commission Regulation (EU) 2017/771 of 3 May 2017 amending Regulation (EC) No 152/2009 as regards the methods for the determination of the levels of dioxins and polychlorinated biphenyls.

Non-Polar POPs: Advanced Analytical Workflows

C. Carrer & H. Fiedler

D16-362 Simultaneous analysis of dioxins and semi-volatile POPs by APGC-MS/MS using nitrogen carrier gas

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Introduction

Atmospheric pressure gas chromatography (APGC) is a soft ionisation technique operated under atmospheric pressure that can maintain high sensitivity even when nitrogen is used as the carrier gas. We previously demonstrated that APGC coupled with tandem quadrupole mass spectrometry (APGC-MS/MS) enables the sensitive analysis of dioxins while separating toxic equivalency factor (TEF)-assigned isomers under nitrogen carrier gas conditions1, 2). Owing to the recent instability in helium supply, this method may provide an alternative approach for stable environmental monitoring of dioxins.

In addition to dioxins, numerous persistent organic pollutants (POPs) pose environmental risks. Simultaneous analysis of dioxins and semi-volatile POPs without compromising dioxin separation and sensitivity would improve the efficiency of environmental monitoring. This study investigated the applicability of APGC-MS/MS using nitrogen carrier gas (N_2-APGC-MS/MS) for the simultaneous analysis of dioxins and semi-volatile POPs, and evaluated its quantitative performance.

Materials and Methods

An APGC source coupled with a Xevo TQ Absolute (Waters) and an 8890 GC system (Agilent) was used. Separation was performed using an Rxi-5Sil MS column (40 m × 0.18 mm, 0.18 µm film thickness). Nitrogen (>99.9999%) was used as the carrier gas at a flow rate of 0.32 mL/min. The GC conditions were optimized to separate 23 of the 29 TEF-assigned dioxin congeners while allowing the elution of high-boiling compounds such as Dechlorane Plus. Selected reaction monitoring (SRM) mode was used for analysis.

A total of 51 persistent organic pollutants (POPs), including 28 organochlorine pesticides, 3 toxaphene congeners, 8 polychlorinated naphthalenes (PCNs), pentachlorobenzene, pentachlorophenol, 7 polybrominated diphenyl ethers (PBDEs), anti- and syn-Dechlorane Plus, and UV-328, were evaluated. Standard solutions were analyzed to evaluate the chromatographic behavior of the target compounds and the applicability of the method. Calibration curves were prepared for analyzable compounds at concentrations ranging from 0.02 to 100 pg/µL. Instrumental detection limits (IDLs) were estimated from the standard deviation of eight replicate measurements near S/N = 10.

Results

Of the 51 target compounds, 38 were successfully analyzed under the analytical conditions used. Severe peak tailing or split peaks were observed for chlordecone, dicofol, and PBDEs, suggesting thermal decomposition during GC analysis. Pentachlorobenzene, PCN-2, and PCN-13 were not sufficiently separated from the nonane solvent peak. Due to its polar hydroxyl group, pentachlorophenol exhibited extreme peak tailing and was considered unsuitable for analysis under the GC conditions. Good linearity was obtained for the 38 analytes, with correlation coefficients (r^2) greater than 0.995. The IDLs ranged from 0.003 pg for trans-chlordane to 0.4 pg for Palar 26. These results indicate that the method has practical sensitivity for these compounds. Furthermore, 23 of the 29 TEF-assigned dioxin congeners, including 2,3,7,8-TCDD and 2,3,7,8-TCDF isomers, were successfully separated and simultaneously analyzed.

Discussion and Conclusion

The results demonstrated that semi-volatile and thermally stable POPs can be simultaneously analyzed with dioxins using N2-APGC-MS/MS. Although only selected congeners of toxaphenes and PCNs were evaluated in this study, the method may also be applicable to additional congeners.

Acknowledgment

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Non-Polar POPs: Advanced Analytical Workflows

C. Carrer & H. Fiedler

D16-352 Developing a low-contamination method for the determination of cyclic volatile methylsiloxanes in air

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Introduction

Cyclic volatile methylsiloxanes (cVMS), specifically octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dodecamethylcyclohexasiloxane (D6), are high-production-volume chemicals widely used in industrial applications and personal care products [1,2]. Due to their persistence and potential for long-range transport, they have recently faced increasing regulatory restrictions [3]. However, assessing their environmental fate remains an analytical challenge. The atmosphere is a critical matrix for understanding their distribution, but monitoring is severely hampered by high risks of background contamination from laboratory materials and operators [4]. Therefore, developing ultra-low-contamination protocols is essential to distinguish true environmental signals from artifacts, especially in remote regions.

Materials and Methods

The primary scope was to develop and validate a robust analytical method for monitoring cVMS in air while minimizing sample handling and external contamination. Analytical steps were systematically optimized to identify the ideal sampling support, adsorbent, and elution conditions under rigorous blank control protocols. The method was deployed across a gradient of potential contamination levels: indoor environments (including specialized clean-room facilities for organic trace analysis and standard laboratories), private residences during routine activities, and outdoor settings. These outdoor measurements included both urban atmospheres and remote alpine sites. This comparative approach allowed for the assessment of method performance and the identification of critical contamination sources during air sampling.

Results

The optimized method yielded recoveries of 77–87% and trueness of 95–99%. When applied to field samples, the highest cVMS concentrations were detected in indoor environments, specifically private residences (D4: 122–1420 ng/m^3; D5: 632–62400 ng/m^3; D6: 38–469 ng/m^3). Notably, cVMS levels in specialized clean-rooms (D4: 1.8–30 ng/m^3; D5: 0.38–54 ng/m^3; D6: 0.47–12 ng/m^3) were significantly lower and comparable to those measured in outdoor urban air (D4: 4.7–69 ng/m^3; D5: 6.6–59 ng/m^3; D6: 1.0–25 ng/m^3). Blank elutions from remote areas showed lower absolute amounts (D4: 0.92 ± 0.06 ng D5: 0.94 ± 0.05 ng, D6: 0.29 ± 0.06 ng) compared to laboratory fume hoods (D4: 1.3 ± 0.7 ng; D5: 2.1 ± 1.0 ng; D6: 1.5 ± 0.8 ng). In remote outdoor samples, concentrations were generally close to detection limits: D6 remained below the LOD, while D4 was occasionally detected above the LOD but below the LOQ. In contrast, D5 was more frequently quantified above the LOQ, reaching a maximum concentration of 0.21 ng/m^3.

Discussion and Conclusion

The results indicate that indoor environments could be a primary source of cVMS contamination, likely due to the ubiquity of silicone-containing materials and the presence of operators. This study highlights the fundamental importance of low-contamination sampling strategies for the accurate determination of cVMS in air. Such protocols are particularly essential for outdoor settings and remote areas, where concentrations are generally closed to detection limits and highly susceptible to external interference

Acknowledgment

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Non-Polar POPs: Advanced Analytical Workflows

C. Carrer & H. Fiedler

D16-694 Multi-Solvent Compatible Automated Cleanup and Direct-to-GC Vial Workflow for Low Background POPs Analysis

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Introduction

Trace analysis of Persistent Organic Pollutants (POPs) including PCDD/Fs and PCBs requires extensive cleanup prior to GC/MS analysis because of complex sample matrices and ultra-trace analytical requirements. Modern laboratories continue to seek workflow improvements that reduce contamination risk, minimize sample handling, and simplify integration between extraction, cleanup, concentration, and final analysis. Many laboratories utilize Soxhlet, PLE/ASE, and other extraction techniques using toluene, hexane, or mixed solvents. Traditional cleanup procedures often require solvent exchange prior to cleanup, increasing analyst handling and contamination opportunities.

Materials and Methods

The automated workflow consists of a six-channel multi-pump combined with a parallel sample processing workstation accommodating six cleanup positions. The system performs automated cleanup, fraction collection, and integrated concentration within a compact low-background architecture. Certified pre-packaged acidic silica, alumina, and optional carbon columns were used depending on application requirements and sample matrices. A key feature of the workflow is compatibility with multiple extraction solvent systems including toluene, hexane, and mixed solvent extracts. Elimination of solvent exchange at the beginning and direct transfer to the concentration system where extracts are evaporated directly into GC vials greatly reduces contamination opportunities and minimizes sample handling prior to GC/MS analysis.

Results

Excellent isotope dilution recoveries were obtained for both PCDD/Fs and PCBs across multiple sample matrices and solvent systems. Reproducible recoveries were observed for both toluene and hexane-based extracts. Method blanks demonstrated very low native background contamination levels. Direct-to-vial concentration reduced extract handling while maintaining excellent analytical sensitivity and reproducibility.

Discussion and Conclusion

The workflow provides laboratories with increased operational flexibility by allowing direct integration of multiple extraction procedures without extensive workflow modification or manual solvent exchange steps. The combination of closed-system cleanup, certified low-background consumables, elimination of solvent exchange, and direct-to-GC vial concentration contributes to low background interference and highly reproducible analytical performance. The integrated automated cleanup and direct-to-GC vial concentration workflow provides a flexible and efficient approach for modern high throughput POPs analysis.

Fate and Transport 1

P. Kurt-Karakus & K. Pozo Gallardo

D17-003 Elucidating biomagnification of persistent organohalogen contaminants in a tropical marine ecosystem using fatty acid and amino acid isotope profiling

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Introduction

Improving our understanding of trophic transfer of organic contaminants is essential for determining their fate in marine ecosystems. Bulk stable isotope approaches (e.g., $\delta^{15}N$ and $\delta^{13}C$ values) have been widely used to estimate trophic positions, despite the uncertainty they bring due to baseline variability in isotope signatures. Alternatively, compound-specific stable isotope analysis of amino acids (CSIA-AA) and fatty acid (FA) profiling have been revealed as powerful tools to determine accurate trophic positions and food web structures (Tao et al., 2019 ; Jiang et al., 2023). In this study, both trophic tracers (CSIA-AA and FA profiles) were used to investigate the biomagnification of selected legacy persistent organic pollutants -POPs (e.g. polychlorinated biphenyls -PCBs, organochlorinated pesticides and polybrominated diphenyl ethers -PBDEs) and contaminants of emerging concern -CECs in fishes of various habitats and trophic levels in a tropical ecosystem around Martinique island, a French outermost territory part of the lesser Antilles.

Materials and Methods

Fishes were collected from local fishermen in 2024 and 2025. They included two coral reef fish species (the doctorfish Acanthurus chirurgus and the redtail parrotfish Sparisoma chrysopterum), the great barracuda Sphyraena barracuda, and four pelagic fish species, namely, the blackfin tuna Thunnus atlanticus, the common dolphinfish Coryphaena hippurus, the yellowfin tuna Thunnus albacares and the blue marlin Makaira nigricans.

Fish total lengths were measured, and muscle samples were transported frozen to the analytical laboratory and processed according to previously-reported methods (Munschy et al., 2020). CSIA-AA and FA analyses were conducted according to Tea et al., 2013 and Sardenne et al., 2020, respectively.

Results

Legacy POPs, and PCBs in particular, showed higher contamination levels than CECs, with median values of 15.4, 5.81, 1.64, 1.11 and 2.37 ng g-1 lw for ∑ 7PCBs, DDTs, mirex, dieldrine and ∑ 7PBDEs respectively. Median concentrations of dechlorane-related compounds and alternative brominated flame retardants were one order of magnitude below, with 0.39 and 0.17 ng g-1 lw, respectively. The highest levels were determined in the blue marlin for all contaminant families. In doctorfish, dieldrin was the second most prevalent contaminant, while this pesticide did not protrude in any other species. In this species, PCB profiles were dominated by the lower-chlorinated congeners.

FA profiles were found to be discriminative towards i) pelagic and reef species, and ii) the two reef species. $\delta^{15}N$ values of phenylalanine and glutamic acid also differed among reef species.

Discussion and Conclusion

The results bring evidence of the occurrence of both major POP groups and CECs in reef and pelagic species from a tropical ecosystem around Martinique island. Interspecific differences in POP and CEC concentrations and profiles were explained by habitat (reef versus pelagic), feeding habit and trophic group (herbivores versus carnivores). FA profiling and CSIA-AA supported the interpretation of several food sources and habitats sustaining the studied species, and definitely improved the determination of trophic levels in comparison to the routinely used bulk stable isotope analysis.

Acknowledgment

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Fate and Transport 1

P. Kurt-Karakus & K. Pozo Gallardo

D17-026 The occurrence and transformation of persistent organic pollutants in factory soil and farmland soil

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Introduction

Persistent organic pollutants (POPs) had environmental persistence, bioaccumulation, long-distance migration, and high toxicity[1]. The contamination of POPs in soil, such as organochlorine pesticides, polybrominated diphenyl ethers, halogenated hydrocarbons, and polycyclic aromatic hydrocarbons, has received increasing attention. This study selected the soil from a chlorinated paraffins (CPs) factory in Shandong, China, and the surrounding farmland soil as the research objects. Through the targeted and non-targeted screening techniques, the levels of CPs and chlorinated paraffin structural analogues (CPSAs) in the soil were identified.

Results

The results showed that the CPs content in the factory soil and the surrounding farmland soil was 9.91-15.57 ng/g d.w. and 7.22-509 ng/g d.w., respectively. CPSAs were all hydroxylation CPs in the farmland soil, while were more diverse in the factory soil, including chloroalkene, hydroxylation, sulfation, acetylation, and amination CPs. The relative abundances of those CPSAs were greater in the factory soil than in the farmland soil. The screened CPSAs were mostly the transformation products of CPs in the soil. And microbial communities were important factors affecting the occurrence and transformation of POPs in soil[2]. By analyzing the diversity of microbial community in soil samples, it was found that Aspergillus, Amauroascus, Alternaria, Sphingomonas, Mycobacterium and Pseudonocardia were relatively abundant in the factory soil, and these fungi and bacteria have been reported to degrade organochlorine in the environment through oxidation and water dehalogenation by P450 and halogenation alkane dehalogenase (HLD). In the farmland soil, the colony contents of Agromyces, Nocardioides and Giaella, which were related to plant metabolism, were higher than in the factory soil. It was indicated that microorganisms were the important factor influencing the environmental transformation behavior of POPs in the soil. At the same time, POPs also inhibited the existence of certain specific microbial communities in the soil.

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Fate and Transport 1

P. Kurt-Karakus & K. Pozo Gallardo

D17-054 Fate and Distribution of PFAS in the Rhône River: An Integrated Targeted and Non-Targeted HRMS Study

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Introduction

Per- and polyfluoroalkyl substances (PFAS) represent a massive analytical challenge, with over 7 million entries listed in PubChem. In the Rhône River valley (France), intense industrial activities, including major fluoropolymer production,have led to significant environmental contamination and a national-scale crisis. While local authorities initiated monitoring in 2022, current programs focus on only 22 compounds. This restricted scope likely underestimates the true chemical burden, as many emerging substances and transformation products remain unidentified. In this context, advanced non-targeted screening (NTS) based on high-resolution mass spectrometry (HRMS) is essential to bridge the gap between regulated monitoring and the actual chemical exposome.

Materials and Methods

This study implemented an integrated analytical workflow combining the targeted quantification of >50 PFAS with NTS on a single HRMS platform (Thermo Exploris 120). Sampling campaigns (2024–2025) targeted fish, sediments, and groundwater along a longitudinal gradient of the Rhône River. Specific focus was placed on the Rhône industrial corridor and a major industrial harbour historically impacted by firefighting activities (AFFF use).

Results

The results reveal a partitioned contamination profile across matrices. Fish tissues were predominantly characterized by legacy PFAS. In contrast, groundwater and sediments exhibited a complex mixture of legacy and emerging compounds, notably fluorotelomer sulfonates (FTS) and fluorotelomer sulfonamidoalkyl betaines (FTAB). Specifically, 6:2 FTAB was detected at concentrations comparable to, or exceeding, PFOS in several samples.

Discussion and Conclusion

Spatial analysis showed the highest contamination levels within industrial harbour sediments, while upstream sites remained significantly less impacted. Preliminary NTS annotations in groundwater further identified unexpected PFAS across various chemical classes, demonstrating that targeted lists miss a substantial fraction of the anthropogenic footprint. While emerging PFAS showed limited bioaccumulation in fish compared to abiotic matrices, their presence in groundwater poses long-term challenges for resource management.
These findings underscore the necessity of complementing regulatory targeted methods with NTS to achieve an accurate assessment of PFAS occurrence and fate. This dual approach not only identifies overlooked contaminants like FTABs but also supports source tracing in complex industrial catchments. Ongoing work focuses on refining suspect identification and developing semi-quantitation strategies using structure-matched reference standards to better prioritize emerging risks.

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Fate and Transport 1

P. Kurt-Karakus & K. Pozo Gallardo

D17-100 Environmental occurrence and transformation behavior of trifluoroacetic acid (TFA) and its precursors

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Introduction
Trifluoroacetic acid (TFA) has garnered worldwide concern due to its extreme persistence, rapid global accumulation, and irreversible environmental burden. Current contamination levels of TFA in environmental compartments are already approaching ecotoxicological thresholds. The contribution of –CF3 containing precursors (refrigerants, fluorinated pesticides and pharmaceuticals, etc.) to TFA contamination remains unclear. This study reveals widespread TFA and precursor pollution across multiple media and assesses their transformation potential via abiotic/biotic simulation experiments.

Materials and Methods
Multi-media environmental samples from China (including surface water, precipitation, dust, soil, floodwater, and sludge) and Pakistan (soils from E-waste sites) were collected. TFA was quantified with high precision by LC MS/MS using an RSpak JJ 50 2D column. Unknown TFA precursors were identified through suspect and nontarget screening by UPLC Orbitrap HRMS. In addition, the abiotic and biotic transformation potential of these precursors was assessed using the total oxidizable precursor (TOP) assay and aerobic sludge microcosm experiments.

Results
Multimedia surveys showed that TFA was ubiquitous, with detection rates approaching 100%, dominating all per- and polyfluoroalkyl substances (PFAS). In surface water from a fluorochemical industrial park (2016), TFA concentrations were one to two orders of magnitude higher than those of other target perfluoroalkyl carboxylic acids (PFCA) and remained at 3000 ng/L 38 km from the source. In a nationwide survey of precipitation (2016), TFA ranged from 8.8 to 1800 ng/L, accounting for 20.4%–97% of total PFAS mass load. In outdoor dust collected across China, TFA concentrations increased from 27–96 ng/g in 2013 to 79–281 ng/g in 2017, representing a threefold increase over four years. In soil from a Chinese oil refinery (2022) and from E-waste sites in Pakistan (2022), TFA levels ranged from 0.11 to 16.4 ng/g and from below the detection limit to 307 ng/g, respectively. In Chinese floodwater samples (2024), TFA ranged from 126 to 1947 ng/L, accounting for 11.9%–95.2% of total PFAS. The TOP assay revealed abundant unknown short-chain precursors: unknown C2–C3 precursors contributed 28%–65% in indoor dust, and 57%–99% in surface water and soil from the oilfield.
Using suspect matching and fragment based nontarget screening, numerous potential TFA precursors were identified. In Pakistan E-waste soil, nine emerging –CF3 containing PFAS were identified (hexafluoroisopropanol, fipronil, and bisphenol AF, etc.), and TOP validation confirmed eight of these as TFA precursors, with molar yields of 8.9%–39.9%. In Chinese industrial sludge (2023), four TFA precursors (e.g., thifluzamide) were identified and validated, with TOP yields of 16.4%–25.6%. Furthermore, aerobic sludge microcosms were used to evaluate the biotransformation potential of emerging TFA precursors. The results demonstrated that the pharmaceutical dexlansoprazole and several synthetic intermediates can generate TFA. Notably, 2,2,2-trifluoro-N-(4-(hydroxymethyl)benzyl)acetamide rapidly produced TFA, achieving a yield up to 80%.

Discussion and Conclusion
TFA is ubiquitous and exhibits high contamination levels across multiple environmental media in China and South Asia. Conventional target analysis explains only a small fraction of TFA sources, whereas unknown precursors contribute substantially to its overall burden. The sources of TFA extend far beyond fluorocarbon refrigerant degradation and fluoropolymer pyrolysis. A wide range of –CF3 containing industrial chemicals, such as pesticides, pharmaceuticals, and electronic chemicals, are also important indirect sources. TFA possesses high water solubility, strong mobility, and environmental persistence, making its removal by conventional treatment nearly impossible. Therefore, it is urgent to integrate TFA and its unknown precursors into environmental monitoring and chemical management systems and to conduct in depth research on their ecotoxicological effects and human exposure risks.

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Fate and Transport 1

P. Kurt-Karakus & K. Pozo Gallardo

D17-101 Redox-dependent transformation of emerging polyfluoroalkyl substances (PFAS) derived from aqueous film-forming foam (AFFF) in soil environments

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Introduction
The use of aqueous film-forming foam (AFFF) has caused severe soil and groundwater contamination by per- and polyfluoroalkyl substances (PFAS). With the phase-out of perfluorooctane sulfonate (PFOS) and its precursors, contemporary AFFF formulations are increasingly dominated by emerging polyfluoroalkyl compounds (poly-PFAS). However, the environmental transformation behavior of these poly-PFAS remains poorly understood. This study systematically investigates the transformation of emerging AFFF-derived poly-PFAS under varying redox conditions.

Materials and Methods
A composite AFFF was prepared by mixing six different formulations used in China and introduced into soil slurry microcosms. Four redox conditions were established: aerobic, nitrate-reducing, sulfate-reducing, and iron-reducing. For each condition, four treatments were included: live treatment, abiotic control, medium control, and matrix control. Aerobic and anoxic microcosms were incubated for 150 and 300 days, respectively. PFAS concentrations and transformation products were analyzed using liquid chromatography-high resolution mass spectrometry (LC-HRMS). Microbial community analysis was performed via 16S rRNA sequencing, and functional gene abundance was predicted using PICRUSt2.

Results
A total of 38 PFAS were identified in the composite AFFF, among which emerging 6:2 fluorotelomer compounds predominated (over 80%). Nine high-abundance poly-PFAS were selected as target parent compounds: 6:2 FTAB, 6:2 FTSA-HOPrS, 6:2 FTAA, 6:2 FtTAoS, 6:2 FTSHA, 6:2 FTSA, PFHxSAm, PFOSAm, and PFOSB.
Under all four redox conditions, 6:2 FTAB, 6:2 FTSA-HOPrS, and PFOSB showed high persistence with no significant degradation. While 6:2 FTSA was biotransformed under aerobic conditions via dehydrogenation, hydroxylation, and desulfonation, it remained recalcitrant under anoxic conditions. In contrast, the other five poly-PFAS (containing thioether or tertiary amine groups) underwent significant biotransformation under all conditions, following first-order kinetics. Their stability followed: PFOSAm > 6:2 FTAA > 6:2 FTSHA ≈ PFHxSAm > 6:2 FtTAoS, and transformation rates followed: aerobic > nitrate-reducing > sulfate-reducing > iron-reducing. Significant abiotic transformation (thioether oxidation and tertiary amine hydroxylation) occurred under aerobic conditions but was absent under anoxic conditions.
A total of 52 transformation products (from six poly-PFAS) were identified under aerobic conditions, and 25 products (from five poly-PFAS) under anoxic conditions, enabling proposal of redox-dependent pathways. No defluorination products or fluoride release were detected under anoxic conditions. Redox-driven shifts in microbial composition led to differential expression of functional enzymes, governing the distinct biotransformation behaviors of poly-PFAS.

Discussion and Conclusion
This study shows that molecular structure and redox conditions critically regulate AFFF-derived poly-PFAS transformation. Structurally, thioether groups are more bio-transformable than sulfonamide groups, while terminal betaine and quaternary ammonium groups are more stable than tertiary amines. Notably, certain poly-PFAS (e.g., 6:2 FTAB, 6:2 FTSA-HOPrS, PFOSB) challenge the conventional view that poly-PFAS are all readily biodegradable.
Regarding redox conditions, aerobic environments promote both biotic and abiotic oxidation, leading to faster transformation and greater product diversity. Anoxic conditions, especially sulfate- and iron-reducing, retard transformation and suppress defluorination. The absence of abiotic transformation under anoxic conditions underscores the critical role of oxygen in driving such reactions, most likely through the generation of reactive oxygen species at redox interfaces. Overall, this study provides critical insights into the redox-dependent fate of emerging PFAS in AFFF-impacted soils and groundwater, emphasizing the need to consider both parent compounds and their transformation products in risk assessment and remediation.

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Fate and Transport 1

P. Kurt-Karakus & K. Pozo Gallardo

D17-112 Mercury Distribution in Air and Soils in a Coal-Fired Power Plant Region in Türkiye

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Introduction

Mercury (Hg) is a persistent atmospheric contaminant that can be transported over long distances and accumulate in terrestrial environments (Schroeder and Munthe, 1998; Selin, 2009). Coal combustion is a major anthropogenic source of Hg emissions in industrial regions (Driscoll et al., 2013; UNEP, 2019). Following emission, Hg is redistributed through atmospheric transport and is deposited onto environmental compartments including soils, where it can accumulate over time (Obrist et al., 2018). This study evaluates the spatial and temporal distribution of Hg in a coal fired power plant area in air and soil in Zonguldak province of Türkiye.

Materials and Methods

Atmospheric mercury (Hg^0) was sampled using passive air samplers (Hg-PAS) with sulphur impregnated activated carbon sorbent (AC), allowing time-integrated monitoring across multiple sites. Mercury adsorbed on AC was quantified using a direct mercury analyzer (DMA-1, Milestone) based on thermal decomposition, amalgamation, and atomic absorption detection. Surface soil samples (0–5 cm) were collected at the same locations and sieved through a 2 mm mesh. Total mercury (ΣHg) in soils was determined using the same analytical approach without chemical pre-treatment. Data were evaluated using descriptive and non-parametric statistics. Soil contamination status was assessed using pollution indices (PI, Igeo, EF, RI), and a screening-level non-carcinogenic exposure assessment was conducted.

Results

Hg^0 concentrations ranged from approx.. 2 ng m^{-3} at background sites to 21.05 ng m^{-3} in source-influenced areas, indicating a clear spatial gradient. Soil Hg concentrations showed higher variability, ranging from 7.60 to 1275.70 ng g^{-1}, with a distinct hotspot at one site. Weak correlations between soil Hg and soil properties ($\rho \approx -0.06$ to 0.17) indicate that intrinsic soil characteristics are not the primary controlling factor. Pollution indices identified localized contamination, with one site classified as strongly polluted (PI = 3.31), moderately enriched (Igeo ≈ 1.14), and associated with elevated ecological risk (RI ≈ 132), while other sites remained within background conditions. Exposure assessment based on worst-case concentrations showed that hazard index values remained below unity for all age groups (HI < 0.20).

Discussion and Conclusion

The results showed that Hg distribution is mainly controlled by atmospheric processes. The spatial agreement between atmospheric and soil Hg supports a deposition-driven system rather than control by soil properties. These findings are consistent with previous studies describing atmospheric deposition as the dominant pathway of Hg accumulation. Although contamination is localized and does not indicate immediate non-carcinogenic risk, the presence of accumulation hotspots and relatively higher exposure in younger age groups indicate the need for continued monitoring. Future studies should focus on long-term observations and Hg speciation to better evaluate environmental and health implications.

Acknowledgment

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Toxicology and Toxicokinetics

P. Brambila & J. Yang

D18-124 A physiologically-based toxicokinetic model of the fate of perfluorooctansulfonic acid (PFOS) in growing lambs

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Introduction

Perfluorooctansulfonic acid (PFOS) shows high bioaccumulative potential, making foods of animal origin important contributors to human exposure (EFSA, 2020). It is therefore essential to understand and quantify the fate of PFOS in farm animal species. Physiologically-based toxicokinetic (PBTK) models are useful tools for quantifying ADME (Mi and Lin, 2025). Ruminant PBTK models for PFOS have been developed for cattle (e.g. Mikkonen et al., 2023), but, as far as we are aware, none have been published for sheep. This study aimed to develop, optimize and evaluate a PBTK model that describes the transfer of PFOS from the oral intake to meat and offal of growing lambs.

Materials and Methods

A PBTK model was developed based on the toxicokinetic study on growing lambs from Aßhoff et al. (2026). Data of ten growing lambs orally exposed to nine PFAS, including linear (n-) and branched (br-) PFOS, for 10 weeks (EXP10, n = 4), 20 weeks (EXP20, n = 3), or for 10 weeks followed by 10 weeks of depuration (DEP10, n = 3) were available. For PFAS analysis, blood plasma was harvested at 12 (EXP10), 18 (EXP20) or 22 (DEP10) time points, as well as longissimus thoracis muscle and liver after euthanasia at 10 (EXP10) or 20 (EXP20 and DEP10) weeks. The PBTK model consists of seven interconnected compartments, one excretion route (lumps faeces and urine), with no metabolic elimination (Lupton et al., 2014). In order to capture the experimentally observed kinetic asymmetry between blood plasma, muscle and liver, the blood plasma was divided into superficial and deep sub-compartments (50% each of total plasma volume) with a diffusion limited transfer in-between. Absorption from intestines (fixed to 100%, Lupton et al., 2014), distribution to muscles and rest of the body (i.e. other tissues), and excretion were connected to the superficial-compartment, whereas distribution to liver was connected to the deep-compartment. Four ADME parameters (plasma sub-compartment diffusion, muscle- and liver-to-plasma partitions, and excretion rate) were optimized against EXP10 and DEP10 lamb data (PayOff procedure, Vensim v.10.3.2). EXP20 lamb data served as evaluation set.

Results

At the optimization step, the model achieved satisfactory goodness-of-fit (mean absolute percentage error [MAPE] = 23% and 34%, R^2 = 0.92 and 0.86, relative RMSE = 31% and 42%), which was confirmed at the evaluation step (MAPE = 11% and 29%, R^2 = 0.99 and 0.99, relative RMSE = 17% and 47% for n-PFOS and br-PFOS, respectively). The optimized excretion rate was numerically higher for n-PFOS (0.08 d-1) than for br-PFOS (0.05 d-1), in accordance with the lower biotransfer factors, and shorter depuration half-life recorded experimentally (Aßhoff et al., 2026).

Discussion and Conclusion

The ADME sub-model was further coupled to a physiological sub-model that describes in detail the feeding and physiology of the lamb. This allows the description of a wide variety of sheep farming systems (extensive suckling lamb to intensive fattening lamb) and the effects of physiological traits on PFOS toxicokinetics.

As an outlook, the model optimization is being pursued for the other eight PFAS from the experiment. An additional phase of external evaluation of the model performances is planned, involving a new experiment on lambs. This will allow the routine use of the lamb PBTK model and enable the exploration of complex scenarios of PFAS exposure and depuration for decision support.

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Toxicology and Toxicokinetics

P. Brambila & J. Yang

D18-127 Accumulation of Per- and Polyfluoroalkyl Substances in the Human Brain and Association with Motor Neuron Disease

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Introduction

Per and polyfluoroalkyl substances (PFAS) are a large group of human-made chemicals widely used in various commercial and consumer products. PFAS has been detected in human cerebrospinal fluid and brain tissues [1-3]. However, the factors influencing their partitioning into the brain and their potential role in neurodegenerative diseases remain poorly understood. This research was conducted in two studies. First, we characterised the presence of PFAS in human brain tissue using paired serum and brain samples while accounting for residual blood contamination, and evaluated determinants contributing to compound-specific variability in their partition and accumulation [4]. Second, we assessed whether PFAS levels are altered in motor neurone disease (MND) to explore potential associations with this neurological condition.

Materials and Methods

For the first part, matched human brain and serum samples were obtained from 10 individuals. Two brain regions, the middle frontal and temporal pole, were analysed. For the second part, brain tissue samples were obtained from 20 individuals with MND and 12 controls without a history of MND. Two brain regions, the motor cortex and temporal pole, were examined in both groups. All samples were analysed for 40 PFAS using high-performance liquid chromatography coupled with tandem mass spectrometry (LC–MS/MS).

Results

In the first study, 18 compounds were detected in at least one serum or brain sample [4]. Seven PFAS were found in brain samples of all individuals, and five PFAS were detected in all serum and brain samples [4]. Brain-to-serum concentration ratios, ranged from 0.04 for perfluorohexanesulfonate (PFHxS) to 1.3 for N-methyl perfluorooctane sulfonamido acetic acid (N-MeFOSAA) and increased with the number of carbons [4]. In the second study, no clear associations were observed between PFAS accumulation and MND status after adjusting for potential confounders, including age, sex, year of sample collection, and post-mortem delay. Although PFAS concentrations in the brain were generally lower in MND samples compared to controls, these differences did not reach statistical significance. No significant differences in PFAS levels were observed between the two brain regions in either study.

Discussion and Conclusion

This study confirms the presence of multiple PFAS within human brain tissue. Variation in the brain-to-serum concentration ratios suggests that PFAS detection in brain tissues cannot be solely attributed to residual blood but instead reflects compound-specific accumulation. The observed increase in these ratios with the increasing number of carbons suggests that biochemical properties, such as lipophilicity, may play an important role in brain partitioning. The second study provides an important first characterisation of PFAS in the context of MND.

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Toxicology and Toxicokinetics

P. Brambila & J. Yang

D18-746 Single-cell analyses of 2,3,7,8-tetrachlorodibenzo-p-dioxin-treated murine skin demonstrate that sebaceous gland differentiation precedes Ahr-dependent seboatrophy with elevated infundibular Blimp1

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Introduction

2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) is known to induce chloracne, a skin condition that presents with acanthosis, hyperkeratosis, comedones, and sebaceous gland (SG) involution. The mechanisms leading to chloracne are not well understood. Recent studies in mice highlight infundibular LRIG1+ progenitor cells colocalizing with TCDD-mediated CYP1A1 induction, indicating that TCDD may target specific cell populations to affect skin homeostasis. To explore a potential mechanism of seboatrophy we tested the hypothesis that TCDD activation of the aryl hydrocarbon receptor (AHR) up-regulates Blimp1 to inhibit Myc expression, a transcription factor known to drive the proliferation and migration of the LRIG1+ progenitors during sebaceous gland morphogenesis.

Materials and Methods

To investigate the effects of TCDD we analyzed single cell in situ RNA expression in wild-type and Ahr-null mice at postnatal day 21 (P21) following in utero and lactational exposure. We analyzed cell-specific and regional RNA expression of two AHR biomarkers, Cyp1a1 and Cyp1b1, as well as Lrig1, Blimp1, and Myc. We also analyzed skin from 3-day topical exposure and further investigated sebaceous gland differentiation. In addition to RNA, we performed immunohistochemical analysis of protein, and quantitative analysis of histology, and SG lipid production.

Results

Exposed mouse skin at P21 showed prominent Ahr-dependent seboatrophy. TCDD preferentially induced the AHR biomarkers, Cyp1a1 and Cyp1b1, in the lower infundibulum (IF) near the junctional zone where Lrig1+ stem cells reside, consistent with reports of protein induction. In response to TCDD, Blimp1 was induced in the lower infundibulum. While this effect was Ahr-dependent it occurred infrequently in the Lrig1+ cells. Blimp1 was mainly expressed in the cells lining the inner surface of the IF, infrequently colocalizing with Myc. In this same region of the IF, Lrig1 and Myc often colocalized and were primarily expressed in the basal cells of the outer surface adjacent to the basement membrane. Unlike Blimp1, no changes were observed in Myc and Lrig1 transcripts in response to TCDD. In addition to the IF, a second region of Cyp1a1 induction was the SG, where Cyp1a1 was markedly elevated in both less differentiated sebocytes and the basal proliferating cells. With 3-day exposure a dose-dependent increase of Cyp1a1 expression was observed in the more differentiated cells of the SG. Expansion of Scd1 expression and elevated Nile Red staining identified sebocyte differentiation and lipid production as early responses to TCDD. Increased numbers of sebocytes expressing high levels of Blimp1 further supported this effect of TCDD to promote SG differentiation.

Discussion and Conclusion

These findings provide strong evidence that TCDD enhances SG differentiation in vivo. This effect precedes Ahr-dependent seboatrophy with elevated expression of infundibular Blimp1. While Blimp1 remains a putative target in this mechanism of TCDD, its infrequent colocalization with either Lrig1 or Myc indicates the need for additional studies to better understand how TCDD affects the cellular dynamics of the pilosebaceous unit.

Acknowledgment

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Toxicology and Toxicokinetics

P. Brambila & J. Yang

D18-071 Abnormal Social Behavior Reprogrammed by Developmental DE-71 Exposure is Prevented by Activation of the Thyroid-Oxytocin Neuroendocrine Axis in Mice

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Introduction

Environmental toxicant exposures are emerging as contributing factors to the rising prevalence of Autism Spectrum Disorder (ASD) since genetic factors alone cannot account for its rapid rise. Polybrominated diphenyl ethers (PBDEs) are thyroid hormone (TH)-disrupting chemicals that we have shown produce ASD-like traits concomitant with altered expression of social neuropeptides in developmentally exposed mice. [1,2] In this study, we hypothesized that the OXT-depleting effects of thyroid-disruptive PBDEs drive the ASD-like phenotype since THs regulate oxytocin (OXT), a key prosocial neuropeptide.

Materials and Methods

C57BL/6N dams were exposed to environmentally-relevant doses of the penta-PBDE mixture, DE-71, i.e., 0.1 mg/kg/d (L-DE-71), 0.4 mg/kg/d (H-DE-71) or vehicle control (VEH/CON) for 10 wks perinatally. A subset of dams received supplementation with levothyroxine (mT4), (8 µg/100 g bw/d starting 7 d before birth). Three cohorts of exposed male and female offspring (n=8-12/groups) were subjected to behavioral testing, in situ hybridization or stereotaxic surgery.

Results

On a social recognition memory (SRM) test, adult male and female L-DE-71 offspring were unable to distinguish a novel from a familiar conspecific but novelty preference was restored with mT4 supplementation ($p<01$). DE-71 markedly reduced the total number of OXTergic cells, critical for SRM ability, in the paraventricular nucleus of the hypothalamus (PVH) ($p<.05$). mT4 supplementation normalized OXT content and cell number in L-DE-71 female ($p<.01$) and H-DE-71 male PVH ($p<.05$). Single molecule RNA in situ hybridization performed on PVH OXTergic neurons showed that sex-dependent gene alterations produced by DE-71 were associated with TH regulation, i.e., Mct8 transporter and Dio3 deiodinase ($p<.05$-$.0001$). Collectively, these results indicate that PBDE-induced SRM deficits and OXT depletion may be modulated indirectly via effects on TH status. [3]
We next sought to directly manipulate endogenous OXTergic signaling via a brain-penetrant melanocortin 4 receptor (MC4R) agonist, Ro21-3225 (7.5, 15 mg/kg ip), or exogenous OXT applied intranasally (iOXT, 9.2 IU/kg). MC4R and iOXT rescued normal behavior in DE-71 males ($p<.05$-$.0001$) but not L-DE-71 exposed females. In contrast, iAVP (9.2 IU/kg) rescued deficient SRM in both L-DE-71 males ($p<.05$) and females ($p<.01$). Since OXT and AVP are highly homologous peptides that engage in receptor crosstalk, we tested the effects of OXTR antagonist L371,257 and found that it abolished SRM improvement after iOXT but not iAVP ($p<.01$) in L-DE-71 males. In females, however, the SRM improvement after iAVP was eliminated after the OXTR block. Together, these results suggest that OXTRs in L-DE-71 females are functional but may have reduced affinity for iOXT, preventing SRM rescue by iOXT. OXTR was also upregulated in the prefrontal cortex in L-DE-71 females ($p<.01$), suggesting a compensatory response to altered OXTR function. Lastly, we chemogenetically evoked endogenous OXT release from synaptic projections of PVH OXTergic neurons to OXTR-containing forebrain regions. Administration of the designer ligand Clozapine N-oxide (3 mg/kg bw), but not saline, to L-DE-71 mice that had PVH OXTergic neurons transfected with the designer excitatory receptor (HM3Dq), rescued SRM in males ($p<.05$) and females ($p<.01$). Therefore, in females, chemogenetic reversal of the abnormal SRM phenotype is likely due to OXT saturation at OXTRs of forebrain social circuits.

Discussion and Conclusion

We conclude that modification of the central OXT system via TH supplementation, endogenous or evoked OXT and chemogenetic activation of PVH OXTergic neurons can rescue social recognition memory in offspring exposed perinatally to thyroid-disrupting PBDEs in a sex-dependent manner. Collectively, our data elucidates the therapeutic potential of direct and indirect targeting of the central oxytocin system to improve ASD-like symptoms in a toxicant model of ASD.

Acknowledgment

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Toxicology and Toxicokinetics

P. Brambila & J. Yang

D18-120 Mechanistic toxicological characterization of chemically complex WEEE plastic mixtures

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Introduction
Plastic waste from electrical and electronic equipment (WEEE) represents one of the fastest growing waste streams globally and contains complex mixtures of plastic-associated chemicals, including persistent organic pollutants, flame retardants, plasticizers, and polyaromatic compounds.[1,2] Despite increasing recycling efforts, limited knowledge exists regarding the mechanistic toxicological effects of chemicals released from WEEE plastics.[3] This study aimed to characterize the chemical complexity of WEEE plastics and investigate their inflammatory, oxidative stress-related, endocrine-disrupting, metabolic, and phenotypic effects using integrated toxicological and multi-omics approaches.

Materials and Methods
Plastic fragments originating from mixed WEEE streams were chemically characterized using Fourier-transform infrared spectroscopy, Raman spectroscopy, gas chromatography coupled to mass spectrometry (GC-MS and GC-HRMS), and inductively coupled plasma mass spectrometry. Organic extracts were fractionated using gas chromatography fractionation to enable effect-directed analysis of biologically active chemical fractions. Either whole extracts or chemical fractions were assessed using phenomics (Cell Painting) in U-2 OS cells and HepaRG hepatocytes, inflammatory response assay in THP-1-derived macrophages, and chemically activated luciferase gene expression (CALUX) reporter bioassays targeting aryl hydrocarbon receptor (AhR), nuclear factor erythroid 2-related factor 2 (Nrf2), estrogen receptor alpha (ERα), and anti-androgenic activity. Cytokine and chemokine secretion was analyzed using multiplex immunoassay and flow cytometry. Untargeted metabolomics and lipidomics using ultra-high-performance liquid chromatography-quadrupole time-of-flight mass spectrometry were performed on intracellular extracts and extracellular media from exposed human hepatocytes to investigate metabolic perturbations.

Results
Polypropylene and polypropylene-containing blends dominated the WEEE plastic composition. Chemical screening of whole extracts identified a complex mixture of plastic-associated contaminants, including polyaromatic compounds, organophosphate flame retardants, phthalates, and benzotriazoles. In human hepatocytes, phenomic profiling of the whole organic extract revealed extensive perturbations in endoplasmic reticulum-associated phenotypes, together with widespread mitochondrial and DNA-related alterations, indicating metabolic stress and multi-organelle dysfunction. In addition, WEEE extracts triggered inflammatory responses in human macrophages characterized by elevated cytokine and chemokine secretion, including TNF, IL-8, and MCP-1. Furthermore, WEEE whole extracts activated AhR and Nrf2 pathways, indicating dioxin-like activity and oxidative stress. Endocrine-disrupting effects included ERα activation and anti-androgenic activity. Fractionation experiments and effect-directed analysis demonstrated that biological activity and phenotypic effects were generally low when distributed across multiple chemical fractions, highlighting the importance of mixture interactions. Metabolomic and lipidomic profiling of the whole extract, together with pathway analysis, highlighted pronounced disruptions in lipid and energy metabolism, including significant modulation of de novo fatty acid biosynthesis, fatty acid metabolism and oxidation, linoleate metabolism, butanoate metabolism, and peroxisomal function. In addition, alterations in xenobiotic metabolism and pentose and glucuronate interconversions suggested broader impacts on cellular detoxification capacity and redox homeostasis.

Discussion and Conclusion
The findings demonstrate that WEEE plastics contain chemically complex mixtures capable of inducing multiple toxicological responses through diverse mechanisms. Combined alterations in inflammatory signaling, oxidative stress pathways, endocrine activity, metabolism, and organelle-associated phenotypes indicate that WEEE-associated exposures may contribute to adverse health outcomes through integrated and potentially synergistic mechanisms. The pronounced metabolic and endoplasmic reticulum-associated perturbations in human hepatocytes suggest that metabolic dysfunction may represent an important but underrecognized consequence of WEEE-associated chemical exposure. This study highlights the value of integrating chemical characterization, effect-directed analysis, phenomics, metabolomics, and mechanism-based toxicology to elucidate how complex WEEE-derived chemical mixtures perturb interconnected cellular pathways and biological systems, thereby improving risk assessment of recycled materials and supporting the development of safer circular material flows.

Toxicology and Toxicokinetics

P. Brambila & J. Yang

D18-120 Mechanistic toxicological characterization of chemically complex WEEE plastic mixtures

Acknowledgment

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Toxicology and Toxicokinetics

P. Brambila & J. Yang

D18-281 Toxicity evaluation of oxidizable pollutants

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Introduction

Almost all man-made pollutants have their specific functions designed, and pass the so-called strict examination of safety and/or toxicity test before use. However, it has been observed that some of them are prone to be transformed into toxic forms during use under various environmental conditions and even in the human body. For example, N-(1,3-Dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD), an antioxidant additive in the rubber industry, can be oxidized into N-(1,3-Dimethylbutyl)-N′-phenyl-p-phenylenediamine Quinone (6PPDQ) by ozone in the environment and P450 enzymes in living organisms. The stronger electrophilicity of the quinone moiety in 6PPDQ should have a much more significant tendency to attack the nucleophilic groups of effector proteins in the body, which will initially trigger its toxic processes.

We developed a sulfhydryl-reactive proteomics platform, which enables the precise identification of covalent binding protein targets of a pollutant. On this platform, 82 6PPDQ-bonded proteins were found in the human model cell line A549. Out of the 82 6PPDQ-bonded proteins, we discovered three 6PPDQ-bonded mitochondrial proteins, NDUS6, COX5B, and ATP5PB, which are involved in mitochondrial dysfunction for the first time. They impede the function of mitochondria, as witnessed by the decreased enzymatic activities of mitochondrial respiratory chain Complexes I (27.63%) and IV (23.11%), the decreased cellular ATP content (19.94%), and the reduced mitochondrial membrane potential (3.2-fold), as well as the elevated mitochondrial ROS level (2.2-fold) under the environmentally relevant 8.9 mg/L 6PPDQ exposure compared to the controls.

Our findings provide experimental evidence for elucidating the toxicities of 6PPDQ at the molecular level, the knowledge learned will enhance the public's awareness of the adverse impacts of environmental pollution on health.

Acknowledgment

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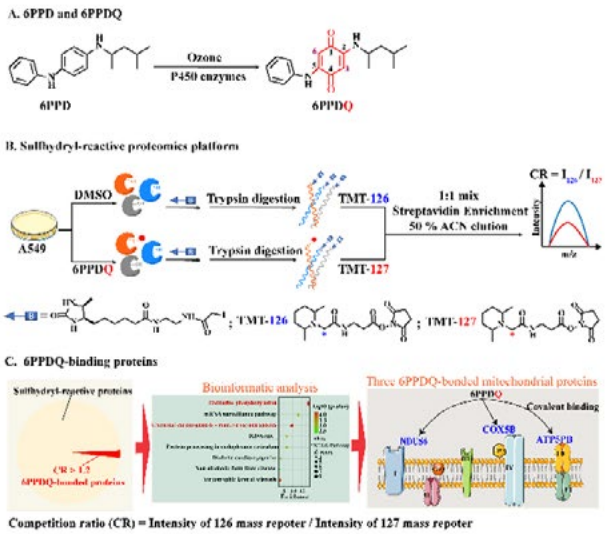


Figure 1. Transformation of 6PPD to 6PPDQ (A); the sulfhydryl-reactive proteomics platform (B); and 6PPDQ-binding proteins

Screening and Identification of Novel Contaminants 1

A. Covaci & M. Zheng

D19-102 Suspect screening of per- and polyfluoroalkyl substances (PFAS) and plastic chemicals in menstrual products

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Introduction
Menstrual products are used by a large portion of the world's population to ensure menstrual health, which is recognized as a fundamental human right by the World Health Organization (WHO). However, these products have been shown to contain chemicals of concern for human health, including per- and polyfluoroalkyl substances (PFAS) and plastic chemicals, such as phthalates, organophosphate esters and alternative plasticisers [1]. The presence of these chemicals in menstrual products is of concern because vulvar and vaginal skin have a high capacity for the absorption of small molecules. Therefore, the use of these products might be a relevant route of exposure for people who menstruate. However, so far, analytical efforts have focused on target analysis of a small set of chemicals. The goal of this study is to move from target to suspect screening of menstrual products to evaluate the presence of novel PFAS and plastic chemicals to provide a more comprehensive description of the composition of these products.

Materials and Methods
A selection of 41 menstrual products, including single-use (10 sanitary pads, 8 panty liners and 9 tampons) and reusable (4 reusable sanitary pads, 4 menstrual underwear and 6 menstrual cups) products, previously analysed for target plastic additives [1], were cut into small pieces and extracted with methanol. The extracts were analysed with an LC-Orbitrap-HRMS operated in full scan with data-dependent MS2 (ddMS2) acquisition in negative and positive ionisation mode. Suspect screening was performed using the open-source software patRoon [2]. Feature detection and retention time alignment were performed using the OPENMS algorithm. Features were filtered based on intensity (intensity > 10,000) and blank threshold (intensity in the samples > 3 times that in the blanks). The filtered features were screened for selected suspect PFAS and plastic chemicals using a mass error <5 ppm. Suspects were further examined and the MS2 spectra were annotated using the PubChem library available within patRoon. Revised diagnostic evidence (e.g. MS2 spectra, retention time) was used to assign suspect identification confidence levels according to the Schymanski scale.

Results
From the analysis of the data acquired in negative mode, 68 PFAS and 336 plastic chemicals suspect hits were identified. Preliminary inspection of the diagnostic evidence of these features led to the identification of 2 PFAS previously detected through target analysis (PFOA and PFDA) with confidence level 1 and of 4 plastic chemicals with confidence level 2. A total of 28 suspect plastic chemicals were assigned confidence level 3. The remaining features were assigned a confidence level of 4 or 5. Among the suspect plastic chemicals identified with confidence level 2, there are ricinoleic acid and 3 chemicals classified by ECHA as presumed reproductive toxicants: bisphenol S, bisphenol A and 2,2'-methylenebis(4-methyl-6-tert-butylphenol).

Discussion and Conclusion
The results of this study show that current target studies performed on menstrual products are not sufficient to describe the chemical composition of these products. Some of the chemicals identified with high confidence are chemicals of concern for human health (e.g.; bisphenols, PFAS) and the use of menstrual products might contribute to exposure to these chemicals. Full analysis of the HRMS data will provide a solid base to prioritise the chemicals in these products for quantitative analysis and realistic measurements of dermal exposure.

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Screening and Identification of Novel Contaminants 1

A. Covaci & M. Zheng

D19-169 Hidden threats in the heights: legacy and emerging pollutants in remote Pyrenean rivers and ecotoxicological assessment

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Introduction
High-mountain rivers sustain biodiversity and provide key ecosystem services, including freshwater supply and downstream ecological integrity. Although often considered pristine, these environments are increasingly exposed to environmental pressures. Climate change may alter contaminant transport, whit pollutants reaching remote mountains through atmospheric deposition and local anthropogenic activities [1]. In areas with intense seasonal tourism such as ski resorts, additional inputs from wastewater, infrastructure, and recreational activities may contribute to contamination. However, the occurrence and ecological relevance of these contaminants in remote environments remain poorly characterised. This study investigated the occurrence and distribution of pollutant mixtures in remote river systems of the Pyrenees and explored their potential ecological relevance.

Materials and Methods
In April and June 2025, two sampling campaigns were conducted in the Naut Aran region (Lleida, Spain), collecting water and sediment samples along a gradient from minimally impacted headwaters to areas influenced by tourism and ski-resort activities. The analytical scope included 90 compounds: plastic additives, personal care products, bisphenols, flame retardants, PFASs, and short-chain chlorinated paraffins. Surface water samples (15 L) were filtered (0.7 µm), pre-concentrated by SPE on HLB cartridges, and reconstituted for targeted chemical analysis and toxicity testing. Chemical characterisation was performed by LC-HRMS and GC-MS/MS. Ceramic passive samplers [2] were used to accumulate contaminants between sampling events, while suspect screening was applied to identify additional emerging pollutants. Toxicity assays were performed to assess in vivo acute to subchronical effects on feeding, behavioural and cardiological functions in Daphnia magna juveniles and zebrafish larvae of 7 days post fertilisation (dpf).

Results
A total of 54 compounds were detected in water and 42 in sediment. The most ubiquitous substance in water was the phthalate DnOP, which also reached the highest concentration (1452 ng/L). The solar filter UV-328 was detected at levels up to 865 ng/L. Among the non-phthalate alternatives, TEC, TBC, and DINCH were the most relevant, together with the bisphenol BpAF, found in all samples. Organophosphate esters and PFASs were detected at low concentrations. Suspect screening suggested the presence of a broader range of contaminant classes, including other UV/B filters as PBSA, the antidepressant pharmaceutical venlafaxine, the plasticizer and flame retardant TOCP, and the insecticide methoprene. In sediment, the highest concentrations were observed for DEHP, reaching up to 5100 ng/g, and short-chain chlorinated paraffins. Legacy flame retardants were the most ubiquitous, revealing their long-term accumulation and persistence in the solid phase. Spatial differences suggest that local anthropogenic pressures may influence contaminant distribution.
Toxicity results highlighted sublethal alterations in feeding activity, locomotor behaviour, and cardiac responses, in both, invertebrate and vertebrate models. These findings indicate that contaminant mixtures present even in apparently low-impact mountain environments may still exert biologically relevant effects with potential ecological consequences.

Discussion and Conclusion
Overall, this study shows that remoteness does not preclude chemical exposure in mountain areas and underlines the importance of combining contaminant analysis with bioassays to improve the evaluation of environmental quality in freshwater systems. These findings support the development of monitoring strategies better suited to capture diffuse contamination and mixture effects under changing environmental conditions.

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Screening and Identification of Novel Contaminants 1

A. Covaci & M. Zheng

D19-437 Vinyl chloride oligomers, a class of polychlorinated alkanes differing from chlorinated paraffins

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Introduction
Polyvinyl chloride (PVC) is one of the most widely used polymers, which contrasts with the low amount of literature on the leaching of associated additives and in particular unintended oligomers [1], a class of non-intentionally added substances (NIAS). This study [2] sheds light on the occurrence of vinyl chloride oligomers (VCOs) in a variety of PVC analytical standards (n = 4), PVC items employed for construction, medical or food contact applications (n = 14), as well as in foodstuffs and environmental matrices (n = 10).

Materials and Methods
Samples were analysed by liquid chromatography coupled to high-resolution mass spectrometry hyphenated with chloride-enhanced electrospray ionisation.

Results
Series of saturated (0VCO), monounsaturated (1VCO), diunsaturated (2VCO) and triunsaturated (3VCO) VCOs were revealed in all PVC items. The dominant series remained 1VCOs of the general formula $C_2nH_{3n}Cl_n$, accounting for ~80 % of VCOs in PVC standards. A risk of signal overlap was found between 0VCOs of the general formula $C_2nH_{3n+1}Cl_{n+1}$ (accounting for ~8 % in PVC standards) and polychlorinated alkanes making up chlorinated paraffins, given that they share the same chemical formulas. A methodology for discriminating between signals arising from VCOs and chlorinated paraffins has been proposed. VCOs were detected in 88 % of the samples analysed (other than standards), and in particular in some foodstuffs and environmental matrices, suggesting that VCOs have the capacity to leach out of PVC materials, and thus contaminate food and the environment.

Discussion and Conclusion
Therefore, Human exposure was shown from occurrence in indoor dust and foodstuffs in contact with PVC-based can coatings. Overall, these results call for greater attention to be paid to vinyl chloride oligomers and raise the question of whether they pose a risk to living organisms.

Acknowledgment
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Screening and Identification of Novel Contaminants 1

A. Covaci & M. Zheng

D19-854 Advancing the Detection of poly- & perfluorinated hydrocarbons in the Environment using GC-MS and GC×GC-MS

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Introduction

Perfluoroalkyl and polyfluoroalkyl substances (PFASs) are a family of manufactured chemicals that are widely employed in consumer goods and industrial applications because of their special qualities. Chemically, these compounds contain a chain of carbon atoms bonded to multiple fluorine atoms, and with different functional groups at the end of the chain.
A portion of these chemicals exhibit a neutral and volatile nature, and are recently gaining more attention from environmental agencies, since they can be released by consumer goods and accumulate in the environment.
Even at molecular weights over 600 Da, the presence of fluorine atoms in PFAS makes them more volatile than non-fluorinated analogues, due to weak van der Waals interaction properties. Therefore, they are suitable for GC-MS analysis.

Materials and Methods

In the current research, a parallel GC and GC×GC methodology coupled with both low-resolution and high-resolution TOF MS was developed for the (semi)volatile PFAS analysis. Specifically, the chemical group under study were fluorotelomer alcohols (FTOH), acrylates (FTAc), and alkyl sulfonamide (N-MeFOSA, N-EtFOSA, N-MeFOSE, and N-EtFOSE) derivatives. Regarding the MS ion source, both electron impact, positive chemical ionization, and negative chemical ionization were exploited to study the spectra of the targeted chemical groups. Dynamic headspace extraction was used for sampling, using the most appropriate adsorbent material in terms of selectivity and sensitivity. Initially, the extraction method was optimized in terms of sampling volume and adsorbent type using a mix of PFAS standards (MW range 264-571 Da) with various environmental samples (water, soil). Electron ionization (EI), positive chemical ionization (PCI), and negative chemical ionization (NCI) modes were employed to elucidate their fragmentation patterns and ionization behavior.

Results

The method was optimized and validated for nine target PFAS, including fluorotelomer alcohols (FTOHs), fluorotelomer acrylates (FTAc), and alkyl sulfonamides (FOSA, FOSE). Three adsorbent materials—Tenax TA, Carbotrap T420, and Carbotrap 202—as well as three extraction volumes (1 L, 2 L, and 5 L) were evaluated. Among these, Tenax TA showed the best performance in terms of recovery and repeatability, while the 1 L extraction volume provided the most consistent and reliable results. The final methodology was refined for both soil and water samples, allowing LODs ranging from 2.2 to 490 ppt, with an average accuracy and precision of 101% and 5.4%, respectively.

Discussion and Conclusion

A novel sensitive workflow was implemented for the extraction and analysis of PFAS from environmental matrices, combining dynamic headspace (DHS) extraction with thermal desorption (TD) tubes and GC×GC-TOFMS. This strategy provides a robust platform for both targeted quantification and untargeted screening of fluorinated contaminants. The applicability of the approach is demonstrated and validated on soil samples.

Screening and Identification of Novel Contaminants 1

A. Covaci & M. Zheng

D19-485 Irrigation Source Drives Pharmaceutical and Pesticide Accumulation in Leafy Vegetables: Novel Detections via Suspect Screening and Implications for Ecological and Human Health

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Introduction
Irrigation sources act as a major conduit for contaminants of emerging concerns (CECs), particularly pharmaceuticals and pesticides, in the agroecosystem. However, field-based studies comparing how different irrigation sources influences transfer of these residues across the water–soil–plant continuum remain limited.

Materials and Methods
Liquid chromatography coupled with high-resolution mass spectrometry (LC-HRMS)–based suspect screening was employed to characterize and compare multiclass contaminant profiles in different irrigation sources (groundwater, river water, and wastewater), associated soils, and leafy vegetables (coriander, spinach, and mint).

Results
Distinct pharmaceutical and pesticide residues were detected across irrigation sources (Schymanski level 2). Wastewater irrigation exhibited the highest diversity and abundance of contaminants, accounting for ~78% of the 69 detected compounds, compared with substantially lower contributions from river water (~16%) and groundwater (~12%). Irrigation-dependent and crop-specific differences in residue profiles were observed across coriander, mint, and spinach, indicating selective rather than proportional transfer of residues from irrigation water to edible tissues. Among the detected compounds, 40 pharmaceutical and 5 pesticide residues in irrigation water, and 16 pharmaceuticals in irrigated vegetables, represent novel detections that expand the known spectrum of chemical pollutants in the agricultural ecosystem. Under wastewater irrigation, ~24-26% of pharmaceutical residues in source water overlapped with vegetables, while ~25% of pesticide residues were crop-specific, reflecting direct application and selective accumulation. In contrast, irrigated soils exhibited substantially lower contaminant diversity than either irrigation water or vegetables. Around 53% of identified compounds in plants have been previously associated with ecological effects and dietary exposure concerns.

Discussion and Conclusion
This field-based study demonstrates that irrigation source strongly influences the diversity, distribution, and potential behavior of pharmaceutical and pesticide residues across the water–soil–plant continuum. As hypothesised, wastewater irrigation was associated with the highest and most distinct contaminant load in leafy vegetables, whereas groundwater irrigation resulted in comparatively minimal contaminant transfer. The incomplete overlap between contaminants detected in irrigation water, soils, and edible plant tissues further supports selective, crop- and compound-specific uptake rather than proportional transfer from source water. These patterns highlight irrigation water quality as a key driver of contaminant transfer and accumulation in food crops, with implications for both ecological and dietary exposure. Future studies should use integrated monitoring approaches that confirm the identity of these compounds and link their environmental occurrence with toxicological data to improve risk assessment. These findings thereby emphasize the need for advanced treatment technologies, sustainable irrigation management, and remediation strategies to mitigate contaminant transfer into food systems and safeguard environmental and public health.

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PFAS Abiotic 1

M. Cristofori & R. Hoogenboom

D20-151 Atmospheric PFAS Deposition Across Germany: Insights from Wet Deposition and Aerosol Monitoring

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are globally distributed contaminants whose atmospheric transport and deposition contribute significantly to contamination in remote and non-urban environments. This study investigated the occurrence, distribution, and temporal variability of more than 40 legacy and emerging PFAS in rainwater and atmospheric particulate matter collected across seven air monitoring stations in Germany between 2024 and 2026. Wet deposition samples and particulate matter from both low-volume (LVS) and high-volume (HVS) air samplers were analysed using CIC and targeted LC-MS/MS for 50+ compounds, including legacy, replacement - and ultshort chain PFAS.

Rainwater samples generally exhibited low PFAS concentrations (<3 ng L^{-1} in most samples), dominated by mid-chain perfluorocarboxylic acids (PFCAs) and sulfonamide-derived compounds, associated with atmospheric oxidation of volatile precursors and long-range transport processes. Episodic concentration increases were observed at selected stations and time periods, indicating temporally variable precursor inputs and meteorological influences on wet scavenging. HVS filters captured a broader spectrum of PFAS, including fluorotelomer sulfonates and precursor-type compounds, whereas LVS filters were dominated by particle-associated PFOA and PFDA and displayed strong episodic concentration spikes.

Principal component analysis identified chemically distinct outlier events associated with elevated precursor-rich air masses and unusual deposition episodes. The results demonstrate substantial spatial and seasonal variability in atmospheric PFAS deposition across Germany and highlight the importance of atmospheric transformation processes, precursor transport, and sampling methodology in shaping observed PFAS patterns.

PFAS Abiotic 1

M. Cristofori & R. Hoogenboom

D20-155 A review of the PFAS occurrences in the Indian environment

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Introduction
The environmental and public health consequences of rising industrial production of PFAS cause India to face increasingly serious health problems. The production of polytetrafluoroethylene (PTFE) is likely to increase at a compound annual growth rate of 7.2% between 2022 and 2029 (from 6.55 kt in 2020 to nearly 10.65 kt in 2029) because of the growing demand in the automotive and aerospace industries. India, as a signatory to the Stockholm Convention, has not established a national monitoring program for PFAS nor provided any enforceable regulations against such use in drinking water and the environment. Consequently, the widespread use of these compounds results in contamination of urban and industrial areas where they are used extensively for fluoropolymer coatings, firefighting foams, and consumer goods.

Materials and Methods
Since 2021, over twenty Scopus-indexed research articles have emerged on PFAS contamination in India. By reviewing the environmental monitoring data and predictive modelling across these studies, this paper assesses current trends. A paper estimating contamination trends over a 30-year used predictive modelling and correlation analysis to link future surface water concentrations with initial contamination levels. Additionally, human exposure was estimated through a bioaccumulation factor model and cumulative daily consumption study to identify the long-term health risks with environmental bioaccumulation.

Results
Monitoring efforts have identified hotspots of PFAS contamination in municipal solid waste across Gujarat and Delhi. These hotspots detected leachate levels of upto 81,000 ng/L, with 50 different PFAS. River systems like the Ganga, Cooum, and Cauvery, serve as primary collection areas and show evidence of PFAS due to intense industrial and urban activities. In terms of water quality, PFOA has reported concentrations of 23.1 ng/L at untreated sewage sites, while tap water from major cities reportedly ranges from 10-100 ng/L. According to modelling of human exposures, populations that consume fish, are at highest risk. It is estimated that each person consumes an average of 23 kg of fish per year in Tamil Nadu. Fish accumulated upto 1,780 micrograms of PFOS per/kg of tissue, which further increased the risk of exposure. Biomonitoring studies support the presence of PFAS in hair samples, blood samples, and breast milk samples of people across the country and indicate an extensive level of bioaccumulation among the population.

Discussion and Conclusion
As evidence of the use of predictive modelling for India suggests concentrations of PFAS have a strong positive relationship to existing levels of contamination in the country; therefore, over the next 30 years, several states will have significantly higher levels of PFAS than their safe health standard limit. While PFOS and PFOA continue to accumulate in sediment for prolonged periods, there is a growing trend toward shorter chain PFAS in water systems that have greater mobility and less amenable to traditional treatment. The regulatory framework in India is still in its infancy compared to those of the European Union and the United States, which have both enacted enforceable limits for select PFAS at levels as low as 4 ng/L. In order to combat this increasing hazard, a systematic national monitoring programme should be established, along with comprehensive assessments of potential sources of PFAS contamination near industrial sites. Addressing the gaps are necessary for achieving chemical management and protecting long-term public and environmental health.

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PFAS Abiotic 1

M. Cristofori & R. Hoogenboom

D20-300 Development of Sampling and Analytical Methods for Atmospheric Per- and Polyfluoroalkyl Substances (PFAS): Study on Gas–Particle Phase Distribution of PFAS in Taiwan's Atmosphere

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Introduction

This study aimed to establish and optimize sampling and analytical methods for atmospheric per- and polyfluoroalkyl substances (PFAS) and to investigate the gas–particle partitioning characteristics and compound composition of atmospheric PFAS in Taiwan under different environmental settings. A total of 24 PFAS compounds were analyzed, including perfluoroalkyl sulfonic acids (PFSAs), perfluoroalkyl carboxylic acids (PFCAs), and their precursors.

Materials and Methods

For sampling method development, different adsorbent media, including XAD-2 resin, polyurethane foam (PUF), and activated carbon fiber (ACF), were compared. Some studies have indicated concerns regarding pressure drop when using XAD-2 under high-flow sampling conditions. In this study, severe background contamination was also observed after cleaning and reuse, with $\Sigma PFAS_{(24)}$ concentrations reaching 27.89 ng. Therefore, a "sandwich-type" PUF–ACF–PUF cartridge was ultimately adopted for collecting gas- and particle-phase samples. After testing, the blank sample $\Sigma PFAS_{(24)}$ concentration was reduced to <1 ng.

Regarding extraction conditions, solvent systems including methanol with different proportions of ammonia, acetone, and dichloromethane (DCM) were evaluated. The results indicated that methanol containing 0.5% ammonia achieved the best recovery efficiency for gas- and particle-phase samples. Soxhlet extraction and ultrasonic extraction were also compared, and significant differences in recovery rates were observed between the two methods. Soxhlet extraction required longer extraction time and greater solvent use, and some compounds exhibited recovery rates below 10%. Therefore, ultrasonic extraction is recommended as a more efficient extraction method.

After method establishment and validation, field sampling was conducted in seven regions of Taiwan, including Taipei, Lulin Mountain in Nantou, Yunlin, Chiayi, Tainan, and Kaohsiung (Nanzih and Fengshan), to analyze the concentrations and distributions of atmospheric PFAS. In the Kaohsiung area, simultaneous detection of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and PFAS using the same PUF–ACF–PUF sampling cartridge was also attempted.

To ensure analytical quality, multiple quality control tests, including field blanks, method blanks, and media blanks, were conducted. The results indicated that there was no significant contamination interference within the analytical system. For perimeter $PM_{2.5}$ sampling, quartz fiber filters (QFF) and glass fiber filters (GFF) were compared. Since previous studies suggested that GFF may adsorb gaseous PFAS and affect measurement accuracy, QFF was ultimately selected as the sampling filter material.

Results

The results showed that the recovery rates of PCDD/F internal standards ranged from 30.9% to 93.3%. Based on the WHO 2022 toxic equivalency factors (TEFs), gas-phase concentrations ranged from 2.21 to 9.83 fg-TEQ/m^3, while particle-phase concentrations ranged from 1.10 to 57.4 fg-TEQ/m^3. PFAS were ubiquitously detected in the ambient atmosphere of Taiwan, with method recovery rates ranging from 39% to 132%. At the perimeter of a specific industrial area, the highest gas-phase $\Sigma PFAS_{(24)}$ concentration reached 106 pg/m^3, while the particle-phase concentration was 51.1 pg/m^3. At the Lulin Mountain atmospheric background station, the average concentrations were 4.58 pg/m^3 for the gas phase and 1.23 pg/m^3 for the particle phase. These findings indicate the existence of potential PFAS exposure risks in the Taiwanese environment.

Keywords: PFAS, LC-MS/MS, Adsorbents, Air Samples

PFAS Abiotic 1

M. Cristofori & R. Hoogenboom

D20-410 Monitoring PFAS Across the Atmospheric Cycle: Belgian experiences from 5 years of Method Validation and Screening in Emissions, Ambient Air and Depositions

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Introduction
As the Flemish reference laboratory for environmental analyses, VITO represents the link between government, commercial laboratories and the industrial sector in Belgium. In response to elevated per- and polyfluoroalkyl compounds (PFAS) levels in various environmental media and human serum in 2021, the lack of existing standards to quantify PFAS in emission and ambient air and the growing notion that inhalation represents a significant human exposure route to PFAS, VITO was commissioned by the government to develop monitoring methods to quantify PFAS in our atmosphere.

Materials and Methods
VITO gained practical experience with the OTM-45 method, published by US EPA in 2021 (EPA, 2021), optimized sampling and quantification procedures (Hofman et al., 2025a, Hofman et al., 2025b) resulting in the first national emission standard (LUC/VI/003), while establishing validated compendium methods for the quantification of PFAS in ambient air and depositions (Peters et al., 2023, Reis de Carvalho et al., 2026). Field experience was obtained by measuring polar volatile (<C4), semi-volatile (C4-C18) and neutral compounds expanding our analytical coverage over time on real-world stacks, ambient background and hotspot locations and deposition samples across Flanders.

Results
Results demonstrate prevalent concentration levels and varying fingerprints between atmospheric emission, ambient air and deposition compartments, while identifying a wealth of emerging PFAS molecules in emission and the ambient air we breathe, beyond current legacy PFAS and often overlooked by traditional target methods. Although atmospheric concentration levels are generally lower than the existing ambient air assessment framework (0.3 ng m-3 for the sum concentration of PFOA, PFNA, PFHxS and PFOS) derived in Flanders, a lot of unknowns remain about the majority of compounds and the associated health risks of emerging compounds.

Discussion and Conclusion
Our work presents methodological developments and field results of PFAS prevalence and fingerprints in emissions, ambient air and deposition. Moreover, present encountered issues and challenges when sampling and analytically quantifying this ever-expanding family of synthetic chemicals.

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PFAS Abiotic 1

M. Cristofori & R. Hoogenboom

D20-566 Emission characteristics of PFAS from carpets: microchamber-based assessment of indoor air contamination

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Introduction

Per- and polyfluoroalkyl substances (PFAS) have been widely used in industrial applications because of their excellent performance such as water and oil repellency. However, some PFAS have attracted attention due to their persistence, high accumulation, and toxicity. In particular, regulations regarding long-chain PFAS have been increasingly strengthened worldwide. Long-chain perfluorocarboxylic acids (LC-PFCAs) were listed under the Stockholm Convention as Persistent Organic Pollutants (POPs) in 2025. Consequently, the use of alternative PFAS, including precursor PFAS and short-chain PFAS such as fluorotelomer alcohols (FTOHs), has increased. These compounds are commonly used in textile products for stain-resistant and water-repellent treatments. Previous studies have reported that the precursor and short-chain PFAS in textile products are emitted into the atmosphere, resulting in human exposure through inhalation. However, information on the emission characteristics of PFAS from textile products is limited. In this study, PFAS emission characteristics from carpets were quantitatively evaluated based on measured emission rates.

Materials and Methods

A total of 54 PFAS were selected as target compounds in this study. Emission tests for carpet samples were conducted using a micro-scale chamber (M-CTE250, Markes International) connected to an adsorbent (Carbon Beads Active, Sibata Scientific Technology). This test was performed at 80°C under a continuous nitrogen flow of 100 mL/min for 1, 6, 12, and 36 h. After sampling, the adsorbents were extracted with 2 mL of dichloromethane/ acetone (v:v = 1:1). The extracts were subsequently analyzed by GC-MS/MS. No breakthroughs of PFAS were observed in the adsorbents.

Discussion and Conclusion

5:1 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, 6:2 FTMAcr, and N-MeFBSE were detected in the emission tests of the carpets. The cumulative emission amounts of 5:1 FTOH, 6:2 FTOH, and 8:2 FTOH showed significant positive correlations with elapsed time ($r = 0.967–0.998$, $p < 0.05$). The emission rates of these compounds were highest during the initial hour of the test and remained relatively constant over the subsequent 35 h period. In general, volatile compounds emitted from materials exhibit high initial emission rates because surface diffusion predominates during the early stage of emission. As compounds in the near-surface region of the material become depleted, emissions gradually shift to an internal diffusion-controlled process, resulting in reduced emission rates [1]. The emission characteristics of 5:1 FTOH, 6:2 FTOH, and 8:2 FTOH from the carpets were consistent with this mechanism.

The emission rates of 6:2 FTMAcr, 10:2 FTOH, and N-MeFBSE from the carpets gradually decreased over time. Compared with 5:1 FTOH, 6:2 FTOH, and 8:2 FTOH, these compounds required a longer time to reach steady-state emission conditions and exhibited lower steady-state emission rates. These results suggest that the emissions of 6:2 FTMAcr, 10:2 FTOH, and N-MeFBSE from the carpets shifted more slowly to internal diffusion-controlled emission than those of 5:1 FTOH, 6:2 FTOH, and 8:2 FTOH, reflecting slower internal diffusion of these compounds within the carpets.

The concentrations of PFAS in indoor air should be estimated based on internal diffusion-controlled emission rates because textile products typically remain indoors for extended periods. This study showed that the transition period from surface diffusion-controlled emission to internal diffusion-controlled emission differed among the compounds. Consequently, the use of compound-specific emission rates under internal diffusion-controlled conditions enables more accurate estimation of indoor PFAS concentrations. In future studies, we plan to quantitatively assess the contribution of PFAS emissions from consumer products, including carpets, to indoor PFAS concentrations using emission rates measured under internal diffusion-controlled conditions.

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PFAS Abiotic 1

M. Cristofori & R. Hoogenboom

D20-403 PFASs in snow from ski trails: Assessing the impact of banning fluorinated ski waxes

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Introduction

Even though the use of per- and polyfluoroalkyl substances (PFASs) in ski waxes is considered a niche application, it can be a relevant source of pollution of soil and groundwater in highly frequented ski areas. This is why the International Ski and Snowboard Federation (FIS) has banned the use of fluorinated ski waxes for all their races and events from the 2023/24 season onwards.

In this case study, we assessed compliance with the ban during the Engadin Skimarathon in 2025 and 2026. The Engadin Skimarathon in Switzerland is the world's second biggest cross-country ski race, with around 14'000 participants, including professional and recreational athletes. As it is not feasible to test each ski for PFASs, we investigated PFAS levels in snow samples taken from the ski trails before and after the race. Using targeted LC-MS/MS analysis, we could show an increase in PFAS levels after the races, indicating the use of fluorinated ski waxes. Fluor testing of the skis of the best professional athletes (using FTIR spectroscopy) did not result in any positive fluor detections, whereas random testing of recreational athletes showed that around 10% were still using fluorinated waxes (in 2025). This suggests that recreational athletes, in particular, may be responsible for the elevated PFAS levels in snow after the race.

The main ingredients of fluorinated ski waxes are semi-fluorinated alkanes that are precursors of perfluoroalkyl carboxylic acids (PFCAs). We could see a decrease in concentration for PFCAs in snow in 2026 compared to 2025 (see Figure below), showing a positive impact of the ban of fluorinated ski waxes. A decrease was also observed for fluorotelomer sulfonic acids (FTSs), but not for perfluorosulfonic acids (PFSAs). FTS and PFSA levels in snow are not linked to ski waxes. Consequently, their levels were one and two orders of magnitude lower, respectively, than those of PFCAs.

To better understand the origin and persistence of PFAS contamination in Engadin, snow samples (from 2025) were compared with soil samples from the same site. Comparing the distribution of the three PFAS classes PFCAs, PFSAs and FTSs in snow and soil showed that both types of samples are dominated by PFCAs (97% and 88%, respectively). When PFCA concentrations in soil from the cross-country ski trail were compared with those from a reference site without skiing activity, it was found that the PFCA soil concentrations at the ski trail were twice as high. This suggests a significant impact from ski waxes. However, PFAS levels in soil also showed a significant proportion of PFSAs (11% compared to 0.11% in snow). This indicates that PFASs from ski waxes are not the only source of PFAS emissions to soil in Engadin.

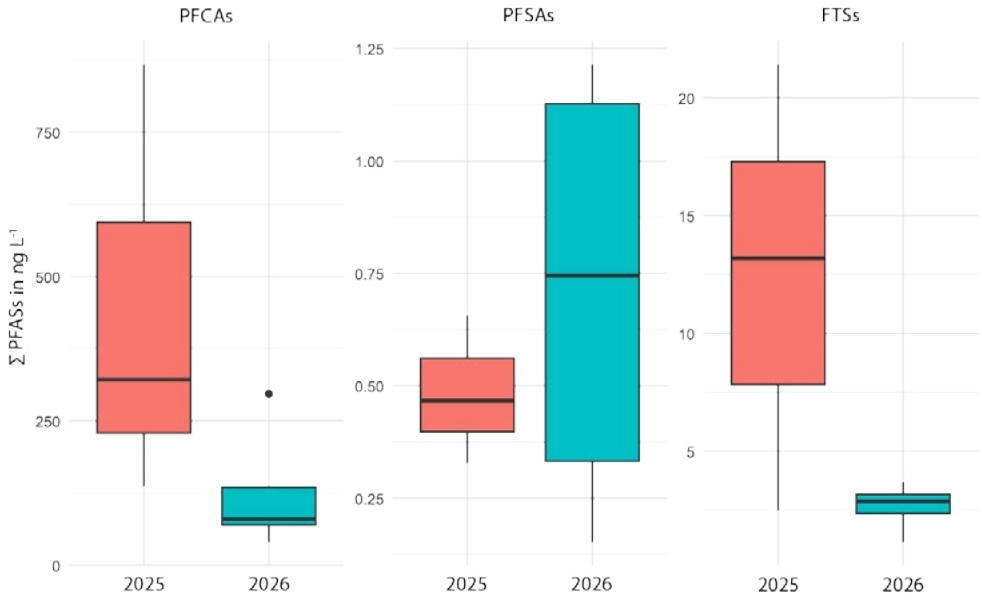


Figure: Sum concentrations of detected PFCAs, PFSAs and FTSs in snow after the ski races in 2025 and 2026.

Human Exposure 2

S. Harrad & B. Le Bizec

D21-104 Description 42 adults and 79 children poisoned by of Polychlorinated Biphenyl (PCBs) in a school.

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Introduction
We measured the concentrations of PCBs in a school which sickened several hundred students, teachers and parents. They entered the building in 2011 and began within a few months with multiple serious symptoms. Ater seven years in the building, one of the teachers found PCBs in her carpet from a leaky PCB light ballast. A law suit was filed, which is now resolved, but many subjects are permanently injured.

Materials and Methods
The fluorescent light ballasts contained Aroclor 2016 installed in the 1980s before the ban of PCBs. The ballasts outlived their normal use life. There was also PCB caulking in the windows and doors. Enviromental air testing revaled 630 ng/m3 of volatle PCBs. Dust contained Aroclor 1016 and PCDFs. We performed detailed medical evaluaions including neuropsychological testing, brain immaging and neurolonal antibodies documented toxic encphalopathy. Many subjects suffered from endocrine disruption and some developed early age cancer.

Results
We found that there were 100% of the tested patients had decreased cognitive function, abnormal MRI DTI scans, elevated neuronal antibodies, and severe impairment in their ability to work and learn. The other health problem reflected systemic problems with numerous adverse health effects requiring life-long medical care.

Discussion and Conclusion
Legacy volatile PCBs are still a major public health concern that is under recognized.There are thousands of buildings and hazardous waste sites with legacy PCBs in the air, dust and water off gassing levels pf PCBs sufficient to have health effects.This issue needs extensive testing and remdiation. There 55,000 scholls in the US alone estimated to contain problem PCBs levels.

Acknowledgment
The citiizens who came forward and solved the mystery of the severe illnesses in the school deserve our appreciation. Many people took part in brining this problem to light. It is still a hidden toxic issue to the scientific community and the general population. Lawyers took a large risk and believed in the case. This is an example of non-scientists discovering a serious health problem not regonized by the public health authorities.

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Human Exposure 2

S. Harrad & B. Le Bizec

D21-305 Clays for Human-Consumption in Africa Pose High Human Health Risks to Dioxins and Require Policy Action

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Introduction
African clays are widely consumed across communities in Africa for cultural, medicinal, cosmetic, and dietary purposes. Their ingestion and are closely associated with traditional practices of geophagy, particularly among pregnant women1. In some countries like Botswana preferably soils from termite mounds are consumed. Pregnant women commonly consume clay or soils to alleviate morning sickness and as a perceived source of essential minerals, like iron. African edible clays have been reported to partly contain elevated levels of PCDD/Fs1 but also toxicants such as lead, arsenic, cadmium, parasites and pesticides with associated health risks.

Materials and Methods
Representative edible clay samples were collected from two different geological zones of Nigeria covering both mining sites and local markets. From Ogun State 8 samples were taken from mines known to be used for human consumption. 3 clays for human consumption were sampled from the market in Ogun State. From Abia State 4 eatable calabash clay were sampled originating from different known quarries where clays for human consumption were mined. To capture region-specific exposure pathways, samples were collected in Botswana, where geophagy predominantly involves termite mound soils. Clay and soil samples were freeze-dried, homogenized, and sieved (60 mesh), followed by accelerated solvent extraction. PCDD/F and other unintentional POPs were analysed by HRGC–HRMS (resolution >10,000, EI-SIM) on a DB-5.

Results
PCDD/Fs were detected in all clays (0.03–75.7 pg WHO2022 TEQ/g) and soils (1.8 and 1.9 pg WHO2022 TEQ/g). For most samples, TEQs derived from WHO2005 and WHO2022 TEFs were comparable but in some samples WHO2022 TEQ were higher than WHO2005TEQ by a factor of 2. The levels of PCDD/Fs in clays and soil in this study (0.03–54.1 pg WHO2022 TEQ/g) were - with exception of two clays - considerable higher than the European regulatory limit for clays/minerals as feed additive (0.75 pg TEQ/g). The PCDD/F levels in the clays from quarries in Abia State/Nigeria (n=8) were all high (10.8 to 75.7 pg WHO2022 TEQ) similar to the dried and salted clays (n=3) from the market in Abia State (35.1 to 52.2 pg WHO2022 TEQ). From the four edible clay samples from Ogun State/Nigeria from four different quarries, two samples had low levels (0.03 and 0.04 pg WHO2022 TEQ/g). The edible clay sample from the Botswana contained also elevated PCDD/F contamination (20.9 pg WHO2022 TEQ/g). PCDD/Fs levels in the termite mound soils—commonly consumed by pregnant women in Botswana—were low (≤1.8 pg WHO2022 TEQ/g). At typical consumption rates (30–80 g/day)1, the highest observed concentration in edible clays (54.1 pg TEQ/g) corresponds to an intake of 11.4–30.4 ng/week. For a 65 kg individual, this intake exceeds the European Food Safety Authority (EFSA) tolerable weekly intake (TWI; 2 pg TEQ/kg bw/week)2 by 88–233-fold. Also the PCDD/Fs in the soil of the termite mounds in Botswana were still higher than the EFSA TWI2 (2–3-fold at 30 g/day and 6–8-fold at 80 g/day).

Discussion and Conclusion
The present study, together with previous evidence1, highlights an urgent need for systematic monitoring of clay deposits which are partly used for human consumption in Nigeria and across African countries practicing geophagy. Currently, specific regulations governing edible clays are largely absent in Africa and only implemented in Europe for clay/minerals used as feed additives. However, the high exposure levels and exceedance of TWI2 highlight that contaminated deposits should be excluded from food use and redirected to industrial applications and only low level quarries should be considered for human consumption.

Acknowledgment
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Human Exposure 2

S. Harrad & B. Le Bizec

D21-324 Evaluating prenatal chemical exposure using placental tissue and silicone wristbands for associations with sex-specific birth outcomes

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Introduction
Environmental chemical exposure begins in utero through placental transfer from mother to fetus and may alter placental function, fetal development, and birth outcomes in sex-specific ways. Because it reflects both maternal and fetal exposures at delivery, the placenta is an informative biospecimen, but it may not capture temporal variation or sensitive windows of exposure during pregnancy. Silicone wristbands are personal passive samplers that measure a broad range of persistent and non-persistent semi-volatile organic chemicals (SVOCs) over short periods and may provide complementary information on external exposure across gestation. We evaluated whether repeated wristband measurements and placental concentrations provide complementary information on prenatal exposure and whether these measures are associated with sex-specific birth outcomes.

Materials and Methods
Participants were enrolled between 2019 and 2024 from Project HOPE 1000, a prospective pregnancy cohort with singleton pregnancies recruited before 24 weeks' gestation at Duke University Health clinics. Placenta samples were collected at delivery (n = 205), and silicone wristbands were worn for 5 days during the first (n = 73), second (n = 234), and/or third trimester (n = 230). A total of 198 participants provided both placenta and wristband samples. Samples were analyzed for 119 semi-volatile organic chemicals, including brominated flame retardants, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, organophosphate esters, pesticides, phthalates, and alkylphenols using isotope dilution GC-HRMS. We examined correlations between matrices and associations with gestational age and birth weight for gestational age z-score (BWGAz), including sex-stratified single-chemical and mixture analyses with linear regression and quantile g-computation (qg-comp).

Results
More chemicals were frequently detected and in higher abundance in wristbands than in placenta. Eight chemicals were frequently detected in both matrices, including BDE 47, BDE 209, nonylphenol (NP), 4-tert-octylphenol (4tOP), triphenyl phosphate (TPhP), tris(2-butoxyethyl) phosphate (TBoEP), and two phthalates. Each doubling of BDE 47 wristband concentrations was associated with a 40% increase in placental BDE 47 concentrations (95% CI: 28%, 53%; $p < 0.001$). In male infants only, a doubling of wristband NP concentration was associated with 57% higher maternal placental NP concentrations (95% CI: 16%, 114%; $p = 0.004$). In sex-stratified outcome models, a doubling of wristband TPhP was associated with approximately 2 fewer days of gestation among males ($\beta = -0.30$, 95% CI: -0.55, -0.05; $p = 0.02$), whereas placental TPhP was associated with a 0.12 SD decrease in BWGAz among females (95% CI: -0.23, -0.01; $p = 0.03$). Mixture analyses also suggested sex-specific associations, with higher exposure associated with larger BWGAz among females, although effect estimates differed when evaluating mixtures using qg-comp or exposure z-score summation.

Discussion and Conclusion
Repeated wristband sampling and placental analysis provided complementary, but not interchangeable, measures of prenatal SVOC exposure. Wristbands captured a broader external exposure profile, whereas placenta reflected biologically relevant exposure at birth. Matrix-specific and sex-specific associations with birth outcomes suggest that integrated exposure assessment may better identify critical windows of vulnerability and improve understanding of prenatal chemical influences on fetal growth.

Acknowledgment
We thank the HOPE 1000 participants for their contribution to this research and acknowledge funding support from the NIEHS (R01 ES031419; R01 AI167850) and the Duke University Superfund Research Center (P42 ES010356).

Human Exposure 2

S. Harrad & B. Le Bizec

D21-382 Synthetic microplastics in hot and cold beverages from the UK market: Comprehensive assessment of human exposure via total beverage intake

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Introduction

Although few studies have assessed human exposure to microplastics (MPs) via drinking, almost all have considered human daily fluid intake as composed solely of water. This study aims to comprehensively assess human exposure to MPs via total fluid intake, including beverages (hot and/or cold), as well as water (tap and/or bottled). To achieve this aim, we used a tiered approach that combined laboratory analysis to quantify synthetic microplastics in 155 cold and hot common beverages sold on the UK market, with a public online survey to assess the average consumption of these beverages on a daily basis.

MPs were detected in all analysed samples. The average concentration in hot coffee was 43 ± 14 MPs/L (n=45, 1 standard deviation (SD)), while iced coffee averaged 37 ± 6 MPs/L (n=10, 1SD). Notably, hot tea demonstrated the highest abundance of microplastics, with an average of 60 ± 21 MPs/L (n=30, 1SD), compared to iced tea which had 31 ± 7 MPs/L (n=10, 1 SD). Hot beverages had higher concentrations of MPs than cold beverages ($P < 0.05$), indicating the role of temperature in enhancing MPs leaching from packaging material to the beverage. Juices contained an average of 30 ± 11 MPs/L (n=20, 1SD), and energy drinks averaged 25 ± 11 MPs/L (n=25, 1SD). In contrast, soft drinks exhibited the lowest concentration, with an average 17 ± 4 MPs/L (n=15, 1SD). The detected MPs in all beverages ranged in size from 10 to 157 µm. Fragments were the most abundant shape followed by fibres. Polypropylene (PP) was the most abundant polymer type followed by Polystyrene (PS), Polyethylene terephthalate (PET) and Polyethylene (PE). Plastic packaging materials (e.g., PET, PP, PE and PS) contributed substantially to the measured MPs contamination in respective beverages. Estimated daily average exposure from all beverages was calculated at 1.7 MPs/kg body weight/day for females and 1.6 MPs/kg body weight/day for males, which is higher than estimated microplastic exposure via drinking water only (1 MPs/Kg body weight/day).

These findings underscore the potential risk associated with MPs contamination in daily beverages. Continued exposure to MPs through commonly consumed beverages may contribute substantially to daily intakes of MPs, leading to potential adverse implications for human health.

Human Exposure 2

S. Harrad & B. Le Bizec

D21-814 Severe 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) intoxication: 28-year update on clinics, laboratory parameters, kinetics and CYP1A2 induction

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Introduction
Presumably in autumn 1997, two women working in a research institute in Vienna were severely contaminated with TCDD under unexplained circumstances. Patient 1 (age 30 years) developed severe generalized chloracne, and in spring 1998, TCDD was identified as cause after blood analysis revealing a level of 144,000 pg/g blood fat. In patient 2 (age 27 years), only mild facial acne lesions were observed, despite a TCDD level of 26,000 pg/g blood fat. Clinical and laboratory observations during the first years after intoxication have been reported in the scientific literature (Ref. 1-3). We here report on clinical observations, laboratory parameters, TCDD kinetics and CYP1A2 induction over a period of 28 years after intoxication.

Materials and Methods
Laboratory parameters were measured at the Department of Laboratory Medicine, Medical University of Vienna. TCDD in blood fat was measured by the accredited Eurofins GfA Lab Service (Hamburg, Germany) using quantification by high resolution gas chromatography-tandem mass spectrometry. Aryl hydrocarbon receptor (AhR)-mediated CYP1A2 induction was measured using the 13C-caffeine test with different methods of metabolite analysis (13CO2 in exhaled air; caffeine and its metabolites in serum and urine, as described elsewhere (Ref. 4)).

Results
Patient 1, diagnosed in 1998 with severe chloracne affecting almost the entire skin, still suffers from scarring follicular damage and undermining sinus tracts. Recurrent inflammatory deep-draining cysts in the gluteal and scapular regions required systemic therapy with TNF-alpha blockers (2018-2021; 40 mg weekly s.c.), over the past two years methotrexate 20 mg/week s.c., and, from time to time, systemic steroids. Blood markers showed elevated levels of inflammatory parameters as well as elevated blood lipids during the first years after intoxication (triglycerides up to about 500 mg/dL, LDL-cholesterol up to 200 mg/dL). In patient 2, such changes could also be observed on a less pronounced level; besides the mild changes observed shortly after the intoxication, she has unremarkable skin. During the first 10 years after intoxication, half-lives of TCDD were about 2 and 3 years in patient 1 and 2, respectively, and increased to about 10 years in both patients since then. Latest measurement in October 2025 revealed TCDD levels of 1030 and 508 pg/g blood fat in patient 1 and 2, respectively. Induction of CYP1A2 could be consistently measured with the different methods, showing a continuous decrease over time. Results based on the respective TCDD levels showed the dose-response slope of the CYP1A2 induction in humans, which recently reached the upper range of a control group of 30 non-smokers investigated in 1999 (Ref. 4). Compared to the EROD induction measured ex-vivo in liver of Wistar rats (Ref. 5), benchmark analysis estimated humans to be less sensitive by a factor of about 40, based on a 5% response.

Discussion and Conclusion
Clinical observations confirmed chloracne as the hallmark of severe TCDD contamination in humans, but also demonstrated its high variability with respect to severity of symptoms. Despite the exceptional high TCDD levels, only few other clinical and biochemical health effects were observed during the first years after intoxication, and long-term observation did not reveal diseases with delayed onset during a 28-year period. TCDD elimination was found to be enhanced during the first years after intoxication, likely due to enzyme induction, as e.g. described for the case of Wiktor Juschtschenko. CYP1A2 induction demonstrated the generally lower sensitivity of humans with respect to AhR-mediated effects of TCDD.

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Human Exposure 2

S. Harrad & B. Le Bizec

D21-036 Source Apportionment and Chemical Oxidative Potential Analysis of Atmospheric PAHs in PM2.5 during the Kao-Ping Experiment (KPEx)

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Introduction
Fine particulate matter (PM2.5) and PM2.5 bound polycyclic aromatic hydrocarbons (PAHs) pose substantial health risks because of their carcinogenic potential and complex atmospheric transformations. Evaluating the sources of these chemical components and their oxidative potential (OP) is crucial for effective air pollution control and public health protection. This study investigates the chemical characteristics and OP of PM2.5 in Kaohsiung, the largest industrial city in southern Taiwan, in conjunction with the Kao-Ping Experiment (KPEx).

Materials and Methods
Intensive and continuous sampling was conducted during the cold and warm seasons at representative industrial and traffic sites to characterize spatial and temporal variability. A total of 27 PAH species were analyzed using gas chromatography-tandem mass spectrometry (GC-MS/MS). Principal Component Analysis (PCA) and Positive Matrix Factorization (PMF) were applied for source apportionment, while the dithiothreitol (DTT) assay was used to assess volume-normalized (OPv) and mass-normalized (OPm) oxidative potential.

Results
The results showed that PM2.5 and PAH-associated Bapeq levels were higher at the industrial site (PM2.5: 34.8±18.2 μg/m^3; Bapeq: 4.71±10.7 ng /m^3) than at the traffic site (PM2.5: 31.0±17.3 μg/m^3; Bapeq: 4.05±7.31 ng /m^3), both PM2.5 and BaPeq levels were significantly higher in the cold season (PM2.5: 45.8±15.9 μg/m^3; Bapeq: 5.53±7.60 ng /m^3) than in the warm season (PM2.5: 23.9±13.5 μg/m^3; Bapeq: 3.57±10.1 ng /m^3). High-molecular-weight PAHs dominated at both sites. PMF analysis identified three major PAH sources including power plant emissions associated with condensable and filterable particulate matter (~40%), sinter emissions (~30%), and traffic activity (~30%). OP analysis indicated that OPv was higher during the daytime, reflecting a greater overall oxidative burden, whereas OPm peaked at night, suggesting stronger intrinsic particle toxicity per unit mass. In addition, statistical analysis incorporating the regional air quality index (AQI) and mortality data revealed a positive association between OPm and mortality.The results showed that PM2.5 and PAH-associated Bapeq levels were higher at the industrial site (PM2.5: 34.8±18.2 μg/m^3; Bapeq: 4.71±10.7 ng /m^3) than at the traffic site (PM2.5: 31.0±17.3 μg/m^3; Bapeq: 4.05±7.31 ng /m^3), both PM2.5 and BaPeq levels were significantly higher in the cold season (PM2.5: 45.8±15.9 μg/m^3; Bapeq: 5.53±7.60 ng /m^3) than in the warm season (PM2.5: 23.9±13.5 μg/m^3; Bapeq: 3.57±10.1 ng /m^3). High-molecular-weight PAHs dominated at both sites. PMF analysis identified three major PAH sources including power plant emissions associated with condensable and filterable particulate matter (~40%), sinter emissions (~30%), and traffic activity (~30%). OP analysis indicated that OPv was higher during the daytime, reflecting a greater overall oxidative burden, whereas OPm peaked at night, suggesting stronger intrinsic particle toxicity per unit mass. In addition, statistical analysis incorporating the regional air quality index (AQI) and mortality data revealed a positive association between OPm and mortality.

Discussion and Conclusion
Overall, this study demonstrates that industrial emissions and traffic activity are major sources of PAHs and important contributors to toxicity-related health risks, highlighting the critical role of OP as an indicator for regional air pollution control and health risk communication.

Acknowledgment
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PFAS in Food 1

R. Malisch & D. Mortimer

D22-203 Elevated PFOS levels in sheep and cows grazing in a floodplain of the Westerschelde

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Introduction
In the autumn of 2024, sheep and cows grazing in "het Verdronken Land van Saefthinge" (VLS) in the Southwest of The Netherlands were shown to contain elevated PFOS levels in plasma. The VLS is a nature area along the Westerschelde close to Antwerpen. The area partly gets flooded during the high tide but the non-flooded parts are used from May till October by several farmers to keep herds of female sheep and cows. The animals are used for reproduction and calves and lambs intended for meat production do not graze in these areas. However, they are exposed to PFOS via the mother. The lambs also drink milk from the mother, and are slaughtered in the year of birth, contrary to the calves that receive artificial milk and are raised for several years. The Netherlands Food and Consumer Product Safety Authority (NVWA) blocked the farms and animals were only allowed to be slaughtered if meat was expected to be below the maximum levels (MLs) based on plasma levels.Levels in animals were investigated to obtain more insight in the plasma levels of PFOS and in the ratios with levels in muscle and organ meat, since EU maximum levels (MLs) only apply to meat products. Also a limited number of grass and soil samples were analysed and compared to samples from areas on the other side of the dykes..

Materials and Methods
Blood samples were obtained from a veterinarian and collected at the farm, muscle meat, kidney and liver samples primarily via the slaugtherhouse. Grass and soil samples were collected by WFSR. A range of PFASs was analysed according to validated methods. WFSR participates in PT-tests organised by the EURL POPs.

Results
Animals grazing in the VLS showed elevated plasma levels of PFOS which decreased during the winter period, in ewes more rapidly than in cows. In beef cattle (n=6) with lower plasma levels, livers contained on average 1.3-fold higher levels than plasma, but 3-fold higher than kidney and 30-fold higher than in muscle meat. In sheep (n=18), PFOS levels in liver were 2.6-fold higher than in plasma, 4-fold higher than in kidney and 43-fold higher than in muscle meat. Grass levels were around 1 to 3 µg/kg dry matter, soil levels around 10 µg/kg dry matter, for both matrices being than on the other side of the dyke.
RIVM and WFSR, through a joint Front Office (2026), provided advice on the levels in plasma that should ensure that MLs in muscle meat, livers and kidney are not exceeded, taking into account the variability in the ratios and also published data..A kinetic model was developed to predict the PFOS levels in ewes and lambs, including the seasonal variation (Front Office, 2025). Additional data are collected to validate and optimize the model. The in utero transfer seems to contribute significantly to the levels in both calves and lambs.

Discussion and Conclusion
Sheep and cows grazing in the VLS show elevated levels in blood and tissues and this also applies to their offspring that did not forage in these areas. Indicator levels for blood were derived to decide on whether animals can go to the slaughtherhouse.

Acknowledgment
The authors would like to thank the NVWA, the farmers for providing the samples and the technicians in the laboratory.

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PFAS in Food 1

R. Malisch & D. Mortimer

D22-441 Per- and polyfluoroalkyl substance accumulation in field-collected mushrooms near a fluorochemical hotspot in Belgium

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Introduction
Despite the growing body of research on per- and polyfluoroalkyl substances (PFAS) in terrestrial ecosystems, most field studies have been performed on plants and mammals. In contrast, the occurrence and behaviour of PFAS in mushrooms remains largely unexplored. To date, only one field study has examined PFAS concentrations in field-collected mushrooms, and a few other studies have determined the accumulation and potential biodegradation of PFAS in mushrooms under controlled experimental conditions. Consequently, there is a substantial knowledge gap on the occurrence, uptake mechanisms and accumulation patterns of PFAS in field mushrooms. Therefore, the present study investigated the accumulation of PFAS in field-collected mushrooms from the vicinity of a PFAS hotspot. Specifically, we (i) quantified PFAS concentrations in mushroom fruiting bodies and corresponding topsoil; (ii) characterised PFAS compositional profiles in both matrices; (iii) calculated bioaccumulation factors (BAFs) to assess PFAS transfer from soil to mushrooms; and (iv) evaluated relationships between PFAS in soils and mushrooms to improve our understanding of fungal PFAS uptake under field conditions.

Materials and Methods
During the autumn of 2024, 4 locations (i.e. 3M site, Blokkersdijk (nature reserve), Vlietbos (public forest) and Fort 7 (nature reserve) were surveyed for mushrooms. At these sites, we respectively collected 4, 6, 19 and 18 mushrooms, as well as corresponding topsoil (0-5 cm). The fraction of organic carbon was determined on the soil samples, and both matrices were analysed for 42 target PFAS using UPLC-MS/MS. PFAS were divided into groups: short-chained perfluoroalkyl carboxylic acid (PFCAs), long-chained PFCAs, short-chained perfluoroalkyl sulfonic acid (PFSAs), long-chained PFSAs, fluorotelomer sulfonates (FTSs), perfluoroalkane sulfonamides (FASAs), N-alkyl perfluoroalkane sulfonamido substances (N-alkyl FASA(A)s), polyfluoroalkyl phosphoric diesters (diPAPs), and others. PFAS compositional profiles of soil and mushrooms, and the corresponding BAFs were calculated per site. Finally, Spearman's associations were made between paired soil and mushroom PFAS concentrations.

Results
The compositional profiles of the topsoil samples at all four locations consisted mainly of N-alkyl FASA(A)s, long chained PFSAs and FASAs, which is consistent with previous studies near this hotspot, where PFOS and its precursors were found to be dominant. The highest mean ∑42PFAS concentration in soil was found at 3M (2025 ng/g DW), followed by Blokkersdijk (293 ng/g DW), Fort 7 (66.0 ng/g DW) and Vlietbos (16.4 ng/g DW). The profiles of the mushrooms at 3M consisted mainly of N-alkyl FASA(A)s (41%) and long-chained PFSAs (34%), but contrary to soil, the profiles of mushrooms from Blokkersdijk were dominated by short-chained PFSAs (28%) and FASAs (27%). The mushrooms from Vlietbos and Fort 7 were dominated by short-chained PFSAs (43% and 44% resp.), short-chained PFCAs (21% and 25% resp.) and FTSs (15% and 17% resp.). Additionally, higher BAFs were found for short-chained PFAS compared to longer-chained variants and sulfonic acids showed higher BAFs compared to carboxylic acids with equal chain lengths. Finally, only at Fort 7 a significant negative association was found between soil and mushroom concentrations for PFOS ($R = -0.616$, $p = 0.008$) and for all sites combined, only one significant positive association was found for ∑42PFAS ($R = 0.350$, $p = 0.016$).

Discussion and Conclusion
Our results suggest a chain-length dependence of PFAS uptake in mushrooms, with shorter-chain compounds being more frequently detected and having higher concentrations within mushrooms compared to long-chain PFAS. Furthermore, PFAS concentrations in mushrooms were not representative for those in the underlying soil. It is therefore plausible that mushrooms obtain PFAS through their mycelia during the rapid uptake of water when fruiting bodies develop, which also explains the higher presence of short-chain PFAS due to their higher hydrophilicity. In this case, the mushrooms may be representative of contamination over a much larger area than just the underlying soil.

PFAS in Food 1

R. Malisch & D. Mortimer

D22-139 PFAS in marine fish from Italian coasts: occurrence and species-specific distribution in ten highly consumed species

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Introduction
Perfluoroalkyl substances (PFASs) are highly fluorinated aliphatic compounds synthesized on a large scale and widely used in many chemical processes and industrial applications (1), now turned into a large group of persistent organic pollutants widely distributed in marine ecosystems and characterized by bioaccumulation potential (2). Marine organisms therefore represent an important pathway for human exposure. Recent regulatory developments in the European Union concerning the setting of maximum limits for per- and polyfluoroalkyl substances (PFAS) in food are likely to influence future considerations and recommendations on fish consumption, although comparative studies across multiple marine species with different ecological characteristics remain limited.

Materials and Methods
A total of 425 samples belonging to ten widely consumed marine species collected from different Italian coastal areas including anchovy, bluefin tuna, clam, cuttlefish, hake, mantis shrimp, octopus, pink shrimp, red mullet and sardine were included in the present study to assess PFAS levels and contamination patterns. Samples were analysed by LC-MS/MS (3) targeting 24 PFAS, 19 legacy compounds, included all the branched isomers of the 4 regulated PFAS, and 5 selected emerging substances listed in Commission Recommendation (EU) 2022/1431. The total legacy PFAS contamination was expressed both as sum of the 4 regulated compounds and of the 19 molecules included in the present study. Sums were calculated in lower-bound mode (results <LOQ were set to zero). The LOQs were 0.010 µg/kg except PFBA=0.20, PFOSA=0.025, Gen-X=0.20 µg/kg.

Results
PFBA, PFPeS, Gen-X, NaDONA, 9Cl-PF3ONS, 11Cl-PF3OUdS were never detected, while, in most of the species, PFPeA, PFBS, PFHxA, PFHpA and PFNS showed detection frequencies below 5% with a not homogeneous distribution across species. Thirteen were the PFASs more frequently measured, including long-chain PFCAs (C8-C14), PFOS, PFHxS, PFOSA and three long chain sulfonates (PFHpS, PFDS and PFDoS). Substantial inter-species variability was observed. Anchovy exhibited the highest total PFAS burden (Σ19PFAS mean 4.4 µg/kg; median 5.3 µg/kg), followed by pink shrimp (mean and median 3.3 µg/kg) and bluefin tuna (mean 3.1 µg/kg; median 3.3 µg/kg), whereas clams (mean 0.21 µg/kg; median 0.18 µg/kg) was the lowest contaminated organism. Long-chain PFCAs and PFOS represent the dominant contributors across species.

Discussion and Conclusion
Non-parametric statistical analysis (Kruskal–Wallis followed by Dunn test with BH correction) confirmed significant differences in total PFAS burden among taxa- ($p < 2.2 \times 10^{-16}$). The results highlight a clear stratification of PFAS burden across species, with pelagic and higher trophic level organisms (bluefin tuna) showing the highest concentrations, while filter feeders (clam) exhibit significant lower levels (4). Differently from expected, pink shrimp shows higher PFAS concentrations than mantis shrimp and interesting contamination patterns were observed. In particular, PFOSA, PFHxS and PFOA showed variable levels of occurrence across different species, with high detection rates in some taxa and a complete absence in others, highlighting species-specific PFAS distribution in marine organisms. Comparison of total PFAS contamination expressed as Σ4PFAS and Σ19PFAS highlights that the 4 regulated molecules accounts for a small percentage of contamination in case of Bluefin tuna, Octopus and Cuttelfish (16, 18 and 25% respectively) while up to 69% in case of red mullet. These outcomes highlight the relevance of multi-species studies to define a more comprehensive list of PFAS to be monitored to assess total contamination and correctly estimate human dietary exposure.

Acknowledgment
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PFAS in Food 1

R. Malisch & D. Mortimer

D22-830 High PFAS levels in eggs from Dutch backyard chickens and an investigation towards the likely sources

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Introduction
Home-produced chicken eggs can be contaminated by a range of contaminants, including PCBs, dioxins and PFASs [1,2]. A previous investigation in a selected part of the Netherlands confirmed the large differences between levels of PFASs in home-produced eggs versus commercial eggs. This could lead to substantial dietary exposure, additional to the exposure stemming from other foods and drinking water. With this in mind, a Dutch nation-wide survey was conducted on PFAS contamination in home-produced chicken eggs (from citizens holding a few chickens). For selected locations, an in-depth investigation was conducted towards the potential source of the contamination, including the role of PFAS precursors. A risk assessment was performed [3], discouraging the consumption of these eggs. Here we report on the levels observed and the possible sources of contamination.

Materials and Methods
We investigated levels in eggs from 60 locations and for selected locations also the PFAS variability over the egg-laying season. In an attempt to identify and quantify major contamination routes we selected 10 locations where we investigated PFAS levels in soil, earthworms, bedding material and water. Legacy PFASs were investigated in all samples and precursors were investigated in selected samples. Extraction was followed by clean-up using a WAX-SPE column. The wash fraction was collected for neutral precursors, followed by elution of the anionic species. UPLC-ESI-MS/MS was used for quantitative analysis.

Results
∑legacyPFAS levels in the 60 egg samples varied <LOQ to 34 ng/g (sum of PFHxS, PFHpS, PFOS, PFHpA to PFTeDA), with a median value of 3.0 ng/g. PFOS was predominant in all samples, contributing approx. 60% to the sum. PFPeA, PFHxA, PFBS, GenX, and DONA were not detected in any of the samples, and PFHpA and PFDS in only a few samples. No clear pattern could be observed during the season. As regards the potential source appointment sub-study, earthworms showed ∑legacyPFAS levels from 5 to 265 ng/g ww (average 74 ng/g ww), with again PFOS dominating the pattern. ∑legacyPFAS levels in soil, bedding material and drinking water were much lower. Precursors were investigated (4:2-, 6:2-, 8:2-, 10:2-FTS, MeFOSAA, EtFOSAA, FOSAA, MeFOSA, EtFOSA, MeFOSE, EtFOSE & FOSA) in earthworms, and levels ranged from <LOQ to 0.71 ng/g ww. A selection of these precursors were also analysed in soil, but in all-but-two cases <LOQ.

Discussion and Conclusion
The results show that ∑legacyPFAS levels in eggs vary substantially among locations, and are much higher than those observed in commercial eggs, including free range chicken eggs (data not shown). The levels are higher than in an earlier study of 2016 [1], considering that in that study only the yolk was analysed (1/3rd of egg weight). Earthworms are considered to play an important role in the contamination of these eggs, but a causal relation was not established. Traces of PFASs were also found in soil, water and bedding material, but these are believed to play a minor role. While precursors were present in earthworms, levels were low and likely will not contribute substantial to the ∑legacyPFAS levels in the eggs. Future research may be directed towards investigating effective measures to reduce levels in eggs.

Acknowledgment
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PFAS in Food 1

R. Malisch & D. Mortimer

D22-067 The transfer of perfluoroalkyl substances from contaminated water into chicken meat during cooking

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Introduction
Perfluoroalkyl substances (PFAS) are a persistent group of environmental contaminants increasingly detected in drinking water worldwide. Although many studies have examined the accumulation of PFAS in raw food products, little is known about the potential for secondary contamination during domestic food preparation. Considering that cooking involves direct contact between food and water, understanding whether PFAS can migrate from contaminated water into food matrices is essential for accurate exposure assessment.
The objective of this study was to assess the transfer of fifteen selected PFAS from contaminated water into non-contaminated chicken breast meat during cooking.

Materials and Methods
The study investigated the influence of three variables PFAS concentration in water, cooking duration and surface area on the extent of PFAS migration. To evaluate whether surface area affects PFAS uptake, chicken meat samples (200 g) were prepared in two forms: whole pieces and sliced portions. To ensure complete immersion throughout the process, each sample was cooked in 1 litre of tap water. Three cooking times were applied: 20, 60, and 90 minutes, representing typical domestic and extended cooking scenarios.
Water was contaminated at three levels reflecting realistic exposure conditions:
High exposure level: 0.1 µg/L corresponding to the maximum PFAS concentration permitted in drinking water under EU Regulation 2020/2184 (spiked concentrations were 7 ng/L for all PFAS except for L-PFOS (8.6 ng/L) and Br-PFOS (0.42 ng/L)
Medium exposure level: 0.05 µg/L
Low exposure level: 0.025 µg/L
The concentrations of analytes were determined using liquid chromatography-tandem mass spectrometry (LC-MS/MS) on a Sciex Triple Quad 7500 system (Sciex, Framingham, USA).

Results
At the low contamination level (0.025 µg/L) none of the 15 PFAS were detected in chicken meat, regardless of cooking time or meat structure (whole vs. sliced). This indicates that under typical environmental low levels, PFAS migration from water to meat during cooking is negligible. At the medium level of water contamination (0.05 µg/L), six of the 15 PFAS were detected at very low levels, which were slightly higher than the limits of quantification. Transfer of 13 PFAS to chicken meat was observed at level representing high exposure (0.1 µg/L). The highest concentrations of individual compounds (0.013 to 0.035 µg/kg) were found in the meat that had been sliced and cooked for the longest time (90 minutes). The presence of PFAS in the meat increased with cooking time, suggesting time dependent diffusion. Sliced meat showed slightly higher uptake, consistent with increased surface area.

Discussion and Conclusion
This study provides evidence that PFAS can migrate from cooking water into chicken breast meat. Under lower, more typical exposure scenarios, the risk of secondary contamination during cooking appears minimal. However, the detection of 13 PFAS at the highest exposure level highlights the need for continued monitoring of PFAS in drinking water, refinement of exposure models to include cooking related transfer pathways, further research on different food matrices and cooking methods.
The results underscore that water quality plays a crucial role not only in direct PFAS ingestion but also in the safety of prepared foods.

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Formation, Sources, Control 2

S. Sakai & G. Hunt

D23-042 The Predictive Emissions Monitoring System (PEMS) in Hazardous Air Pollutants Related with Stationary Sources Air Pollution Control Devices Parameter

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Introduction
This study focuses on stationary emission sources, including coal-fired power plants and municipal solid waste incinerators. It integrates fuel characteristics, operational conditions (such as combustion temperature, flue gas conditions, exhaust flow rate, and pressure drop across air pollution control devices [APCDs]), and historical data from continuous emissions monitoring systems (CEMS) to evaluate the emission characteristics of conventional air pollutants and hazardous air pollutants. Based on these data, a Predictive Emissions Monitoring System (PEMS) was developed to reduce the barriers to real-time monitoring and to serve as a supplementary or alternative approach to CEMS.

Materials and Methods
PM-CEMS and the NCU-CS3 continuous flue gas monitoring system were employed to collect and analyze filterable particulate matter from the flue gas of coal-fired power plants and municipal solid waste incinerators. Concentrations of persistent organic pollutants (e.g., PCDD/Fs) and heavy metals were determined and combined with information on fuel type, APCD operational parameters, and pressure differentials to establish predictive models for the gas–particle partitioning of PCDD/Fs in flue gas. Furthermore, the chemical composition of ambient air pollutants at facility boundaries was analyzed to elucidate their potential sources.

Results
The results indicate a strong correlation between APCD operating temperature and the formation of particulate matter and PCDD/Fs in coal-fired power plants. Analysis of 13 consecutive days of operational data from Unit 3 of a coal-fired power plant revealed that incomplete combustion or flue gas temperatures within the intermediate range of 250–500 °C significantly promoted precursor reactions and de novo synthesis of dioxins, with the most active formation occurring between 250 and 350 °C. In addition, seawater flue gas desulfurization (SWFGD) systems may increase particulate matter concentrations and enhance the risk of dioxin reformation due to the influence of water vapor and temperature adjustments. PM-CEMS monitoring results showed a negative correlation between temperature and measurements from the Thermo Fisher system, whereas a positive correlation was observed for the SICK system, indicating substantial discrepancies between different CEMS instruments under high-temperature conditions. Correlation coefficients between temperature and flue gas particulate matter, particle-phase dioxins, and gas-phase dioxins were 0.72, 0.93, and 0.69, respectively, highlighting temperature as a key factor governing pollutant formation.

Discussion and Conclusion
In contrast, APCD operating temperature in municipal solid waste incinerators exhibited a negative correlation with both gas- and particle-phase dioxin concentrations in flue gas, suggesting that appropriate operational conditions effectively suppress dioxin formation. Moreover, PCDD/Fs in the flue gas of both coal-fired power plants and incinerators were dominated by the gas phase, whereas particle-phase PCDD/Fs prevailed in ambient air at facility boundaries, indicating phase transformation during atmospheric transport and deposition. PEMS prediction results showed that the trends of particle-phase dioxin concentrations were consistent with measured values, while gas-phase dioxins were underestimated. The relative percentage differences of the developed dioxin prediction models were 194% for coal-fired power plants and 98% for municipal solid waste incinerators. Overall, the results demonstrate that integrating operational parameters with CEMS data to develop PEMS models has considerable potential; however, further refinement is required to reduce uncertainties in gas-phase dioxin prediction and to enhance practical applicability and regulatory effectiveness.

Acknowledgment
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Formation, Sources, Control 2

S. Sakai & G. Hunt

D23-580 Evaluation of T99 values for selected agricultural plant protection products

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Introduction

Development of the thermal stability and destruction of the unused or expired agricultural plant protection products is of great importance. This aspect was discussed extensively in recent publication, indicating the overall prioritization of different chemicals in respect of the hydrolytic decomposition in soils 1. However thermal treatment is a viable option, particularly for the off-spec products. This study is aimed at the evaluation of the thermal degradation potential of the selected agricultural fungicides and pesticides used in seeds protection.

Materials and Methods

The estimation of the temperature of the thermal destruction of compounds of interest (principal compounds) was performed using a first order kinetic model at pyrolytic conditions, assuming a unimolecular bond fission of the weakest bond in the structure of each molecule as the main driving force of thermal degradation. The following expression describing the kinetic behavior during the thermal degradation process is used for all calculations: T99=503Ea[ln(-tA/lnfr)-1]
where T99 is temperature at which 99% destruction occurs and t is a residence time of the evaluated compound in the heated, post-flame zone and fr is fraction remaining (0.01 as a default). The estimation of the Ea and A can be achieved by a comparison to the thermal degradation of similar compounds or the compounds with functional structural similarities. In the case of a complex compounds with many functional groups, bond dissociation energies can provide an indication which bond fission will contribute to the degradation at lowest possible temperature

Results

The kinetic parameters for principal compounds were estimated based on the available in literature kinetic data of the compounds of similar chemical structure or those that represent similar structural fragments of the principal compounds. Based on that data and general knowledge of the effects of structural stabilization, steric impacts and structural stress, adjustments to activation energy and Arrhenius factor parameters were applied to fit with the corresponding structural differences to the principal compounds.We have divided the studied compounds into 6 groups characterized by the presence of similar chemical structure elements. The primary reactions considered for the T99 evaluation is the pyrolytic unimolecular thermal decomposition process, which will constitute the “worst case” scenario for the post-flame pyrolytic pockets controlling the degradation process.

Discussion and Conclusion

Based on such procedure the following T99 values for the principal compounds have been estimated as presented in the table below. The similarity of the structure of compounds used as basis of A and Ea adjustments served as a guidance to the confidence factor of the estimates in a descriptive manner.

Preincipal Component	T99 oC	Confidence
abamectin	206	very high
azoxystrobin	415	high
fluoxastrobin	717	medium
chlorantraniliprole	319	very high
ethaboxam	435	high
metaxyl	247	high
sedaxane	484	high
clothianidin	241	high
thiamethoxam	287	high
difenoconazole	754	high
ipconazole	791	medium
metconazole	772	medium
prothioconazole	799	medium
tebuconazole	781	medium
fludioxonil	733	medium
thiabendazole	741	low

The accuracy and adjustment of the developed T99 values can be performed in future by a selectivve experimental degradation profiles.

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Formation, Sources, Control 2

S. Sakai & G. Hunt

D23-524 Decomposition Behavior of Per- and Polyfluoroalkyl Substances During Steam Reactivation of Spent Granular Activated Carbon

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Introduction
Thermal steam reactivation has been used to reactivate spent granular activated carbon (GAC). Unfortunately, a recent case of contamination of soil and groundwater by per- and polyfluoroalkyl substances (PFAS) that leached from long-term dumped spent GAC has created growing interest in the behavior of PFAS during the reactivation of spent GAC. However, since earlier studies1,2) have shown that steam reactivation has the potential to effectively destroy PFAS, this study investigated the destruction efficiency of PFAS and their mass flow at a steam reactivation facility that processes spent GAC.

Materials and Methods
We collected spent GAC used as a part of wastewater treatment at a landfill site. This spent GAC was steam-reactivated using a rotary kiln furnace at a facility. The media discharged during the reactivation were collected. The PFAS concentrations in the samples were determined according to EPA-1633a3) protocols with a minor modification and the Japanese technical notes4). The destruction efficiency (DE) was calculated by the sum of PFAS in the discharged materials during reactivation over the amount of PFAS in the spent GAC. In this destruction test, a blank test was also conducted to understand the PFAS concentrations in all media. We evaluated the mass balance of fluorine during the reactivation, and we examined whether the reactivated GAC could be used commercially.

Results
The major components of the PFAS in the spent GAC were perfluorooctanoic acid (PFOA) and perfluorohexanoic acid, with a total PFAS concentration of >300,000 ng/g-dry. In contrast, the concentrations of all target PFAS in the reactivated GAC were below the limit of quantification (LOQ; 0.2 ng/g-dry), comparable to those in unused GAC. Especially, DE values for PFOA reached >99.999%, the Japanese technical requirement4). The PFOA concentrations in the wastewater and the reactivated GAC also satisfied the relevant requirements. Mass flow analysis found that residual PFAS were distributed in the following order: wastewater > reactivated carbon > flue gas. It should be noted that the analysis utilized LOQ values. The fluorine (F) mass balance was approximately 110%. Furthermore, the surface properties of the reactivated GAC were equivalent to or better than those of unused GAC.

Discussion and Conclusion
The results demonstrate that the conventional steam reactivation can effectively remove and destroy PFAS accumulated in spent GAC. The non-detectable PFAS concentrations in the reactivated GAC reveal highly effective PFAS removal while maintaining the adsorption performance of the carbon. Although DE values for some regulated PFAS such as perfluorooctane sulfonic acid did not show >99.999% because of their low initial concentrations, earlier studies5,6) have indicated that thermal decomposition characteristics of the regulated PFAS are comparable to or less stable than those of PFOA. Therefore, these compounds could be destroyed at efficiencies exceeding 99.999%. The F mass balance suggests substantial mineralization of PFAS, with F converted mainly to HF and inorganic fluorides. Overall, the present steam reactivation is a highly effective treatment for PFAS-contaminated spent GAC and satisfies the Japanese technical notes4).

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Formation, Sources, Control 2

S. Sakai & G. Hunt

D23-709 Environmental source determination: a multi-model receptor-modeling framework for source apportionment of persistent organic pollutants

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Introduction

Environmental forensics relies on accurate source apportionment to allocate persistent organic pollutants (POPs) to their origins and to inform remediation, liability, and regulatory action. Receptor modeling is the tool of choice for resolving mixed environmental samples into a small number of contributing source profiles and their contributions. In practice, most studies depend on a single matrix factorization algorithm, commonly Positive Matrix Factorization (PMF). Model selection is important because each algorithm carries its own constraints and assumptions, a single-model solution can be biased toward model-specific artifacts that are difficult to distinguish from genuine sources, and offers no internal check on whether a resolved factor is real or numerical.

Materials and Methods

We developed a reproducible pipeline that runs multiple receptor models, namely Polytopic Vector Analysis (PVA), Non-negative Matrix Factorization (NMF), Alternating Least Squares (ALS), and PMF, across a range of factor counts (k) on the same dataset, then reconciles their outputs. Rather than selecting a single "best" k, plateau detection across explained variance, sample-reconstruction coverage, and per-model residual mass yields a defensible consensus range of factor counts. Resolved end members from every model and k are clustered and scored by cross-model agreement: factors recovered independently by multiple algorithms are flagged as consensus sources, while factors appearing in only one model are flagged as candidate artifacts (redundant or under-resolved factors). Each cluster is matched against a curated reference library of known chemical fingerprints to assign a chemical identity. Follow-up residual and geospatial analyses test whether structured signal remains unaccounted for, and auto-generated interpretation reports document the model-side (k-selection) and data-side (model clustering) accounting at the end of every run, making each result fully traceable.

Results

Applied to environmental PCB sediment samples, the multi-model consensus resolves a range of legacy (Aroclor) and non-legacy (e.g., pigment-derived, such as PCB-11) sources. Critically, the cross-model comparison exposes interpretive nuances invisible to any single model. The geometric reconstruction of PVA and the uncertainty aware reconstruction of PMF tend to agree on smooth, blended Aroclor signatures. ALS and NMF were able to isolate sharper minor sources like pigment based signatures in addition to Aroclor signatures. Treating these disagreements as information rather than noise, the framework distinguishes sources that all models corroborate from those an individual algorithm over- or under-resolves, and quantifies how much of the dataset each shared source explains.

Discussion and Conclusion

The same architecture is pollutant-agnostic and extends directly to other POP classes, including PCDD/Fs, where source profiles overlap and single-model artifacts are equally consequential. Because each algorithm has distinct strengths and failure modes, a complete and defensible characterization of a contaminated system is better achieved by running multiple receptor models in parallel and evaluating them together than by trusting any one in isolation.

Formation, Sources, Control 2

S. Sakai & G. Hunt

D23-885 Hexachlorobutadiene formations in the Trichloroethylene/Perchloroethylene Co-production

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Introduction

Hexachlorobutadiene (HCBD) is a high toxic and long range-transported substance. It is regulated by Stockholm Convention and United States Toxic Substances Control Act1,2. HCBD is highly nephrotoxic in animals and may cause kidney cancer5. HCBD is widely distributed in various biotic and abiotic media, including surface waters, drinking water, ambient air, aquatic organisms, terrestrial fauna, and even geographically isolated areas like the Arctic, posing potential hazards to the global environment and human health. This study aims to calculate the HCBD emission factors from typical Trichloroethylene (TCE) and perchloroethylene (PCE) co-production plants in China by collecting and analyzing the samples of different processes, and to clarify the main pathways of HCBD releasing into the environment.

Materials and Methods

Three typical TCE/PCE co-production plants using different process techniques were investigated and twenty-one samples from different process stages were collected and analyzed in this study. In terms of production capacity, these three plants account for 45% of China TCE production capacity and 22% of global TCE production capacity. Isotope dilution gas chromatography-mass spectrometry (GC-MS) is internationally recognized as the optimal method for the trace analysis of persistent organic pollutants in complex environmental matrices. In this study, we also employed the isotope dilution GC-MS technique for the quantification of HCBD. The method used in this study were referenced to our previous studies with slightly modifications.

Results

The concentrations of HCBD in samples from TCE/PCE co-production plants ranged from 6.08 × 10-2 (S1-3) to 3.77 × 105 (S3-4) μg/mL. HCBD concentrations in bottom ranged from 6.63 × 102 (S1-1) to 3.77 × 105 (S3-4) μg/mL, in overhead ranged from 8.22 × 10-2 (S2-9) to 2.94 × 101 (S3-5) μg/mL. The proportions of HCBD occurrence in waste liquid and products, and the emission proportions through detergent products, other products and the incineration of waste liquid. It was based on production data from Plants 2 and 3. Although more than 99.5% of HCBD is distributed in the waste liquid, 99.99% of HCBD in the waste liquid can be removed by incineration disposal. HCBD in the product was very challenging to remove and most of it released into the environment along with the use of the product. The US EPA reported that only about 1% of TCE was used for non-refrigerant and non-detergent.

Discussion and Conclusion

HCBD concentrations keep increasing despite HCBD has been added into the POPs list covered under Stockholm Convention. HCBD is primarily recognized as a byproduct in the manufacture of other chlorinated substances. Generally, recognition on the sources of HCBD is still very lacking. Comprehensive source identification and quantification is emergently required for reducing HCBD levels in environment.

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Levels and Trends (Biota, Food and Feed) 2

R. Ceci & M. Petreas

D25-051 Emerging halogenated natural products rather than PCBs detected in commercially sourced tuna fish oil: method validation and quantification

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Introduction
Halogenated natural products (HNPs) are a diverse group of organohalogen compounds, mostly containing chlorine and/or bromine atoms. To date, over 8,000 HNPs have been identified, and this number continues to grow. Many HNPs are structurally similar to POPs, such as polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs), raising concerns regarding their potential for bioaccumulation and subsequent human exposure. Fish oil supplements, rich in eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), have become widely used health products. However, their high lipid content also poses an increased risk of contamination by lipophilic pollutants, including halogenated compounds. In this study, we aim to validate a pretreatment method for emerging HNPs and investigate their occurrence and concentrations in fish oil dietary supplements.

Materials and Methods
Tuna fish oil samples were obtained from an online retailer in China. An aliquot of 0.8 g was accurately weighed and diluted to 5 mL with a cyclohexane/ethyl acetate mixture (1:1, v/v). A series of internal standards, including α-PDHCH, β-HCH, HCB, trans-Chlordane, OCN, PCB 209 (absent in the sample matrix), were spiked for recovery validation. The purification steps were then carried out sequentially using preparative chromatography followed by silica gel column chromatography. Specifically, the sample was first purified on an Elite preparative system equipped with an EliteUQ Bio-Beads S-X3 column (400 mm × 25 mm). Cyclohexane/ethyl acetate (1:1, v/v) was used as the mobile phase at a flow rate of 5 mL/min. The resulting eluate was concentrated by rotary evaporation and then loaded onto a silica gel column (3 g silica gel, 30% water content), from which the target analytes were eluted with 60 mL of n-hexane. Finally, the eluate was concentrated to 100 µL for subsequent instrumental analysis. Recovery assessment of the internal standards and quantification of HNPs were performed using an Agilent 7890B GC-ECD and an Agilent 7890B/5975C GC-ECNI-MS, respectively.

Results
After 20 min of elution by preparative chromatography, the residual lipid content in the system was significantly lower than the loading capacity of the subsequent silica gel column (≤100 mg). Meanwhile, the recovery rates of all spiked standards in the eluate (20–52 min) ranged from 76 % to 108 %, falling within the acceptable range of 70%–120%. It is worth noting that the recovery analysis using GC-ECD revealed many additional peaks in the sample. Quantitative analysis of the ten known HNPs in the present sample using GC-ECNI-MS revealed that 2′ -MeO-BDE 68 (BC-2) was the predominant analyte, with a mean concentration of 49.0 ng/g lipid weight (lw), followed by 3,5-dibromo-2-(3′ ,5′ -dibromo-2′ -methoxy) phenoxyanisole (BC-11, 19.2 ng/g lw) and 6-MeO-BDE 47 (BC-3, 19.1 ng/g lw). In comparison, the anthropogenic PCBs were not detected.

Discussion and Conclusion
These results are consistent with the criteria reported in previous studies, indicating that the present purification method is reliable. The many additional peaks observed in the sample warrant further investigation of these compounds. The absence of detectable PCBs, together with the predominance of HNPs (especially BC-2 at 49.0 ng/g lw), suggests a potential risk posed by the presence of emerging HNPs in fish oil supplements. In conclusion, the present study validated a matrix purification method for the analysis of HNPs in tuna fish oil, using preparative chromatography coupled with silica gel column chromatography, which achieved acceptable recovery rates. Subsequent quantification for commercial fish oil products revealed the predominance of HNPs, but the PCBs were not detected.

Acknowledgment
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Levels and Trends (Biota, Food and Feed) 2

R. Ceci & M. Petreas

D25-115 Bayesian Whole Body PBTK Modeling of Congener Specific PCDD/F and PCB Transfer to Milk and Tissues of High Yielding Dairy Cows

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Introduction
PCDD/Fs and PCBs accumulate along the food chain, with dairy products being a major contributor to human exposure. Congener specific prediction of transfer from feed to cow's milk and tissues is important for risk analysis, especially in high yielding dairy systems where dynamic changes in body fat and milk fat yield alter kinetic behavior over a single lactation. Existing cattle toxicokinetic models often concentrate on milk or use simplified physiology, which constrains their description of tissue burdens and seldom provides probabilistic uncertainty bands for predictions. This work presents a whole body physiologically based toxicokinetic (wbPBTK) model for 29 PCDD/Fs and PCBs in high yielding cows, parametrized via a modular Bayesian inference strategy specifically designed to handle the imbalance between dense milk time series and sparse tissue measurements.

Materials and Methods
A controlled in vivo study in high yielding German Holstein cows comprised 2 oral supplementation phases with a bolus containing 35 dioxin and PCB congeners, started at the onset of lactation (negative energy balance) and mid lactation (positive energy balance), each followed by depuration; samples from 3 exposed and 3 control animals formed the basis for model parametrization. The wbPBTK model has 11 compartments (blood, liver, udder, dynamic adipose, muscle, spleen, kidney, brain, heart, ovary, rest), with adipose tissue explicitly modeled from experimental data to reflect energy status while other compartments scale with body weight. Congener specific parameters (fractions absorbed from bolus and feed, partition coefficients, liver metabolic elimination, milk fat partitioning and permeability terms) were inferred using a modular Bayesian approach that primarily exploits feces data for absorption, slaughter tissue burdens for partitioning, control cow milk data for background exposure, and exposed cow milk and adipose time series for the core kinetic parameters. Markov chain Monte Carlo yielded posterior distributions and credible intervals for time-course profiles and steady-state transfer rates, including TEQ-weighted sums.

Results
A robust model was obtained for 29 congeners, yielding at least reasonable performance in describing milk data for 28, adipose tissue data during lactation for 27, blood data for 21, and terminal organ tissues at slaughter for 21 congeners. For most congeners, the model reproduced the biphasic depuration in milk and adipose tissue using only four high level kinetic parameters to control the joint shapes of milk, blood, and adipose time profiles. Median steady-state milk-fat transfer rates were ~6% higher during negative versus positive energy balance, reflecting later lactation declines in milk yield and greater metabolism. For 21 of 29 congeners, excretion via milk fat dominated elimination after systemic uptake, whereas for several hepta chlorinated dioxins and furans and PCB 81, non milk elimination (likely hepatic) was larger than traditionally assumed. Validation against an independent literature dataset with lower yielding cows exposed to a dioxin mixture showed good agreement for milk TEQ concentrations and acceptable coverage of adipose TEQ within the model's credible intervals, supporting extrapolation across production levels.

Discussion and Conclusion
The modular Bayesian wbPBTK framework integrates milk, tissue, feces, and blood data while reducing overfitting and avoiding biologically implausible tissue partition coefficients. By providing congener specific posterior distributions rather than single point estimates for absorption, partitioning, metabolism and milk fat clearance, the model allows risk assessors to propagate kinetic uncertainty into predicted body burdens, TEQ time courses and tissue specific transfer rates for realistic contamination scenarios. Its detailed physiology and dynamic adipose/milk-yield representation enable adaptation to other breeds, body condition trajectories and feeding regimes by substituting appropriate physiological time courses, thereby supporting scenario analysis for different production systems and life stages. The implementation for an idealized Holstein Friesian cow is made available as executable code and via the tool https://ConTrans.bfr.bund.de to facilitate practical application.

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Levels and Trends (Biota, Food and Feed) 2

R. Ceci & M. Petreas

D25-320 Occurrence, Dietary Exposure and Risk Assessment of Dioxins and PCBs in Singapore's Locally Produced Eggs, Fish and Milk

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Introduction

Dioxins and polychlorinated biphenyls (PCBs) are persistent organic pollutants of public health concern due to their bioaccumulative, toxic and carcinogenic properties. Food consumption is one of the routes for human exposure, particularly through animal-derived foods such as eggs, fish and milk, making the monitoring of contaminant levels in produced foods important for evidence-based food safety risk management. This study assessed the occurrence of dioxins and PCBs in locally produced eggs, fish and milk in Singapore, and evaluated dietary exposure and associated health risks in the local population. Between 2020 and 2025, a total of 471 egg, 945 fish and 85 milk samples were collected from local farms in Singapore. Polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans (PCDD/Fs), dioxin-like PCBs (DL-PCBs) and indicator PCBs were analysed using gas chromatography–tandem mass spectrometry (GC-MS/MS), while dietary exposure was estimated using contaminant occurrence data and food consumption data from the Singapore Food Agency's national food consumption survey. The levels of dioxins and PCBs in local farm produce were well below the European Food Safety Authority (EFSA) maximum limit and are comparable or lower than the levels found in most studies reported by developed countries. The sum of PCDD/Fs and DL-PCBs ranged from 0.01–0.67 pg WHO-TEQ/g fat in eggs, 0.01–2.6 pg WHO-TEQ/g fresh weight in fish, and 0.01–1.7 pg WHO-TEQ/g fat in milk. Estimated weekly dietary exposure at mean consumption levels was 0.0492, 0.669 and 0.083 pg WHO-TEQ/kg body weight/week for eggs, fish and milk, respectively. Dietary exposure from eggs, fish and milk remained well below the EFSA tolerable weekly intake (TWI) of 2 pg WHO-TEQ/kg body weight/week. Overall, our study found that dietary exposure to PCDD/Fs and DL-PCBs from locally produced eggs, fish and milk in Singapore is unlikely to pose a health concern to the general population. This study provides important baseline data to support food safety risk assessment and management in Singapore and highlights the value of extending future monitoring efforts to imported food commodities to provide an even more complete and robust picture of the regional dietary exposure to dioxins and PCBs.

Levels and Trends (Biota, Food and Feed) 2

R. Ceci & M. Petreas

D25-277 Valorisation of agricultural waste into potential adsorbent for removal of chlorinated paraffins in aqueous solutions

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Introduction

Chlorinated paraffins are complex mixtures of polychlorinated n-alkanes, produced by the chlorination of unbranched paraffin fractions. They are subdivided into short-chain, medium-chain, and long-chain CPs based on their carbon chain length. These compounds are used in various industrial applications, including flame retardants, plasticizers, and additives in metalworking fluids, paints, adhesives, textiles, leather fat, and coatings. Because of their usage, they have been detected in many environmental matrices including water. Their presence in water originated from activities such as industrial emissions, waste disposal, and wastewater treatment deposit these compounds into water. SCCPs have toxic effects on humans and wildlife, and, therefore, their presence in the environment is not desirable. Conventional wastewater treatments do not remove these chemicals efficiently, hence several techniques have been tested for their removal from aqueous solution. However, some of the techniques are costly. Adsorption, using locally sourced materials such as maize tassel, an agricultural waste, offers a potential, low-cost solution. While research has mostly focused on metal and dye removal, this study explores the use of maize tassels to remove SCCP from water.

Materials and Methods

Maize tassel was collected from the Tshwane University of Technology farm in Pretoria. SCCPs standards were purchased from Dr. Ehrenstorfer GmbH (Augsburg, Germany). Sodium hydroxide and sulphuric acid were purchased from Merck.

Results

Figure 1(a) shows the optimal pH for SCCP removal from water is 8, unlike metal cation removal, optimal at pH 2 (Zvinowanda et al., 2009). In basic conditions, dechlorination and oxidation reactions destabilize SCCPs (DiMento et al., 2002). The hydroxide ions on the adsorbent surface promote cleavage of C-Cl bonds, thereby forming reactive radicals that attack SCCPs and enhance adsorption (DiMento et al., 2022). Increasing adsorbent dose boosts SCCP adsorption due to more surface area and binding sites, with 2000 mg/l as optimal (Figure 1(b)). The optimal contact time is 60 min; beyond this, active sites are exhausted. Initial concentration has minimal impact on removal efficiency (Figure 1(d)). SCCP removal can be improved by optimizing parameters, physically or chemically activating the adsorbent, or adding catalytic metals like zinc or silver.

Discussion and Conclusion

Maize tassel is an inexpensive, widely available adsorbent. It achieved up to 80% removal efficiency unmodified. Its performance can improve through physical or chemical modifications, like pyrolysis or acid activation, or by adding photocatalysts such as zinc or silver. The study is a work in progress and will further investigate these methods to enhance the adsorbent for the removal of SCCPs from water.

Acknowledgment

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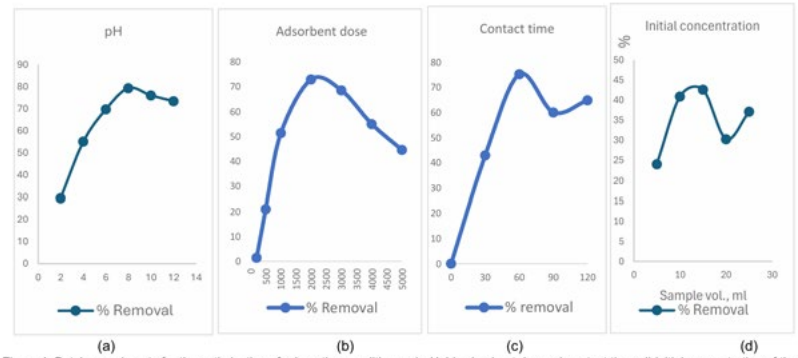


Figure 1: Batch experiments for the optimisation of adsorption conditions. a) pH, b) adsorbent dose, c) contact time, d) initial concentration of the analyte

Micro- and Nano-plastics

F. Corami & S. Lievens

D26-302 Car tire particles and their additives: biomarkers for recent exposure and implications for the human exposome

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Introduction

Every year, 1.7 billion new vehicle tires are produced world-wide. During its active use, an average car tire loses about 1.5 kg in mass, forming millions of tire wear particles (TWPs), which become part of the inhalable air pollution in urban areas and close to highways. In addition to TWPs, crumb rubber produced from end-of-life tires has been used as infill on artificial grass on outdoor sport pitches, where it has become a popular low-cost substitute for natural grass, sand, or gravel, but is prone to runoff and additive chemical leaching into the surrounding environment, as well as being an additional exposure route to humans.

The magnitude of emissions and their complex composition, which includes rubber polymers, chemical additives, and their derivatives make these particles problematic, with soils, waterways, and eventually coastal and marine systems acting as the main environmental sink compartments. Here, both rubber particles and their leachates, may induce toxic effects across a range of exposed habitats, species, and functional groups, entering both terrestrial and aquatic food webs. In urbanized areas, TWPs are emitted from roads, and granulates disperse from artificial sports fields and other urban surfaces to the environment, suggesting that runoff to coastal systems is likely and a route of exposure to marine organisms.

Materials and Methods

The current study investigated the presence of TWP related chemicals in relevant environmental samples such as urban air, road runoff, snow, sediments and marine organisms to improve our knowledge of the potential pathways for human exposure beyond particle inhalation. In addition, exposure experiments with blue mussels and lumpfish, commonly consumed seafood species, were conducted to better understand the uptake kinetics of TWP chemicals.

Results

Findings from both field- and lab studies confirm the predominant influence of tire-derived chemicals in car tire–affected environments and their uptake by marine organisms. Furthermore, when tire particles are no longer present, associated chemicals exhibit longer persistence in environmental matrices, including biological tissues, leading to the formation of transformation products that are more persistent than their well-known parent compounds (6PPD-Q, CPPD-Q), potentially useful bioindicators for TWP exposure.

Discussion and Conclusion

Implications for human health, in contrast, continue to be little understood.

Acknowledgment

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Micro- and Nano-plastics

F. Corami & S. Lievens

D26-131 The plastic soup: an investigation into the leaching and prioritization of persistent mobile and toxic chemicals in plastic products

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Introduction

Plastic pollution is an escalating global crisis, with microplastics now ubiquitous across Earth's environments1. This widespread contamination poses profound and largely irreversible risks, particularly through the leaching of diverse chemicals embedded within plastic products. The release of these plastic-associated chemicals has been recognized as a planetary boundary threat2.

In my lab, we are interested in the ability of different plastics to leach additives that are persistent, mobile, and toxic (PMT). Our recent research identified 124 PMT plastic additives registered for use in Canada, with applications ranging from biocide, colorants, to flame retardants3. Our model-based analysis suggested that many of these compounds would not be removed during wastewater treatment. However, for most of the identified PMT plastic additives there was no available experimental data on occurrence in the environment or research on sampling techniques for PMT plastic additives as a class of compounds.

Materials and Methods

To address these knowledge gaps, we developed product leaching as well as passive sampling methods in combination with high-performance liquid chromatography coupled with high-resolution mass-spectrometry to investigate which PMT plastic additive mixtures leach out of different plastic products and whether these compounds can pass through wastewater treatment. We investigated the leaching kinetics of PMT plastic additives out of 70 plastic items from 11 use categories and compared the patterns of detected PMT plastic additives and leaching levels to PMT plastic additive patterns in the final effluent of wastewater treatment plants (WWTPs) in the Greater Toronto Area in Canada.

Results

The results showed clear differences between PMT plastic additive concentrations in different plastic items, with hardware supplies and children's toys consistently showing some of the highest and most diverse PMT plastic additive levels. Commonly found PMT plastic additive use categories included colorants, processing aids, and fillers, while some organophosphate ester (OPEs) were found in highest concentrations in individual products. These OPEs were also some of the most prevalent compounds found in the final effluent of WWTPs with concentrations in the µg/L range, indicating that they are not sufficiently removed during the treatment process.

Combining information on leaching of PMT plastic additives and patterns in the final effluent of WWTPs showed that amongst the 57 PMT plastic additives found in both plastic product leachates and wastewater effluent, compounds contributed very differently to the mixture composition and potential mixture risk. Two crosslinking agents and OPE flame retardants together contributed 99% of the screening-level risk of the PMT plastic additives in the final effluent (modelled with EAS-E suite).

Discussion and Conclusion

The measured PMT plastic additives in product leachates and final effluents provide important information on the environmental fate and potential risk from this understudied group of plastic additives. The results shoed that PMT plastic additives are entering the environment and are not removed during wastewater treatment. It is clear that more environmental analyses and regulatory monitoring are needed to understand the risk these compounds pose to drinking water security and the health of the aquatic environment.

Acknowledgment

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Micro- and Nano-plastics

F. Corami & S. Lievens

D26-273 Small Microplastics and Plastic Additives in Freshwater: A Multi-Analytical Study for Water Resource Safety

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Introduction

Despite extensive research in marine and freshwater systems, microplastics (MPs) remain largely unregulated, especially in water intended for human consumption. While the EU Directive 2020/2184 and subsequent decisions have established a legal basis and harmonized methodologies for monitoring, specific binding thresholds or parametric values have yet to be defined. Small microplastics (SMPs < 100 µm) represents a particularly critical fraction of environmental plastics due to their high environmental mobility and their ability to enter the food web, posing a potential risks to human health. Plastics are associated with over 13,000 chemicals, including plastic additives (PAs) intentionally added substances to enhance polymer properties. These additives, as stabilizers, pigments, flame retardants, and plasticizers—can account for up to 70% of a material's total weight. Because many PAs are not chemically bound to the plastic matrix, they can leach into the environment, where they may degrade into other toxic compounds. Given the toxic properties of both MPs and PAs, there is an urgent need for improved monitoring strategies that align with the "One Health" approach.

Materials and Methods

This study investigates the occurrence of these contaminants and other microlitter components (MLCs)in the CUAI canal, a freshwater source for the Venice drinking water treatment plant. The research employs a novel multi-analytical framework combining microscale Fourier transform infrared spectroscopy (micro-FTIR) for the physical identification and quantification of SMPs and liquid cromatography-high resolution mass spectrometry (HPLC-HRMS) for the non-target and suspect screening of PAs in the dissolved phase.

Results

Results revealed a constant, year-round presence of SMPs, with a significant seasonal distribution. Tyre wear particles (TWPs) were a major component, accounting for over 50% of the total SMPs in nearly every month. The HPLC-HRMS analysis focused on samples from winter months (December to February) due to strong correlations observed between SMPs and MLCs during this period. Results showed a higher diversity and concentration of PAs in the dissolved phase compared to the particulate phase, suggesting these chemicals leach from the plastic matrix into the water.By providing a cross-validated framework, this work emphasizes the need for integrated monitoring protocols that account for both particulate and dissolved chemical burdens to safeguard public health and optimize water treatment technologies.

Micro- and Nano-plastics

F. Corami & S. Lievens

D26-804 A snapshot on microplastics in sediments from Croation lake

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Introduction
Microplastics (MPs) are particles composed of mixtures of polymers and functional additives. They are in solid state and may also contain residual impurities. MPs can be intentionally manufactured and added to products for specific purposes, such as exfoliating beads in facial or body scrubs or unintentionally formed when larger pieces of plastic break down during use phase or under environmental conditions. Much concern is related to MPs in the oceans; here, we report first findings on occurrence of MPs in sediments of Croatian lakes.

Materials and Methods
Eight sediment samples were collected from four lakes in the Zagreb area (LakeA to LakeD; each sample indicated by 1 or 2 after the lake name); the two sampling sites in each lake were about 2 m apart. In the laboratory1,2, the sediments were dried sieved and split into three subsamples (S1-S3). 100 g of each subsample was dissolved in a 200 mL ZnCl2-solution for density separation. The supernatant was placed on Si filters and MP particles identified by Raman spectroscopy. Three laboratory blanks were analyzed for quality control.

Results
Six polymers, namely polystyrene (PS), polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), nylon6 and nylon12 could be identified and quantified in the 24 sediment and three blank samples. The box whisker plots in the figure below show that the Blanks were negligible for all polymers. Differences between and within polymers but also lakes were found. Whereas across all samples, nylon12 could hardly be seen (median value=0 particles/g sediment; mean=6.7±10.4 particles/g), the most abundant polymer was PS with a mean value of 72.6±84.5 particles/g, followed by PP (55.5±64.9 particles/g), and nylon 6 (44.7±65.1). The large standard deviation indicates wide ranges of measured data. By far the highest number of particles was found in LakeA (407 particles/g sediment); the other three lakes had similar amounts (between 203 particles/g and 276 particles/g); however high variation in polymer composition and between the two samples from the same lake (e.g., LakeD_1 and LakeD_2).

Discussion and Conclusion
The data from this study show considerable variability in MP concentrations and polymer compositions across the four lakes; so far for unknown reasons. In order to compare with other studies, much harmonization including sampling protocols, sample preparation, identification and quantification as well as reporting needs to be done.

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Micro- and Nano-plastics

F. Corami & S. Lievens

D26-386 Neurotoxic Effects and Mechanisms of TBBPA Mediated by Polystyrene Micro/Nanoplastics in Zebrafish

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Introduction

Environmental micro/nanoplastics (MNPs) are widely distributed in aquatic ecosystems and pose potential risks to wildlife and human health. Tetrabromobisphenol A (TBBPA), a prevalent brominated flame retardant, is often co-occurring with MNPs and has been implicated in neurotoxicity through multiple pathways. Despite growing evidence of individual toxicity, the combined effects and mechanisms of MNP-mediated TBBPA exposure on neurodevelopment remain largely unexplored. This study aimed to investigate the neurotoxic effects and underlying mechanisms of TBBPA when mediated by polystyrene micro/nanoplastics (PS-MNPs) in zebrafish (Danio rerio).

Materials and Methods

Zebrafish embryos and adults were exposed to environmentally relevant concentrations of TBBPA alone or combined with PS-MNPs for both short-term (embryos) and long-term (adults) periods. MNPs were characterized using SEM and DLS, confirming spherical morphology and an average particle size of 112.7 ± 19.3 nm. Behavioral endpoints included spontaneous locomotion, anxiety-like behavior (light-dark preference), and social interaction. Neurotransmitter levels (dopamine, GABA, 5-HT, AchE activity) were quantified. Gene expression related to dopaminergic, serotonergic, and cholinergic systems (drd1b, th, tph1b, ache) was assessed by qRT-PCR. Confocal imaging of transgenic zebrafish lines (Vmat2:GFP) was used to evaluate dopaminergic neuron distribution and development.

Results

Behavioral analyses revealed that TBBPA exposure reduced locomotor activity in both 5- and 7-day-old larvae in a concentration-dependent manner, with combined PS-MNP exposure amplifying this effect. Light-dark preference and social behavior assays indicated increased anxiety-like responses and decreased social interaction under combined exposure. Neurotransmitter analyses showed that dopamine concentrations significantly decreased in high TBBPA and medium-to-high MNP co-exposure groups, correlating with impaired locomotion and social behavior. GABA and 5-HT levels remained relatively stable, while AchE activity was slightly altered without statistical significance. qRT-PCR demonstrated upregulation of drd1b, th, and tph1b genes, suggesting interference in neurotransmitter synthesis and signaling. Confocal imaging confirmed a dose-dependent suppression of dopaminergic neuron development under TBBPA exposure, further exacerbated by PS-MNPs.

Discussion and Conclusion

Our findings indicate that PS-MNPs can mediate and enhance TBBPA-induced neurotoxicity in zebrafish, with combined exposure leading to synergistic effects on locomotion, anxiety-like behavior, social interaction, neurotransmitter homeostasis, and dopaminergic neuron development. The results underscore the ecological risk of concurrent MNP and TBBPA exposure in aquatic environments and suggest potential implications for human neurodevelopmental health via trophic transfer. These data provide mechanistic insights for risk assessment and environmental management of plastic-associated contaminants.

Acknowledgment

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PFAS Exposure 1

G. Becher & T.Webster

D27-309 Measuring PFASs in Serum Samples Can Underpredict Total PFAS Body Burden

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Introduction
Per- and polyfluoroalkyl substances (PFASs) are fluorinated compounds used in numerous industrial and consumer applications, including aqueous film-forming foams (AFFFs), resulting in global environmental PFAS contamination and increasing environmental regulation. Human biomonitoring typically relies on measurements of PFASs in serum or plasma, potentially underestimating the total exposure burden of PFASs that partition to blood cells. In this study, we aimed to examine the partitioning of PFAS in varying blood matrices.

Materials and Methods
We assessed the distribution of up to 50 PFASs in different blood matrices by i) assessing the partitioning of PFASs between serum and whole blood in a laboratory partitioning experiment using human blood spiked with PFASs, and ii) measuring paired serum and whole blood samples belonging to wild caught exposed freshwater turtles from an AFFF-impacted site, representing environmental relevant exposures to a complex PFAS mixture.

Results
Most PFASs, including those commonly monitored, preferentially partitioned to serum, with an estimated fraction in serum above 0.8. The most notable deviation from this trend was for perfluoroalkyl sulfonamides, with a fraction in serum <0.11, indicating substantial association with blood cells.

Discussion and Conclusion
The blood cell fraction may be an important reservoir of sulfonamides and reliance on measurements in serum alone, or on commonly utilised serum-to-whole blood conversion factors such as 2:1, can misrepresent internal exposure to complex PFAS mixtures.

PFAS Exposure 1

G. Becher & T.Webster

D27-186 Serum PFAS concentrations in the Australian population: Comparison between data from the National Health Measures Survey and pooled surplus pathology samples

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Introduction
Since 2002, we have conducted a biennial human biomonitoring (HBM) program based on the subsampling and pooling of deidentified surplus pathology specimens; a low-cost, scalable and efficient alternative to traditional methods. This globally unique HBM framework has been useful for discerning baseline serum concentrations and trends of legacy and emerging environmental pollutants, including per- and polyfluoroalkyl substances (PFAS), in the Australian population. However, limitations with this approach concern the unknown fitness for purpose of pooled pathology samples (PPS) for assessing general population exposure to chemicals (i.e. due to a sampling bias towards "sick" individuals with different exposures and/or bioaccumulation/elimination rates, non-uniformity of specimen handling, etc.). In 2025, the Australian Bureau of Statistics (ABS) released age and sex-stratified data on serum PFAS concentrations for the National Health Measures Survey (NHMS), based on approximately 6900 individual specimens from a 'representative' sample of the Australian population. This is the first time that the NHMS have included the analysis of environmental contaminants within their methodology, providing the opportunity to compare estimates of population exposure to PFAS derived independently from both the NHMS and matched PPS collected simultaneously. Accordingly, this investigation aimed to provide a first comparison of PFAS data from the NHMS (i.e. nationally representative data) and from a HBM program based on PPS to evaluate if there are systematic congener-, sex- and age-specific differences in mean serum PFAS concentrations and trends between the two programs.

Materials and Methods
We assessed the fitness for purpose of a HBM program based on PPS for monitoring Australian population exposure to PFAS by comparing age and sex-stratified mean serum PFAS concentrations measured in PPS (2022-2023 sampling campaign) with corresponding publicly available data from the NHMS (2022-2024 sampling campaign). Identical NIST standard reference material (NIST SRM 1957) was also included in both programs to evaluate the accuracy of the respective analytical methods.

Results
Importantly, the overall trends in mean serum PFAS levels (i.e. by age, sex and congener) were broadly consistent between the two programs. However, for the four PFAS frequently detected in both studies, differences in mean serum concentrations were observed and varied in magnitude by congener. For example, in people aged ≥30-<45 years, mean serum PFAS concentrations were higher in PPS by 24-51% and 3-45% in females and males respectively. The laboratory that undertook the analysis of the PPS reported slightly but consistently higher NIST SRM PFAS concentrations than the NHMS (percent difference range: 6-22%), although these results were marginally closer to the NIST reference values. Notably, both laboratories reported acceptable results.

Discussion and Conclusion
The observed differences in mean serum PFAS levels between the NHMS data and PPS were partially attributable to analytical uncertainty. Despite the higher levels measured in PPS, the broad uniformity of trends between the two studies indicated the potential fitness for purpose of PPS for evaluating Australian population-level trends in serum PFAS concentrations. To date, only publicly available NHMS data has been assessed, and uncertainty remains with respect to population weighting methodologies applied to serum PFAS measurements in the NHMS. An application to obtain the complete NHMS dataset of individual PFAS measurements, including data associated with sample population weights, postcode, age and sex, has commenced and will allow for a more comprehensive comparison and the evaluation of the basis for the observed differences within this study. This will be included within the conference presentation if the additional data is received in time.

PFAS Exposure 1

G. Becher & T.Webster

D27-349 Assessment of the Human exposure to TFA: to what extend are we exposed in Belgium?

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Introduction

Perfluoroalkyl substances (PFAS) are of growing concerns due to the widespread environmental contamination and related potential adverse health effects. Numerous studies have highlighted the ubiquitous PFAS human exposure (1). Trifluoroacetic acid (TFA) is included in the ultra-short chain (USC) PFAS which contains up to 3 carbon atoms. The main particularity of UCS PFAS compared to longer-chains is their high-water solubility, and their expected lower bioaccumulation properties. However, they are considered as persistent as legacy PFAS and were sometimes found at higher levels in different environmental matrices such like water, food, air or soils (2). Nevertheless, the human exposure to USC PFAS is still scarcely studied, likely due to the disinterest because their lower accumulation potency in living organisms and expected lower toxicity than their longer-chain homologues, but also more probably because of the high analytical challenge to measure these highly polar substances. To partly fill this gap, a small human biomonitoring study was carried out in the French speaking part of Belgium (Wallonia) to provide the first data on the European population exposure to TFA.

Materials and Methods

Study population:

In 2025, plasma samples from 98 female and 99 male patients aged from 20 years to 84 years old initially collected for hemoglobin analyses from EDTA tubes in the University Hospital of Liege were selected and stored at -20°C the day after the collection for further TFA analyses. This study was approved by the Hospital Faculty Ethics Committee of the University of Liege.

Chemical analyses:

Methanol was added to the plasma sample for protein precipitation. After centrifugation, the supernatant was diluted in water before injection on a liquid chromatograph equipped coupled to triple quadrupole mass spectrometer operating in negative electrospray, and monitoring 2 different MRM transitions. The quantification was based on isotopic dilution using TFA 13C2 as internal standard. The limit of quantification was evaluated according to the total error approach and set at 4 µg/L.

Results

The below table gathers the results obtained.

Discussion and Conclusion

Ninety-two percents of the samples analysed showed levels above the LOQ demonstrating the widespread exposure of the studied population. TFA levels tends to slightly but significantly increase with age. The median levels measured seems nearly twice higher than those reported for US (3) and Chinese (4) populations, but lower than those observed for US residents living near a fluorochemical manufacturing facility exposed to high TFA levels through drinking water (5).

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	N	N>LOQ	MG	P5	P25	P50	P75	P95
		%	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
All	197	92.3	12.3	<4.0	7.72	13.3	21.9	42.9
20-39 yrs	61	88.5	9.45	<4.0	7.10	10.0	15.9	33.1
40-59 yrs	71	90.1	13.0	<4.0	7.95	13.1	21.6	50.1
>60 yrs	65	96.9	14.9	5.44	8.95	14.8	24.6	39.8

PFAS Exposure 1

G. Becher & T.Webster

D27-732 Distribution of per and polyfluorinated alkyl substances in autopsy human tissues

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Introduction
Despite research over the last few years assessing perfluoroalkyl substances (PFASs) in the environment and their accumulation and impacts on humans, knowledge of their metabolism and distribution in the different organs remains incomplete, and the number of studies assessing them in human tissues remains very limited.
In this study, autopsy tissues (brain, liver, lung, bone, adipose tissues, and kidney) pertaining to 22 subjects living in Tarragona (Catalonia, Spain) were analysed.

Materials and Methods
The extraction and purification of the samples were carried out by ultrasonic solvent extraction followed by solid-phase extraction (SPE) using weak anion exchange and reversed-phase (WAX) cartridges. The analysis was performed by liquid chromatography coupled to high-resolution mass spectrometry equipped with an electrospray ionisation (ESI) source operating in negative mode (LC-ESI(-)-HRMS). The chromatographic separation of ultrashort-chain analytes was achieved using a mixed-mode Atlantis™ Premier BEH C18 AX column, while a Hypersil GOLD PFP C18 column was used for legacy and replacement PFAS. The mass spectrometry analysis was performed using an Orbitrap Exploris 240. A suspected screening approach and target analysis of 24 analytes in 110 human samples was applied, working in triplicate.

Results
The analysis showed that trifluoroacetic acid (TFA) was one of the most frequently found compounds, followed by perfluorohexanesulfonic acid (PFHxS), perfluorooctanoic acid (PFOA) and perfluorooctanoic acid (PFOS). In terms of concentrations, the highest values were found in the lung, particularly for short-chain compounds, and in the liver for legacy PFAS such as PFOS. These results will be discussed in detail by organs and compounds and will be compared with a previous publication of the same group of authors1 in 2013. After 13 years and the phase-out of PFOS and PFOA in 2002 and 2015, respectively, a reduction in the accumulation levels of these two compounds is observed when comparing the mean values for the same tissues in the first and current studies, despite these compounds remaining prevalent at higher levels. However, some compounds, such as TFA, which had not been studied before, were found at concentrations reaching 215 ng/g in the lung.

Discussion and Conclusion
To the best of our knowledge, the accumulation of different PFASs in samples of various human tissues from the same subjects has been studied only in these two studies. These results may be of great importance for the validation of physiologically based pharmacokinetic models being developed for humans. However, further studies on the distribution of the same compounds in the human body are still required.

Acknowledgment
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PFAS Exposure 1

G. Becher & T.Webster

D27-074 PFAS exposure of pet cats and the validation of hair as a biomonitoring matrix

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Introduction
Endocrine diseases are rising globally. This upward trend in humans and pets has been linked to environmental chemical exposure [1, 2]. As both species share same home environment, they experience similar indoor contaminant levels. Pet cats have been suggested as sentinels for human chemical exposure, especially for toddlers, due to their shared dust ingestion pathways [3]. PFAS are of concern due to their persistence and endocrine-disrupting potential. Notably, similar levels of PFAS have been reported in both human and cat blood [4]. While blood is a widely used matrix for biomonitoring of chemical exposure, hair has emerged as a promising, non-invasive complementary approach [5].
This study aims at a) elucidating PFAS exposure profiles in pet cat blood, and b) evaluating cat hair as a non-invasive matrix for PFAS monitoring by comparing levels to blood levels. Additionally, paired hair and household dust are analyzed to investigate dust as an exposure pathway.

Materials and Methods
Two cohorts are investigated: Cohort A (n=20) focuses on indoor exposure, where volunteering cat owners provided cat hair and household dust samples. Cohort B (n=50) consist of cat hair and serum samples collected during routine veterinary visits, alongside recorded health status, e.g., the Body Condition Scores (BCS).
Cat hair was cryomilled and pulverized before extraction. All matrices were extracted using acetonitrile. Depending on the matrix, either ENVI-Carb (Supelclean Merck) or Enhanced Matrix Removal-Lipid (Agilent) was used for the clean-up. More than 300 PFAS, including novel ones, have been analyzed with both target and suspect screening using ultrahigh performance liquid chromatography (Dionex Ultimate 3000), coupled to a high-resolution mass spectrometer (Q Exactive HF hybrid Orbitrap, Thermo Fisher Scientific Inc.).

Results
Individual PFAS were detected in cat hair ranging from <LOQ to 37 ng/g. With PFOA exhibiting the highest average concentration (3.5 ng/g) in cohort A. In indoor dust samples, concentrations ranged from <LOQ–260 ng/g, with 6:2 diPAP showing the highest average concentration (41 ng/g). Significant correlations ($p < 0.05$) between paired indoor dust and cat hair samples were identified for PFNA, PFDA and PFDoDA. Current work is analysing samples in Cohort B.

Discussion and Conclusion
Cat hair demonstrates potential as a reliable matrix for PFAS biomonitoring. The cohort size is limited and while significant correlations for 3 PFAS confirm that indoor dust is a contributor to cat PFAS burden, the lack of correlation for other PFAS could imply other exposure sources, such as diet or water. Alongside this, potential associations between PFAS exposure and physical health indicators, specifically the BCS, are being investigated and will be reported at the conference.

Acknowledgment
Molly Jansson for analytical support and FORMAS for financial support of the FELIX project (Dnr: 2021-00899).

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Human Exposure 3

S. Harrad & B. Le Bizec

D28-271 Pet dogs as sentinels of persistent organic pollutant exposure and disease

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Introduction

Pet dogs are increasingly recognized as sentinel species for human environmental health due to shared environments, conserved disease biology, and shorter disease latency. Here we integrate findings from multiple studies using personal passive silicone samplers and biological samples analyzed with targeted and non-targeted GC–HRMS approaches to assess exposures to a variety of persistent organic pollutants (POPs) including pesticides, brominated flame retardants (BFRs), phthalates, polycyclic aromatic hydrocarbons (PAHs), and other semi-volatile organic compounds.

Results

Comparative analyses of paired households (n = 30) demonstrated strong correlations between exposures measured in dogs and their owners across several POPs (rs = 0.38–0.96, $p < 0.05$), demonstrating shared exposure profiles within the home. Notably, silicone samplers worn by dogs (on their collars) showed stronger and significant correlations with urinary biomarkers compared to their owners for organophosphate esters and some pesticides, indicating that dogs may serve as more consistent integrators of environmental exposure, likely due to reduced variability in daily microenvironments and more uniform dietary exposures relative to humans.

Expanding to nationwide assessments, we recruited pet dogs (n=76) from the Dog Aging Project (DAP), a long-term, longitudinal study of pet dogs in the U.S., to investigate differences in chemical exposures along the urban vs rural divide. We measured exposures using silicone samplers analyzed via targeted and non-targeted GC–HRMS approaches. Overall, forty-two targeted compounds were detected frequently spanning multiple classes of POPs and related contaminants. Significant differences in exposure profiles were observed across groups, including higher levels of PCB-28, tris(2-ethylhexyl) phosphate (TEHP), 4-tert-Octylphenol (4tOP) and diethyl phthalate (DEP) (1.5–4.6X, $p < 0.05$) in urban areas, whereas BDE-47 (3.8X) and DEET (2.2X) were higher in the rural areas ($p<0.05$). Non-targeted analyses identified 1,364 chemical features that had higher exposures in urban dogs, of which 36 were significantly higher (1.6-25X, $p < 0.01$). In contrast, only 688 chemical features were higher in rural dogs, and only 4 of those features were significantly higher (1.4-4.4X, $p < 0.01$), underscoring the complexity of environmental exposures by region. Episodic exposure events were also captured, with dogs in regions impacted by wildfire smoke exhibiting higher PAH levels (1.3–1.8X).

Linking exposure to disease, a case–control study of canine bladder cancer (n = 25 cases, n = 76 controls) across the U.S. identified significantly higher levels (2–3×) of BDE-47, BDE-99, anthracene, and benzyl butyl phthalate (BBP) in dogs with early molecular indicators of disease. Nontargeted analyses of the silicone tags also revealed that cases experienced an overall greater chemical burden of exposure compared to controls. Ongoing analyses within a second nested case-control study (n = 100 hemangiosarcoma cases, n = 200 controls) using the Golden Retriever Lifetime Study (GRLS) cohort are extending this framework to evaluate associations between serum POPs, including PCBs, organochlorine pesticides, BFRs, and PFAS, and cancer risk.

Discussion and Conclusion

Together, these studies demonstrate that pet dogs provide a powerful, noninvasive model for characterizing real-world exposures to POPs, capturing complex chemical mixtures, and identifying links between environmental contaminants and disease. These findings highlight the relevance of companion animals in advancing exposomic research on legacy and emerging POPs and support their application as translational models for human health within a One Health framework.

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Human Exposure 3

S. Harrad & B. Le Bizec

D28-415 Companion animals as One Health sentinels of environmental exposure to toxic chemicals: the global MARIAH network

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Introduction

The scale and complexity of environmental changes in the last decades poses major challenges for environmental health research fields including prevention of adverse biological effects. Humans are potentially exposed to thousands of synthetic chemicals that are now ubiquitous across indoor environments and ecosystems worldwide. Yet, toxicological assessment still relies largely on reductionist single-compound approaches that fail to capture the chronic low-dose and mixture exposures characterising real-world conditions. This is at the base of environmentally mediated diseases, including metabolic disorders, reproductive dysfunction, neurotoxicity, immune dysregulation, and cancer. The nature of these effects makes, by definition, causal attribution in human populations extremely difficult if not impossible due to lack of multiple robust cohorts. Although advances in exposomics and New Approach Methodologies (NAMs) are improving environmental risk assessment, there remains a need for integrated surveillance systems capable of detecting biologically relevant environmental signals earlier and under shared exposure conditions. Within this context, companion animals may represent a valuable, yet underused, opportunity for strengthening environmental exposure assessment within a One Health framework. Dogs and cats share air, water, consumer products, indoor dust and household contaminants with humans, resulting in highly overlapping exposures. Due to their shorter lifespans and proportionally accelerated disease progression, companion animals develop environmentally associated biological effects earlier than humans, creating opportunities for anticipatory environmental health surveillance. An increasing number of studies support this sentinel role. Companion animals accumulate PFAS, flame retardants, pesticides, and other persistent organic contaminants associated with indoor environments. Correlations between pet and owner exposure profiles have been demonstrated using paired biomonitoring approaches, including serum analyses and silicone passive samplers. Environmentally associated diseases in companion animals have also shown geographical and epidemiological parallels with human disease patterns, including spatial overlap between canine and human cancers in polluted urban environments and endocrine dysfunction linked to indoor contaminants in cats. Together, these findings suggest that companion animals may function as biologically integrated sentinels capable of reflecting environmentally relevant exposures occurring within shared human environments.

Despite accumulating evidence, veterinary and human environmental health systems remain poorly integrated. Most large-scale human cohort studies rarely include biological sampling from companion animals, while veterinary surveillance systems are generally designed around animal health outcomes rather than environmental public health applications. Consequently, substantial cross-species exposure information remains fragmented across disciplines and institutions. In response to these limitations, the MARIAH (Multidisciplinary Alliance for Research in Animals and Humans) network was established to provide the critical interdisciplinary mass needed to advance integrated One Health environmental surveillance using companion animals as sentinels of shared exposure. Emerging from the international workshop My Best Friend, My Surrogate: Pets as Sentinels of Human Health, held at the University of Évora (Portugal) in 2023, MARIAH brings together researchers from environmental chemistry, toxicology, epidemiology, veterinary sciences, clinical sciences and public health. This presentation aims to introduce the MARIAH network, its scientific rationale and vision on integrating companion animals into environmental exposure science. Current objectives include mapping existing evidence, harmonising non-invasive biomonitoring methodologies across species, integrating linked human–animal exposure datasets, and developing prospective cohort approaches capable of characterising real-world exposure to contaminants and complex environmental mixtures under shared living conditions. By strengthening collaboration between sectors, MARIAH seeks to contribute to earlier detection of environmental risks and more prevention-oriented approaches to public health in the context of accelerating environmental change.

MARIAH members

Ait Bamai Y, Andersen-Ranberg EU, Cerquetella M, Dietz R, Franco-Martínez L, Hallberg I, Isobe T, Lea R, Mizukawa H, Namorado S, Nomiyama K, Palermo FA, Ruple A, Taborda-Barata L, Vaz Patto M.

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Human Exposure 3

S. Harrad & B. Le Bizec

D28-788 Assessment of the Potential Contribution of House Dust Exposure to Chlordane Concentration in Breast Milk in Japan

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Introduction
Chlordane (CHL) was formerly used as a termiticide in Japanese wooden houses. Although its production and use were discontinued in Japan in 1986, CHL is still detected in human biological samples, including breast milk. These findings suggest that exposure to legacy CHL may continue long after its ban. Because CHL can persist in indoor environments for extended periods, house dust ingestion may represent one possible pathway of ongoing human exposure. However, information on CHL residues in house dust in Japan remains limited, and its relevance to CHL detection in breast milk has not been fully examined. In this study, we investigated CHL and selected organic pollutants in house dust and breast milk collected from homes in and around Fukuoka, Japan, and evaluated the potential contribution of house dust exposure to long-term human CHL burden.Chlordane (CHL) was formerly used as a termiticide in Japanese wooden houses. Although its production and use were discontinued in Japan in 1986, CHL is still detected in human biological samples, including breast milk. These findings suggest that exposure to legacy CHL may continue long after its ban. Because CHL can persist in indoor environments for extended periods, house dust ingestion may represent one possible pathway of ongoing human exposure. However, information on CHL residues in house dust in Japan remains limited, and its relevance to CHL detection in breast milk has not been fully examined. In this study, we investigated CHL and selected organic pollutants in house dust and breast milk collected from homes in and around Fukuoka, Japan, and evaluated the potential contribution of house dust exposure to long-term human CHL burden.

Materials and Methods
House dust and breast milk samples were collected from 27 homes in Fukuoka Prefecture and neighbouring areas in 2017. Dust was retrieved from used household vacuum cleaner bags, placed in polyethylene bags, transported to the laboratory, and sieved to obtain the <500 µm fraction. CHL-related compounds, including oxychlordane, trans-chlordane, cis-chlordane, trans-nonachlor, and cis-nonachlor, were analyzed together with selected halogenated flame retardants, including BDE 209, decabromodiphenyl ethane, and dechlorane plus. The target compounds were determined by gas chromatography–mass spectrometry using electron capture negative ionization. The estimated daily intake of CHL through dust ingestion was calculated assuming a dust intake rate of 50 mg/day and a body weight of 60 kg, and was compared with the reference dose for CHL.

Results
CHL-related compounds were detected in many of the house dust samples, indicating that CHL can remain in Japanese indoor environments even decades after its use was discontinued. Several chlordane and nonachlor isomers were frequently detected, whereas oxychlordane was detected less frequently. The detection pattern suggested that residues from past termiticide applications may still be present in residential dust. Compared with some brominated flame retardants analyzed in the same samples, CHL concentrations tended to be lower. The estimated intake of CHL through dust ingestion was well below the reference dose, suggesting that ordinary dust ingestion is unlikely to pose an immediate health concern. Some chlordane-related compounds showed correlations between their concentrations in breast milk and those in house dust.

Discussion and Conclusion
This study confirmed the continued presence of CHL in house dust from Japanese homes more than 30 years after its ban. Although the estimated exposure through dust ingestion was low, CHL is persistent and bioaccumulative, and long-term low-level indoor exposure may contribute to human body burdens. Considering the continued detection of CHL in breast milk, house dust should be considered as one possible exposure pathway that may contribute to ongoing human exposure.

Epidemology and Exposome 1

A. Covaci & N. Kajiwara

D29-551 Results of an epidemiological study on PFAS exposure in Antwerp, Belgium

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Introduction
For several decades a large production facility near Antwerp, Belgium, has produced a host of different per- and polyfluorinated alkyl (PFAS) compounds. Until around 2000, perfluorooctylsulfonic acid (PFOS) was the main component. After termination of the PFOS production, the production was shifted towards shorter-chain PFAS with chain lengths of, e.g., four carbon atoms. In 2021, soil excavations, required for the construction of a new highway, revealed high levels (up to > 100 mg/kg dry weight (dw) of PFOS in soil) in and around the plant. A first small pilot study on PFAS in blood of the local population showed extremely high PFOS levels, up to 1100 mg/L for the sum of total-PFOS, total-PFOA, PFHxS and PFNA in serum, whereas the European advisory level set by the European Food Safety Agency (EFSA) is 6.9 mg/L serum for these PFAS. More than 90% of this sum consisted of PFOS, suggesting a relation with the production facility. The Flemish government therefore decided to follow-up this pilot study and carry out an epidemiological study on PFAS.

Materials and Methods
Over 80,000 inhabitants within a radius of 5 km from the production facility, including part of the centre of Antwerp, were invited to donate blood and complete extensive questionnaires on their lifestyle and background. Nine thousand people joined this study which took place in 2023-2024. A separate study was carried out in mother and child pairs, and a third sub-study focused on a comparison between the analysis of PFAS in serum and that in whole blood, following a finger prick method. A questionnaire was to be completed by all participants, with information on, among others, their background, work, age, time they lived in the area, and health complaints.

Results
The study resulted in a wealth of data of which the main observations were the following. Within ca. 2 km from the production plant people were heavily exposed to PFOS with levels up to 500 mg/L serum. Between 2 and 5 km, a drop in the concentrations occurred to background PFOS levels in the rest of Flanders of just above those (ca. 5-20 mg/L serum). Two self-reported health effects could significantly be coupled to the high PFOS levels: an impaired thyroid function and deviations (e.g., inflammations) of the liver. There were indications that so-called no-regret measures (no consumption of food from own gardens, eggs from own chickens, and groundwater) taken ca. four years ago, after the discovery of the pollution, might have helped to lower the PFOS levels to some extent.

Discussion and Conclusion
More than 20 years after the termination of the PFOS-production, people living within 3 km from the production facility suffered from strongly elevated PFOS levels in their blood, in several cases leading to significant health effects, in particular liver dysfunction and impaired thyroid function.

Acknowledgment
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Epidemology and Exposome 1

A. Covaci & N. Kajiwara

D29-708 Age- and ethnicity-stratified temporal trends of legacy PFAS in U.S. serum: demographic disparities in NHANES 2003–2018 biomonitoring

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Introduction

Legacy per- and polyfluoroalkyl substances (PFAS) are persistent, bioaccumulative contaminants that partition strongly to serum and have multi-year human elimination half-lives. Following the phase-out of perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) production in the early 2000s, U.S. national biomonitoring (NHANES) has documented broadly declining population serum concentrations. When conducting exposure assessment, it's important to compare results to benchmark studies like NHANES for context. Careful considerations need to be made during these comparisons because serum PFAS reflect both recent exposure and accumulated body burden, within the broader trend of declining population levels. Whether declines are uniform across age, sex, and race/ethnicity has direct consequences for exposure reconstruction, half-life interpretation, and identifying populations retaining the highest body burdens.

Materials and Methods

We compiled serum PFAS measurements from eight consecutive NHANES cycles (2003–2018) for seven legacy analytes: PFOA, PFOS, perfluorohexane sulfonate (PFHxS), perfluorononanoate (PFNA), perfluorodecanoate (PFDA), perfluoroundecanoate (PFUnDA), and 2-(N-methyl-perfluorooctane sulfonamido) acetate (Me-PFOSA-AcOH). Measurements were harmonized across cycles to account for changes in analytical methods and method reporting limits (values below the limit of detection were imputed at LOD/$\sqrt{2}$). Data were divided into Sex × Ethnicity × Compound strata (n = 70). Within each stratum we fit a linear model of log-transformed concentration as a function of year of measurement × age, allowing the temporal slope to vary with age. Marginal time and age slopes were extracted with 95% confidence intervals and back-transformed to annual percent change.

Results

All seven PFAS declined significantly across the study period. PFOS exhibited the steepest declines (−9.9 to −12.4%/yr across ethnic groups), followed by Me-PFOSA-AcOH (−5.9 to −10.1%/yr) and PFOA (−6.1 to −8.6%/yr). PFHxS declined most slowly (−3.8 to −6.0%/yr). These rates are a function of both exposure changes due to phase outs and differences in elimination half-lives. Within this analysis, age effects were positive in 63 of 70 strata (median +0.7%/yr of age; range −0.3 to +2.0), indicating that older individuals carried higher concentrations, consistent with lifetime accumulation and higher historical exposure. Time × age interactions were significant ($p < 0.01$) in 33 of 70 strata, confirming that decline rates genuinely differ across the age span.

Ethnicity differences were substantial and consistent: Non-Hispanic Black (NHB) participants showed both the steepest temporal declines across analytes (NHB: −7.9%/yr vs Non-Hispanic White [NHW]: −7.1%/yr) and the largest age gradients (NHB: +1.0%/yr of age vs NHW: +0.54%/yr), implying higher historical body burden combined with faster recent reduction. Disparities were larger at the compound level. For PFHxS, NHB declines were nearly double those in NHW (−6.0 vs −3.8%/yr), with markedly steeper age gradients (+0.55 vs +0.14%/yr).

Discussion and Conclusion

Temporal declines in U.S. serum PFAS are not demographically uniform; both the rate of decline and the age dependence of body burden vary systematically by race/ethnicity and compound. Reporting age- and ethnicity-resolved trends, rather than single population rates, provides a more accurate basis for estimating residual body burden, reconstructing past exposure, and identifying subgroups that remain most highly exposed.

Epidemology and Exposome 1

A. Covaci & N. Kajiwara

D29-740 A novel ex vivo pituitary model for neuroendocrine disruptive chemicals - can PFAS exposure interfere with regulation of gonadotropin transcription and secretion?

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are increasingly recognized as chemicals capable of altering reproductive endocrine functions. However, the effects of PFAS on pituitary gonadotropes remains to be understood. Ex vivo pituitary cultures provide a physiologically relevant model that preserves tissue architecture and cell-cell interactions while allowing controlled assessment of endocrine regulation. In teleosts, luteinizing hormone (Lh) and follicle-stimulating hormone (Fsh) are produced by distinct cell populations, enabling independent investigation of their regulatory mechanisms. This study examined the effects of neuroendocrine stimulation by perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) on gonadotropin gene expression and secretory activity in ex vivo medaka (Oryzias latipes) pituitaries. Estradiol (E2) and bisphenol A (BPA) were used for optimalization of the model for testing endocrine disruptive potential of chemicals, and further used as estrogenic reference controls.

This study is a part of the Eu funded project CHIASMA - Accessible Innovative Methods for the Safety & Sustainability Assessment of Chemicals & Materials, which aim to devise and demonstrate a comprehensive set of New Approach Methodologies (NAMs) and integrate them in a user friendly, reliable and robust framework to perform human and environmental safety evaluation in a regulatory context.

Materials and Methods

Pituitaries from adult medaka were cultured ex vivo for up to 10 days. Gonadotropin regulation was assessed using gonadotropin-releasing hormone (mdGnRH) and cholecystokinin octapeptide (CCK8) stimulation. Transcript levels of lhb and fshb were quantified by qPCR at defined culture time points. To evaluate hormone secretion dynamics, transgenic medaka lines expressing genetically encoded calcium indicators in Lh or Fsh cells were used for live calcium imaging as a proxy for secretory activity. Pituitaries were exposed acutely or for 48 h to environmentally relevant concentrations of PFOS and PFOA. Parallel exposures to E2 and BPA served as positive estrogenic controls. Changes in gene expression and calcium responses following mdGnRH or CCK8 stimulation were analyzed relative to untreated controls.

Results

Expression of both lhb and fshb declined progressively during ex vivo culture, indicating loss of endogenous hypothalamic input. Neuroendocrine stimulation restored gonadotropin expression, with CCK8 maintaining significant fshb responsiveness for up to 10 days, whereas mdGnRH-induced lhb responsiveness persisted for 4 days. Calcium imaging demonstrated sustained functional responsiveness of Fsh cells to mdGnRH and CCK8 for up to 6 days in culture, while Lh-cell responses remained detectable for up to 4 days.

Exposure to E2 reduced fshb transcript abundance, whereas BPA induced a non-monotonic response, confirming the sensitivity of the model to estrogenic disruption. Despite transcriptional alterations, the estrogenic controls did not significantly affect stimulation-induced calcium responses in Lh or Fsh cells following acute or 48 h exposure. These findings suggest preservation of secretory competence despite changes in transcriptional regulation. PFOS and PFOA experiments are ongoing and results will be presented at the conference.

Discussion and Conclusion

The present study demonstrates that ex vivo medaka pituitaries retain functional responsiveness to hypothalamic regulators for several days and represent a robust platform for investigating pituitary-targeted endocrine disruption. The results will provide new insight to whether PFOS and PFOA can act at the pituitary level and highlight the value of ex vivo teleost models as a NAM for mechanistic assessment of persistent environmental contaminants.

Acknowledgment

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PFAS Abiotic 2

M. Cristofori & R. Hoogenboom

D30-182 Seasonal occurrence of per- and poly- fluoroalkyl substances (PFAS) in surface waters, groundwaters, and wastewaters of the Küçük Menderes River Basin, Türkiye

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are synthetic fluorinated chemicals produced since the 1940s for consumer and industrial uses, including non-stick coatings, food-contact materials, textiles, electronics, aqueous film-forming foams, paper treatments, and metal plating. Under the current OECD definition, more than 7 million substances are classified as PFAS. Their strong C–F bonds make them resistant to hydrolysis, photolysis, metabolism, and biodegradation, giving them exceptional persistence, mobility, and bioaccumulation potential. Today, several PFAS (PFOS, PFOA, PFHxS, and related substances) are listed under the Stockholm Convention. As PFAS are poorly removed by conventional drinking-water and wastewater treatment processes, industrial and municipal discharges are ongoing sources to rivers and aquifers used for water supply and irrigation, making occurrence data across water matrices central to source tracking, exposure assessment, and regulatory management.

Materials and Methods

Study area, sampling, and analysis. The Küçük Menderes River Basin (≈702,900 ha), almost entirely within İzmir Province on Türkiye's Aegean coast, drains to the Aegean Sea and contains six organized industrial zones together with thousands of individual textile, leather, ceramic, paper, metal-finishing and food-processing facilities, and receives their treated and untreated domestic and industrial wastewater along its course.
Sampling is conducted seasonally over two years across 28 locations: 14 surface-water stations along the main stem and tributaries between the Beydağ Reservoir and Pamucak Bay, including transitional water at the river mouth and coastal water in Pamucak Bay; 7 groundwater wells; and the inlets and outlets of 7 wastewater treatment plants (WWTPs) comprising 1 standalone textile-sector and 1 standalone ceramic-sector industrial WWTP located outside the organized industrial zones, 3 organized industrial zone WWTPs, and 2 urban WWTPs. Samples are collected in PFAS-free HDPE bottles using standard contamination-control procedures, with on-site measurements of pH, temperature, electrical conductivity, dissolved oxygen, and salinity, and are preserved at 4 °C. An in-house analytical procedure based on USEPA Method 1633 was developed and applied, using solid-phase extraction (SPE) followed by liquid chromatography–tandem mass spectrometry (LC-MS/MS).

Results

The method achieved LODs of 0.05–5.35 ppb and LOQs of 0.16–17.83 ppb across the 27 target PFAS. To date, 36 samples have been analyzed in the first season (winter), and approximately 53% had ΣPFAS < LOD, indicating low background contamination across much of the basin. In detected samples, ΣPFAS ranged from 0.2 to 104.1 ppb, with the highest values confined to industrial WWTP influents and surface waters receiving direct industrial discharges, indicating that the basin's PFAS burden is driven by a limited number of point industrial sources rather than non-point sources. By matrix, ΣPFAS above the LOD spanned 0.2–4.6 ppb in surface waters (with a paper-industry-adjacent stream reaching 83.6 ppb); <LOD–1.4 ppb in groundwater; <LOD–2.4 ppb in industrial discharge outlets; 45.8–104.1 ppb in WWTP influents; and <LOD–2.3 ppb in WWTP effluents. Inlet–outlet contrasts at WWTPs indicate substantial apparent reductions in summed PFAS, although these may partly reflect precursor transformation rather than true elimination. Concentrations are being benchmarked against EU environmental quality standards and US EPA health advisories.

Discussion and Conclusion

This work will provide the earliest basin-scale Turkish dataset covering a broad PFAS suite simultaneously in surface water, groundwater, and wastewater, and the first seasonal PFAS characterization reported for the Küçük Menderes River Basin. Outputs will establish baselines for subsequent seasonal comparisons and support the development of PFAS-related environmental quality standards in Türkiye. The dataset will also enable screening-level risk evaluation in line with US EPA frameworks, providing a foundation for more comprehensive future assessments.

Acknowledgment

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PFAS Abiotic 2

M. Cristofori & R. Hoogenboom

D30-394 Characterization of known and unknown PFAS in groundwater and surface water at an AFFF-contaminated site treated with a colloidal activated carbon (CAC) barrier

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Introduction
The occurrence of per- and polyfluoroalkyl substances (PFAS) in soil and groundwater poses a significant risk to both human health and the environment. The historical use of aqueous film-forming foam (AFFF) at firefighting training sites by airports and military facilities has resulted in extensive contamination of soil, groundwater, and surface water. Remediation of PFAS-contaminated sites is essential, as leaching and transport of contaminant plumes from point sources can result in significant exposure. Conventional treatment methods, such as ex-situ treatment that requires excavation and transportation, are often costly, energy-intensive, and may generate secondary contaminated waste. However, in-situ stabilization treatments, such as PFAS retention by colloidal activated carbon (CAC) barrier, are innovative and sustainable, and could effectively stabilize and limit PFAS migration in soil and groundwater at comparatively lower costs and with lower energy consumption.

Materials and Methods
In this project, an in-situ permeable CAC barrier was implemented at an AFFF-contaminated site. Groundwater and surface water samples were collected in May 2024 and 2025 to evaluate the total PFAS levels. A comprehensive analytical workflow was applied for PFAS characterization, including target analysis by using liquid chromatography-tandem mass spectrometry (LC-MS/MS), determination of extractable organofluorine (EOF) by using combustion ion chromatography (CIC) in combination with fluorine mass balance, total oxidizable precursor (TOP) assay on raw samples and extracts, and suspect screening.

Results
Groundwater and surface water samples collected at varying distances from the source zone have demonstrated clear differences in PFAS profiles. Groundwater samples collected within the source zone showed PFAS concentrations ranging from 16,600 to 204,000 ng/L, where the most abundant compounds were T-PFOS (71%), T-PFHxS (6%), and T-FHxSA (4%). Groundwater samples closest to the CAC barrier contained a higher proportion of ultra-short-chain PFAS, particularly those collected in 2025, contributing between 27 and 99% of the total target PFAS concentration. The EOF concentrations ranged from 36 to 132,000 ng/L, while the proportion of known EOF ranged from 9 to 98%. Oxidation experiments revealed substantial precursor degradation, particularly in raw samples, demonstrating the presence of significant precursor fractions not captured by conventional target analysis.

Discussion and Conclusion
Overall, the levels of both identified and unidentified EOF were reduced in groundwater and surface water samples collected in May 2025, both within and near the barrier, compared to prior samples collected in May 2024, suggesting sorption of both known and unknown fluorinated substances. EOF analysis demonstrated lower concentrations of known EOF near the barrier, suggesting retention or transformation of target PFAS. Differences in oxidation profiles between samples collected near and further from the barrier further indicated spatial variations in precursor composition and transformation potential. The results have demonstrated the importance of combining target analysis with fluorine mass balance and oxidation-based approaches for better characterization of PFAS contamination and evaluation of remediation performance at AFFF-impacted sites.

Acknowledgment
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PFAS Abiotic 2

M. Cristofori & R. Hoogenboom

D30-619 Ten years of PFAS monitoring and regulatory assessment in surface waters of the Duero basin (Spain)

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are synthetic chemicals widely used due to their thermal and chemical stability, and resistance to degradation. Some of their common applications are as polymers, surfactants, stain repellents, and flame retardants in several products such as paper, textiles, or fire-fighting foams (FFF). These excellent properties, along with their wide industrial applications, and combined with their mobility and bioaccumulative potential, has raised serious environmental and health concerns. Known as "forever chemicals", their environmental persistence and global distribution have led to regulatory actions under the Stockholm Convention (SC), including PFOS (2009), PFOA (2019), and PFHxS (2022). Attending to the ionic and water-soluble nature of many PFAS, surface water is one of the best matrices for monitoring in the environment. This study presents the Spanish Monitoring Program of POPs data for the evaluation of PFAS presence in the Duero basin in Spain between 2013 – 2024. The main objectives of this work are to evaluate spatial and seasonal variations, analyze patterns in the contamination profiles, identify sources of pollution, and document the regulatory compliance and effectiveness of the SC.

Materials and Methods
Surface water was seasonally collected across four locations. The selected sites represented distinct land-use scenarios: an upstream area with low human activity (Uzquiza), two sites situated near industrialized and populated areas downstream of the cities of Burgos and Valladolid (Villavieja and Simancas), and a background reservoir located in the lower part of the basin near the Portuguese border (Fregeneda). PFOS, PFOA and PFHxS were analyzed in the water samples using a SPE followed by UPLC-MS/MS

Results
Median concentrations of PFOS, PFOA, and PFHxS were 0.50, 0.30 and 0.16 ng/L, respectively, with PFOS predominating (PFOS > PFOA > PFHxS). Statistical analyses, revealed a great anthropogenic footprint where median concentrations for all three compounds exhibited a clear spatial variability gradient: headwaters sites had low or non-detectable PFAS levels, whereas urban-influenced areas such as Villavieja and Simancas sites recorded the highest concentrations. This is attributed to localized industrial activities, including waste management facilities, metal coating operations, and the manufacturing of pulp, paper, and paperboard articles, close to these locations.Although PFOS levels remained below the maximum allowable concentration (MAC = 36 µg/L), several sites approached up to 50 % of the annual Environmental Quality Standard (AA-EQS) set (0.65 ng/L). Long-term temporal trend analysis showed mixed dynamics, where PFOS concentrations showed isolated declines reflecting the positive impact of regulatory bans, and PFHxS exhibited localized increasing trend (4% PFHxS increase at Fregeneda), signaling potential ongoing emissions or environmental reservoirs.

Discussion and Conclusion
These findings underscore the importance of spatial and temporal trends studies in water, emphasizing the critical need for continued local assessments, strict regulatory oversight, and targeted water quality management under the SC and EU Water Framework Directive. Besides, this study highlights how historical regulations have successfully mitigated PFOS contamination, and further monitoring efforts are required to track the long-term trends of PFOA and PFHxS following their more recent regulatory restrictions.

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PFAS Abiotic 2

M. Cristofori & R. Hoogenboom

D30-752 Occurrence and profiles of target and suspect PFAS in water and sediment from a highly industrialized artificial lake of Korea

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are widely used in industrial applications and consumer products, including textiles, food-packaging materials, and grease repellents. Industrialized coastal areas are particularly important for understanding PFAS contamination because they may receive direct and indirect inputs from various manufacturing activities. In addition to conventional perfluoroalkyl acids (PFAAs), increasing attention has been paid to precursors, emerging alternatives, and their transformation products. Comprehensive investigation of these compounds is essential for better evaluating PFAS contamination and for understanding their potential sources, transformation processes, and environmental fate.

Materials and Methods
Surface water (n = 41) and sediment samples (n = 41) were collected from Lake Shihwa, Korea, and its surrounding creek areas near industrial complexes in 2021. Target and suspect PFAS were analyzed using an integrated analytical approach based on gas chromatography- and liquid chromatography-tandem mass spectrometry (GC- and LC-MS/MS). Ionic PFAS, including PFAAs, were determined by LC-MS/MS, while volatile and neutral PFAS were determined using GC-MS/MS. Suspect analysis was focused on fluorotelomer-related homologues and chain-length analogues of the target compounds. Tentatively identified suspect compounds were further evaluated by semi-quantification.

Results
Several longer-chain fluorotelomer-based compounds were detected through suspect analysis, including fluorotelomer alcohols (FTOHs), fluorotelomer acrylates (FTACs), and fluorotelomer carboxylic acids (FTCAs). Both target and suspect PFAS showed elevated levels in industrial creek areas compared with lake sites. Emerging fluorotelomer-based alternatives, including 6:2 fluorotelomer sulfonic acid (6:2 FTSA) and 6:2 fluorotelomer methacrylate (6:2 FTMAC), were also found near industrial complexes. Matrix-dependent patterns were observed between water and sediment, with short-chain PFAS predominating in water and longer-chain PFAS showing greater relative contributions in sediment. Fluorotelomer precursors were positively correlated with their related transformation products, suggesting a possible precursor–product relationship.

Discussion and Conclusion
This study demonstrates that Lake Shihwa and its surrounding creek areas are affected by diverse PFAS inputs from nearby industrial activities. The presence of C6-based alternatives, such as 6:2 FTSA and 6:2 FTMAC, suggests a possible shift from legacy C8-based PFAS chemistry toward shorter-chain replacement compounds. The matrix-dependent profiles emphasize the need for multi-matrix monitoring to better characterize PFAS distribution, partitioning, and fate. The relationship between fluorotelomer precursors and their transformation products suggests that precursor-related pathways should be considered in evaluating PFAS contamination and the potential formation of terminal PFAAs. These findings highlight the importance of expanding PFAS monitoring beyond routinely targeted PFAAs to include precursors, emerging alternatives, and transformation products for a more comprehensive assessment of industrially influenced aquatic environments.

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PFAS in Food 2

R. Malisch & D. Mortimer

D31-107 Bioaccumulation, distribution and depuration of PFAS in chickens from a contaminated region

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Introduction
The presence of per- and polyfluoroalkyl substances (PFAS) in the environment raises concerns for food safety, particularly for households producing their own food. This study investigated PFAS bioaccumulation, distribution, and depuration in laying chickens from Belgian households located near industrial PFAS sources.

Materials and Methods
A total of 27 laying chickens were included. Twenty-two chickens were euthanized to assess PFAS occurrence across nine biological matrices (serum, breast, fat, gizzard, heart, kidney, liver, skin, and thigh). Five chickens were relocated to a PFAS-free environment for 40 days to evaluate. Thirty-two PFAS, including perfluoroalkyl carboxylates (PFCA), sulfonates (PFSA), and emerging compounds, were quantified using liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS). The analytical methods were validated in accordance with Commission Implementing Regulation (EU) 2022/1428 and aligned with European Union Reference Laboratory (EURL) guidance (2024) for PFAS determination in food and feed. Limits of quantification (LOQs) were 0.010 µg/kg for most biological matrices and 0.025 µg/kg for fat, with slightly higher compound-specific LOQs for PFOS and 6:2 FTS.

Results
PFAS were widely detected in chickens prior to depuration. PFOS was present in nearly 100% of the samples across all biological matrices, except fat, with the highest mean concentration of 22 chickens in serum (18.3 µg/L), liver (13.6 µg/kg), and kidney (11.5 µg/kg). Other regulated PFAS, including PFHxS and PFOA, were also frequently detected, particularly in metabolically active biological matrices (e.g., liver, kidney, and serum), with matrix-specific concentrations reaching 2.03 µg/L in serum or 0.89 µg/kg in kidney for PFHxS and 0.90-0.96 (serum and kidney) for PFOA. Long-chain PFCA ($n \geq 8$) showed high detection frequencies in liver, kidney, gizzard, and heart. PFSA, besides PFOS and PFHxS, were detected at lower frequencies. Emerging PFAS were only sporadically detected. PFAS distribution across biological matrices showed clear compartmental differences, with serum, kidney, and liver identified as the main accumulation sites. The gizzard and heart serve as secondary accumulation sites, whereas the skin and thigh, followed by the breast and fat, exhibit moderate to low PFAS accumulation.
Following relocation to a PFAS-free environment, PFAS concentrations decreased markedly across all biological matrices. Forty days later, residual concentrations had decreased on average to 2.2% for PFOS, 6.7% for PFHxS, and 6% for PFOA across all biological matrices. The most pronounced reductions occurred in liver and kidney, whereas fat showed slower depuration. The most prevalent PFAS before depuration (PFOS and PFHxS) remained the dominant compounds across all matrices after depuration.
Egg monitoring from contaminated chickens relocated for 40 days in a PFAS-free environment revealed a progressive decline in all PFAS concentrations over time. PFOS concentrations decreased consistently in chickens with high initial burdens of up to 80–100 times the regulatory limit of 1 µg/kg, whereas PFOS in chickens with lower initial concentrations (10-20 µg/kg) reached a plateau around 3 µg/kg after approximately 20 days. PFOA and PFHxS concentrations declined steadily and fell below regulatory thresholds within approximately two weeks in most cases, whereas PFNA remained below its regulatory limit throughout the study.

Discussion and Conclusion
These findings show the influence of environmental exposure on PFAS accumulation and their preferential distribution in protein-rich biological matrices such as liver, kidney, and serum. Depuration patterns differed by biological matrix, with faster elimination in metabolically active organs (serum, liver, kidney) and slower reduction in fat. The consistent decline of PFAS in eggs supports their role as both an indicator of exposure and a pathway of depuration in laying chickens.

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PFAS in Food 2

R. Malisch & D. Mortimer

D31-130 PFAS Marine: Occurrence and trophic distribution of PFAS in marine food sources

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Introduction

Diet is one of the main sources of exposure to per- and polyfluoroalkyl substances (PFAS) for a large part of the European population, with a major contribution derived from fish and other marine products (Schrenk et al., 2020). Marine based foods account for 43% of perfluorooctane sulfonic acid (PFOS) dietary exposure in adults and 47% in children. Therefore, PFAS levels in fish are closely monitored by the authorities (Commission Recommendation (EU) 2022/1431). Since 2011, the Danish NOVANA program is conducting surveillance on 22 PFAS in fish liver. While several studies have documented PFAS occurrence in fish, in particular perfluoro sulfonic acids (PFSAs) and perfluoro carboxylic acids (PFCAs), information on other potentially bioaccumulative PFAS and marine organisms remains scarce. This is particularly relevant as seaweed, starfish, and other marine species are increasingly used for human consumption or livestock feed. Seaweed is receiving increasing attention as a sustainable food source, but it may also present safety concerns as it absorbs nutrients from seawater and may bioaccumulate contaminants. Addressing this knowledge gap within the PFAS-Marine project is essential, given its direct implications on exposure through consumption and highlights the need to understand PFAS occurrence, distribution, and bioaccumulation in marine food webs to support monitoring, and risk evaluation.

Materials and Methods

The project focuses on the investigation of PFAS levels in different organisms that are part of Danish marine ecosystems and can lead to dietary exposure through consumption or usage as livestock feed. Marine species representative of different trophic levels are collected to identify contamination profile and food chain transfer. The samples (~300) are extracted using the QuEChERS approach and the extracts are measured using liquid chromatography-high resolution mass spectrometry (LC-HRMS Orbitrap). The extractable organic fluorine (EOF) content is measured via combustion ion chromatography (CIC). Non-targeted analysis is performed, in addition to the quantification by liquid chromatography-tandem mass spectrometry (LC-MS/MS) of targeted PFAS compounds, including PFCAs, PFSAs, fluorotelomer compounds, and emerging PFAS replacements. Additionally, sediment and water samples are collected, extracted with solid phase extraction (SPE) and analysed using LC-HRMS Orbitrap.

Results

In previous work it has been reported that the total PFAS concentrations in herring and cod liver are lowest in the Kattegat and higher in the southern Baltic Sea. Spatial patterns indicate differences in PFAS composition between regions: the PFOS precursor perfluorooctanesulfonamide (PFOSA) is relatively more abundant in the Kattegat, while PFOS dominates in the southern Baltic Sea. PFOS proportions further increase with trophic level, accounting for approximately 60–80% of total PFAS in lower trophic species and 80–90% in higher trophic organisms. PFOSA, which may have similar or greater bioaccumulation potential than PFOS, can also be metabolised into PFOS in apex predators. In the Baltic Sea, PFOSA represents 42–85% of total PFOS precursors (Gebbink et al., 2016). PFAS presence was detected in previous studies on seaweed from Danish coastal waters in lower amounts than in other biota, with a prevalence of PFCAs compounds. Despite increasing concern, knowledge of PFAS accumulation in aquatic organisms other than fish remains limited in Denmark.

Discussion and Conclusion

For most marine food sources, there is limited knowledge about the extent of PFAS exposure. The dataset generated contributes to a better understanding of several key areas, including: the trophic distribution of PFAS compounds in Danish marine environment, exposure to PFAS through marine food sources, and identification of species and compounds of interest for future monitoring.

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PFAS in Food 2

R. Malisch & D. Mortimer

D31-786 Occurrence, Sources and Mitigation of PFAS Uptake in Eggs from Hobby Hens: Implications for Dietary Exposure Reduction

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Introduction

Elevated Per- and polyfluoroalkyl substances (PFAS) concentrations have been detected in eggs from hobby hens in several European countries suggesting substantial contributions from worms and other environmental uptake pathways [1, 2]. This raises concern about dietary exposure among households consuming home-produced eggs. Similarly, preliminary monitoring by the Danish Veterinary and Food Administration (DFVA) found PFAS concentrations frequently exceeding EU limit values [3]. However, the importance of different exposure vectors and the occurrence of a wider range of PFAS remain poorly understood, and exposure mitigation studies lack. This study aims to characterize PFAS occurrence in hobby-hen eggs, identify contamination sources, evaluate transfer pathways, and assess mitigation interventions designed to reduce PFAS uptake in eggs. Findings will support evidence-based recommendations for safer egg production and consumption in Denmark and countries abroad.

Materials and Methods

Statistical planning and power-test ensured sufficient statistical certainty of the study. Egg collection and interventions began after the hens had free garden access for several months ensuring steady-state PFAS concentration. The BfR ConTrans model was used to select sampling times. After pre-tests of PFAS levels in eggs, 24 locations across Denmark were selected. Owners were instructed to perform mitigation interventions and sampling. Eggs were sampled before/after interventions and collected five times over 30 days. Three interventions were evaluated: 1) restricting access to garden, 2) restricting soil contact through tiled/membraned aviaries, and 3) supplementing feed with activated carbon. Other samples included soil, earthworms, invertebrates, grass, bedding materials, feed. Accredited target and in-house validated non-target analysis were used to quantify PFAS, precursors and transformation products. Samples were prepared using QuEChERS and analyzed on RPLC-HRMS/Orbitrap. Chemical fingerprints from the samples were compared with information on local contamination sources, including wastewater, groundwater, soil pollution, and historical PFAS use. Questionnaire data on husbandry practices, garden characteristics, and nearby pollution sources supports interpretation. Duplicate analyses and composite sampling were used to evaluate variability within locations. Risk assessment combined measured concentrations with consumption data to estimate dietary exposure before and after intervention.

Results

As the study is ongoing, results will focus on occurrence patterns, source attribution, and mitigation performance. Elevated long-chain PFAS concentrations are expected in a subset of hobby-hen eggs, with profiles potentially reflecting soil-mediated exposure. Comparison with environmental matrices is expected to identify fingerprints linking contamination to earthworms, insects, soil, or specific PFAS use patterns. Inclusion of precursor compounds, zwitterionic and ether PFAS, and extractable organic fluorine will provide a broader assessment than conventional monitoring. The intervention study will provide evidence on the extent to which reduced soil contact or activated carbon supplementation decreases PFAS transfer to eggs. Integration of targeted, suspect-screening, and non-target data is expected to strengthen identification of primary contamination sources and pathways relevant for risk management. Results will also inform future monitoring priorities across Europe.

Discussion and Conclusion

This project will deliver new knowledge on PFAS occurrence, uptake pathways, and source identification in hobby-hen eggs. By evaluating practical mitigation interventions and quantifying their impact on dietary exposure, the study will provide actionable guidance for households and authorities. The outcomes are expected to support risk reduction strategies and safer consumption of home-produced eggs in Denmark and beyond.

Acknowledgment

The authors acknowledge the Danish PFAS Center for funding, and co-funding from ARAGORN (EU Grant. No. 101112723). We are thankful for the great support from advisors from the DFVA, Gerard Cornelissen (NIBIO), Erlend Sørmo (NMBU), Jorge Numata (BfR), Stefan van Leeuwen (WUR), Lene Søe Højberg (Danish Regions), and from the participating hobby hen owners.

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PFAS in Food 2

R. Malisch & D. Mortimer

D31-215 PFAS analysis in paper-based food contact materials: How far can GC-MS take us?

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Introduction
PFAS (per- and polyfluoroalkyl substances) represent a broad class of synthetically produced chemicals. Due to their persistence, bioaccumulation potential, toxicity, and widespread environmental occurrence, PFAS have gained scientific attention over the past decade, particularly in the areas of identification, quantification and toxicity assessment, and investigation of potential pathways into the environment [1,2]. To date, many PFAS are in active use across various industries. Due to their hydrophobic and oleophobic properties, PFAS are particularly well-suited for the application in the production of food contact materials (FCMs). PFAS makes especially paper-based FCM impermeable to grease and moisture-containing foods, which enables the usage of those materials. Since these materials come into direct contact with food, there is a potential risk of migration, representing a potential pathway of exposure to these substances to humans. Since the 2000s, numerous regulatory measures have been taken to restrict PFAS use and establish maximum levels in foodstuffs and FCMs (e.g. EN 2022/2388, PPWR 2025/40). Supporting these regulatory developments requires the ongoing advancement of sensitive and reliable analytical methods. Currently, liquid chromatography-(tandem) mass spectrometry (LC-MS(/MS)) remains the gold standard for PFAS detection. Nevertheless, gas chromatography-mass spectrometry (GC-MS)-based approaches are being actively developed and optimized to expand accessibility and enable more process-independent testing.

Materials and Methods
Within the presented research, two GC-MS-based methods have been systematically optimized and evaluated for the simultaneous quantification of perfluorocarboxylic acids (PFCA), fluorotelomer alcohols (FTOH), and fluorotelomer carboxylic acids (FTCA). The primary objective was to develop sensitive and rapid methods. To this end, an automated derivatization procedure was developed as a key component of the optimized workflow. The optimized methods were subsequently applied to various paper-based FCMs to assess the practical performance under real-world analytical conditions.

Results
The results of the systematic method optimization will be presented. The optimization of one of the derivatization procedures, together with the implemented automation, achieved run times comparable to established LC-MS(/MS) approaches. With this one-step derivatization method, LODs down to 0.85 ng/mL were reached. Application to paper-based FCMs such as pizza or noodle boxes confirmed sufficient sensitivity for the reliable quantification of PFAS at relevant concentration levels. The detected PFAS concentrations for individual PFAS in the analyzed paper-based FCMs ranged from 26.6 to 261.38 ng/g.

Discussion and Conclusion
The application to real-world samples demonstrated the practical utility and performance. Collectively, these developments contribute to a more robust and accessible analytical toolbox for PFAS monitoring, ultimately supporting enhanced food safety and regulatory compliance. Further possibilities for optimizing the methods will be discussed, including the incorporation of additional PFAS classes and targeted improvements across each step of sample preparation.

Acknowledgment
The project (23IND13, ScreenFood) has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States.

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Risk Assessment and Risk Management 1

M. Rose & T. Webster

D32-331 TEFs and RPFs: Progress in mixtures toxicology and epidemiology and its application to Dioxin-like compounds, PFAS and Saxitoxins

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Introduction
TEFs have been applied to dioxin-like compounds since the 1980s, with expansion of the range of compounds (e.g., to certain PCBs) and refinement of numerical values. The concept has also been applied to other groups of compounds (e.g., saxitoxins) and proposed for others, including a subclass of PFAS. Relative potency factors (RPFs) is a synonym for TEFs. Meanwhile, there have been substantial advances in mixtures toxicology/pharmacology and the birth of a new field, mixtures epidemiology. This paper reviews some advances and discuss how they apply to TEFs/RPFs.

Results
Mixtures toxicology and TEFs/RPFs: TEFs/RPFs are a special case of concentration/dose addition, a century old concept from pharmacology used to estimate the combined effect of a group of compounds that act by the same or similar mechanisms; there has been substantial discussion about the latter. In addition to following dose addition, the compounds must have the same dose-response curve (shape and maximal effect), differing only in potency. Equivalently, the isoboles of the dose-response surface have parallel isoboles. The dose-response curve of a reference compound (e.g., 2,3,7,8-TCDD for dioxin-like compounds) is applied to a weighted sum of the doses. Advances include: 1) Generalized concentration/dose addition was developed to expand the range of applicable compounds to include those that differ in maximal effect, including partial agonists and competitive antagonists. This often occurs for compounds that act via the same receptor. Although TEFs/RPFs no longer apply over the entire dose range, approximate values can be derived at doses well below ED50s; these weights include aspects of both potency and maximal effect. Remarkably, competitive antagonists can be accommodated via negative weights. 2) If a group of compounds act via a single molecular initiating event (MIE), then the mixtures effects at the MIE are retained downstream.
Mixtures epidemiology and TEFs/RPFs: There has been an explosion of interest in mixtures epidemiology in the last decade or so. Several different statistical methods have been proposed that use single index models. Two prominent methods, weighted quantile sum regression (wqs) and quantile g-computation (qgcomp), use quantiles and differ in whether they allow negative weights. The Bayesian multiple index model (BMIM) is flexible as to the choice of dose metric and sign of weights. Single index models are a mathematical relative of the TEF/RPF model: weights and TEFs/RPFs are interconvertible. BMIM has this explicit biological framework. Use of quantiles can distort dose-response curves and isoboles, violating assumptions of the TEF/RPF model. Negative weights are consistent with competitive antagonism. When properly applied, epidemiologic (and toxicologic) data can be analyzed using single index models to generate TEFs/RPFs.

Discussion and Conclusion
Recent progress in mixtures toxicology and epidemiology 1) expands the type of compounds that be studied using full or approximate TEF/RPF models and 2) provides a solid basis for applicability and interpretation of single index models. The latter can in principle be used to estimate TEFs/RPFs from epidemiologic data as well as toxicologic field data. The assumed mechanism for the neurologic effects of saxitoxins (blocking of certain ion channels) appears well suited to TEF/RPF methods, although this needs further confirmation. Most if not all toxicologic effects of dioxin-like compounds appear to depend on the AhR, but it is unclear whether all currently included compounds have the same maximal effect; this could potentially require adjustment of TEFs. While a subclass of PFAS follow generalized concentration addition for activation of PPARalpha in reporter assays, multiple receptors appear to be involved for certain key outcomes (e.g., cholesterol levels), making application of even approximate TEFs/RPFs potentially problematic.

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Risk Assessment and Risk Management 1

M. Rose & T. Webster

D32-007 Multimedia environmental risk assessment of facilities co-firing solid recovered fuel (SRF) in Taiwan

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Introduction
Taiwan actively promotes SRF as a substitute for coal under its 2050 Net-Zero Emissions Pathway, aiming to achieve the dual benefits of carbon reduction and energy recovery. However, the diverse origins and complex compositions of SRF feedstocks raise concerns over the generation of hazardous pollutants—including PCDD/Fs, PAHs, and heavy metals—during combustion, potentially posing long-term accumulative risks to surrounding soil, water, and sediment environments. This study focuses on the multimedia environmental risk assessment of eleven SRF co-firing facilities distributed across northern, central, southern, and eastern Taiwan over a multi-year period (2023–2025), with the aim of elucidating the spatial distribution of ecological risks nationwide.

Materials and Methods
The AERMOD dispersion model was integrated with multimedia transport equations and 5,000-iteration Monte Carlo simulations to derive predicted environmental concentrations (PECs) of PCDD/Fs, PAHs, and heavy metals across soil, water, and sediment. Risk Quotients (RQ = PEC/PNEC) were calculated using U.S. EPA Ecological Soil Screening Levels (Eco-SSLs) and freshwater sediment screening benchmarks as PNECs to systematically evaluate ecological risks at each facility.

Results
Among the eleven facilities assessed, RQs across soil, water, and sediment media were below 1 at the majority of sites, with most pollutants falling within acceptable ecological risk ranges. The only exceedance was observed at Plant O, where the soil mercury RQ reached 2.08. Multi-year comparisons revealed that accumulative risks of heavy metals tended to concentrate at specific facilities: Plants D and O exhibited relatively elevated heavy metal concentrations in both soil and sediment, while Plant J recorded comparatively higher PAH-associated RQs in sediment.

Discussion and Conclusion
Risk attribution analysis at Plant O demonstrated that approximately 71% of the elevated soil mercury risk was attributable to local environmental background concentrations and valley topography conducive to pollutant stagnation and deposition, rather than direct SRF combustion emissions. The elevated heavy metal risks at Plants D and O were closely linked to fuel mercury content and the gas-phase mercury removal efficiencies of their respective APCDs. Plant J's higher PAH risks were associated with fuel composition characteristics and combustion conditions. Collectively, these findings highlight that site-specific environmental conditions and fuel composition are critical determinants of multimedia ecological risk, with significance comparable to—or even exceeding—that of emission control performance alone.
Overall, this study confirms that SRF co-firing under stringent emission controls poses limited multimedia environmental risks, with RQs for nearly all pollutants remaining below 1 across soil, water, and sediment media. Nevertheless, targeted and continuous monitoring of key pollutants is strongly recommended—particularly soil mercury at Plant O, sediment arsenic and cadmium at Plant D, and PAHs at Plant J. Tracking land use changes and sediment dynamics around high-risk facilities is also essential to enable effective pollution management and maintain environmental risks within safe boundaries throughout Taiwan's net-zero transition.

Acknowledgment
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Risk Assessment and Risk Management 1

M. Rose & T. Webster

D32-007 Multimedia environmental risk assessment of facilities co-firing solid recovered fuel (SRF) in Taiwan

Fig.1 Heavy metal Risk Quotients in Soil at Manufacturing Facilities (2023-2025)

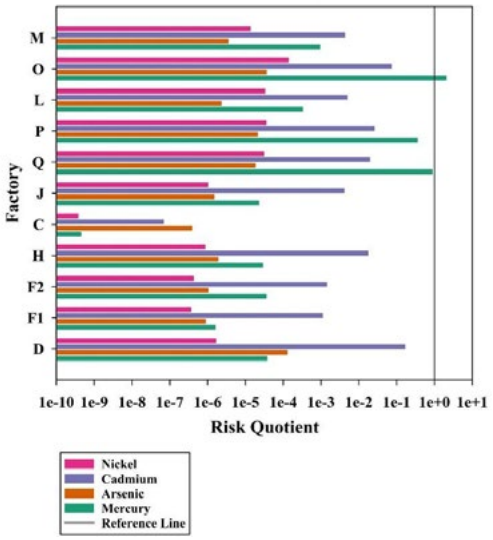
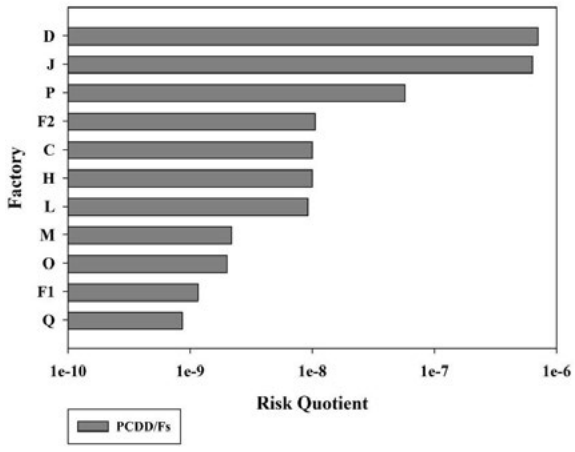


Fig.2 PCDD/Fs Risk Quotients in Soil at Manufacturing Facilities (2023-2025)



Risk Assessment and Risk Management 1

M. Rose & T. Webster

D32-007 Multimedia environmental risk assessment of facilities co-firing solid recovered fuel (SRF) in Taiwan

Fig.3 Heavy metal Risk Quotients in Water at Manufacturing Facilities (2023-2025)

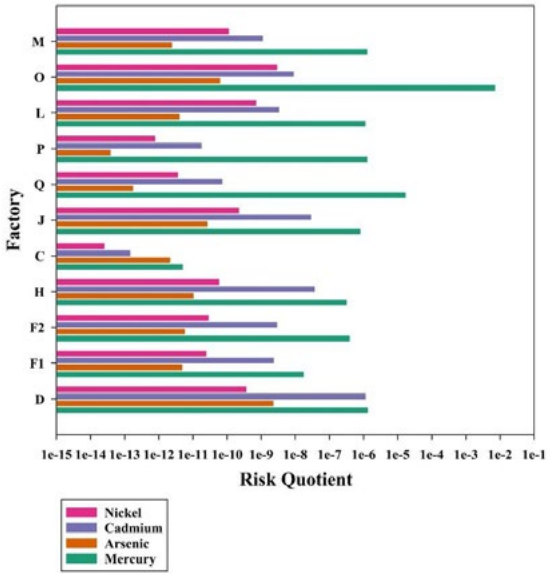
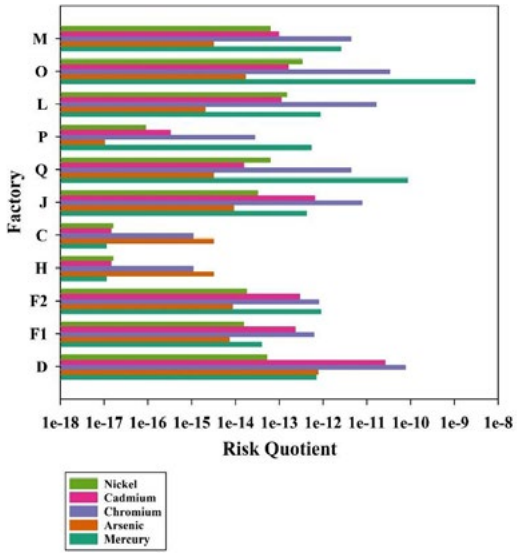
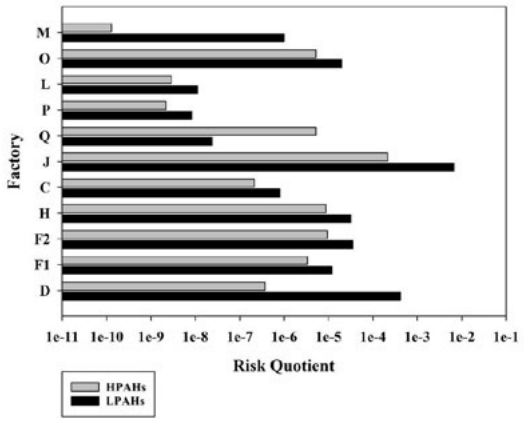


Fig.4 Heavy metal Risk Quotients in Sediment at Manufacturing Facilities (2023-2025)



D32-007 Multimedia environmental risk assessment of facilities co-firing solid recovered fuel (SRF) in Taiwan

Fig.5 H/L PAHs Risk Quotients in Sediment at Manufacturing Facilities (2023-2025)



Selection of Predicted No-Effect Concentrations (PNECs)

U.S. EPA Region 5 Resource Conservation and Recovery Act (RCRA) ecological screening values (ESLs)【Fig.1】

Taiwan's soil pollutant control standards【Fig.2】

U.S. EPA Region 5 RCRA ecological screening values【Fig.3】

U.S. EPA Region 3 freshwater sediment screening benchmarks【Fig.4-5】

Risk Assessment and Risk Management 1

M. Rose & T. Webster

D32-084 From soil contamination to food safety management: physiologically based toxicokinetic modelling to predict PCDD/F transfer in beef production systems

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Introduction
Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) are persistent organic pollutants that accumulate in animal tissues and pose a risk to food safety (EFSA, 2018). In grass-based ruminant systems, soil ingestion may represent a major pathway of animal exposure to PCDD/Fs (Weber et al., 2018). However, interactions between soil and feed PCDD/F contamination, transfer to animals, and final concentrations in animal products remain insufficiently characterized. This study proposes an integrated framework combining limited on-farm measurements and physiologically based toxicokinetic (PBTK) modelling to predict PCDD/F concentrations in beef meat from a soil-contaminated environment and support risk assessment and management strategies.

Materials and Methods
A study was conducted on a suckler beef farm in the Lausanne area (Switzerland), where topsoil PCDD/F concentrations ranged from 5 to 20 ng TEQ/kg DM (Vernez et al., 2023). For PCDD/F analyses, soil, feed, and blood samples from five multiparous cows and their offspring were collected over one production cycle, as well as adipose tissue, muscle and liver at slaughter from five post-weaning fattening bulls. Hay, silage and pasture grass contamination levels were estimated from the proportion of soil inorganic impurities measured in forages and paired soil PCDD/F levels, and compared to measured forage PCDD/F concentrations. Two PBTK models were then applied to reproduce first the on-farm study, and further prospective scenarios: the RuMoPOP model for lactating cows (Lerch et al., 2025), and the BeefPOP model for growing cattle (Tiercin et al., 2026). These models describe the absorption, distribution, metabolism and excretion of lipophilic contaminants across body compartments, allowing simulation of accumulation and depuration kinetics in adipose tissues, muscles and milk. Prospective exposure scenarios ranged from background feed contamination (0.1 ng TEQ/kg DM) to regulatory feed action and maximum levels (0.57 and 0.85 ng TEQ/kg DM, respectively; Regulation EU No 277/2012), and a worst-case scenario (1.0 ng TEQ/kg DM).

Results
A linear relationship was observed between measured PCDD/F concentrations in forages and those estimated from soil inorganic impurities (R^2 = 0.91). The BeefPOP model closely reproduced on-farm measurements, with predictions within 1.1- and 1.4-fold of observations for adipose tissue and muscle of fattening bulls. Under constant exposure with feed contamination at the action level (0.57 ng TEQ/kg DM), PCDD/F concentrations in cow and growing cattle adipose tissues could exceed the maximum level for meat (2.5 pg TEQ/g lipids; Regulation EU No 2023/915). With soil ingestion of 1% of DM intake, a soil PCDD/F concentration above 30 ng TEQ/kg DM would lead to non-compliant meat.

Discussion and Conclusion
The strong agreement between measured and soil inorganic impurities-estimated PCDD/F concentrations in forages suggests that feed soiling is the dominant source of PCDD/F and that concomitant soil ingestion drives PCDD/F exposure in this beef production case-study. Accordingly, analysis of soil inorganic impurities in forages combined with mapping of soil PCDD/F contamination could allow estimating cattle exposure risks without systematically performing costly PCDD/F analyses. Integrating PBTK modelling further allows predictions of PCDD/F concentrations in meat and offal products. Prospective model simulations also suggest that current feed regulatory maximum and action levels may not always ensure compliance of beef meat under constant exposure conditions. Overall, PBTK models prove to be valuable tools for risk assessment and food safety management in livestock systems exposed to PCDD/Fs.

Acknowledgment
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PFAS Toxicity

G. Brambilla & J. De Boer

D34-033 Comparative stress responses of two freshwater bivalves to emerging PFAS contaminants

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants, with emerging compounds such as perfluorobutane sulfonate (PFBS) and perfluorobutane sulfonamide (FBSA) increasingly detected in aquatic ecosystems. Short-chain PFAS are generally considered more mobile, less bioaccumulative, and less toxic than long-chain counterparts, but chronic exposure may result in bioaccumulation. Furthermore, their toxicity remains insufficiently characterized, with studies indicating potential effects on neuronal function, behaviour, development, reproduction, oxidative stress, and many other endpoints. This lack of data hampers effective ecological risk assessment. We conducted a chronic exposure study to assess species-specific stress responses in Dreissena polymorpha and Corbicula sp. exposed to FBSA and PFBS.

Materials and Methods

Bivalves are widely used in ecotoxicological studies due to their filter-feeding behaviour, sedentary lifestyle, and high capacity to accumulate pollutants. They show changes in physiological parameters before showing signs of serious damage or mortality. In the present study, the two bivalve species (N = 450 per species) were exposed to PFBS or FBSA across environmentally relevant to extreme concentrations (0, 0.001, 0.01, 0.1, 1, 10, 100, and 100,000 μg/L). Mortality was assessed throughout the experiment, whereas behavioural endpoints and physiological responses were measured after exposure. The behavioural endpoints included valve movement behaviour, and species-specific natural responses in either burrowing speed and depth (only Corbicula sp.) or attachment to substrates (D. polymorpha only). As physiological response, oxygen consumption was determined.

Results

The total survival at the end of the exposure was 91.3% for Corbicula sp. and 81.3% for D. polymorpha, showing substantially higher mortality in the latter species. The 100,000 μg/L FBSA treatment resulted in 100% mortality of both species. A higher mortality was observed for FBSA (LC50 = 37800 μg/L for Corbicula sp.; 140 μg/L for D. polymorpha) than for PFBS (LC50 > 100,000 μg/L for both species), indicating greater FBSA potency and higher sensitivity of D. polymorpha.

Valve movement response variables (N = 30) were grouped into principal components to reduce collinearity. Overall, the majority of behavioural variability could be explained by differences between species, whereas PFAS-induced effects were generally subtle, concentration-dependent, and species-specific. Treatment effects were more consistently observed in Corbicula sp. than D. polymorpha.

Oxygen consumption of both species increased significantly with increasing body mass, but there was no significant effect of PFAS type and exposure concentration.

PFAS exposure, pooled across compounds and exposure concentrations, significantly affected attachment probability of D. polymorpha relative to controls. Across exposure concentrations, PFBS (40.6%) showed lower attachment probabilities than FBSA (62.3%), indicating a consistent difference between both PFAS. Overall, PFBS and FBSA differed primarily in the initial attachment probability, rather than having a concentration-dependent effect, which likely explains the absence of significant interactions between PFAS type and exposure concentration.

Burrowing depth of Corbicula sp. was significantly affected by PFAS exposure, with organisms burrowing deeper when exposed to 100,000 μg/L PFBS compared to the lower exposure concentrations (0 – 1 μg/L PFBS). The initiation of movement and burrowing, and burrowing time showed consistent patterns across FBSA and PFBS treatments. FBSA did not show any concentration-dependent effects, whereas PFBS exposure induced a clear concentration-dependent response driven by the 100,000 μg/L treatment. At this concentration, PFBS increased the probability of movement and burrowing initiation as well as the burrowing time compared to lower concentrations (0 – 1 μg/L PFBS).

Discussion and Conclusion

Overall, PFBS triggers behavioural responses, whereas FBSA is more lethal. Our findings highlight the value of behavioural and physiological endpoints to detect sub-lethal stress and reveal species-specific responses to emerging PFAS in aquatic ecosystems.

Acknowledgment

In Memoriam - Łukasz Jermacz (1988 – 2026). A remarkable scientist, a devoted friend, whose enthusiasm for science and openness to people will remain an inspiration to us all.

PFAS Toxicity

G. Brambilla & J. De Boer

D34-146 Environmentally Relevant Concentrations of PFOA/PFHxS Disrupt Gut Barriers and Exacerbate DSS-Induced Chronic Colitis in Mice

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Introduction
Exposure to perfluorooctanoic acid (PFOA) and perfluorohexane sulfonic acid (PFHxS) is linked to various diseases. Inflammatory bowel disease (IBD) prevalence has risen with industrialization. Yet, how these compounds cause intestinal injury and what role they play in the progression of chronic IBD remain unclear.

Materials and Methods
To investigate the effects of PFOA and PFHxS on intestinal function and dextran sodium sulfate (DSS)-induced chronic colitis, mouse models exposed to PFOA or PFHxS established via exposure to environmentally relevant doses (0.012 and 12 μg/kg/day) of these compounds for 10 weeks. Mechanistic studies encompassed histopathology evaluation, barrier function assays, gene/protein expression analyses, and transcriptomics profiling.

Results
PFOA or PFHxS exposure induced intestinal damage and colonic inflammation in a dose-dependent manner, with concomitant activation of NF-κB signaling. Notably, exposure to environmentally relevant or higher doses of PFOA significantly upregulated cystic fibrosis transmembrane conductance regulator (CFTR) and secretory IgA (SIgA), indicating disrupted intestinal homeostasis, whereas PFHxS elicited only mild or non-significant alterations. PFOA or PFHxS exposure also altered the richness and composition of gut microbiota compared with the control group. Fecal short-chain fatty acids (SCFAs), which are vital microbial metabolites and crucial for gut health, showed an upward trend, reaching statistical significance in certain exposure groups. Interestingly, PFOA exposure notably upregulated tight junction proteins, suggesting a potential compensatory response to gut barrier damage. In contrast, no such effect was observed in the PFHxS-treated group. In the DSS-induced chronic colitis model, PFOA and PFHxS exacerbated disease symptoms, worsened colonic histopathology, and intensified the inflammatory response. PFOA partly exacerbated intestinal barrier disruption in colitic mice. Additionally, PFOA or PFHxS exposure perturbed the gut microbiota by reducing its diversity and altering community structure. Colon transcriptomics revealed that differentially expressed genes following PFOA or PFHxS treatment were both significantly enriched in pathways associated with IBD.

Discussion and Conclusion
This study demonstrated that exposure to PFOA or PFHxS disrupts intestinal homeostasis even at environmentally relevant doses and may pose potential risks to individuals with chronic intestinal inflammation. These findings underscore the detrimental effects of PFAS on intestinal health at environmental doses and provide a new perspective on the role of PFAS in the pathogenesis of chronic IBD. However, caution is warranted when extrapolating from animal models to humans. Further epidemiological and clinical investigations are needed to confirm these associations in human populations. A limitation of this study is the use of only two exposure concentrations without intermediate doses, which restricts the ability to fully characterize dose–response relationships. Future studies incorporating a broader range of exposure levels would help to better define the relationship between PFAS dose and intestinal effects.

Acknowledgment
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PFAS Toxicity

G. Brambilla & J. De Boer

D34-190 Sex-based tissue distribution and bioaccumulation of emerging and legacy PFAS

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Introduction
Despite established tissue distributions of legacy PFAS, such as perfluorooctane sulfonic acid (PFOS), observations of sex-specific differences are often limited by lacking experimental controls and the collection of few tissue types. Furthermore, the accumulation and tissue distributions of emerging per- and polyfluoroalkyl substances (PFAS), such as chloro-substituted-perfluorooctane sulfonic acid (Cl-PFOS) and 6:2 chlorinated polyfluoroalkyl ether sulfonate (6:2 Cl-PFESA), are not well understood. In this study, sex-specific accumulation and tissue distributions of PFOS, Cl-PFOS and 6:2 Cl-PFESA in twelve tissues were investigated in mice.

Materials and Methods
Twenty adult wild-type C57BL/6 mice were randomly divided into four groups (five same-sex mice per group). Two groups (one of each sex) were controls and administered 3.33 mL/kg/day 10% (v/v) ethanol. The other two groups (one of each sex) were PFAS treatment and administered a mixture containing 1.67 mg/kg of PFOS, Cl-PFOS and 6:2 Cl-PFESA each, dissolved in 10% (v/v) ethanol by oral gavage dosed every second day for 28 days. The mice were euthanized on day 29 and twelve tissues (brain, gonads, heart, jejunum, kidney, liver, lung, spleen, subcutaneous adipose tissue, thymus, thyroid, and perigonadal visceral adipose tissue) were collected as whole organs (except adipose tissues). Tissue samples were homogenised in isopropyl alcohol and acetonitrile, with supernatants undergoing C18 dispersive solid-phase extraction clean-up prior to LC-MS/MS analysis.

Results
All three PFAS were detected in every tissue retrieved from the exposed mice. Regardless of sex, the greatest PFAS accumulation occurred in the liver, with concentrations ranging from 142 ng/g PFOS to 308 ng/g Cl-PFOS, which corresponded to up to 60% of the total administered dose. Kidney and lung PFAS concentrations were also elevated compared to the remaining tissues. The lowest concentration of PFAS was observed in brain tissue ranging from 1.8 ng/g 6:2 Cl-PFESA to 4.6 ng/g PFOS.
The tissue distribution of PFOS and Cl-PFOS were near indistinguishable, with the only difference observed in male brain tissue, where PFOS was more concentrated than Cl-PFOS. In contrast, the concentration of 6:2 Cl-PFESA differed to PFOS in both male and female brain, jejunum, kidney, spleen, thymus and thyroid, and male gonads and heart. In all instances where differences were observed, the concentration of 6:2 Cl-PFESA was significantly lower than that of PFOS. Despite differences in tissue distribution between PFOS and 6:2 Cl-PFESA, their overall accumulation was equivalent, largely due to the significant proportion accumulated in the liver.

Discussion and Conclusion
PFAS accumulation showed a clear sex-dependent distribution pattern. PFAS accumulation in the liver was consistently lower in females than males, accumulating 13%, 13% and 8.7% less of the total administered dose of PFOS, Cl-PFOS and 6:2 Cl-PFESA respectively. Whereas accumulation of all three PFAS in brain, lung, spleen and subcutaneous adipose tissue were all greater in females than males. Additionally, PFAS concentrations in female visceral adipose tissue were approximately four times greater than that of males, and female heart, jejunum and kidney tissue all accumulated more of at least one PFAS than the corresponding male tissue. Overall, female body burden was observed to be more dispersed than that of males, however on average males accumulated a greater proportion of the total PFAS dose.
Biological monitoring for PFAS is primarily undertaken by analysing liver and blood samples, this gives a good indication of an organism's exposure. However, the marked sex-specific accumulation observed in adipose tissue suggests that adipose sampling could offer additional insight into tissue-specific and sex-dependent PFAS distribution. To capture a complete indication of gastrointestinal exposure to both legacy and emerging PFAS, monitoring strategies should include blood, liver, and adipose tissue.

PFAS Toxicity

G. Brambilla & J. De Boer

D34-529 From Pollinator Exposure to Human Intake: Modeling PFOS Transfer via Honey

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Introduction
Perfluorooctane sulfonate (PFOS) is not only a persistent long-chain per- and polyfluoroalkyl substance, but also a compound with strong bioaccumulation potential, making it important for understanding contaminant transport within ecosystems and the food chain. Apis mellifera, the western honeybee, interact with PFOS contaminated water, nectar, pollen, guttation droplets, and airborne particles during foraging, making them important indicators of local contamination and potential vectors of PFOS transfer into apicultural products. Most bee-related PFAS studies provide static concentration data, while research on the time-dependent transfer of PFOS through bee colonies, stored honey, and human consumers remains under-quantified.

Materials and Methods
In the study, a dynamic toxicokinetic model was developed to simulate PFOS transport through four linked trophic and apicultural compartments: forager bees, hive bees, stored honey, and human consumers. The model was formulated as a system of ordinary differential equations describing environmental uptake, trophallactic transfer, dietary intake, honey partitioning, elimination, mortality, and human bioaccumulation through harvested honey consumption. A 120-day honey harvesting cycle was incorporated to represent apicultural management, with residual honey retained in the hive between harvests. Parameter uncertainty was addressed using Monte Carlo simulation with 10,000 iterations, drawing environmental concentrations and biological parameters from literature-based ranges. Simulations were performed over one year and six years. A local one-at-a-time sensitivity analysis was used to identify dominant drivers of PFOS accumulation, and model performance was evaluated against independent controlled exposure data for honeybee tissue and honey.

Results

The model predicted rapid near-steady-state accumulation in bee compartments within approximately 25–30 days. Simulated PFOS concentrations ranged from 1.0 to 183.3 ng/g in forager bees and from 3.1 to 565.4 ng/g in hive bees, indicating greater accumulation in the hive due to trophallactic transfer and pollen-associated intake. Stored honey in combs reached near-steady state within the first harvest cycle, with predicted concentrations of 0.4–213.5 ng/g and a mean of 32.9 ng/g. Over six years, mean honey concentration increased by only about 1%, suggesting that continuous environmental input rather than long-term hive storage controlled honey contamination under the modeled conditions.
PFOS accumulation through honey consumption in humans was slower and did not reach steady state within one year. In the six-year simulation, steady state occurred after approximately 950 days, with a mean human body-burden estimate of 2.27 ng/g body weight. The corresponding average dietary intake from honey was approximately 7.7 ng/kg body weight/week, exceeding the current EFSA tolerable weekly intake of 4.4 ng/kg body weight/week for the sum of four major PFAS. Sensitivity analysis showed that bee exposure was most strongly influenced by water-related parameters, while human exposure was primarily driven by the bee-to-honey transfer factor, honey consumption rate, and gastrointestinal assimilation efficiency. Model validation showed acceptable performance, with RSR values of 0.66 for bee tissue and 0.48 for honey.

Discussion and Conclusion
These findings indicate that environmentally relevant PFOS contamination may not necessarily cause acute honeybee mortality, but can create chronic sublethal colony risks and a potential dietary exposure pathway for humans. The model provides a predictive framework for linking PFOS occurrence in environmental media to pollinator exposure, honey contamination, and food-chain risk assessment.

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PFAS Toxicity

G. Brambilla & J. De Boer

D34-379 Per- and Polyfluoroalkyl Substances Can Induce Immunotoxicity via Direct Intestinal Lymphatic Absorption

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are persistent, bioaccumulative environmental pollutants associated with multi-organ toxicity, among which immunotoxicity is of particular concern. Owing to their hydrophobic fluorocarbon tails and hydrophilic charged head groups, PFAS are structurally analogous to endogenous fatty acids, which are assembled into chylomicrons and selectively absorbed via the intestinal lymphatic system. This suggests a plausible yet unexamined mechanism: PFAS could be absorbed via the intestinal lymphatic system, bypassing hepatic detoxification and directly exposing dense immune-cell populations residing within the lymphatic network. However, the prevailing toxicokinetic paradigm remains almost exclusively blood centric, while the lymphatic system, a central hub of immune responses, has been overlooked as a potential exposure compartment. This omission likely leads to a profound underestimation of local exposure levels within the lymphatic system as well as the dose-dependent immunological consequences. Determining whether PFAS are absorbed via the intestinal lymphatic route and elucidating the consequent immunotoxic effects are therefore essential to bridge this critical gap in current health risk assessment paradigms.
To address this, the present study established a rat model involving simultaneous cannulation of mesenteric lymph duct and jugular vein. Following oral administration of six representative PFAS, lymph and blood samples were continuously collected and analyzed by liquid chromatography-mass spectrometry (LC-MS) to elucidate the dynamic process of PFAS lymphatic absorption and transport.

Results
The results showed that PFAS were directly absorbed via the intestinal lymphatic pathway, with mean concentrations in mesenteric lymph reaching 27-116% of serum levels within 10 h post-exposure. Intestinal lymphatic absorption and subsequent return to systemic circulation significantly prolonged PFAS half-lives and altered their exposure profiles, identifying the lymphatic system as an important compartment contributing to long-term retention. Moreover, PFAS entering the systemic circulation redistributed into the lymphatic network via interstitial fluid and showed selective relative enrichment in lymph nodes. In vitro experiments demonstrated that even at environmentally relevant concentrations (ng/mL), perfluorooctanesulfonic acid (PFOS) and perfluorohexanesulfonic acid (PFHxS) significantly impaired monocyte differentiation and function, indicating a high immunotoxicity risk associated with the lymphatic absorption and distribution of PFAS.

Discussion and Conclusion
This work expands the prevailing blood-centric toxicokinetic paradigm and demonstrates that the lymphatic system is an indispensable dimension of PFAS exposure and immunotoxicity assessment. It is therefore proposed that the lymphatic compartment be integrated into health risk assessment frameworks, not only for PFAS but also for other lipophilic environmental contaminants. To achieve this, future studies should define the immunotoxic effects of PFAS on lymphoid organs via lymphatic transport, elucidate the molecular mechanisms underlying the interaction between PFAS and immune cells in the lymphatic microenvironment, and incorporate lymphatic exposure parameters into physiologically based toxicokinetic (PBTK) models, thereby enabling more accurate, compartment-specific risk predictions.

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PFAS Toxicity

G. Brambilla & J. De Boer

D34-849 Prenatal Exposure to PFOS or PFOA Produces Lasting Social Behavioral Deficits in an Environmental Model of Autism

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Introduction
Autism Spectrum Disorder (ASD) affects approximately 1 in 31 children in the United States, with a strong male bias. ASD is characterized by impairments in social communication and interaction, as well as restricted/repetitive behaviors. Although the etiology of ASD remains unclear, growing evidence suggests that environmental factors contribute to ASD risk. Polyfluoroalkyl substances (PFAS), commonly referred to as "Forever Chemicals," represent a class of persistent environmental contaminants widely used in industrial and consumer products including food packaging, water-repellent textiles and cookware. As a result, many PFAS species have contaminated drinking water and soil, with perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) being detected in 99% of Americans and PFAS has been detected in the blood of nearly all populations studied.[1] Epidemiological studies have associated PFAS exposure with endocrine disruption of thyroid hormones[2], which are critical for normal neurodevelopment and linked to childhood development and ASD risk.[3,4] However, experimental studies testing causality are lacking. In this study, we tested the hypothesis that maternal exposure to PFOS or PFOA produces ASD-like behavioral phenotypes in mouse offspring.

Materials and Methods
C57BL/6N dams were exposed to one of five treatment groups: vehicle control (VEH/CON), low or high PFOA (0.1 or 0.3 mg/kg), or low- or high PFOS (0.1 or 0.3 mg/kg) via infused cornflake treats throughout mating and gestation up to day of birth. Offspring (9-14 mice/group) were weaned at postnatal day 21 (P21) and behaviorally evaluated using a battery of behavioral assays targeting core ASD-relevant domains, including exploration of familiar pup after a previous day exposure (long-term social recognition memory test-SMRT) at P32, marble burying test (repetitive behavior) at P40, three-chamber apparatus (sociability) at P50, Open Field Test (exploratory locomotor activity and habituation) at P60, and Novel Object Recognition Test (NORT) (long-term non-social recognition memory) at P70 and Social Novelty Preference (SNP) at P80.

Results
Our results show that low PFOA and PFOS prevented SRM in males whereas VEH/CON showed the typical reduction in exploration of the stimulus mouse on Day 2 vs Day 1 ($p<0.001$). In females, low-dose PFOA and high PFOS produced abnormal SRM whereas other groups showed normal SRM ($p<0.05$-0.01). Deficient SNP scores were observed in low and high PFOS male groups at P80, but not other groups ($p<0.05$, 0.01 and 0.0001), suggesting a permanent deficit in social recognition ability. MB scores were significantly elevated in males exposed to high-PFOS ($p<0.05$) and reduced in L-PFOA ($p<0.01$) relative to VEH/CON whereas all female groups appeared normal. There were no group effects on sociability or exploratory locomotor behavior in males. For NORT, VEH/CON males, but not exposed males, showed increased exploration of novel over familiar objects after 30 min memory retention ($p<0.001$).

Discussion and Conclusion
Collectively, these findings demonstrate that developmental exposure to PFOS and PFOA induced sex-dependent ASD-like behavioral phenotypes in mice, that persisted into adulthood, establishing a causal link between PFAS exposure and neurobehavioral reprogramming relevant to ASD. This model provides a critical experimental platform for future mechanistic studies examining how Forever Chemicals may alter specific social and non-social recognition memory and repetitive behavior neural circuits. Future LC/MS analysis of exposed offspring brains will help determine the penetration of our environmentally relevant doses of PFOS and PFOA and translational relevance of our experimental PFOS and PFOA model of ASD.

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Non-Polar POPs: Screening, Modelling and Data Tools

C. Carrer & G. Passos de Resende

D35-836 Determination of Polychlorinated Naphthalenes - Guidance on Analytical Parameters for Food and Feed Analysis

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Introduction
Polychlorinated naphthalenes (PCNs) are a compound group comprising of 75 congeners with varying degree of persistence, toxicity and bioaccumulation and have been listed as persistent organic pollutants (POPs) under the Stockholm convention (1). The network of the European Union Reference Laboratory (EURL) with National Reference Laboratories (NRLs) of EU member states and invited experts have established working groups to develop analytical methodologies for halogenated POPs of concern, including PCNs. This working group has previously prioritized 20 relevant PCN congeners for the analysis of food (2) based on toxicology and occurrence data covering 98% of summed toxic equivalent (PCN-TEQ) using the available respective relative potencies for dioxin-like toxicity (3, 4).
With the aim of assisting laboratories to develop analytical methods for monitoring their occurrence this working group also prepared a guidance document on the determination of PCNs providing analytical parameters for their analysis in food and feed (5).

Results
Established methodologies in the EURL/NRL POPs network regarding the different steps of sample preparation are compiled in modular format comprising extraction (module 1), purification (module 2), combined extraction and purification (module 3) and instrumental analysis (module 4). For the individual modular steps several methods applying different techniques are described allowing laboratories the flexibility of utilising existing equipment and expertise.

Discussion and Conclusion
The guidance document for the analysis of PCNs prepared by the European Union Reference Laboratory for halogenated Persistent Organic Pollutants in feed and food (EURL POPs) and the working group "Brominated Contaminants and PCN" gives general analytical performance parameter and guidance on quality assurance together with detailed methodologies. It serves as guidance for the establishment of new or adaption of existing methods for PCN analysis contributing to further harmonization, monitoring and assurance of reliable occurrence data.

Acknowledgment
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Non-Polar POPs: Screening, Modelling and Data Tools

C. Carrer & G. Passos de Resende

D35-297 Machine learning prediction of retention indices for polychlorinated naphthalene isomers using interpretable molecular descriptors

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Introduction

Polychlorinated naphthalenes (PCNs) are persistent organic pollutants encompassing 75 congeners and positional isomers that vary in the degree and position of chlorination of the naphthalene skeleton. Their toxicity, bioaccumulation, and long-range transport potential led to their listing under the Stockholm Convention in 2015 [1, 2]. Gas chromatographic (GC) identification of individual isomers is hampered by closely spaced elution orders within each chlorination homologue—up to 22 positional isomers share a single chlorine count—and by near-identical mass spectra. The scarcity of authentic standards further limits experimental characterization. We propose a retention-index prediction model that captures subtle structural differences arising from chlorine substitution position without relying on hand-crafted positional descriptors.

Materials and Methods

All 75 PCN congeners were represented as SMILES strings, from which multidimensional physicochemical descriptors—including molecular weight, logP, topological polar surface area, and the number of rotatable bonds—were computed with RDKit. The Programmed Temperature Retention Index (PTRI), obtained by normalizing GC retention times against n-alkane internal standards under temperature-programmed conditions, was adopted as the target variable to ensure cross-laboratory comparability [3]. LASSO and XGBoost regression models were trained and compared under three data-partitioning schemes designed to probe extrapolation across chlorination homologues: (i) random 80/20 split, (ii) stratified 80/20 split preserving the homologue ratios, and (iii) group split, in which all 22 tetrachloronaphthalene (TeCN) isomers were held out for testing and the remaining homologues used for training.

Results

Prediction accuracy by sampling strategy

Sampling Method	Model	R^2 (Test)	RMSE (Test)
Random Split	XGBoost	0.996	21.59
	LASSO	0.967	48.79
Stratified Split	XGBoost	0.927	88.93
	LASSO	0.994	25.95
Group Split	XGBoost	−4.190	114.60
	LASSO	0.850	19.50

In random and stratified splits, both models achieved high predictive accuracy. LASSO attained R^2 = 0.994 in the stratified split, demonstrating that a linear model effectively captures the global physicochemical trend between RDKit descriptors and PTRI when all chlorine classes are represented in training. Under the group split—the most demanding scenario—XGBoost collapsed to R^2 = −4.190 (RMSE = 114.60), while LASSO maintained practical accuracy (R^2 = 0.850, RMSE = 19.50). Furthermore, a detailed investigation of TeCN isomer predictions, as shown in the figure, confirmed that the relative elution order among the 22 isomers was well reproduced, even for completely unknown congener classes, indicating that geometric structural information related to chlorine substitution positions is implicitly encoded in the RDKit descriptor space.

Discussion and Conclusion

Tree-based models performed well in interpolation but failed when extrapolating to an unseen chlorination homologue, consistent with their inherent dependence on within-range partitioning. The linear LASSO model, in contrast, captured the global physicochemical trend linking chlorination degree and PTRI and additionally encoded geometric information from chlorine substitution positions through correlations among RDKit descriptors. This enabled extrapolation across homologue boundaries while preserving intra-homologue isomer ordering. The robustness against variation in analytical conditions, together with the capacity to predict unseen homologues, suggests that the framework is well suited to non-target analysis of POPs lacking authentic standards, including the rapidly expanding inventory of per- and polyfluoroalkyl substances (PFAS) [4]. These results provide a predictive foundation for the non-target identification of unknown isomers with limited reference data.

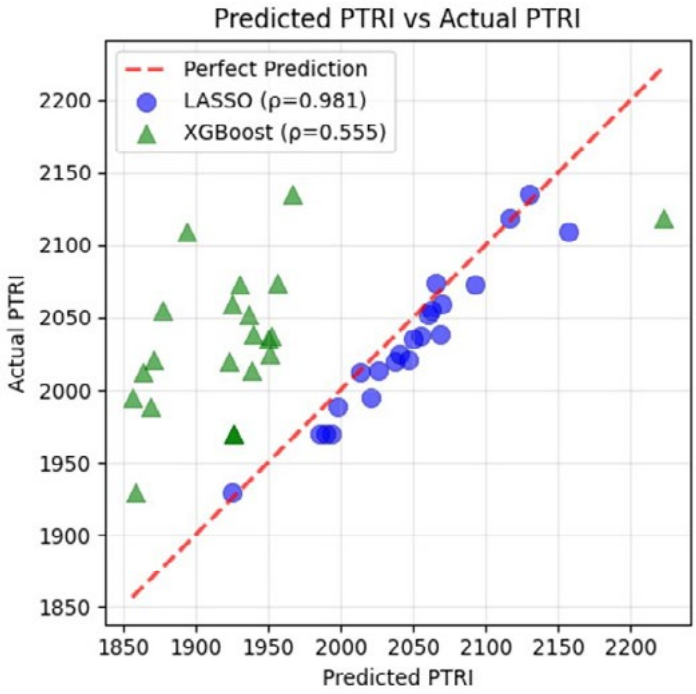
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Non-Polar POPs: Screening, Modelling and Data Tools

C. Carrer & G. Passos de Resende

D35-297 Machine learning prediction of retention indices for polychlorinated naphthalene isomers using interpretable molecular descriptors



Non-Polar POPs: Screening, Modelling and Data Tools

C. Carrer & G. Passos de Resende

D35-147 Thermodynamic stability in mass spectrometry as a predictor of primary electrophilic mutagenicity in polycyclic aromatic hydrocarbons

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Introduction

For decades, predicting the toxicity of organic micropollutants has relied on complex biological models and non-specific instrumental analyses. Inspired by J.E. Lovelock's historical hypothesis (1961), which postulated that carcinogenic compounds act as cellular "electron traps", numerous scientists attempted to correlate pure electron affinity (EA) with carcinogenesis [1]. This approach often yielded contradictory results due to the strong analytical response of biologically inert molecules. In this study, we propose a paradigm shift, demonstrating that it is not the simple transient electron capture, but rather the post-capture thermodynamic stability in a vacuum that unequivocally correlates with primary mutagenicity in polycyclic aromatic hydrocarbons (PAHs).

Materials and Methods

Chromatographic separations were achieved using a Restek Rxi-XLB capillary column (60 m length, 0.25 mm internal diameter, 0.25 µm film thickness). Calibration and extraction standards, including LS429IS and the PAH-CVS-B series (CS1-5), were manufactured by Wellington Laboratories and provided by CR2000srl (Italy). For standard dilutions, glassware cleaning, and extraction/purification phases, Romil Super Purity Solvents (provided by Delchimica, Naples, Italy) were utilized, specifically Toluene, Acetone, Methanol, n-Hexane, 2,2,4-trimethylpentane, and Dichloromethane. Adsorbents for column packing included Silica (Polygoprep 60-130, Macherey-Nagel, Germany), Na2SO4 (Merck, Germany), and Al2O3 (MP Alumina B – Super I EcoChrom, Germany). Analytical procedures for real-world sample evaluation were performed as described by Balducci et al. (2018)[2]. Instrumental optimization was conducted using gas chromatography-mass spectrometry (GC/MS) under strictly controlled plasma conditions to isolate the electronic stabilization events.

Results

The results reveal that the gas-phase response acts as a direct quantum sensor for LUMO (Lowest Unoccupied Molecular Orbital) energies[3]. This methodology resolves historical anomalies present in in vivo risk scales. Indeno[1,2,3-cd]pyrene, for example, despite possessing a low Toxic Equivalency Factor (TEF) in mammalian carcinogenicity scales, showed extreme stabilization responses in a vacuum. By shifting the toxicological endpoint, we demonstrated that this specific signal does not model macroscopic tumor genesis, which is heavily influenced by the efficiency of DNA repair systems, but rigorously maps intrinsic electrophilicity and direct-acting mutation rates as detected in in vitro assays such as the Ames test [4].

Discussion and Conclusion

In polyconjugated systems such as PAHs, molecules exhibiting breaks in aromatic symmetry (induced by 5-carbon rings or specific steric bays) generate deep electrostatic potential wells. Our data demonstrate that such topologies stabilize the radical anion in the spectrometer plasma exactly as their metabolic intermediates (epoxides) stabilize the nucleophilic attack on DNA bases in biology. The use of these highly controlled analytical conditions in GC/MS transforms the instrument into a true "Electronic Ames Test". By demonstrating a perfect alignment between instrumental stabilization thermodynamics and biological alkylation potential, this technique provides a universal and rapid physico-chemical predictive tool for assessing the genotoxic risk of aromatic fractions.

Acknowledgment

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Non-Polar POPs: Screening, Modelling and Data Tools

C. Carrer & G. Passos de Resende

D35-016 mzXplorer: a rapid tool for exploration of complex high-resolution mass spectrometer data

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Introduction

Synthetic organic chemicals are ubiquitous in modern society, leading to continuous release into the environment and raising concerns for ecosystem and human health. Conventional target screening captures only known analytes, leaving numerous unknowns—including transformation products—undetected. High resolution mass spectrometry (HRMS) enables suspect and nontarget screening (SNTS), allowing detection of previously uncharacterized compounds through accurate mass measurements, isotopic pattern analysis, and molecular formula assignment.1 Coupling ion mobility spectrometry (IMS) to HRMS improves separation of isomers and isobars, increasing structural confidence. However, the resulting multidimensional datasets are complex, and data processing and feature annotation remain major bottlenecks, particularly when in source fragmentation (ISF) generates additional, misleading features.

Mass defect (MD) analysis provides a powerful strategy for prioritising features in SNTS workflows. Normalised MD approaches can reveal homologous series or compound classes, such as halogenated substances (e.g., CF2 based patterns for PFAS2 or Cl–H substitutions for chlorinated compounds3). Original and relative MD (OMD/ RMD) metrics can highlight predictable shifts associated with biotransformation or other chemical modifications.4 Together, MD based visualisation and interpretation offer an efficient means to explore complex HRMS and IMS HRMS datasets and guides identification of halogenated and other environmentally relevant contaminants.

This project aims to develop mzXplorer, a user friendly application that streamlines exploration of HRMS datasets through MD visualisation, homologue series detection, and ISF recognition. The tool will be applied to wastewater to enhance the detection of halogenated compounds, metabolites, and transformation products by integrating homologue series patterns with predicted MD shifts, while simultaneously reducing false positive features through automated ISF removal.

Materials and Methods

Standard mixtures of ~60 environmentally relevant compounds were used for method development. Influent wastewater will be prepared by solid phase extraction. Liquid chromatography-HRMS analyses were performed on an Agilent 6550 QTOF and a VION IMS QTOF. Data were processed in the open source platform MZmine, and the application mzXplorer was developed in R using the Shiny package.

Results

An SNTS data mining strategy was developed and implemented in the user friendly application mzXplorer to rapidly simplify complex HRMS datasets. The application contains two interactive modules. The first integrates MD analysis with homologue series detection. Users upload simple feature list tables (m/z, retention time, intensity), apply MD filters (e.g., CF2, Cl–H), and visualise OMD/RMD trends or homologous patterns. For IMS HRMS data, series detection can incorporate CCS-trends. Selected features can be exported for downstream identification. The second module identifies ISF by combining feature list with fragment information. ISF are flagged when fragment m/z values appear as MS1 features at matching retention times, with user defined tolerances. Interactive plots display ISF relationships and allow export of cleaned feature lists.

Together, these modules enable rapid exploration, prioritisation, and artefact removal without requiring programming expertise. When applied to environmental samples such as wastewater, mzXplorer will effectively reduce ISF derived features and facilitate the detection of halogenated compounds using CF2 and Cl–H based MD patterns along with OMD/ RMD.

Discussion and Conclusion

A major strength of mzXplorer is its platform independent design. It requires a minimal set of common feature level variables, allowing users to preprocess HRMS data in their preferred software. The only current limitation is the need for fragment information in .mgf-format for ISF detection, but support for additional formats is under development.

Overall, mzXplorer streamlines SNTS workflows by combining MD filtering, homologue series detection, and automated ISF recognition in an accessible interface. By rapidly reducing data complexity, it supports efficient identification of halogenated compounds and transformation products.

Acknowledgment

Thanks to Tekniska Verken for providing samples.

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Non-Polar POPs: Screening, Modelling and Data Tools

C. Carrer & G. Passos de Resende

D35-499 Non-invasive biomonitoring of polychlorinated dibenzo-p-dioxin and dibenzofuran level in ewes from wool and cerumen target or volatile organic compound analyses

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Introduction
Whenever contamination of farm animals with polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) is suspected, it is mandatory to monitor their levels in livestock prior to slaughter in order to alleviate the disposal of carcasses. The "gold standard" reference method for quantifying in vivo the contamination level involves a biopsy of adipose tissue, followed by targeted PCDD/F analysis. This method is quite invasive, time-consuming and costly. To overcome these limitations, non-invasive biomonitoring of body contamination levels is required. In sheep, sampling wool or cerumen is a promising option, and non-targeted analyses offer alternative proxies of the contamination status. In this case, alternative omics and chemometric techniques are combined to detect the specific metabolic fingerprints of exposure to pollutants. This study aimed to assess the reliability of target and non-target analyses (i.e. profile in volatile organic compounds, VOCs) on wool and cerumen as proxies for the level of PCDD/Fs in adipose tissue.

Materials and Methods
The toxicokinetic experiment is presented in detail elsewhere (Lerch et al., 2024). Six suckler ewes ("Roux du Valais", 4.7±1.6 years old, 53.9±9.6 kg body weight) were environmentally exposed (from birth) to PCDD/F through feeding of pasture and hay from soil-polluted grasslands of the Lausanne area (Switzerland). They were further depurated after being switched to a non-contaminated hay from day 29 of lactation. Four additional ewes were used as controls and fed with non-contaminated hay continuously. On depuration days 0 (end of the exposure period), 32, 60 (weaning), 130 and 188 (slaughter), samples of milk, sternal adipose tissue, wool and cerumen were taken for analysis of PCDD/Fs by atmospheric pressure gas chromatography-mass spectrometry (APGC-MS). On depuration days 0, 60 and 188, the VOC profile of the milk, wool and cerumen was analysed using solid phase micro extraction (SPME) gas chromatography-mass spectrometry (GC-MS; Ratel et al., 2022). Linear regressions were fitted to the data for PCDD/Fs in the different tissues, whereas VOC data were analysed using principal component analysis (PCA).

Results
Target analysis of PCDD/Fs in wool provided a fair estimate of the corresponding contamination level in adipose tissue (for the total toxic equivalent, TEQ sum: R^2 = 0.85, mean bias = +1.2 pg g-1 lipids). Agreement between wool and adipose tissue levels was better at moderate and high PCDD/F concentrations (2–30 pg TEQ g-1 lipids). At lower PCDD/F levels, external contamination of the wool, presumably through air deposition, may explain the poorer correlation between the concentrations in the wool and the adipose tissue. Conversely, the very low amount of cerumen collected from individual ewes (34–130 mg of extracted lipids) was insufficient for reliable PCDD/F analysis but permitted VOC analysis. Milk, cerumen and, in particular, wool enabled the distinction to be made between exposed, depurated and non-exposed ewes based on their VOC signatures.

Discussion and Conclusion
Due to the ease of non-invasive sampling, the potential of wool, and to a lesser extent of cerumen, as biomonitoring tool for estimating the contamination status in PCDD/Fs of sheep was confirmed.

Acknowledgment
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Fate and Transport 2

P. Kurt-Karakus & K. Pozo Gallardo

D36-128 Occurrence, spatial distribution, sediment-water exchange and ecological risk assessment of organophosphate flame retardants in an urban river of India

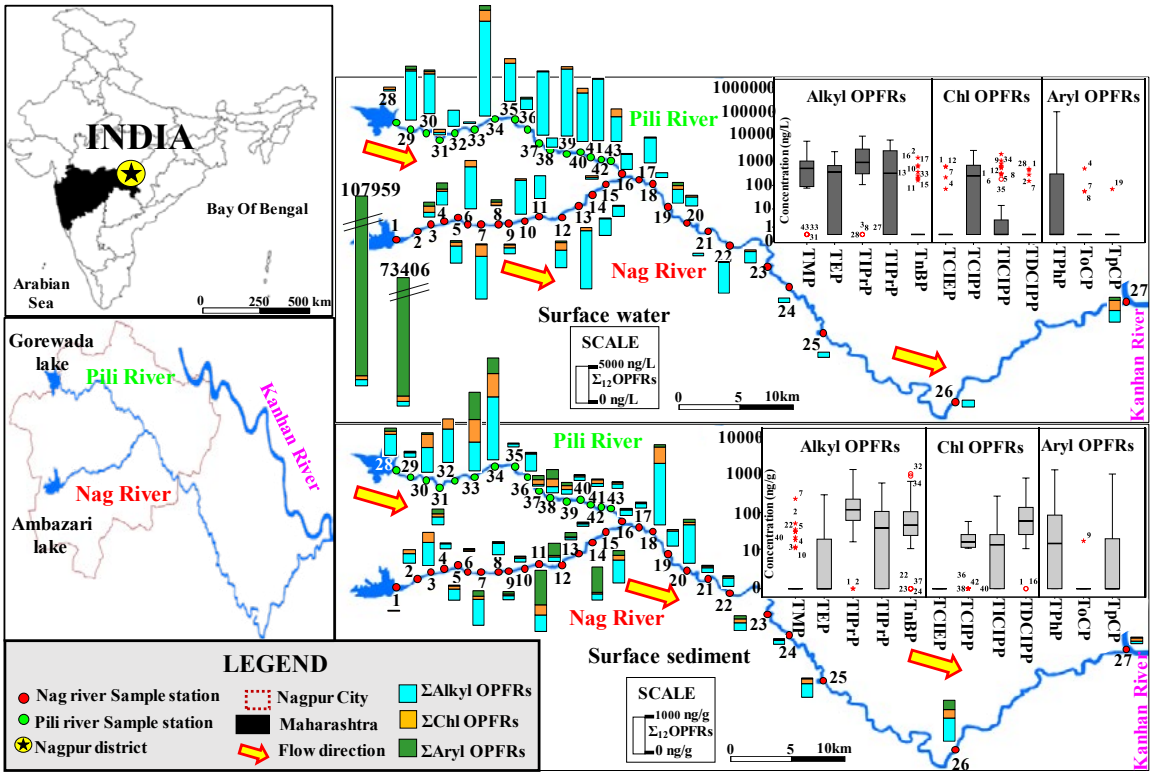
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Introduction

Organophosphate flame retardants (OPFRs) are high production volume chemicals and account for about 30% share of the global flame-retardant market. Global production of OPFRs has increased substantially since the phaseout of brominated flame retardants (BFRs), with China alone producing approximately 598,000 metric tons in 2020 (Huang et al., 2022). However, growing toxicological evidence indicates that several OPFRs, including triphenyl phosphate (TPhP), and chlorinated OPFRs such as tris(2-chloroethyl) phosphate (TCEP), tris(1-chloro-2-propyl) phosphate (TICIPP), and tris(1,3-dichloro-2-propyl) phosphate (TDCIPP), pose significant ecological and human health risks (Tang et al., 2025). The European Union (EU) has listed TCEP, TCPP and TDCPP as substances of very high concern. OPFRs have been detected ubiquitously in the environment, but information on their occurrence in the Indian environment remains scarce. Therefore, the objectives of the present study were to assess the levels, distribution, sediment-water exchange, and ecological risk assessment of OPFRs in an urban river of India.

Materials and Methods

Water and sediment samples (n = 43) were collected from the Nag River and its tributary, the Pili River. The Nag river flows across the city of Nagpur, central India. Untreated urban wastewater is discharged into this river at several points along its length. We determined 12 OPFRs in water and sediment samples using GC-MS/MS. Quality assurance and quality control procedures included procedural, field blanks, recovery analysis of spiked blanks, and matrix spikes using native and isotopically labelled standards. The water-sediment distribution coefficient (log Kd), field-based organic carbon normalized distribution coefficient (log KOC), and predicted organic carbon normalized distribution coefficient (log KOC') were calculated to study the partitioning behaviour of OPFRs (Lian et al., 2022a). The fugacity fraction (ff) was used to predict the diffusion direction of individual OPFRs in the riverine system (Zhang and Wang, 2025a).



Fate and Transport 2

P. Kurt-Karakus & K. Pozo Gallardo

D36-128 Occurrence, spatial distribution, sediment-water exchange and ecological risk assessment of organophosphate flame retardants in an urban river of India

Results

The concentration of ∑12OPFRs was in the range of 366–108,000 ng/L (mean: 9,400 ng/L) and 11–4,000 ng/g (mean: 870 ng/g) in river water and sediments, respectively. The DF of OPFRs in river water ranged from 2 to 90%, with tris-p-cresyl phosphate (TpCP) showing the lowest detection and triisopropyl phosphate (TiPrP) the highest abundance. The occurrence of the three OPFRs groups followed the order: alkyl OPFRs (50%) > aryl OPFRs (44%) > chlorinated OPFRs (7%). OPFRs in sediments showed DFs ranging from 2 to 95%, with TiPrP and TDCIPP showing the highest DF (95%). In sediments, Σalkyl OPFRs were dominant (60%), followed by Σchlorinated and Σaryl OPFRs (each contributing ~20%). Among alkyl OPFRs, TiPrP was the most abundant, with an average concentration of 1,970 ng/L, accounting for 21% of ∑12OPFRs and 42% of Σalkyl OPFRs, and a median value of 870 ng/L. In the aryl OPFR group, TPhP overwhelmingly dominated (97% of ∑aryl OPFRs), with an average concentration of 4,000 ng/L. In contrast, among chlorinated OPFRs, TCIPP accounted for 69% of ∑chlorinated OPFRs, with an average concentration of 443 ng/L.

Discussion and Conclusion

The spatial distribution showed significantly elevated concentrations of OPFRs in urban areas with the predominance of alkyl OPFRs. The mean OPFR concentrations observed in this study exceeded those in most Chinese and EU rivers. However, sediment OPFR levels were lower than those of major rivers of several countries. OPFRs are used both as plasticizers and flame retardants, and improper municipal waste and plastic waste disposal, urban runoff etc are the major contributors. Field-derived partitioning indicators (log KOC vs. log KOC') and fugacity fraction (ff) suggested most OPFRs have approached sediment saturation, promoting diffusion-driven release into the overlying water column. High ecological risk (RQ > 1) for TPhP to fish, invertebrates, and algae was observed at specific sites, while moderate risk for TDCIPP, ToCP, TpCP, and TnBP suggests potential bioaccumulation and trophic transfer.

Fate and Transport 2

P. Kurt-Karakus & K. Pozo Gallardo

D36-141 Contaminants of Emerging Arctic Concern in seabirds from the Canadian Arctic

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Introduction
Plastic particles (including microplastics < 5mm and larger macroplastics) have been found virtually everywhere on the planet1. Plastic pollution has entered the depth of our oceans, contaminates animals and humans across the world, and has even found its way into such remote areas as the Canadian High Arctic2. Recent studies have shown that Arctic seabirds are bioconcentrators for plastic particles that they then excrete around their colonies3. However, what we do not know yet is whether these bioconcentrated plastic particles are transport vehicles for further contamination into the Arctic – including for contaminants that would otherwise not undergo long-range transport.

Materials and Methods
To better understand co-contamination of plastic particles and chemical pollutants in Arctic seabirds, investigate factors that impact contaminant exposure and patterns for the birds, and identify pollutants with potential plastic-enabled transport, we conducted an exploratory study on plastic particles, organic plastic additives, and trace metals in Northern Fulmars (Fulmarus glacialis) and Black-legged Kittiwakes (Rissa tridactyla) in the Canadian High Arctic, as well as additional analyses of organophosphate ester (OPE) flame retardants and plasticizers in Common Eiders (Somateria mollissima), Black Guillemot (Cepphus grylle), and Great Black-backed Gulls (Larus marinus).

Results
The results of our study showed that species-level differences in foraging behavior had a significant impact on the plastic particle loads detected in the bird stomachs. Species with longer foraging distances from colonies had higher plastic contamination levels. Higher plastic particle levels coincided with high concentrations of plastic additives that are considered Contaminants of Emerging Arctic Concern (including OPEs and UV stabilizers), whereas concentrations of legacy persistent organic pollutants seemed to be independent of plastic particle levels in the bird stomachs. Interestingly, non-halogenated OPEs – many of which are expected to have low potential for long-range transport and bioaccumulation– dominated the OPE patterns in all analysed species, with median concentrations of up to 20 ng/g ww (Figure 1).

Discussion and Conclusion
The research highlights the importance of treating plastic particles and organic plastic-additives as co-contaminants rather than separate pollution issues. It points to exposure pathways for different Arctic seabird species and provides new insights into the role of plastic particles as potential transport vehicles for organic contaminants.

Acknowledgment
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Fate and Transport 2

P. Kurt-Karakus & K. Pozo Gallardo

D36-187 Known and Unknown Organofluorine Behavior in Soil–Activated Carbon Systems: From Batch to Column Scale

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants that pose significant risks due to their mobility in soils and potential transfer to groundwater and surface waters.1 Activated carbon (AC) amendments are widely applied to immobilize PFAS.2 Recently, novel porous carbons (NPCs), such as Triporous™ rice husk-derived materials developed by the Sony Group Corporation, have been designed to enhance surface area and pore structure, thereby improving adsorption capacity.3 However, how effectively they retain PFAS under flow conditions is still unclear. In addition, conventional target analysis may underestimate total PFAS levels due to unidentified precursors and other fluorinated compounds. Therefore, a comprehensive assessment is needed to accurately evaluate PFAS fate and removal. This study aims to investigate PFAS behavior in soil–activated carbon systems by integrating target analysis, extractable organofluorine (EOF), total fluorine (TF), total oxidizable precursor assay (TOPA), and suspect screening across batch and column scales.

Materials and Methods
Two standardized leaching tests were modified and applied: the batch test (ISO 21268-2:2019) and the up-flow percolation test (ISO 21268-3:2019). Six soil samples were analyzed in triplicate, whereas four soils from different sites in Japan and two additional samples were collected from one site after a one-year interval. Soils were homogenized with and without NPC for batch experiments to evaluate PFAS and EOF desorption. Initial characterization used sequential alkaline and acidic extraction to quantify target PFAS, EOF, and TF. Suspect screening and TOPA were applied to assess precursor compounds. Effluent was collected with the up-flow column experiments as a function of L/S ratio and analyzed for target PFAS, EOF, and transformation products. In addition, soil samples were taken along the column using mini-core extraction to assess spatial retention. Post-experimental extraction enabled mass balance evaluation and assessment of compositional changes.

Results
Initial characterization of the soils showed that PFCAs were the dominant PFAS detected. NPC amendments mostly reduced PFAS mobility, though the effect was smaller for short-chain PFAS. Activated carbon showed compound-specific adsorption, with adsorption rates of 10–40% for short-chain PFCAs (C2–C3) and 30–98% for short-chain PFSAs (C1–C3), while zwitterionic compounds were completely adsorbed. In the batch sorption tests, conductivity increased over time, likely due to the release of dissolved ions from the soil into the 1 mM CaClα solution, whereas the addition of activated carbon lowered conductivity, with a greater decrease observed at 5% AC than at 1% AC. Up-flow percolation column tests were also performed to further investigate PFAS transport under dynamic flow conditions, and analysis of these results is ongoing.

Discussion and Conclusion
The results highlight the compound-specific behavior of PFAS in soil–activated carbon systems, with lower adsorption efficiencies observed for short-chain PFAS. However, the contribution of unidentified organofluorine compounds and precursor transformation products has not yet been fully assessed. Integrating advanced analytical techniques with column-scale experiments will provide a more comprehensive understanding of PFAS fate and mobility than targeted analysis alone and should be considered when evaluating remediation strategies.

Acknowledgment
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Fate and Transport 2

P. Kurt-Karakus & K. Pozo Gallardo

D36-443 Highly volatile POPs in urban air across Asia and Africa

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Introduction

Highly volatile persistent organic pollutants (HV-POPs) are characterized by high volatility, environmental persistence, and long-range transport potential. However, atmospheric data on HV-POPs remain limited, particularly in rapidly urbanizing regions of Asia and Africa. In this study, 52 HV-POPs were investigated in urban air from six major cities across Asia and Africa, including Stockholm Convention-listed pollutants and nonlisted compounds such as volatile methylsiloxanes (VMS), halogenated hydrocarbons (HHCs), and chlorinated nitrobenzenes (CNBs). The study aimed to characterize their atmospheric occurrence, spatial distribution, potential sources, and inhalation risks.Highly volatile persistent organic pollutants (HV-POPs) are characterized by high volatility, environmental persistence, and long-range transport potential. However, atmospheric data on HV-POPs remain limited, particularly in rapidly urbanizing regions of Asia and Africa. In this study, 52 HV-POPs were investigated in urban air from six major cities across Asia and Africa, including Stockholm Convention-listed pollutants and nonlisted compounds such as volatile methylsiloxanes (VMS), halogenated hydrocarbons (HHCs), and chlorinated nitrobenzenes (CNBs). The study aimed to characterize their atmospheric occurrence, spatial distribution, potential sources, and inhalation risks.

Materials and Methods

Active air sampling campaigns were conducted during 2022–2023 using high-volume air samplers equipped with quartz fiber filters and PUF/XAD/PUF cartridges. A total of 78 samples were collected from representative urban environments. Gas-phase compounds were analyzed using GC–MS/MS operated in multiple reaction monitoring mode. Quality assurance and quality control procedures included field blanks, surrogate recoveries, and breakthrough tests. Statistical analyses were performed using nonparametric methods and Spearman correlation analysis. Inhalation exposure and health risks were evaluated using country-specific exposure parameters.

Discussion and Conclusion

HV-POPs were widely detected in urban air across all sampling cities, with substantial spatial variability. VMS overwhelmingly dominated the atmospheric profiles and were present at levels far higher than other target compounds, highlighting their importance as emerging atmospheric contaminants. Distinct VMS congener patterns suggested different emission sources among cities. Industrial activities appeared to be the major source in Guangzhou, whereas emissions associated with personal care product usage were more important in the other cities.

Elevated concentrations of hexachlorobutadiene (HCBD) in Guangzhou suggested significant unintentional industrial emissions, while correlations with chlorinated benzenes indicated potential common industrial sources. In contrast, hexachlorocyclohexane (HCH) profiles suggested that long-range atmospheric transport contributed substantially to atmospheric HCH occurrence in some regions.

Health risk assessments suggested negligible carcinogenic and noncarcinogenic risks for the measured HV-POPs under current exposure conditions. Nevertheless, the widespread occurrence and dominance of VMS in urban air highlight the importance of including HV-POPs in future atmospheric monitoring and international chemical management frameworks. This study provides one of the first cross-regional datasets on HV-POPs in urban air across Asia and Africa and improves understanding of their atmospheric occurrence and potential sources.

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Fate and Transport 2

P. Kurt-Karakus & K. Pozo Gallardo

D36-775 Long Term Temporal Trends of PCBs and PBDEs in Landlocked Char in High Arctic Lakes: Influence of Local Sources versus Long Range Transport

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Introduction
Landlocked Arctic char (Salvelinus alpinus) are the only top predators in most high Arctic lakes and serve as sentinels for changes in atmospheric inputs of persistent organic pollutants (POPs) to remote freshwater environments1. Polychlorinated biphenyls (PCBs) have been declining in air in the Canadian Arctic over the past 20 years while polybrominated diphenyl ethers (PBDEs) show slow declines after peaking in 20102,3. There are no other recent records (post 2010) of PCB or PBDE deposition, such as dated sediment or ice cores, in the Arctic. We hypothesized that the trends of PCBs and PBDEs in air would be reflected in the muscle of landlocked char in remote lakes receiving only atmospheric inputs to the lake surface and catchments. However, as two of our lakes were near the community of Resolute Bay, we also considered whether trends of PCBs and PBDEs were influenced by local sources.

Materials and Methods
Data were available for char from 2 very remote high Arctic lakes (Amituk, Hazen) and 2 (Resolute, Char) near Resolute Bay (pop 150), spanning up to 23 sampling years from the early-1990s to 2025, with sample sizes ranging from 3 to 10 fish per year1. Temporal trends of lipid-normalized concentrations were analysed using HARSAT, an open-source, R-based statistical package.

Results
Total (Σ33)PCBs have declined significantly in all 4 lakes from the early 1990s to 2025. However, the decline has been more rapid in remote lakes (Amituk, -6.7 %/y; Hazen, -8.7%/y) than in Resolute (-3.5 %/y) and Char Lakes (-5.3 %/y). Total (Σ13)PBDEs increased significantly in char from Hazen (6.6%/y), Char (7.1 %/y) and Resolute (9.5 %/y) but not in Amituk (-2.6 %/y) from the early 2000s to 2017, and have declined in all lakes from 2017 to 2025.

Discussion and Conclusion
Declining PCBs in char from the 1990s is consistent with long term air measurements at Alert on northern Ellesmere Island. Previous PCB use at the airport and former military base, which are within the catchment of Resolute Lake, may explain the slower decline there and nearby Char Lake. The increase of ΣPBDEs in char paralleled air measurements at Alert but contrasted with phase out of PBDEs in the mid-2000s in the USA, Canada and Europe, and with predictions of a decline of global in-use and waste stocks. The greater rate of increase of PBDEs in char from Resolute and Char lakes up to 2017, may reflect poor solid waste handling in the community, which results in plastics and other light weight materials blowing from landfill site to lakes , then entering the lakes during the short open water season (July-September). Rates of decline of several other legacy POPs in char (chlordanes, hexachlorocyclohexanes) did not differ between the near field and remote lakes1, while hexachlorobenzene has shown significant increases over the period ~2005 to 20244. The results illustrate the need to carefully consider the location of lakes for assessing long term trends. Resolute and Char Lake were selected in the 1990s for contaminant trend monitoring due to their convenient locations and available data since the early 1970s. Nevertheless, the legacy contamination within or near their catchments, offers an opportunity to monitor the influence of secondary sources of contaminants, which are likely to become more important as Arctic climate warms.

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Fate and Transport 2

P. Kurt-Karakus & K. Pozo Gallardo

D36-807 Concentration of Polychlorinated dibenzo-p-dioxins and Polychlorinated dibenzofurans and Their Correlation with the Occurrence of Wildfires in the City of Concepción, Chile, South America.

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Introduction

Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) are widely distributed in the environment. There are many well-known sources of PCDD and PCDF such as wildfires, which are the main source of exposition in those areas surrounded by large surfaces of forest and a high occurrence of this kind of disasters. The city of Concepcion, in southern Chile, is surrounded by large surfaces of forest which is affected every year during the summer season for at least one big and uncontrolled wildfire, exposing their population to a wide variety of pollutants, including PCDD/Fs, as consequence of that, the concentration of those pollutants show a pattern with high concentrations in summer and some specific pick of concentration in winter. The main goal of this research is to evaluate a correlation between the behavior of concentration of PCDD and PCDF and wildfires season, in the air of Concepcion city, Chile.

Materials and Methods

Active air samplers were installed in the city of Concepcion during the occurrence of wildfires. The samples were stored in the laboratory and kept in cold and dark conditions. Gas and particulate fractions were extracted with dichloromethane:hexane 1:1 in a PLE-FMS System, and purified with a Power Prep system using silica, alumina and carbon columns. The analysis was performed using HRGC-HRMS. Extraction, cleanup and analysis were based on the method EPA-23. The concentrations of both fractions were finally added to calculate the total concentration in the sample (total concentration is defined as the sum of 17 congeners of PCDD/PCDF reported in the sample), the results were expressed as fg*m-3 of air sampled. Additionally, the concentration of levoglucosan was evaluated in all samples analyzed.

Results

The results showed the presence of PeCDD, HxCDD, HpCDD, HpCDF, OCDD and OCDF in all samples. The highest concentration detected in every sample was for the congener OCDD, followed by OCDF and HpCDD. The total concentration of PCDD/F ranged between 40.26 and 415.4 fg*m-3 (Table N°1). The congener 2,3,7,8-TCDD was not detected in any sample. High concentrations of levoglucosan were detected in all wildfires samples analyzed and in some specific samples from the winter season.

Table 1: PCDD/PCDF concentrations in air (values in fg m^{-3})

Sample ID	Sampling Date	SPCDD/PCDF (fg*m-3)	TEQ (g*m-3)(a)
ATM-A	26-11-2021	143.16	9.55
ATM-B	20.12.2021	239.88	10.16
ATM-C	12-08-2021	415.4	25.38
ATM-D	14-09-2021	304.61	21.38
ATM-E	18-02-2022	193.27	14.98
ATM-F	03-02-2023	60.64	2.02
ATM-G	06-02-2023	55.23	2.00
ATM-H	07-02-2023	61.36	1.6
ATM-I	08-02-2023	70.67	2.11
ATM-J	09-02-2023	40.26	1.59

(a)TEF-WHO-2005 were used for TEQ Calculation

Discussion and Conclusion

Wildfires contribute mainly with congeners of PCDD/F with high degree of chlorination and have lower concentrations of less chlorinated congeners (usually under the limit of quantification. Wildfires produce a characteristic PCDD/F fingerprint, which can be differentiated from other known sources. The TEQ of the particulate matter produced by wildfires in the area of study is comparable to the one observed in some industrialized areas.

A correlation between the concentrations of Levoglucosan, PCDD/F and the occurrence of forest wildfires was found in the area under research., confirming the fingerprint signal identified for the concentration of PCDD/F during the occurrence if this kind of disasters.

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European POPs Monitoring

H. Fiedler & R. Weber

D37-117 Distribution of PFAS in animal- and plant-derived foodstuffs from contaminated areas in Belgium

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are persistent pollutants that have been widely detected in environmental compartments and can transfer into foodstuffs through different exposure pathways. Understanding their distribution within food matrices is essential for reducing their presence in the food chain. This study investigated PFAS distribution in a range of foodstuffs collected from contaminated areas in Belgium.

Materials and Methods
Samples, including animal products (fish, crabs, langoustines, cattle, chickens, and pork) and plant products (apples, carrots and potatoes), were collected from areas impacted by industrial PFAS sources and surrounding environments, or as part of laboratory experiments conducted in control chambers using soils from PFAS-contaminated sites (lettuce, wheat, pea and canola). Different fractions of each food item were analyzed separately to assess internal distribution patterns. The analytical approach on a sensitive, validated liquid chromatography–tandem mass spectrometry (LC-MS/MS) method. In total, 33 PFAS, including perfluoroalkyl carboxylates (PFCA), perfluoroalkyl sulfonates (PFSA), and emerging PFAS, were quantified across food matrices. Analyses were performed in compliance with Commission Implementing Regulation (EU) 2022/1428, and aligned with European Union Reference Laboratory (EURL) guidance for PFAS determination in food and feed. Sample preparation followed a QuEChERS-based extraction, followed by a two-step solid-phase extraction (SPE) clean-up prior to instrumental analysis. Limits of quantification (LOQ) were generally 0.010 µg/kg across animal-derived matrices, with compound-specific exceptions such as PFBA and 6:2 FTS, whereas plant-derived matrices showed lower LOQs, mainly 0.001–0.005 µg/kg, with higher values for PFBA, PF4OPeA, and 6:2 FTS.

Results
In these contaminated matrices, mainly PFSA (C6, C8), PFCA (C6-C13) were detected in animal products, whereas mainly PFSA (C4-C8), PFCA (C4-C10) were detected in plant products. Across all matrices, PFAS were unevenly distributed between sample fractions. For fruits and vegetables, leaves consistently showed the highest concentrations for all PFAS, followed by peels, while internal edible fractions such as cores generally contained lower levels, except for one apple, where levels are similar in peel and core. In animal origin products, liver and serum (when analyzed) concentrations were 10–20 times higher than in muscle for cattle, chicken, and pork, whereas concentrations in different parts of crustacean were close (a factor of 3 maximum between meat and offal). Strong correlations were observed between liver and muscle PFOS levels, regardless of the animal species. In general, skin and exoskeleton fractions contained lower levels.

Discussion and Conclusion
Across all animal categories, PFAS distribution was matrix-dependent, with higher concentrations generally found in internal or protein-rich biological fractions (offal, kidney) compared to outer or structural parts. The ages of the different animals were unknown and not permitted for accumulation evaluation. In contaminated plant products, peeling was shown to reduce PFAS exposure by removing a fraction of the contamination. These results improve the understanding of how PFAS behave across diverse foods and their fractions.

Acknowledgment
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European POPs Monitoring

H. Fiedler & R. Weber

D37-135 PFAS in homegrown food - A borderline case between food control and public health concerns

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Introduction

Per- and polyfluorinated alkyl substances (PFASs) are a contaminant group that is dominating both science and public debate. In the EU, maximum levels (MLs) for four of the PFASs in certain food products were laid down in 2022. Since then, official food control is analysing hundreds of samples per year to enforce these limits and collect occurrence data. Most findings are below MLs or even below the limit of quantification. Still, EFSA concluded in their assessment of commercial food sample data that PFAS dietary exposure in the EU is of potential health concern. But do these results represent the full dietary PFAS intake? In the Netherlands, thousands of households own or have access to privately held chickens and their eggs, and roughly 20-30% of the population grow their own food, in garden allotments or on their own land [1]. This represents a sizeable contribution to the daily diet not under the purview of official food controls or food safety regulations. With this contribution we wish to stimulate discussion on PFAS contamination in home produce and the absence of these food sources in risk management across Europe.

Materials and Methods

Publicly available reports and peer-reviewed publications of sampling campaigns targeting private food production in Europe and beyond were compiled. The analysis results were compared to concentration ranges reported for commercially available food in the same regions. Data from areas with known PFAS sources were viewed separately from areas with no known or diffuse PFAS sources.

Results

In most cases, the soil and produce samples from gardens or allotments close to known industrial (e.g., [former] PFAS factories) or environmental (e.g., sea-spray) PFAS sources showed increased PFAS levels [2,3]. Produce from gardens on the lee side of point sources or in reference areas were comparable to store-bought food [4]. However, PFAS garden soil levels away from contamination sources were stable over a decade, emphasising the need for active mitigation measures to avoid further accumulation. A broader overview over PFAS ranges in homegrown produce is currently unavailable.

The available data on PFAS in homegrown eggs are broader in distribution and with lower skew towards known contamination sources. While eggs from near contamination sources are clearly higher contaminated than those sampled elsewhere, there was a significant difference between most homegrown eggs and their commercially available counterparts [5]. Studies suggested different, very localised, contamination pathways all over the country, though no final conclusions could be drawn.

Discussion and Conclusion

The results of the different studies suggest that while there is a clear connection to point sources, PFASs are present across all tested forms of homegrown food. The contamination sources in homegrown eggs seem to be so diverse that they cannot be identified, making mitigation very challenging. The potential danger of this situation lies in -among others- 1) the lack of data and 2) the low suitability of available risk management tools. In Europe, information is only broadly available for the Netherlands and Belgium, leaving a large knowledge gap for risk assessment in other countries. Since most homegrown commodities are (presumably) not put on the market, they are out of scope for official food controls, and only general health or consumption advices can be given to mitigate dietary exposure. In the interest of consumer protection, authorities should prioritise investigating low-cost, accessible mitigation options that can be applied to homegrown foods to target this area of concern.

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European POPs Monitoring

H. Fiedler & R. Weber

D37-162 Determination of polychlorinated dibenzo-p-dioxins and furans in food and feed using high-resolution accurate mass gas chromatography–mass spectrometry

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Introduction

Polychlorinated dibenzo-p-dioxins and furans (PCDD/F) are highly toxic contaminants that require ultra-trace level determination in food and feed. Analytical methods must meet strict regulatory criteria, including high sensitivity, selectivity, and accuracy, as defined in European Union Regulation (EU) 2017/644. Magnetic sector high-resolution mass spectrometry (GC-HRMS) is widely used for compliance; however, alternative high-resolution accurate mass approaches are increasingly evaluated for routine analysis.

Materials and Methods

A range of food and feed matrices, including butter, laying hen fat, fish oil, sunflower oil, edible flowers, and dill tips, were extracted using established sample preparation procedures, including solvent extraction, lipid removal, and multi-column cleanup. Quantification was performed using isotopic dilution with ^{13}C-labelled internal standards and a multi-level calibration curve.
Gas chromatography separation was coupled to Orbitrap high-resolution accurate mass spectrometry, operated in timed single ion monitoring mode. Data processing included automated workflows with evaluation of ion ratios, calibration response, and quantification performance in accordance with EU regulatory criteria.

Results

The method demonstrated high sensitivity, enabling accurate quantification of PCDD/F congeners at concentrations as low as 2 fg/µL (10 fg on column), with results within ±25% of the calibration response. Check standards at higher concentrations (4 and 20 fg/µL) also met the same accuracy criteria, confirming consistent performance across the calibration range. Ion ratio deviations between quantifier and qualifier ions remained within ±15% of theoretical values for all analytes and standards, fulfilling regulatory requirements.
Excellent linearity was observed for all congeners, with correlation coefficients (R^2) greater than 0.999 and relative standard deviations ≤2.25%. Response factors across calibration levels remained within ±20% of the average response factor, demonstrating stable instrument performance.
Limits of quantification (LOQs) for all investigated food and feed matrices were below one-fifth of the maximum levels specified by regulation. For example, LOQs of approximately 0.229 pg WHO-TEQ/g for butter and 0.062 pg WHO-TEQ/g for edible flowers were achieved, both below the respective regulatory thresholds . These results confirm compliance with EU 2017/644 requirements for sensitivity across diverse matrices.
High mass resolving power enabled effective discrimination of isobaric interferences across the full mass range. For high-mass analytes such as octachlorodibenzodioxin, resolving power exceeded that required for regulatory compliance, supporting confident identification at ultra-trace levels.
Comparison with GC-HRMS data showed good agreement across all matrices, including samples above and below regulatory limits, indicating equivalent quantitative performance between approaches.

Discussion and Conclusion

The results demonstrate that high-resolution accurate mass gas chromatography–mass spectrometry provides a sensitive and selective approach for the determination of PCDD/F in complex food and feed matrices. The method meets key regulatory performance criteria, including sensitivity, mass resolution, ion ratio tolerance, and quantification accuracy.
Performance equivalent to GC-HRMS was observed, supporting its suitability for regulatory applications. The ability to achieve limits of quantification below one-fifth of maximum levels indicates that the method is capable of addressing current requirements and potential future reductions in regulatory thresholds.
Overall, this approach represents a robust alternative for routine dioxin analysis in food safety monitoring.

European POPs Monitoring

H. Fiedler & R. Weber

D37-165 Performance-based determination of polychlorinated dibenzo-p-dioxins and furans in environmental samples using GC Orbitrap high-resolution mass spectrometry

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Introduction

Polychlorinated dibenzo-p-dioxins and furans (PCDD/F) are persistent organic pollutants requiring ultra-trace level determination in environmental matrices. Due to their toxicity and regulatory importance, analytical methods must meet stringent confirmation and quantification criteria, as defined in EPA Method 1613. This includes requirements for isotope dilution quantitation, ion ratio confirmation, and high mass resolution to avoid interferences. While magnetic sector high-resolution mass spectrometry is widely used, alternative high-resolution accurate mass approaches are increasingly evaluated for performance-based compliance.

Materials and Methods

Calibration standards and environmental samples, including spiked soil and sludge extracts, were prepared following EPA Method 1613 principles using isotopically labelled PCDD/F standards. An extended multi-level calibration series was generated, covering ultra-trace to routine concentration ranges.

Gas chromatography separation was coupled to Orbitrap high-resolution accurate mass spectrometry operated in timed single ion monitoring mode at high resolving power. Two exact-mass ions per analyte were monitored for quantification and confirmation. Data processing included isotope dilution quantitation, ion ratio evaluation (±15% tolerance), and calibration performance assessment.

Results

Ultra-trace sensitivity was demonstrated using 2,3,7,8-TCDD, with reproducible detection at 15 fg on-column. Replicate injections showed consistent signal response at this level, exceeding the EPA Method 1613 requirement for signal-to-noise ratio ≥10 at the lowest calibration level. Extracted ion chromatograms show clear, repeatable peaks across multiple injections, supported by reduced background interference through accurate mass extraction .

Calibration performance was evaluated across all 17 regulated congeners using a multi-level calibration approach. Excellent linearity was observed across the full working range, from the lowest diluted calibration level through higher concentration standards. Calibration plots demonstrate consistent response behavior across congeners, supporting accurate isotope dilution quantitation at both ultra-trace and routine levels .

Response factor stability was confirmed across the calibration series, with %RSD values ≤15% for all congeners, meeting strict performance criteria. As shown in the response factor summary, all compounds remained within tolerance, indicating stable instrument response and suitability for average response factor-based quantitation .

Repeatability in matrix was demonstrated using soil extracts spiked at 15 fg on-column. Ten replicate injections yielded %RSD values ranging from 3.5% to 6.9%, indicating strong precision at ultra-trace levels in complex environmental matrices. Ion ratio confirmation was maintained across all replicates, with deviations within ±15%, supporting robust compound identification under matrix conditions.

Mass resolving power consistently exceeded regulatory requirements. Measured resolution at 5% peak height ranged from approximately 19,000 to 23,000 across all congeners at both low and mid calibration levels, surpassing the minimum requirement of 10,000 and enabling effective discrimination of near-isobaric interferences .

Discussion and Conclusion

The results demonstrate that high-resolution accurate mass gas chromatography–mass spectrometry provides a robust and sensitive approach for performance-based dioxin analysis in environmental matrices. The method meets key EPA Method 1613 criteria, including ultra-trace sensitivity, ion ratio confirmation, response factor stability, and high mass resolution.

Reliable performance was demonstrated across calibration standards and complex matrices, with consistent quantitation and confirmation at the lowest evaluated levels. These findings support the suitability of this approach for regulatory monitoring of PCDD/F in environmental samples.

European POPs Monitoring

H. Fiedler & R. Weber

D37-035 Emerging contaminants in novel foods: comprehensive assessment of SCCPs and MCCPs in edible insects

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Introduction

The demand for high-value protein sources with low ecological impacts has led to the classification of edible insects as novel food in the European Union (EU) since 2021. The insects may be a source of proteins, essential fatty acids, fibre, and minerals. In contrast, they also may bioaccumulate various contaminants, such as chlorinated paraffins.

Short- and medium-chain chlorinated paraffins (SCCPs and MCCPs, respectively) are emerging and ubiquitous groups of environmental pollutants associated with adverse effects on human health (endocrine disruption and possible carcinogenicity). Both of these compounds are listed in the Stockholm Convention as persistent organic pollutants (POPs), thus being limited in signatory countries.

Materials and Methods

In this study, risk assessment of SCCPs and MCCPs in edible insects was evaluated. CPs were extracted from insect-based food from the Czech market (n=67) and samples obtained directly from farms (n=22) by ethyl acetate partitioning. The CPs were then isolated from co-extracting lipids using solid phase extraction on a silica gel and then analysed using an Agilent 7890B gas chromatograph coupled to a hybrid quadrupole time-of-flight mass analyser (7200B GC/Q-TOF; Agilent Technologies, Santa Clara, USA) in negative chemical ionisation mode. The method was validated (on levels 0.02 – 0.8 µg/g lipid weight; lw), with recoveries in the range of 70 – 108% and repeatabilities (expressed as relative standard deviations) <17%.

Results

Regarding the samples from the market, the SCCP concentrations varied from <15 to 21,360 ng/g lw (mean 612 ng/g lw) and the MCCP concentrations varied from <60 to 7744 ng/g lw (mean 471 ng/g lw). Looking at the samples obtained directly from farms, the concentrations were 85 – 2163 ng/g lw (mean 491 ng/g lw) and <60 – 1814 ng/g lw (mean 582 ng/g lw) for SCCPs and MCCPs, respectively.

Insect powders showed higher levels of both SCCPs and MCCPs than other commodities (dried or fried insects or crackers and chips). Therefore, the milling process is being considered as a possible source of contamination.

Estimated daily intakes (EDIs) were considered for an adult (70 kg) by model portions of 20 - 80 g based on food cathegory. The EDIs suggested that consumption of these products would contribute up to 1 and 18% of the tolerable daily intake (TDI) for SCCPs and MCCPs, respectively. Based on current knowledge, insect-based foods do not appear to pose a significant health risk. However, they may represent a non-negligible source of CPs in the human diet.

Potential sources of CP contamination were investigated at the farm level. Contact materials, particularly those made of moulded pulp and carton, exhibited high contamination levels (~102-103 ng/g). Although the feed contained lower concentrations (~101 ng/g), its contribution cannot be excluded, especially given the potential for CP bioaccumulation in the lipid-rich insect tissue.

Discussion and Conclusion

Overall, these findings highlight several important directions for future research. In particular, the impact of feed composition and living conditions on CP accumulation should be further clarified. Additionally, species-specific differences and the influence of food processing should be addressed in future research.

Acknowledgment

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European POPs Monitoring

H. Fiedler & R. Weber

D37-664 A Pilot Study on Microplastics Monitoring in Drinking Water Using a Self-Designed Modular Sampler and µ-Raman Spectroscopy

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Introduction

Microplastics (MPs) are ubiquitous contaminants of emerging concern (CECs). Despite Directive (EU) 2020/2184 promoting preventive Water Safety Plans, data on drinking water supply chains remain limited [1], hindering exposure risk assessments [2]. Data comparability is further restricted by unstandardized methodologies. To address this, Commission Delegated Decision (EU) 2024/1441 established harmonized requirements, including 1000 L sample volumes and spectroscopic identification to determine particle size, morphology, and chemical composition. Among these, Raman spectroscopy is highly effective for drinking water characterization [3]. However, large-volume sampling faces major operational challenges, including prolonged processing times, increased contamination risks, and low analytical efficiency. These time-consuming protocols remain difficult for routine water utility laboratory implementation. Consequently, this pilot study evaluated a custom-designed, fast-flow sampling system able to collect 1000 L samples in <1 hour, ensuring high recovery rates and compliance with EU requirements for Raman characterization

Materials and Methods

Self-Designed Sampler

A positive-pressure, modular filtration train connected four filters in series to collect suspended particles (20 µm to 5 mm) and fibers (20 µm to 15 mm). The configuration included sampling filters (a: 100 µm, b: 20 µm), procedural blank filters (c: 100 µm, d: 20 µm) for contamination tracking, and reference material filters (e: 100 µm, f: 20 µm) for recovery validation.

Sampling

A volume of 1000 L per sample was collected based on on-site flow measurements from four Southern Italian drinking water treatment plants (DWTPs). Matrices included raw inlet surface waters and treated outlet drinking waters, all analyzed via Raman spectroscopy within 24 hours of sampling.

Microplastics Analysis Workflow

To prevent subsampling bias, the entire silicon filter surface was analyzed using two distinct workflows:

- Automatic Workflow: Software-driven particle detection via image analysis, automated coordinate assignment, automated spectral acquisition, and automated library matching. Optimized for high throughput in routine monitoring.
- Manual Workflow: Operator-driven visual identification, counting, and target spectral acquisition. Served as the time-consuming but highly accurate confirmatory approach, especially under inorganic interference.

Particle Detection and Morphological Analysis

Dark-field mosaic images were acquired at 10x magnification. Particle coordinates were mapped using the integrated system algorithm and validated against manual operator counts.

Microplastics Identification

Analysis was conducted using a DXR3 µRaman system (Thermo Fisher Scientific) equipped with a 532 nm laser (0.1–6.2 mW) and OMNIC Atlus software. Automated acquisitions used a 900 lines/mm grating, three 3-second exposures at 6.2 mW, yielding a spectral resolution of 2.7–4.1 cm-1 in the range: 3500–600 cm-1. Polymer identification was confirmed for spectral matching scores >60% against reference libraries.

Results

Validation studies confirmed recovery rates of 80–98% for particles. Microplastic contamination was absent in analyzed drinking water samples, with only minimal, isolated detections in raw water.

Discussion and Conclusion

The methodology achieved high reliability and EU compliance with 80–98% recovery rates. The custom 1000 L modular sampler optimizes routine utility monitoring by simultaneously evaluating blanks and recovery rates. Future performance can be enhanced using 500 µm pre-filtration to reduce inorganic interference in raw waters and adopting pre-counted reference materials. Ultimately, real sample monitoring confirmed very low microplastic contamination, aligning with current literature.

Acknowledgment

U.O. Microinquinanti Organici- Direzione Laboratori e Controllo Igienico Sanitario - Acquedotto Pugliese Spa - Bari, Italy

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Detection and Analysis of Chlorinated Paraffins

G. Brambilla & J. De Boer

BFR1-432 Presence of chlorinated paraffins in beeswax wraps

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Introduction

Chlorinated paraffins (CPs) are complex mixtures of chlorinated alkanes, which are regulatory subcategorized into short-chain CPs (SCCPs), medium-chain CPs (MCCPs), and long-chain CPs (LCCPs) [1]. SCCPs (2017) and MCCPs (2025) were classified as POPs due to their adverse environmental properties [2]. The high production volume of CPs results from their widespread industrial use, including as flame retardants, plasticisers, and lubricants [3].

Beeswax wraps (BWs) have recently gained popularity as a sustainable alternative to conventional packaging materials. Commercial production uses fully automated beeswax wrapper coating machines. The beeswax frequently contains jojoba oil, tree resin, or coconut oil, as additives to increase flexibility and prevent drying or cracking [4]. During manufacturing, unintended contamination with CPs cannot ruled out. CPs could be present in beeswax or additives. E.g. Dong et al. reported the presence of SCCPs (up to 16 µg/g dw) and MCCPs (up to 94 µg/g dw) in beeswax from a small region in China [5]. Due to the direct contact with foods CPs could be transferred into the food. Also, BWs may sorb CPs from the surroundings, as it was previously observed in the case of dishcloths [6].

Materials and Methods

This study aimed to determine the presence of CPs in BWs. Initial test showed that established POP/CP sample preparation methods, including cold extraction, ASE, GPC, sulfuric acid treatment, were unsuitable for beeswax. The first objective was the development of an alternative sample preparation method for this uncommon sample matrix. Subsequently, the method was applied to 19 new commercial BWs from China (n=9), other Asian countries (n=3), Germany (n=4), and samples of non-declared origins (n=3). Many of the samples were declared as organic products. Furthermore, five used and two purposefully stored BWs were tested on CPs.

Results

Due to the complex physical and chemical properties and the high melting point of beeswax (>60 °C), a multi-stage sample preparation method was developed. After focused open vessel microwave-assisted extraction (MAE) [7], the wax matrix was removed by freezing out with acetonitrile, followed by removal of the wax matrix by countercurrent chromatography in co-current mode [8]. A final silica adsorption chromatography step preceded analysis by GC/ECNI-Orbitrap-HRMS [9]. SCCPs and MCCPs were detected in all 26 samples. New BWs (n=19) contained 0.2-15 (average: 2.8) µg CPs per dm2. CP pattern analysis indicated the presence of LCCPs in some samples. Likewise, indications were found that the CPs detected in the BWs originated from two or multiple sources. Most used BWs were in the same range as the new ones, except for two samples, which showed much higher CP levels (20 and 260 µg/dm2 CPs). The highest CP amount was found in a BW stored unused and unpackaged for three years in a drawer below the baking oven. This showed that the sample had likely sorbed CPs from its environment.

In the absence of transfer data of CPs, into food from food contact material, an adequate risk assessment was not possible. Selecting an example as close as possible to the present situation, a preliminary risk estimation was made based on the experimental data of the transfer of (non-chlorinated) paraffins into salami [10]. Using three typical scenarios, the transfer of CPs from new BWs into food was estimated at 0.4-4.5% of the daily intake of CPs via food (2-4.5 µg CPs) [11]. In the case of inadequate storage, the transfer of CPs from contaminated BWs could be in the range or even exceed the average daily CP uptake via food as estimated in a food basket study [9].

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Detection and Analysis of Chlorinated Paraffins

G. Brambilla & J. De Boer

BFR1-450 Fate of chlorinated paraffins during the refining of vegetable oils

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Introduction

Chlorinated paraffins (CPs) are industrially mixtures of thousands of polychlorinated alkanes [1]. Based on carbon chain length ranges, CPs are subdivided into short-chain (SCCPs, C10-C13), medium-chain (MCCPs, C14-C17), and long-chain CPs (LCCPs, C>17) [2]. SCCPs and MCCPs were added to Annex A of the Stockholm Convention on POPs due to their hazardous environmental properties [3]. Market basket surveys in European countries showed that oils and fats contribute substantially to CP intake via food [4,5]. Some studies also suggested that native oils were more contaminated with CPs than refined oils [4,6,7]. Elevated CP levels in vitamin E capsules, produced from side streams of edible oils refining, suggested that CPs may be removed during refining [8]. Industrial oil refining usually consists of four main steps: [9] (1) degumming with diluted phosphoric acid is carried out removing phospholipids, (2) neutralization with diluted NaOH removing free fatty acids, (3) bleaching with Fuller´s earth removing chlorophyll and other pigments, (4) deodorization by vacuum distillation removing unwanted odors and trace elements [9].

Materials and Methods

The study aimed to confirm alterations in CP content and composition during refining by conducting the respective refining steps in the laboratory. The four refining steps were performed using parameters similar to industrial conditions [10-12]. For this purpose, native olive oil (CP-free) was spiked with ~1 µg/g each of two single-chain CP standards (C12-CPs and C15-CPs) [13]. After each step, an aliquot (40 g) was removed, and the remaining sample was supplied to the next step. Quantification was carried out by GC/ECNI-MS [13].

Results

During degumming (160 g, 8 mL 5% w/w demineralized water, 0.15% w/w 85% phosphoric acid, 85 °C, 30 min) and neutralization (120 g oil, 0.5 mL 114 mg/ mL NaOH solution, 85 °C), no changes in the CP levels or pattern could be noted (100 ± 9.8%). However, step 3, (80 g oil, 0.8 g Fuller´s earth, stirring at ~20 mbar for 30 min at 95 °C) removed ~12% of the C12-CPs and ~44% of the C15-CPs. After repeating the bleaching process using the same parameters without steps 1-2, no loss of CPs was observed. This showed that moisture content played a crucial role in the bleaching process. Increasing the temperature in the latest experiment, to 110 °C resulted in a loss of ~31% C12-CPs and ~37% C15-CPs in the oil. In both experiments, the loss of CPs was accompanied by a decrease of the share the penta- and hexachlorinated isomers and a relative increase in hepta- to decachlorinated isomers. In step 4 (40 g oil, 200 °C, 3-5 mbar), using the crude oil directly removes ~64% C12-CPs and ~16% C15-CPs. The chlorination pattern was shifted in the same way as with bleaching.
Analysis of eight native olive oils from the EU revealed three positive samples (0.39 – 9.2 µg/g CPs). The sample with the highest CP content (only MCCPs detected) was subjected to deodorization. Overall, the loss of CPs was ~22%. The loss of CPs decreased with increasing chain length, i.e. -30% C14-CPs, -25% C15-CPs, -13% C16-CPs, and no changes in C17-CPs. Once again, the trend of a decrease in the lower-chlorinated isomers and an increase in the higher-chlorinated isomers was evident.

Discussion and Conclusion

The laboratory study experimentally verified previous observations and indications that refining of native oils can lead to a loss of CPs. The analysis of the positive samples confirmed that edible oils can contribute to the daily intake of CPs, the analysis of various olive oils in this study showed that less than 50% were contaminated with CPs. This shows that edible oils must not necessarily contain CP. Depending on the used oil press, the CP levels may vary.

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Detection and Analysis of Chlorinated Paraffins

G. Brambilla & J. De Boer

BFR1-611 Using silicone wristbands as screening tools for occupational exposure to chlorinated paraffins

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Introduction
Chlorinated paraffins (CPs) are complex mixtures of polychlorinated alkanes which are classified by their carbon chain length– short (SCCP, C10-13), medium (MCCPs, C14-17), and long chain (LCCP, ≥C18)– and are typically 30-70% chlorine by weight.1 As flame retardants and plasticizers, they are widely used in various consumer and industrial products such as paints, sealants, plastics/polymers, and metalworking fluids. Both SCCPs and MCCPs are regulated by the Stockholm Convention, but exemptions particularly for MCCPs suggest that occupational exposure could be of potential concern. Here, we deployed silicone wristbands as personal passive samplers among workers from various occupational settings in Denmark to identify high-risk jobs for CP exposure.

Materials and Methods
Pre-cleaned silicone wristbands (n=84) were deployed among workers for 1–3 working days, where participants only wore the wristbands while at work and otherwise stored them in an air-tight bag. Job types included sludge workers, plastic and electronic waste handlers, demolition workers, electricians, plumbers, scrap metal handlers, and computer numerical control (CNC) metalworking machinists as well as an office worker reference group. ~1 g wristband was extracted via sonication in an ethyl acetate:methanol (1:1 v/v) mix and analyzed using liquid chromatography high resolution mass spectrometry (LC-Orbitrap). Pattern deconvolution was adapted from the method developed by Bogdal et al.2 using single chain length standards with 3-5 different chlorination degrees ranging from C10 to C24, and an isotopically labeled SCCP, MCCP, and LCCP, each. Semi-quantification was conducted in R.

Results
SCCPs, MCCPs, and LCCPs were detected in wristbands across all job types, including the office worker reference group. Overall, median wristband concentrations from workers were 74.5 ng/g/8h workday for SCCPs, 670 ng/g/8h workday for MCCPs, and 87.4 ng/g/8h workday for LCCPs. Plastic waste recyclers had the highest median concentrations in the wristbands, followed by scrap metal handling. In general, most job types evaluated had significantly higher concentrations in wristbands compared to the office worker reference group. For most wristbands, MCCPs were the dominating group, but still several worker groups, including demolition workers, had elevated SCCPs compared to the other chain lengths.

Discussion and Conclusion
Relative concentrations of the various chain lengths were comparable to previous work measuring CPs in hand wipes from a Norwegian cohort,3 but occupationally exposed wristbands had an order of magnitude higher concentrations than the one previous study on CPs in wristbands.4 Still, despite the prevalence of CP use in general use products, there has been rather limited examination of where and how people are exposed to these chemicals in everyday life. This work provides preliminary insights on CPs as 'emerging contaminants' in occupational health and points to the use of wristbands as a simple tool to map occupational exposure and identify specific occupations with the highest risk of exposure.

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Detection and Analysis of Chlorinated Paraffins

G. Brambilla & J. De Boer

BFR1-839 Analysis of ∑PCAs-C_{10-17} by GC-EI-MS/MS – Screening of food and consumer goods

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Introduction

Polychlorinated alkanes (PCA) are the main components of technically produced chlorinated paraffins (CPs) [1]. The unspecific industrial production of CPs results in technical mixtures containing a wide range of PCAs with varying chain lengths and numbers of chlorine atoms [1]. While commercial CP products are usually classified by their chlorination degree and do not specify which chain lengths are present, they are categorized by their chain length from a legislation and analytical point of view, i.e. short-chain (SC-PCAs, C10-C13), medium-chain (MC-PCAs, C14-C17) and long-chain PCAs (LC-PCAs, C>17) [1]. CPs are used as flame retardants, plasticizers and lubricants leading to their presence in various consumer products as well as food contact materials, contributing also to their transfer into food [1, 2, 3]. SC-PCAs and MC-PCAs have been classified as persistent organic pollutants (POPs) by the Stockholm Convention [4]. Analysis of PCAs is challenging as PCAs can not be separated chromatographically due to the high number of homologues and isomers present which therefore elute in a broad peak hump [3]. Furthermore, the characterization of the homologues requires high resolution mass spectrometry or is laborious and time consuming if low resolution is used [3]. Thus occurrence data are limited further hampering the risk assessment. In order to facilitate the demanding analysis of PCAs and make it accessible to more laboratories, a GC-EI-MS/MS screening method enabling the quick and easy analysis of the sum parameter ∑PCAs-C10-17 was introduced in the updated guidance document by the EURL POPs. This method is also referred in the Commission Recommendation on monitoring of PCAs in food.

Materials and Methods

Use of electron ionization results in strong fragmentation of PCAs with formation of several unspecific fragment ions of the (chloro)alkane backbone common to all PCAs. While information on chain length and chlorination degree can thus not be obtained, acquisition of three mass transitions allows fast and easy determination of the sum parameter ∑PCAs-C10-17 by GC-EI-MS/MS [5]. The performance and comparability of this GC-EI-MS/MS screening method for the sum parameter αPCAs-C10-17 was assessed in an interlaboratory study (ILS) within the Working Group "Chlorinated Paraffins".

Results

For the assessment of the method performance powdered infant milk and fish oil were analysed by the participating laboratories. Overall, the ILS results showed good comparability. Additionally, the ILS evaluated the effects of some method variations (e.g. used standards, quantification strategy) to determine which parameters of the screening method should be predetermined and used laboratories. Further, the method was transferred to the analysis of different food contact materials and consumer goods. Preliminary investigations of food contact materials made of rubber have shown very high PCA contents in some samples, while most of them did not contain PCAs [1]. Therefore, the screening method was used for different food contact materials mainly made of silicon as well as toys and products which are regularly in direct contact with the human body. Samples for which the screening method indicated the presence of PCAs were further characterized by GC-ECNI-Orbitrap-HRMS.

Acknowledgment

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Detection and Analysis of Chlorinated Paraffins

G. Brambilla & J. De Boer

BFR1-418 Determination of Polychlorinated Alkanes in Marine Mammals: Investigating Species Differences, Blubber-to-Brain Movement and Maternal-Fetal Transfer

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Introduction

Polychlorinated alkanes (PCAs), main components of chlorinated paraffins, are used in a variety of applications, such as plasticizers (particularly in PVC production), flame retardants, and industrial lubricants, among others. Traditionally, they have been classified by their chain length into short-chain chlorinated paraffins (SCCPs), medium-chain chlorinated paraffins (MCCPs) and long-chain chlorinated paraffins (LCCPs). SCCPs were included in the Stockholm Convention in 2017 due to their persistent organic pollutant properties (POPs), and more recently in 2025, MCCPs were also listed. PCA analysis is complex due to the challenges of separating homologue groups, the presence of thousands of isomers, a lack of reference materials and standard mixtures that accurately represent the PCAs distribution in environmental samples, and the interference from other compounds. Despite their relevance, occurrence data in biota remain scarce. Specifically, data regarding PCA profiles in marine cetaceans are limited, and have primarily focused on marine species from the Arctic and Norway (1,2). Hence, the goal of this study is to characterize PCA occurrence, tissue distribution and maternal transfer in the brain and blubber of marine cetacean species. To the best of our knowledge, this is the first attempt to assess the PCA patterns for the evaluation of maternal transfer in marine mammals.

Materials and Methods

Brain and blubber samples were obtained from 10 adults and 5 fetal fin whales (Balaenoptera physalus) from West Iceland. Blubber samples of 23 Striped dolphins (Stenella coeruleoalba), 11 from the 1990, and 12 from the 2007-2009, were obtained from stranded individuals from the Mediterranean Sea. Sample extraction was performed on 0.3 g of blubber or 1 g of brain. The method involved three solvent extraction steps and a clean-up step using silica SPE adapted from a previous optimized method (3). PCAs were determined using an UHPLC-ESI-QToF in full-scan mode (Agilent 6550), and the [M + Cl]- adducts were enhanced by the addition of tetramethyl ammonium chloride to the mobile phases. The quantification and PCAs-C10-30 patterns were determined using CPxplorer, a quantification tool that integrates Skyline, based on the pattern deconvolution (4).

Results

Preliminary results show higher concentrations of ∑PCAs-C10-30 in striped dolphin blubber than in fin whale blubber. In fin whales, PCA concentrations in the brain and blubber were found to be comparable.

Discussion and Conclusion

The results of this study will provide insights into the maternal transfer of PCAs to fin whale fetuses and the similarities in homologue group patterns between mothers and fetuses. Furthermore, this study contributes to assessing the potential of PCAs to cross the blood-brain barrier and characterizes the temporal trends of these compounds between the 1990s and 2000s in the Mediterranean Sea.

Acknowledgment

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Environment and FRs

K. Fernie & H. Moon

BFR2-083 Emerging brominated flame retardants in biota in the Veneto region

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Introduction
Polybrominated organic compounds are a group of anthropogenic substances used as flame retardants in many products, including electronic equipment, textiles, and especially in polyurethane foams. Their persistence and potential for bioaccumulation have led some organobromine compounds to be included in the list of substances regulated under the Stockholm Convention. In this study a method for the purification and analysis of brominated organic substances in biota, that are not subject to environmental regulations, was developed.
This study investigated the presence of emerging brominated flame retardants (eBFRs), more specifically decabromodiphenylethane (DBDPE), hexabromobenzene (HBBZ), and pentabromoethylbenzene (PBEB). According to EFSA, these are flame retardants that have been identified in many environmental compartments, in wildlife, in food or in humans.

Materials and Methods
eBFRs were searched for in different species of freshwater fish, saltwater fish, and in molluscs collected throughout 2023 in the Veneto region. In this study, whole fishes were analysed; in some cases, several fish of the same species were caught at the same time from the same body of water and combined into a composite sample. A total of 25 samples were collected and analysed.
The analytical technique coupled HRGC, HRMS, and isotopic dilution, allowing the determination of eBFRs at low concentrations even in complex matrices such as biota. The purification system used in this work greatly reduced most interfering compounds and allowed the treatment of highly fatty matrices. The fluidics design of the system used prevented the sample from coming into contact with the solvent supply circuits, thus reducing expensive cleaning operations.

Results
PBEB was below LOD in all samples analysed. HBBZ was only quantified in eight samples, at concentrations ranging between 0.005 µg/kg and 0.018 µg/kg. DBDPE was detected in all samples. Three samples presented concentrations of DBDPE between LOD and LOQ. The maximum detected concentration of DBDPE was 0.242 µg/kg, while the average concentration, calculated by assigning half of the LOQ to values below the LOQ, was 0.087 µg/kg. No correlation between lipid content in biota samples and DBDPE concentration was found.
Moreover, in accordance with the Directive 2013/39/EU and using the EPA 1614 method, several congeners of polybrominated diphenyl ethers (PBDEs) were also investigated in the same biota samples. Regulated congeners 28, 47, 99, 100, 153, and 154, and unregulated congeners 183 and 209 were analysed. No correlation between these PBDE congeners and DBDPE was found.
The sum of total regulated PBDEs in the samples (min: 0.079 µg/kg; avg: 0.386 µg/kg) was significantly higher than the water quality standard established by the European Directive 2013/39/EU (0.0085 µg/kg).

Discussion and Conclusion
These findings suggest that the waters of the Veneto plain present a widespread and extensive contamination of brominated compounds, which can be detected almost exclusively through the evaluation of these contaminants in biota. Indeed, water analysis does not allow the quantification of these bromine-derived compounds, because their concentrations are below the quantification limit owing their low hydrophilicity. Unfortunately, similar situations are widespread and occurring in other countries as well.
Among the substances analysed in this work, the highest concentration was that of DBDPE. Although this is not considered a highly toxic compound, little is known about its metabolites and their synergistic effect with other substances. The characteristic persistence of these pollutants is already an environmental problem in itself. Their introduction into food and integration into the food chain cannot be overlooked. In the past, substances that were thought to be well tolerated have often turned out to have a dark side.

Acknowledgment
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Environment and FRs

K. Fernie & H. Moon

BFR2-269 Dermal migration of Triethyl Phosphate from certain products available to consumers

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Introduction
Canada's Chemicals Management Plan (CMP) is an initiative aimed at reducing the risks posed by chemicals to Canadians and their environment. Since 2006, approximately 50 flame retardants have been assessed under the CMP; and ~70 additional organic FRs have been identified for further evaluation as part of the 2025 Plan of Priorities. An important route of human exposure to flame retardants assessed under CEPA thus far has been dermal exposure from prolonged skin contact with foam mattresses or furniture. A key parameter in estimating human exposures to this source is measured migration data; however, limited data are available in the literature. This poster will present results of a study conducted to determine the migration of triethyl phosphate (TEP) from a number of foam-containing products using a simulated sweat solution.

Materials and Methods
Initial testing was conducted in 2019 to determine the concentration of TEP in foam samples from products such as children's furniture, crib wedges, child restraint seats, mattresses, mattress toppers, and pillows (50 items, 150 specimens). Sample extraction was performed using an Accelerate Solvent Extractor (ASE) or wrist-action shaker extraction, and TEP was measured using gas chromatography-mass spectrometry (GC-MS). Samples in which TEP was detected were then tested for dermal migration. Foam samples were covered with a stack of 3 filter papers then 3 mL of synthetic sweat and a 1.5 kg weight were added. This experimental set-up was maintained at room temperature for a period of 4 hours. The filter papers were extracted using toluene and the concentration of TEP in the extracts was measured using GC-MS.

Results
TEP was detected in 10 of the 50 samples tested (25 of the 150 specimens). Items that contained TEP included child restraint seats, a crib wedge, a foam mattress, and a mattress topper. Some evidence of loss was seen for tested products that had been in storage, with the total concentrations of TEP after re-testing approximately the same or lower than the initial concentrations. The migration of TEP was measured in 22 of the 25 foam specimens ranging from 0.2 to 12% of the starting concentration after the 4-hour incubation. Migration rates were calculated from the TEP concentrations that had migrated to the 3 filter papers over 4 hours by also considering the surface area of the sample in contact with the filter papers. Migration rates for TEP from the various foam products, assuming a constant rate of migration over the 4 hours, will be presented.

Discussion and Conclusion
Results from this study will advance our understanding of how flame retardants migrate in textile/foam consumer products as well as aid in estimating potential dermal exposures to TEP in vulnerable populations such as infants and toddlers.

Environment and FRs

K. Fernie & H. Moon

BFR2-152 HBCDD diastereomers and TBBP-A in Brazilian solid waste: concentrations and regulatory implications

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Introduction
Hexabromocyclododecane (HBCDD) and tetrabromobisphenol A (TBBP-A) are brominated flame retardants (BFRs) of environmental and toxicological concern. HBCDD, listed under Annex A of the Stockholm Convention in 2013, has been extensively used in expanded polystyrene (EPS) insulation. TBBP-A, the most widely produced BFR globally, is employed primarily as a reactive flame retardant in epoxy and polycarbonate resins but is also used as an additive in thermoplastics such as acrylonitrile butadiene styrene (ABS) and high-impact polystyrene (HIPS), where it remains unbound and potentially leachable. TBBP-A has been classified as a Substance of Very High Concern (SVHC) under the EU REACH Regulation and as a Group 2A carcinogen by IARC. In recycling streams, both compounds can be reintroduced into new materials, extending human and environmental exposure. Despite Brazil being a signatory to the Stockholm Convention, no data on HBCDD diastereomers or TBBP-A in Brazilian waste existed prior to this study, and no specific concentration limits for BFRs in waste have been established under Brazilian legislation, including the National Solid Waste Policy (PNRS). Given this gap, the low POP concentration limits (LPCLs) under EU Regulation 2019/1021 were adopted as reference thresholds.

Materials and Methods
A total of 49 polymeric waste samples were selected from approximately 300 items collected in the Sorocaba metropolitan region (São Paulo State, Brazil) between 2022 and 2024, spanning four waste streams: construction and demolition waste (C&D), waste electrical and electronic equipment (WEEE), end-of-life vehicles (ELV), and soft furnishings. Samples were pre-screened by portable XRF (Br >50 mg/kg) and quantified by LC-MS/MS, with $^{13}C_{12}$-labelled internal standards.

Results
TBBP-A was detected in 84% of samples (41/49), whereas individual HBCDD diastereomers were detected in 43–45%. HBCDD was found almost exclusively in EPS insulation from C&D waste, with total HBCDD ranging from 91 to 11,900 mg/kg (median: 510 mg/kg; mean total BFR: 2,750 mg/kg). The γ diastereomer predominated (55%), consistent with the commercial technical formulation; however, half of the C&D samples exhibited α- and/or β-enrichment attributable to thermally induced isomerisation during service life, a shift of toxicological relevance given the longer biological half-life (~17 vs. ~1–4 days) and greater bioaccumulation potential of α-HBCDD. TBBP-A dominated WEEE plastics, with concentrations in CPU casings reaching 212,000 mg/kg (~21.2% by weight; mean ~37,150 mg/kg), consistent with additive flame retardant incorporation. In soft furnishings and ELV, BFR concentrations were substantially lower (3.5–137 and 4.9–46.0 mg/kg, respectively). PERMANOVA on z-score-standardized concentrations detected a significant effect of waste stream (pseudo-F = 3.74, R^2 = 0.20, p = 0.013), with C&D vs. WEEE as the only robust pairwise contrast (p-Bonferroni = 0.0006). Similarity percentage analysis (SIMPER), which decomposes overall dissimilarity between groups into compound contributions, attributed 80.9% of the C&D-WEEE dissimilarity to the three HBCDD diastereomers, while TBBP-A contributed 19.1%. Against EU thresholds, 50% of C&D samples exceeded the current HBCDD LPCL of 500 mg/kg (71% would exceed the proposed 200 mg/kg limit), and 59% of WEEE samples surpassed the 1,000 mg/kg SVHC threshold for TBBP-A.

Discussion and Conclusion
These concentrations indicate that a substantial proportion of Brazilian C&D and WEEE waste would require diversion from conventional recycling under an LPCL-based framework. The diastereomeric shifts observed in aged EPS suggest that waste-stage risk may differ qualitatively from that of freshly manufactured material. These findings support implementing enforceable concentration limits for HBCDD and TBBP-A in Brazilian waste legislation and mandatory XRF-based screening protocols for recyclable waste destined for the circular economy.

Acknowledgment
FAPESP: 2022/14797-7, 2025/11187-1, 2025/25530-0

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BFR Analysis

L. Leondiadis & H. Stapleton

BFR3-654 Development and optimization of analytical methods for the determination of brominated dioxins and furans (PBDD/Fs) in air emission samples

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Introduction

Polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD/Fs) are persistent organic pollutants (POPs) with toxicological properties comparable to their chlorinated counterparts (PCDD/Fs). These compounds are mainly generated during industrial thermal processes and released into the atmosphere. Although specific regulation for PBDD/Fs is not yet established, European authorities recommend periodic monitoring of emission sources such as waste incinerators. Nevertheless, no standardized analytical procedures currently exist for quantifying PBDD/Fs in complex matrices. Some methodologies suggest adapting well-established PCDD/Fs procedures, but the different physicochemical properties of PBDD/Fs require a more tailored analytical approach to ensure their precise determination.

Results

In the present work an analytical methods involving an optimized multi-step sample preparation strategy, consisting of Soxhlet extraction, a cleanup stage and instrumental analysis by gas chromatography coupled to high-resolution mass spectrometry (GC-HRMS) was developed. The method was validated, assessing precision (RSD < 10%), accuracy (bias from -7.6 % to +17.4 %), linearity (at least two orders of magnitude), detection limits (0.014–0.429 pg Nm–3), and recovery rates (85-105% for all the congeners, except for octabrominated congeners with values around 50%). The validation results proved its accuracy, robustness, and suitability for trace-level environmental monitoring of PBDD/Fs in air emission samples.

Method performance was assessed through real emission samples collected during seasonal (11 months) monitoring campaign in Spain. In those samples 13 target toxic congeners were analysed, total Σ13PBDD/F concentrations varied from1.33 pg Nm–3 to 5.46 pg Nm–3, with brominated furans prevailing over dioxins. Notably, the most brominated congeners, along with tetra-brominated congeners, were detected at the highest concentrations.

BFR Analysis

L. Leondiadis & H. Stapleton

BFR3-137 One size fits (almost) all: Developing guidance for a common polychlorinated alkane monitoring method for food analysis

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Introduction

Polychlorinated alkanes (PCAs), are the main components of chlorinated paraffins, a class of industrial lubricants, flame retardants, and plasticizers. They can be found in any type of flexible plastic, from yoga mat to charging cable - and consequently, also as contaminants in food. The complexity of PCA mixtures with several thousand congeners potentially present in a sample proves analytically challenging. Over the course of the last two decades, an increasingly sophisticated array of analytical and statistical approaches were developed to tackle this challenge. However, to this day, a full separation of all PCA congeners is still not feasible. On the other hand, the material and instrument cost as well as the complexity of data evaluation for the more sophisticated methods has led to only a few laboratories able to analyse PCAs in food. In the last decade, only a few hundred sample results for PCAs in food were submitted every year to EFSA by official food control laboratories. However, to gain an overview of PCA occurrence in food on the EU market and thus allowing further risk assessment, a larger dataset, from more member states, is needed.

Results

An updated guidance document for the analysis of PCAs was prepared by the European Union Reference Laboratory for halogenated Persistent Organic Pollutants in feed and food (EURL POPs) in cooperation with expert laboratories across the EU, now also describing a quantitative monitoring method for the determination of ΣPCAs-C10-17 as screening parameter. This method is also referred to in the Commission recommendation on monitoring PCAs / chlorinated paraffins in food.

Discussion and Conclusion

One of the main challenges in integrating the analysis of PCAs in food control was for the longest time the limited range of compounds actually classified as being of concern. Until 2025, only short-chain chlorinated paraffins, consisting of PCAs with chain length C10-13 and at least 48% chlorine, were listed as POPs [1]. Quantifying them in the presence of other PCAs was challenging due to mass interferences and limitations in available standards. The multitude of high-resolution mass spectrometry methods and complex quantification strategies developed to produce more specific results showed limited comparability, especially when the results were not metrologically traceable through linking with a reference standard. While method comparability has improved over the years, it still remains a major concern when using combined occurrence data for risk assessment. With now also medium-chain chlorinated paraffins (PCAs-C14-17) listed as POPs [2], a wider approach can be taken for determining PCA levels in food: Determination of ΣPCAs-C10-17 as sum parameter. By reverting back to scanning three relatively unspecific chloroalkane-related mass transitions and removing the need for full chromatographic separation, the instrumental and analytical requirements are much easier to match in a broad range of laboratories. Additionally, interlaboratory comparisons have shown in the past that the agreement on the sum parameter level was often much better than for more specific PCA results [3].
This recommended monitoring method marks a departure from previous efforts to perform food control on the same analytical level as research: The simplified monitoring allows easy implementation and thus for more occurrence data to be collected, while a mechanism for samples with high-PCA contamination still ensures more detailed characterisation and source investigation.

Acknowledgment

We would like to thank the European Commission for the financial support of the work of the EURL for halogenated POPs in feed and food and the members of the Core Working Group "Chlorinated Paraffins" for their contribution to the guidance document and ongoing harmonisation efforts.

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Screening and Identification of Novel Contaminants 2

A. Covaci & M. Zheng

D38-333 Uncovering Hidden Contaminants of Emerging Concern in Campus Indoor Dust by Ion Mobility High-Resolution Mass Spectrometry

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Introduction

Indoor dust is an important sink and exposure pathway for contaminants of emerging concern (CECs). Frequently co-released industrial additives, such as phosphate flame retardants (PFRs), alternative plasticizers (APs), fluorescent brighteners (FBs) and antioxidants (AOs) have attracted increasing attention due to their potential risks to human health. However, their high structural diversity and the limited availability of reference standards challenge conventional mass spectrometric identification. In this study, drift-tube ion mobility high-resolution mass spectrometry (DTIM-HRMS) was applied for the analysis of indoor dust samples, using the calculation of collision cross section (DTCCSN2) values from measured drift times to improve identification confidence [1].

Materials and Methods

Dust samples (n=35) were collected from a major university in North China. Samples were extracted by ultrasonic-assisted solvent extraction followed by SPE fractionation and nitrogen evaporation. An Agilent 6560 DTIM-QTOF platform was applied for LC-HRMS analysis. A hybrid workflow combining diagnostic fragment filtering and nontarget screening analysis was applied. DTCCSN2 values were calculated and evaluated as an orthogonal identification parameter. Toxicity was evaluated via ADMETlab 3.0 and the Toxicological Priority Index (ToxPi) [2].

Results

Through target screening by HRMS, 14 APs and PFRs were detected and confirmed at CL1 with reference standards, with total concentrations ranging from 107 to 2743 µg/g at various sites, and a median concentration of 1071 µg/g. HRMS-based suspect screening identified 33 additional CECs which were assigned at confidence level 3 or better [3]. Notably, total semi-quantified concentrations of these newly annotated CECs (1064–4983 µg/g, median 3564 µg/g) substantially exceeded those from target analysis. These findings reveal a substantial "hidden" pool of CECs and underscore the critical role of nontarget screening. In ToxPi-based risk assessment, newly annotated antioxidants showed the highest risk scores, followed by APs, suggesting that these two classes may pose notable health concerns due to their widespread occurrence.
DTCCSN2-m/z trendlines were established, covering 187 adducts, and DTCCSN2 values for 22 compounds are reported here for the first time. All classes showed strong linear DTCCSN2–m/z relationships (R^2 > 0.93), allowing a clear distinguishment between them. Elemental composition and structural similarity governed DTCCSN2–m/z linearity, whereas marked shifts in chemical space resulted in poorer correlation and deviation from trendlines. Moreover, DTCCSN2 provides new evidence for the discrimination of complex phthalate isomers that are otherwise challenging to separate. These class-specific chemical-space patterns can improve confidence in nontarget identification by providing an additional orthogonal dimension for confirmation and filtering.

Discussion and Conclusion

This study applied a hybrid IM-HRMS screening strategy to characterize CECs in university indoor dust, identifying a total of 47 CECs. The integration of DTCCSN2–m/z trendlines showed strong class-specific regression consistency and served as a valuable orthogonal filter, significantly improving identification confidence. This approach provides a practical methodological framework for the exclusion of false positives and the discovery of CECs in complex environmental matrices.

Acknowledgment

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Screening and Identification of Novel Contaminants 2

A. Covaci & M. Zheng

D38-333 Uncovering Hidden Contaminants of Emerging Concern in Campus Indoor Dust by Ion Mobility High-Resolution Mass Spectrometry

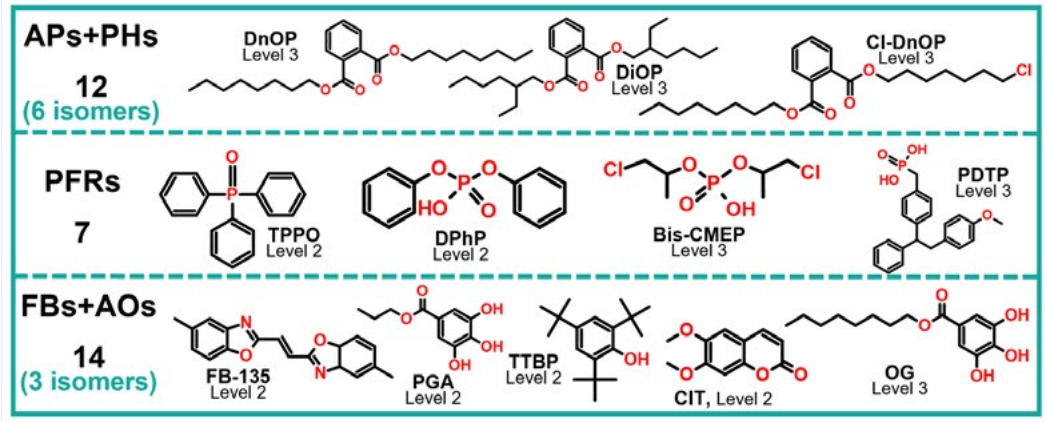


Fig.1 Probable HRMS-identified CECs structures in the dust

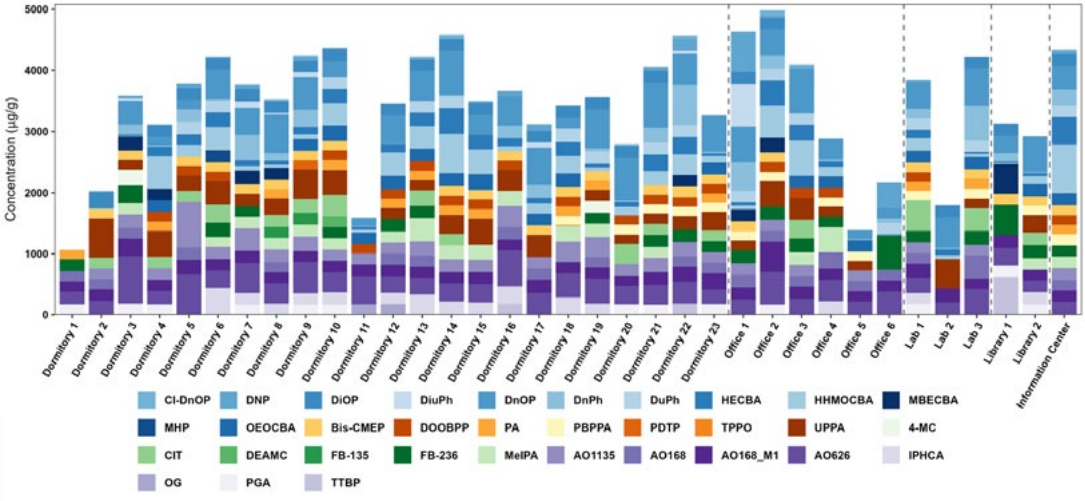


Fig.2 Semi-quantified concentrations (μg/g) of newly identified CECs

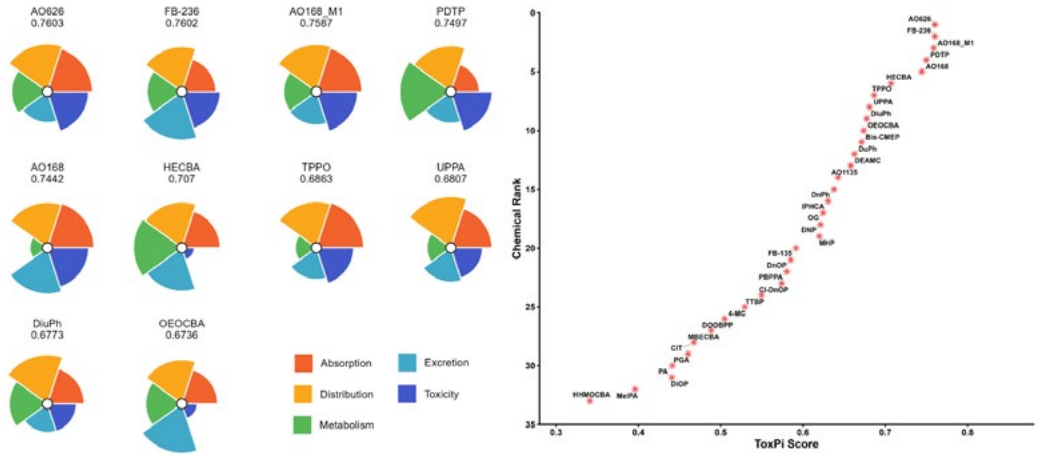


Fig.3 The top 10 ToxPi score HRMS-identified CECs and overall ranking.

Screening and Identification of Novel Contaminants 2

A. Covaci & M. Zheng

D38-852 Human exposure to indoor house dust: Characterization of unknown chemical compounds and their potential sources

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Introduction
People spend most of their time indoors, making the indoor environment an important contributor to chemical exposure. House dust acts as a reservoir for a wide range of contaminants originating from consumer products, building materials, and outdoor sources. Characterizing the chemical composition of indoor dust is therefore essential for understanding human exposure to complex chemical mixtures. This study aimed to identify known and previously uncharacterized chemical compounds in indoor dust and investigate potential sources of indoor contamination.

Materials and Methods
Approximately 300 dust samples were collected from households in eight European countries as part of the INQUIRE project. Samples were extracted and analysed using liquid chromatography coupled to high-resolution trapped ion mobility spectrometry time-of-flight mass spectrometry (LC-ESI-timsTOF-MS) in both positive and negative ionization modes. A combined suspect and non-target screening workflow was applied to characterize chemical features present in the samples. Household questionnaire data were used to explore associations between chemical occurrence, occupant behaviour, product use, and housing characteristics.

Results
More than 20,000 chemical features were detected across the analysed dust samples, including compounds associated with consumer products, personal care products, insect repellents, and plasticizers. Distinct differences in chemical profiles were observed between countries, suggesting the influence of regional practices, product use patterns, and regulatory frameworks. Questionnaire data indicated potential sources for several groups of compounds, linking indoor contamination patterns to household characteristics and personal habits.

Discussion and Conclusion
The large number and diversity of detected compounds demonstrate the complexity of chemical mixtures present in indoor environments. The observed differences between countries suggest that both behavioural and regulatory factors may influence indoor contamination patterns. Combining chemical screening data with questionnaire information provided valuable insight into potential exposure sources and pathways. House dust is an important matrix for assessing human exposure to indoor contaminants. The integration of suspect and non-target screening with household information improves the identification of contamination sources and exposure pathways. These findings support continued monitoring of indoor environments and contribute to a better understanding of human exposure to complex chemical mixtures.

Acknowledgment
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Screening and Identification of Novel Contaminants 2

A. Covaci & M. Zheng

D38-487 Nontarget GC-ECNI-Orbitrap-HRMS screening and Phyton-based evaluation of polyhalogenated compounds in the blubber of a dolphin from the Great Barrier Reef in Australia

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Introduction

Gas chromatography with electron capture negative ion high resolution mass spectrometry (GC-ECNI-Orbitrap-HRMS) was applied for the comprehensive analysis of halogenated natural products (HNPs) and anthropogenic organohalogen compounds in a dolphin sample from the Great Barrier Reef (Australia). The thorough evaluation enabled the detection of ~250 polyhalogenated compounds. The complete evaluation of such large data sets is challenging.

Materials and Methods

After evaluating the low mass range (e.g., 49 bromine- and chlorine-containing compounds were detected in this way), the polyhalogenated compounds whose molecular ion was visible were listed with the exact mass as determined by GC-ECNI-Orbitrap-HRMS. Then, the halogens in the molecular formula (always presented with four decimal places) were substituted with hydrogens (e.g. 2,4,6-tribromophenol, C6H3Br3O, was transferred into phenol, C6H6O), and the corresponding mass was labeled "primary list" [2]. To simplify this procedure for the many molecular formulae in the present work, the described process was automated using Python (version 3.14.0), resulting in an Excel spreadsheet containing the original and result data (details will be shown in the presentation).

Results

Subsequently, this primary list with the backbones was listed with increasing exact mass. Hence, congeners of the same group (e.g. PCBs) appear next to each other in the list, which facilitates the interpretation of the data [2].
The developed scheme allowed adding secondary lists, for compounds having an additional -CH2- or -C2H4- moiety which indicate homologues if the resulting exact mass is also found in the primary list [2]. The same approach can be used by creating a secondary list with an additional oxygen (compare biphenyls with diphenyl ethers).
Thanks to the automated process, this method can be applied to any molecular formula and even large datasets in a matter of minutes.
Table 1 shows an excerpt of the Excel list (six detected compounds). Three compounds (#69, #83, #56) had the same backbone and thus were isomers. One explanation for their structure could be an O-bridged phenyl and N-methylpyrrole unit. Also, #207 and #201 were isomers, and these featured an uncommonly high number of N and O (Table 1). In either case, these compounds seemed to be halogenated natural products. In the same way, several polychlorinated terphenyls (Cl7-Cl9) could be assigned which are scarcely reported in the literature.
Table 1. Excerpt of the Excel list with the peak number (according to tR), the molecular formula with the exact mass, the molecular formula and mass (monoisotopic peak) of the nonhalogenated backbone (primary list) and two chosen secondary lists. The data was sorted with increasing mass of the primary list.

This approach simplified the evaluation of complex datasets of polyhalogenated compounds. Especially, the primary list-based approach enabled the detection of previously unknown or non-considered polyhalogenated compounds.

Table 1. Excerpt of the Excel list with the peak number (according to t_R), the molecular formula with the exact mass, the molecular formula and mass (monoisotopic peak) of the nonhalogenated backbone (primary list) and two chosen secondary lists. The data was sorted with increasing mass of the primary list.

Peak number	Molecular formula	Exact mass of M^+ (*m/z*)	Backbone (nonhalogenated)	Primary list (*m/z*)	Secondary list 1 +CH_2 mass	Secondary list 2 +C_2H_4 mass
69	$C_{11}H_4ONBrCl_6$	454.7603	$C_{11}H_{11}NO$	173.0838	187.0994	201.1150
83	$C_{11}H_3ONBrCl_7$	488.7213	$C_{11}H_{11}NO$	173.0838	187.0994	201.1150
56	$C_{11}H_4ONCl_7$	410.8108	$C_{11}H_{11}NO$	173.0838	187.0994	201.1150
207	$C_6H_3O_4N_2BrCl_6$	455.7403	$C_6H_{10}N_2O_4$	174.0638	188.0794	202.0950
201	$C_6H_3O_4N_2BrCl_6$	455.7403	$C_6H_{10}N_2O_4$	174.0638	188.0794	202.0950
34	$C_{10}H_5ON_2Cl_5$	343.8841	$C_{10}H_{10}N_2O$	174.0791	188.0947	202.1103

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Screening and Identification of Novel Contaminants 2

A. Covaci & M. Zheng

D38-547 EU Legislation and Standardization – Relevance of EN 1948 emission measurements of PCDDs/PCDFs/dioxin-like PCBs

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Introduction
CEN/TC 264 "Air Quality" has been established in 1991, considering the relevance of air pollution and the necessity of standardized measurement methods to survey the limit values set by the European Commission. Because of the Seveso disaster and the relevance of Dioxins, WG 1 "Emissions: Dioxins/PCBs" has been established as first working group of CEN/TC 264. The first Convenor was Prof. Günter Bröker, Germany, followed in 2019 by Dr. Esteban Abad Holgado, Spain. Three national Guidelines (VDI 3499) served as discussion basis for developing three European Standards, they are still available as examples for applying DIN EN 1948 for the concentration range <0,1 ng I-TEQ/m3 in filter dust, ash, slag. In October 1992, validation measurements for the short-term measurements of PCDDs/PCDFs took place at a municipal waste incinerator in Düsseldorf using the three established sampling methods: filter/condenser method, dilution method and cooled probe method. In 1996 three European Standards on PCDDs/PCDFs have been published: EN 1948 Part 1 Sampling; Part 2 Extraction/clean-up; Part 3: Identification/quantification. In 2021 the relevance of dioxin-like PCBs came into focus of European legislators and the development of EN 1948 Part 4 Sampling and analysis of dioxin-like PCBs was initiated. In 2006/2007 the validation of PCBs emission measurements was requested and financially supported by the European Commission in support of M/388. The sampling campaign has been performed in June 2007 at a municipal waste incinerator in Vienna using all three standardised sampling methods confirming their equivalency. EN 1948 Part 4 has been published in 2010 and was amended in 2015.

Results
Nowadays, long-term measurements become increasingly important, e.g. to cover critical start-up and shutdown processes that can lead to increased emissions. Directive 2010/75/EU states in Article 48 Monitoring of emissions: "As soon as appropriate measurement techniques are available within the Union, the Commission shall, by means of delegated acts […] set the date from which continuous measurements of emissions into the air of heavy metals and dioxins and furans are to be carried out". In 2022 EC issued Standardization Request (M/588) asking CEN to develop a European Standard on long-term sampling of PCDDs/PCDFs/dioxin-like PCBs. Consequently, WG 1 is transferring the existing CEN/TS 1948-5:2015 Long-term sampling of PCDDs/PCDFs/PCBs into a full European Standard. Unfortunately, validation measurements could not be performed due to missing funding. However, more than 20 years of application experience and existing comparison data allowed the use of the structured procedure, put in place by CEN/TC 264 to validate methods without testing, and the completion of a comprehensive questionnaire as a prerequisite for the transfer of a TS into an EN (CEN/TC 264 Decision 1445). The draft prEN 1948-05 has been published in May 2026, the enquiry deadline is August 2026.

Discussion and Conclusion
A major task of standardization process is the regular review of the standards taking into account new technical developments, ongoing modernization and quality assurance of the regulatory framework. During this review process, the experts decide if the Standards that have proven effective are retained, while others are eliminated or updated. This keeps the regulatory framework streamlined and also in accordance with the law. The principles of reducing bureaucracy and modernization are therefore implemented by this regular review process.
Recent examples are the review of EN 1948-04:2013, where Germany proposes a revision considering technical developments of GC/HRMS systems: nowadays, many HRMS systems do not show usable noise in the mass traces. Thus, the calculation of signal to noise ratios would lead to unrealistically low LOQ values. Therefore, an alternative LOQ criterion should be defined. The decision process on the revision is ongoing. Addionally, EN 1948 currently serves as discussion basis for standardising PFAS emission measurements.

Recent Advances in Microplastics Analysis

F. Corami & S. Lomnicki

D39-523 Additive fingerprinting of airborne micro- and nanoplastics in industrial facilities: combining targeted and untargeted GC-MS analysis

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Introduction

Airborne micro- and nanoplastics (MNPs) represent an emerging class of contaminants of global concern due to their environmental persistence and potential adverse health effects. MNPs act as carriers for polymer additives including plasticizers, flame retardants, antioxidants, and UV stabilizers, some of which are recognised endocrine-disrupting chemicals. Recent literature indicates that the most abundant atmospheric MNPs originate from synthetic textile fibres (80-90% of atmospheric counts), packaging polymers (PET, PE, PP), and tyre wear particles1,2. This study investigated whether polymer additives could serve as chemical markers to discriminate source-specific emission fingerprints in particulate matter from three representative facilities: recycled textile fibre production, mineral water bottling (PET), and tyre service and repair (rubber).

Materials and Methods

Sampling campaigns were conducted in each site using sequential samplers for PM_{10} and multi-stage impactors for size-resolved aerosol collection at near-source, ambient, and outdoor sites. A dual analytical approach combined targeted and untargeted GC-MS screening. Targeted analysis quantified 74 analytes (phthalates, alternative plasticizers, phenolic antioxidants, organophosphate flame retardants, benzothiazoles) by GC-MS with isotopically labelled internal standards. Untargeted screening employed GC-HRMS (Orbitrap) with spectral deconvolution, high-resolution library matching, and retention index calculation. Data processing included sequential blank subtraction, indoor/outdoor enrichment filtering, and compound classification into 11 functional classes at three Schymanski confidence levels3. Source materials (textile fibres, PET preforms, tyre rubber) were analysed using identical procedures to validate source-to-receptor traceability.

Results

Distinct additive fingerprints were observed for each facility. Textile facility: DEHP and DEHT dominated (0.56-10 ng/m^3 and 0.85-8.9 ng/m^3), with strong workday/weekend gradients indicating process-dependent emissions. Additives enriched in fine fractions (0.38-0.94 µm) consistent with fibre spinning. Untargeted screening identified textile-specific markers including sterols, triterpenoids, odd-chain n-alkanes C_{27}-C_{33} (cotton waxes), benzyl benzoate (finishing agents), and aromatic nitrogen compounds (dye markers), traceable to source fibres. Bottling plant: ATBC and DEHA predominated (up to 30 ng/m^3 and 4.1 ng/m^3) with indoor/outdoor ratios up to 90×. Bimodal size distribution (<0.18 µm and >10 µm) suggested combined fine particle generation and mechanical micro-fragment release. Untargeted analysis revealed propanoic acid esters (label adhesive coalescents) and branched alkanes C_{15}-C_{20} (process oils), consistent with PET preforms. Tyre workshop: 6PPD reached 3.3 ng/m^3 (vs <0.27 ng/m^3 at other sites) and benzothiazole 0.60-2.3 ng/m^3, with antioxidants representing ~5% of total additives vs <1.5% elsewhere. Coarse fraction enrichment indicated mechanical abrasion. Untargeted screening identified 33 compounds including p-phenylenediamines, sterane-like compounds (process oils), and isopropylated aryl phosphates, traceable to rubber material.

Discussion and Conclusion

The combined targeted and untargeted approach effectively discriminated emission scenarios through site-specific chemical fingerprints. Targeted analysis revealed distinct additive profiles: high-MW phthalates/terephthalates (textile), citrate/adipate plasticizers (bottling), and tyre-specific antioxidants (6PPD/benzothiazole). Untargeted screening complemented this characterization by identifying process-specific markers not included in the targeted panel: sterols and finishing agents (textile), coalescent esters (bottling), and sterane-like compounds with p-phenylenediamines (tyre). Comparison with source materials validated fingerprint traceability from emission to receptor. Size-resolved analysis revealed process-specific mechanisms: fine fraction enrichment (fibre spinning), bimodal patterns (generation plus fragmentation), and coarse fraction dominance (mechanical abrasion). Worker exposure appears driven by distinct emission mechanisms and semivolatile partitioning. Additive-based monitoring therefore enables source discrimination and provides a practical framework for characterising polymer-containing particulate matter in occupational settings, supporting risk-informed mitigation strategies and targeted exposure surveillance.

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Recent Advances in Microplastics Analysis

F. Corami & S. Lomnicki

D39-523 Additive fingerprinting of airborne micro- and nanoplastics in industrial facilities: combining targeted and untargeted GC-MS analysis

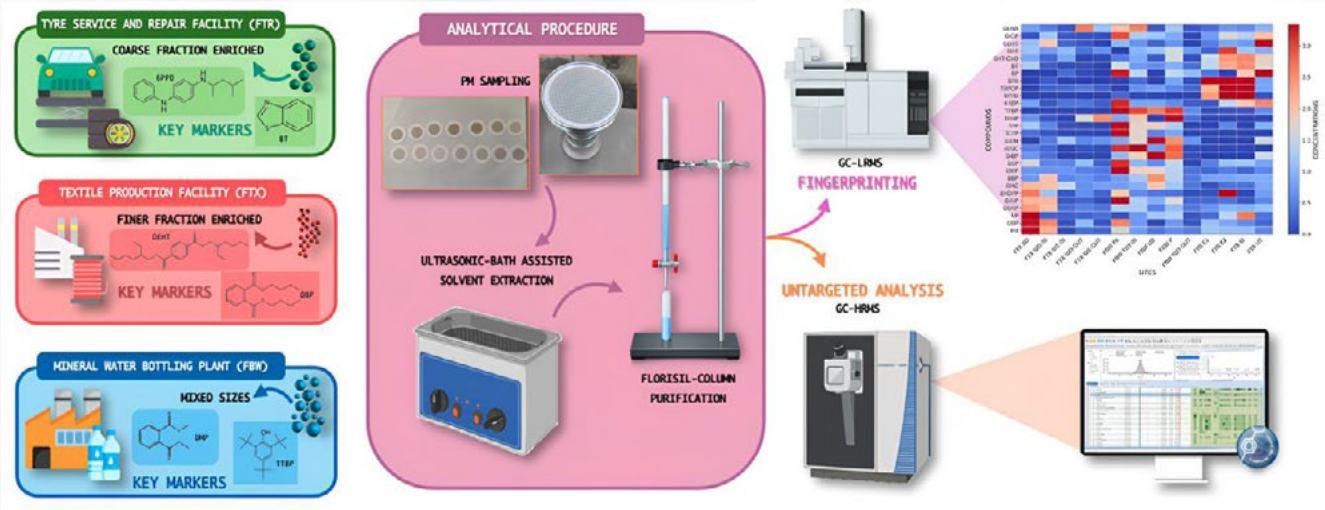


Figure 1 Schematic workflow of the study design showing the three investigated occupational facilities, targeted and untargeted GC–MS analytical strategies, source-to-receptor comparison with representative raw materials, and chemical fingerprinting approach for emission-source discrimination.

Recent Advances in Microplastics Analysis

F. Corami & S. Lomnicki

D39-500 Deep Learning Based Spectral Classification of Microplastic Aging

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Introduction

Microplastic pollution is a global environmental issue. The physico-chemical properties of microplastics allow long-range transport and bioavailability thus increasing the ecological and human health risks that need to be investigated. Polymer type and quantity are main parameters for the assessment, yet aging is also a serious concern. When exposed to the environment, pristine particles undergo physicochemical transformations due to ultraviolet radiation, as well as other oxidative, mechanical and biological factors. These processes modify the polymer matrix, changing functional groups, crystallinity, among other modifications. The emergence of oxygenated functional groups, especially, make ATR-FTIR an efficient method to follow the aging of microplastics. FTIR output has conventionally been evaluated by manual inspection or calculation of absorbance ratios such as the Carbonyl Index, which is time-consuming and prone to errors and/or inconsistencies due to sample heterogeneity or calculation methods. Recent studies have integrated deep learning (DL) to overcome these limitations. While substantial progress has been achieved in polymer type classification, the differentiation between aged and pristine microplastics using spectral data remains a less explored area. In this study, a DL-based analytical framework was developed to systematically evaluate the automated classification of polyethylene microplastics aging stage, using FTIR spectral data.

Materials and Methods

The FTIR spectral dataset belongs to high-density polyethylene microplastics that have been exposed to varying degrees of UV radiation and grouped as: Pristine and UV-aged (i.e., UV-aging Stage-1 through -4). To improve generalization, data augmentation was applied to 258 original samples, yielding 1,498 spectral sequences via random noise injection, y-axis shifting, x-axis jittering, and intensity scaling. A strict sample-level GroupShuffleSplit strategy was implemented to prevent data leakage. To ensure uniform input dimensions without raw data interpolation or distortion, zero padding was applied, resulting in a fixed matrix dimension of 3,601. A custom three-layer 1D-CNN was iteratively designed from scratch to capture localized sequential dependencies. The model was trained using the AdamW optimizer with Cross-Entropy Loss, incorporating Dropout (0.5), a dynamic learning rate scheduler, and an early stopping mechanism with a validation loss-based checkpoint system to ensure stable convergence and robust performance. The training and validation loss curves demonstrated stable convergence throughout 2,000 epochs, confirming successful optimization with no indications of

Results

The custom 1D-CNN model achieved a high predictive performance with a final test accuracy of 83.7%. Detailed analysis of the confusion matrix revealed that the network successfully learned highly discriminative spectral features for extreme states, accurately classifying 34 out of 37 Pristine samples. A perfect classification (50 out of 50) was achieved for Stage-4 (i.e., highly UV-aged) samples. Minor misclassifications occurred primarily between sequential intermediate aging states, most notably with 11 Stage-1 spectra being predicted as Stage-2, and 9 Stage-3 spectra being predicted as Stage-2.

Discussion and Conclusion

Observed spectral overlapping between intermediate classes reflects the realistic, continuous gradient nature of UV-induced chemical degradation rather than discrete transitions, making manual index calculations less reliable for early aging phases. The results suggest that the custom 1D-CNN framework combined with appropriate spectral augmentation provides a reliable, rapid, and automated alternative to traditional manual interpretations of FTIR spectra. Crucially, the robust automated differentiation across distinct UV-aging stages provides essential field-insights regarding the environmental risks of degraded polymers. Literature indicates that these chemical modifications greatly enhance the sorption capacity of aged microplastics for hazardous hydrophobic organic contaminants, such as persistent organic pollutants (POPs) and endocrine disruptors, thus augmenting their bioavailability and potential ecotoxicological vector effects in aquatic systems. Thus, the use of this high-throughput DL framework for accurate aging-stage identification has the potential to enhance realistic evaluation of microplastic-related chemical hazards and their interactions with pollutants in the environment.

Recent Advances in Microplastics Analysis

F. Corami & S. Lomnicki

D39-684 Advancing Microplastics Analysis: TD-PY-GC×GC-ToFMS for Direct Quantification in Complex Organic Matrices

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Introduction

Plastics are used in myriads of applications because of their favourable properties. However, their extensive use has also led to significant challenges regarding waste management and thus ending up partly in the environment. Once released, plastics can degrade further into microplastics, which in turn lead to increasing concerns regarding environmental and human health issues related to microplastic exposure. To better assess these exposure levels and to map the environmental occurrence, robust and accurate analytical methods to identify and quantify microplastics are required.

Materials and Methods

Currently, conventional techniques such as Fourier-Transform infrared (FTIR) spectroscopy, Raman spectroscopy and analytical pyrolysis coupled to gas chromatography and mass spectrometry (Py-GC-MS) are commonly used to identify and quantify microplastics either on a particle number or mass basis. Even though these techniques are commonly used, they generally also require, depending on the matrix, extensive sample preparation to isolate microplastics from the interfering matrices. However, such sample preparation steps can also introduce sample losses. To address this limitation and to reduce sample preparation handlings, this study proposes an alternative approach based on in-line sample clean-up for the direct analysis of microplastics in complex organic/biogenic matrices (e.g. organic waste streams). The latter is crucial since the main analytical challenge with pyrolyzing organic matrices is the formation of pyrolysis products that are identical or co-elute with the polymeric marker compounds (e.g. fatty acids profiles that interfere with polyethylene analysis), which in turn can lead to an over- or underestimation of the actual polymer quantity. To minimize these interferences, enhanced chromatographic separation was achieved by using comprehensive two-dimensional gas chromatography coupled to Time-of-Flight Mass Spectrometry (GC×GC-ToFMS), combined with thermal desorption and analytical pyrolysis techniques (TD-PY-GC×GC-ToFMS).

Results

This multi-hyphenated approach enables selective removal of semi-volatile biogenic matrix and improved separation of the remaining interferences from the polymer marker compounds. However, to remove the biogenic-related signal, classical thermal desorption temperatures (i.e. 200 – 300 °C) were not sufficient. Therefore, a temperature of 450 °C was selected being on the interface between thermal desorption and pyrolysis. To assess the impact of the method both on the biogenic matrix and microplastics, mixtures of artificial organic waste and microplastic standards (i.e. 11 different types of polymers) were subjected to an initial thermal desorption step at 450 °C for 30 s to volatilize and remove the biogenic fraction while retaining the polymer material within the pyrolyzer. Results revealed that by applying this step, the organic matrix was effectively removed, while minimal polymeric degradation was observed. Subsequently, a pyrolysis step was executed on the remaining fraction and in turn analysed by GC×GC-ToFMS. This approach led to an effective removal of a major part of the biogenic matrix without affecting the polymers of interest, thereby reducing the over- and underestimation with approximately 10 to 20 % of the total polymers present compared to direct pyrolysis. However, greater reductions were obtained on individual polymer level up to approximately 35 % for PVC due to its non-selective marker compound, enabling more reliable microplastic quantification.

Discussion and Conclusion

The proposed TD-PY-GC×GC-ToFMS methodology enables the direct quantification of microplastics in complex organic/biogenic matrices without extensive sample preparation. By minimizing particle losses and reducing analytical workload, this approach provides an accurate and less labour-intensive strategy for microplastic analysis in environmental samples.

Recent Advances in Microplastics Analysis

F. Corami & S. Lomnicki

D39-304 Assessment of UV-induced changes in the pyrolysis behaviour of tire wear particles: a multidimensional approach by Py-GC×GC-ToFMS

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Introduction

Plastics and microplastics are ubiquitous in the global environment, drawing increasing attention due to their adverse environmental impact. Particles originating from tire abrasion represent a substantial share of microplastic pollution, particularly in traffic-dominated and urban environments. Following their release, several environmental processes occur, including mechanical abrasion and physicochemical degradation, such as UV-irradiation. These processes can lead to pronounced changes in the chemical fingerprint and functional characteristics of tire wear particles (TWPs); hence, their overall impact has not yet been elucidated. This knowledge gap mainly arises from the complex analytical approach required to tackle these heterogeneous samples. Conventional pyrolysis coupled to gas chromatography mass spectrometry (Py-GC-MS) is seen as the go-to strategy to characterize TWPs by identifying their polymer-specific marker compounds. However, due to the sample complexity, Py-GC-MS faces limitations in resolving power, restricting research to unravel the full chemical fingerprint of TWPs. Comprehensive two-dimensional gas chromatography hyphenated with analytical pyrolysis and time-of-flight mass spectrometry (Py-GC×GC-ToFMS) can present a potential solution to overcome the conventional shortcomings.

In the current study, laboratory generated TWPs were artificially aged for four weeks using a weathering chamber with UV-irradiation, and a subsample was collected every week. The pristine and aged TWPs were subsequently analysed using Py-GC×GC-ToFMS, revealing a time dependent alteration pattern in the relative abundance of characteristic pyrolysis compound groups, specific to the polymer type, and additives (e.g. antioxidants). This outcome supports the hypothesis that UV-irradiation can induce degradation of TWPs, altering their chemical composition, and in turn complicating accurate quantification. In conclusion, such non-targeted screening approaches are of major importance for tracing degradation products and acquiring reliable TWP data for environmental mitigation strategies.

Acknowledgment

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EFSA EU Food-Feed Legislation

H. Knutsen & L. Ramos Bordajandi

D40-673 BFRs in food: outcome of the last EFSA risk assessments on TBBPA, brominated phenols, and emerging and novel BFRs

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Introduction

The European Food Safety Authority (EFSA) was established in January 2002 as an independent body providing scientific advice and communication on risks associated with the food chain (Regulation (EC) No 178/2002). As a risk assessor, EFSA produces scientific opinions and advice to provide a sound foundation for European policies and legislation and to support the European Commission, European Parliament and EU Member States in taking effective and timely risk management decisions.

Between 2010-2012, the EFSA Panel on Contaminants in the food chain (CONTAM Panel) published six scientific opinions on main groups of brominated flame retardants (BFRs) and the potential risks to public health from their presence in food. Based on the outcome of these assessments, the European Commission recommended that further data on levels in food and in humans should be gathered in particular for HBCDDs (total and individual α-, β-, γ-HBCDD), TBBPA and derivatives, brominated phenols and their derivatives, PBDEs and for emerging and novel BFRs.

Since then, new occurrence data in food and new scientific information became available. Thus, in 2018, the European Commission requested EFSA to update its 2010–2012 risk assessments on the different families of these BFRs.

The CONTAM Panel is since then updating the risk assessments of different classes of BFRs in a series of separate Opinions. The first four Opinions have updated the risk assessments of HBCDDs in food (1), PBDEs in food (2), TBBPA and its derivatives in food (3) and brominated phenols and their derivatives in food (4). The update of the Opinion on emerging and Novel BRs is ongoing. In addition, the similarities in chemical properties and effects seen in the previous EFSA assessments for the different BFR families warrant the consideration of a risk assessment of combined exposure to different BFRs. Thus, the CONTAM Panel will evaluate the appropriateness of applying a mixture approach in an additional Opinion. It will be based on the EFSA Guidance on harmonised methodologies for human health, animal health and ecological risk assessment of combined exposure to multiple chemicals published in 2019 and 2021.

Discussion and Conclusion

In this talk, the main conclusions of the EFSA's risk assessments on TBBPA, brominated phenols and emerging and novel BFRs in relation to the adverse effects of PCDD/Fs and DL-PCBs in humans will be presented, as well as the updated dietary exposure assessments performed.

Acknowledgment

EFSA thanks the members of the CONTAM Panel and the members of the WG on BFRs. EFSA also thanks all European Competent Authorities and other stakeholders that provided occurrence data in food and supported the consumption data collection for the Comprehensive European Food Consumption Database

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EFSA EU Food-Feed Legislation

H. Knutsen & L. Ramos Bordajandi

D40-674 Dioxins in food: human dietary exposure assessment and impact of the new 2022 WHO-TEFs

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Introduction

The European Food Safety Authority (EFSA) was established in January 2002 as an independent body providing scientific advice and communication on risks associated with the food chain (Regulation (EC) No 178/2002). As a risk assessor, EFSA produces scientific opinions and advice to provide a sound foundation for European policies and legislation and to support the European Commission, European Parliament and EU Member States in taking effective and timely risk management decisions.

In 2018, the EFSA Panel on Contaminants in the Food Chain (CONTAM Panel) published an Opinion on the health risks for humans and animals related to the presence of PCDD/Fs and DL-PCBs in food and feed (1). The assessment of the human health risk was done following the risk assessment paradigm: hazard identification, exposure assessment, hazard characterisation and risk characterisation. A Tolerable Weekly Intake (TWI) was derived for humans, expressed using the Toxicity Equivalency Factors (TEFs) set by WHO in 2005. The EFSA Opinion recommended, among others, that the 2005 WHO-TEFs should be re-evaluated in order to take into account new in vivo and in vitro data (in particular, more insight into the reported lower relative potency of PCB-126 in humans, an important contributor to human exposure).

In 2022, an Expert meeting was organised by the WHO in which the 2005 WHO-TEFs for PCDD/Fs and DL-PCBs were reevaluated (2). TEFs for most PCDD/Fs and non-ortho DL-PCBs were changed. For mono-ortho DL-PCBs, it was decided to retain their 2005 WHO-TEFs because of the limited and heterogenous data available for these congeners. In 2024, WHO published its updated WHO-TEF values.

Following this publication, the European Commission requested EFSA for an update of the scientific Opinion on the risk for human and animal health related to the presence of PCDD/Fs and DL-PCBs in food and feed on the basis of the new 2022 WHO-TEF values. EFSA was also asked to update the information on exposure of food-producing animals and the transfer of PCDD/Fs and DL-PCBs from feed to animal-derived food products. The updated scientific Opinion underwent public consultation from November 2025 until January 2026 (3, and it was adopted by the CONTAM Panel in April 2026.

Discussion and Conclusion

In this talk, the results of the update of the human dietary exposure assessment for the European population using the 2022 WHO-TEFs will be presented. The occurrence data on PCDD/Fs and DL-PCBs in food submitted to EFSA between 2013 and 2023 were considered and combined with consumption data from the EFSA Comprehensive European Food Consumption Database. A range of exposure scenarios were estimated for all age groups including exposure estimates for the 29 PCDD/Fs and DL-PCBs, the 17 PCDD/Fs and the individual congeners using the 2005 WHO-TEFs and the 2022 WHO-TEFs. The contribution of individual congeners and congeners groups as well as the contribution of various food categories to the dietary exposure were estimated. These results and the impact of the new 2022 WHO-TEFs on the dietary exposure estimates will be presented.

Acknowledgment

EFSA thanks the members of the CONTAM Panel and the members of the WG Dioxins update. EFSA also thanks all European Competent Authorities and other stakeholders that provided occurrence data in food/feed and supported the consumption data collection for the Comprehensive European Food Consumption Database.

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EFSA EU Food-Feed Legislation

H. Knutsen & L. Ramos Bordajandi

D40-670 Dioxins in food: what is behind the revised EFSA's TWI

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Introduction

The European Food Safety Authority (EFSA) was established in January 2002 as an independent body providing scientific advice and communication on risks associated with the food chain (Regulation (EC) No 178/2002). As a risk assessor, EFSA produces scientific opinions and advice to provide a sound foundation for European policies and legislation and to support the European Commission, European Parliament and EU Member States in taking effective and timely risk management decisions.

In 2018, the EFSA Panel on Contaminants in the Food Chain (CONTAM Panel) published an Opinion on the health risks for humans and animals related to the presence of PCDD/Fs and DL-PCBs in food and feed (1). A Tolerable Weekly Intake (TWI) was derived for humans, expressed using the Toxicity Equivalency Factors (TEFs) set by WHO in 2005. The EFSA Opinion recommended, among others, that the 2005 WHO-TEFs should be re-evaluated to take into account new in vivo and in vitro data (in particular, more insight into the reported lower relative potency of PCB-126 in humans, an important contributor to human exposure).

In 2022, an Expert meeting was organised by the WHO in which the 2005 WHO-TEFs for PCDD/Fs and DL-PCBs were reevaluated (2). In 2024, WHO published its updated WHO-TEF values.

Following this publication, the European Commission requested EFSA for an update of the scientific Opinion on the risk for human and animal health related to the presence of PCDD/Fs and DL-PCBs in food and feed on the basis of the new 2022 WHO-TEF values. EFSA was also asked to update the information on exposure of food-producing animals and the transfer of PCDD/Fs and DL-PCBs from feed to animal-derived food products. The updated scientific Opinion underwent public consultation from November 2025 until January 2026 (3) and was adopted by the CONTAM Panel in April 2026.

Discussion and Conclusion

The main conclusions of the EFSA risk assessment in relation to the adverse effects of PCDD/Fs and DL-PCBs in humans will be presented, in particular the reasoning and methodology followed by ther CONTAM Panel to revise the TWI in view of the new 2022 WHO-TEFs. In 2018, EFSA derived a TWI using the previous 2005 WHO TEFs, based on the association between lower sperm concentrations and PCDD/F-TEQ levels at earlier age (8-9 years) in a study on Russian boys. The poor association with DL-PCB-TEQ and total-TEQ (PCDD/Fs and DL-PCBs) was ignored regarding the reported low relative potencies of these compounds in human cells as compared to the 2005 WHO-TEFs (4). The new 2022 WHO TEFs did not improve the association between serum total-TEQ levels and sperm concentrations. The new TWI using the 2022 WHO TEFs is therefore derived based on the critical study used by SCF (2001), showing a reduced sperm production in male offspring of rat dams treated with TCDD. Based on the evaluation of human data, only a factor 3.16 for intraspecies differences in toxicokinetics was applied. A pharmacokinetic model was used to calculate the long-term exposure resulting in the critical body burden in future mothers, which should protect the infants. Both the outcome of the dietary exposure assessment and reported human milk levels were used to evaluate the potential health concern of the European population.

Acknowledgment

EFSA thanks the members of the CONTAM Panel and the members of the WG Dioxins update. EFSA also thanks all European Competent Authorities and other stakeholders that provided data and comments to inform the scientific Opinion.

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EFSA EU Food-Feed Legislation

H. Knutsen & L. Ramos Bordajandi

D40-677 EFSA's risk assessments of other persistent contaminants: microplastics, organophosphorous flame retardants, polychlorinated naphthalenes and chlorinated paraffins

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Introduction
The European Food Safety Authority (EFSA) was established in January 2002 as an independent body providing scientific advice and communication on risks associated with the food chain (Regulation (EC) No 178/2002). As a risk assessor, EFSA produces scientific opinions and advice to provide a sound foundation for European policies and legislation and to support the European Commission, European Parliament and EU Member States in taking effective and timely risk management decisions.

Materials and Methods
The EFSA Panel on Contaminants in the food chain (CONTAM Panel) performs risk assessment of contaminants following the risk assessment paradigm: hazard identification, exposure assessment, hazard characterisation and risk characterisation. The exposure assessment combines the data on human consumption for the different food categories with the occurrence data on the particular compounds under study in the respective food categories. A range of intake/exposure scenario estimates are foreseen that cover all age groups. For the hazard characterization, available peer-reviewed toxicological, epidemiological and toxicokinetic studies are considered, as well as application of PBK and BMD modelling to inform the characterisation of the hazard.

Results
EFSA assessed the risks for animal and human health related to the presence of polychlorinated naphthalenes in feed and food (1). Furthermore, it assessed the risks of chlorinated paraffins in feed and food (2). The main outcomes of these risk assessments will be presented.

Discussion and Conclusion
In addition, an overview of currently ongoing EFSA risk assessments on microplastics and on organophosphorous flame retardants (OPFRs) will be given (3, 4). The European Parliament requested EFSA to assess the potential health risks associated with microplastics, including nanoplastics in food, water and air. EFSA aims to provide an update of the current knowledge on micro- and nano- plastics in food and to make recommendations for their risk assessment. Furthermore, the European Commission requested EFSA to assess the risks to public health related to the presence of OPFRs in food and drinking water.
The presentation will discuss main challenges and recommendations made to address the risks to human and animal health of the presented persistent contaminants.

Acknowledgment
EFSA wishes to thank the members of the Panel on Contaminants in the Food Chain (CONTAM Panel) and CONTAM WG members. EFSA would also like to thank all European Competent Authorities and other stakeholders that provide occurrence data in food/feed and support the consumption data collection for the Comprehensive European Food Consumption Database.

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EFSA EU Food-Feed Legislation

H. Knutsen & L. Ramos Bordajandi

D40-701 The EU Member States Initiative Group on PFAS: Fostering Exchange to Navigate Regulatory and Scientific Challenges

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Introduction

Per- and polyfluoroalkyl substances (PFAS) represent a group of synthetic chemicals of concern due to their persistence, pervasive environmental distribution, and associated human health risks. As the European Union (EU) grapples with the transition from assessing legacy PFAS to addressing the broader implications of these so-called "forever chemicals," a strong need has emerged for informal exchange and mutual learning, utilizing previously unused synergies, and avoiding duplicate efforts. Acknowledging that the pending EU REACH universal restriction proposal will require substantial time to be fully effective, there remains a critical interim period where historical and ongoing exposures and societal concerns must be addressed consistently within the EU and associated countries.

Results

Traditionally, national agencies tended to navigate the complex landscape of PFAS food safety evaluations independently, operating in parallel with the European Food Safety Authority's (EFSA) overarching assessments. To foster direct collaboration and optimize resources, the EU Member States Initiative Group on PFAS was established in January 2024 following initial discussions at the EFSA Advisory Forum. The initiative provides a dedicated platform for national authorities and their scientific staff to engage actively with one another, organically complementing EFSA's central role. The overarching objective is to streamline research, share scientific developments related to risk assessment and science-to-policy translation, and systematically identify data gaps. The group currently unites institutes from 12 European countries with a strong focus on PFAS to share knowledge, their research initiatives, and to build a resilient community based on mutual trust.

The initiative operates through a structured two-tier system: a Steering Board (SB), which helps shape the overarching direction and discusses science-to-policy concerns, and a Risk Assessors Team (RAT), which conducts in-depth technical exchanges. The group maintains low administrative formalism to ensure agility when addressing pressing scientific questions while establishing strategic links with the European Chemicals Agency (ECHA) and the European Environment Agency (EEA) and global organizations such as the World Health Organization (WHO). Since its inception, the RAT has convened multiple times, with specialized expert subgroups actively exchanging information on distinct scientific hurdles.

Discussion and Conclusion

Recognizing that numerous science-to-policy needs will not be resolved in the near future, the group has outlined an explicit roadmap of priority areas to guide collaborative discussions. Key themes include the necessity to expand toxicological assessments, including New Approach Methodologies (NAMs) and mixture toxicity, and to exchange insights on developing reference values beyond the 'EFSA-4' compounds. A dedicated expert subgroup is actively facilitating this exchange. Another core priority focuses on PFAS transfer in the food chain; a specific subgroup was formed to share progress on feeding experiments and computational toxicokinetic modeling for livestock.

Additional areas emphasized by the group that may need more attention include advancing analytical methods for detecting broader PFAS categories in diverse matrices, discussing monitoring needs for food, feed, water, air, and soil, as well as understanding contamination hot spots and advancing human biomonitoring. The initiative also continuously maps environmental sources and fate while maintaining a central repository of ongoing research projects across member states. By exchanging international expertise, the EU Member States Initiative Group on PFAS provides an essential mechanism to identify emerging issues early and ensure an informed science-to-policy foundation for future European risk assessment and risk communication.

EFSA EU Food-Feed Legislation

H. Knutsen & L. Ramos Bordajandi

D40-773 Risk management of halogenated persistent pollutants at EU level. Recent developments and outlook

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Introduction
The regulatory framework for regulating halogenated persistent pollutants at EU level in food is Council Regulation (EEC) No 315/93 laying down Community procedures for contaminants in food[1] and in feed Directive 2002/32/EC on undesirable substances in animal feed[2].

Materials and Methods
It is foreseen that contaminant levels shall be kept as low as can reasonably be achieved by following good practices at all stages of the production chain. In order to protect animal and public health, maximum levels for specific contaminants are established where necessary, following a risk assessment performed by the European Food Safety Authority (EFSA). The maximum levels in feed take into account the possible adverse animal health effects and the transfer from feed to food of animal origin.

Results
Maximum levels have been established for dioxins and PCBs in feed and food and for PFAS in food. The maximum levels in feed are established in the Annex to Directive 2002/32/EC while the maximum levels in food are established in a separate Regulation, i.e. Commission Regulation (EU) 2023/915 on maximum levels for certain contaminants in food[3]
Maximum levels are set at a level "As Low As Reasonably Achievable" (ALARA) by applying good practices.
While the outcome of the risk assessment performed by EFSA is the basis of the measures, other legitmate factors are considered such as the feasibiltiy of the levels by applying good practices, risk-benefit considerations, analytical feasibiltiy, ... The setting of maximum levels is combined with sampling provisions and requirements for the methods of analysis for enforcement of the maximum levels. Besides the establishment of maximum levels, also other risk management measures are considered such as monitoring recommendations to collect more data on the occurrence, ...

Discussion and Conclusion
In the presentation, recent developments as regards EU policy on halogenated persistent pollutants to ensure a high level of animal and human health protection will be explained in detail and an outlook will be given on the risk management measures under consideration together with the justification of the measures as regards:

- Dioxins and dioxin-like PCBs in food and feed following the update of the Toxic Equivalency Factors (TEF) values and outcome of most recent EFSA opinion;
- PFAS in food and feed;
- Brominated flame retardants in food, in particular hexabromocyclododecanes (HBCDDs), polybrominated diphenyl ethers (PBDEs), tetrabromobisphenol A (TBBPA) and brominated phenols and their derivatives;
- Polychlorinated naphthalenes in food;
- Chlorinated paraffins in food.

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Progress in PFAS Analysis

C. Carrer & J. Focant

D41-025 Integration of Ultra-short Chain PFAS into Routine Analysis Methods: Addressing Retention and Confirmatory Ions

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Introduction

The emerging problem of environmental and health hazards of long chain (≥C8) PFAS meant many have been substituted for short and ultra-short chain PFAS. This has led to the analytical requirement to analyze ultra-short chain PFAS in the same methods developed and applied for longer chain PFAS. This is challenging not only in terms of a suitable chromatographic method that will retain this set of compounds but also in terms of ion ratio identification of shorter chain length PFAS, such as PFPrA and PFBA, due to the limited mass fragments generated. Both challenges have been addressed in this work.

The ultra-short chain PFAS were chromatographically retained using a mixed mode column that uses both reverse phase and anion exchange retention mechanisms. The use of this mixed mode column provides significantly increased retention for the ultra-short chain PFAS compounds. A method specific for only ultra-short chain PFAS analysis, as well as a method including ultra-short through long chain PFAS analysis in a single injection will be discussed. Each method has been tested using complex samples demonstrating the robustness of the methods.

Additional fragments for the ultra-short chain PFAS were evaluated using the m/z 19 fragment to provide a confirmatory ion for those that historically have not had one easily available by enhancing low mass transmission of the mass spectrometer. Using these settings, there was an observed increase in the response from the m/z 19 fragment of 6 times for PFPrA, 17 times for PFBA and 30 times for PFPeA, compared to the response using the standard settings. This allows for a confirmatory ion to be routinely used for these compounds. By using a mixed mode separation column and tandem mass spectrometer with automatically applied low mass transmission settings quantitation and confirmation is possible for a much wider range of PFAS compounds in a single LC-MS/MS injection.

Progress in PFAS Analysis

C. Carrer & J. Focant

D41-337 Mapping the PFAS Fluorine Gap: Systematic Evidence on Method Disparity and Assessment Implications

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Introduction

Per- and polyfluoroalkyl substance (PFAS) monitoring has expanded beyond fixed target lists to include total fluorine, organofluorine, precursor, and non-targeted analytical approaches. This shift reflects a practical limitation in current monitoring: targeted LC-MS/MS methods provide quantitative and regulatory-relevant data, but only for compounds included in defined method scopes. In contrast, total fluorine and organofluorine methods can indicate a broader fluorinated burden, while non-targeted analysis can provide molecular evidence for known, suspect, and previously unmonitored PFAS. These approaches are often described as complementary, yet their results frequently diverge. This divergence is usually treated as analytical uncertainty, but it can also provide diagnostic information about the unresolved chemical space between measured fluorine and identified PFAS.

Materials and Methods

This work integrates findings from two companion PRISMA-based systematic reviews, encompassing 271 peer-reviewed articles, to evaluate the scale and interpretation of this "fluorine gap." The first review evaluated 156 studies on total PFAS and organofluorine methods, including total fluorine (TF), total organic fluorine (TOF), extractable organic fluorine (EOF), adsorbable organic fluorine (AOF), and the total oxidizable precursor (TOP) assay across water, soil, sediment, biota, human samples, and consumer products. The second review evaluated 115 PFAS non-targeted analysis studies, including high-resolution mass spectrometry workflows, sample preparation, ionization modes, suspect screening, confidence-level reporting, semi-quantification, and PFAS class identification. Findings from both reviews were integrated to characterize the nature and scale of method disparities across matrices and geographies.

Results

The evidence shows that differences among PFAS methods follow consistent, interpretable patterns based on the operational fraction measured, rather than random analytical variability. In one river-water comparison, EOF and AOF each accounted for less than 1% of TF, whereas in industrial and municipal wastewater, 73 identified PFAS accounted for only 10% of total EOF, leaving 90% unidentified. Similar mass-balance gaps were reported in other matrices, including sediment examples where 96.6-99.39% of EOF was unidentified and textile-related matrices where methanol-extractable target PFAS plus oxidizable precursors explained no more than 0.1% of measured TF. Across the reviewed NTA literature, more than 1000 PFAS from 382 reported classes were identified, yet more than 300 of these classes occurred in fewer than 5% of studies. Geographic coverage was skewed, with most studies originating from the Northern Hemisphere and limited coverage from data-deficient regions.

Discussion and Conclusion

These findings support a diagnostic interpretation framework in which the fluorine gap is not reported as a single unresolved "total PFAS" value. Instead, it should be separated into quantified target PFAS, oxidizable precursor contribution, operational organofluorine fractions, non-extractable or polymeric fluorine, and confidence-weighted NTA identifications. This is practically relevant given that the EU Drinking Water Directive establishes separate parametric values for Sum of PFAS and PFAS Total in drinking water, requiring an understanding of why these measurements may differ. Interpreting these evidence streams together can improve PFAS monitoring design, exposure assessment, environmental forensics, and regulatory communication. Further progress will require harmonized reporting units, transparent mass-balance calculations, matrix-appropriate QA/QC, confidence-level reporting, and broader geographic coverage in regions where PFAS burdens remain poorly characterized.

Acknowledgment

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Progress in PFAS Analysis

C. Carrer & J. Focant

D41-391 A novel method for the determination of PFAS in water samples containing suspended solids (NARO Method 202401)

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Introduction

Various analytical methods for per- and polyfluoroalkyl substances (PFAS) in water have been proposed worldwide; however, their application to environmental and agricultural waters remains limited when suspended solids (SS) and biological materials are present. In such complex matrices, SS poses significant challenges in sample pretreatment and purification. In particular, clogging of solid-phase extraction (SPE) cartridges frequently occurs if SS is not removed prior to extraction, preventing proper sample processing. Moreover, PFAS strongly adsorb onto particulate matter, leading to reduced extraction efficiency and poor recovery of surrogate standards. These issues often necessitate repeated analyses, increasing time, labor, and analytical uncertainty.

Filtration-based approaches, including syringe filtration, are commonly used to remove suspended solids; however, they introduce additional complications. The handling and extraction of PFAS associated with filter-retained solids are not well standardized, and fine particles that pass through filters are often overlooked. Consequently, existing methods are generally suitable only for relatively clean water matrices and are not readily applicable to real environmental samples. Therefore, a simple, robust, and reliable method for PFAS determination in SS-containing water is required. In this study, we developed a pretreatment approach, "PFAS in Water (with insoluble matter), NARO Method 202401 1," to enable simultaneous determination of PFAS in such complex matrices.

Materials and Methods

The developed method enables simultaneous determination of PFAS in small-volume (40 mL) water samples containing suspended solids. Samples were centrifuged to separate supernatant and sediment fractions, and PFAS in both fractions were extracted using ammonia–methanol solution.

An interlaboratory comparison study was conducted involving 24 laboratories using standardized agricultural water samples containing several milligrams of suspended solids. A mixture of 30 PFAS compounds (ISO 21675) 2, 3 was distributed to all laboratories, and harmonized analytical procedures were implemented to ensure consistency.

Results

The method demonstrated excellent analytical performance despite the complexity of the sample matrix. Among the 30 PFAS compounds tested, 25 exhibited coefficients of variation within 5%, indicating high precision and reproducibility across laboratories.

Centrifugation and dual-phase extraction enabled efficient recovery of PFAS from both dissolved and particulate fractions, overcoming limitations of conventional SPE-based methods. The method effectively avoided cartridge clogging, even in samples with high SS content.

Furthermore, the reduced sample volume (40 mL), compared with conventional methods (hundreds of milliliters to 1 L), improved sample handling efficiency and reduced resource consumption. Overall, the method provided stable and reliable PFAS quantification across multiple laboratories.

Discussion and Conclusion

The developed method provides a practical and robust solution for PFAS analysis in water samples containing suspended solids. By integrating centrifugation-based separation and extraction of both supernatant and sediment fractions, the method enables comprehensive recovery of PFAS in both dissolved and particle-associated forms. This represents a significant improvement over conventional approaches, which often underestimate PFAS concentrations due to incomplete recovery from particulate phases.

The high reproducibility observed in the interlaboratory study confirms the reliability and robustness of the method. In addition, the simplified workflow and reduced sample volume improve analytical efficiency and reduce operational burden, making the method well suited for routine monitoring.

This approach expands the applicability of PFAS analysis to complex environmental samples such as agricultural runoff and particulate-rich waters. It is expected to support more accurate environmental assessment and facilitate broader implementation in monitoring and regulatory evaluation of PFAS contamination.

Acknowledgment

The authors gratefully acknowledge the contributions of all participating laboratories involved in the interlaboratory comparison study.

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Progress in PFAS Analysis

C. Carrer & J. Focant

D41-032 Interlaboratory study on semi volatile PFAS analysis in stationary sources emissions

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Introduction

Per- and polyfluoroalkyl substances (PFAS) constitute a family of several thousand molecules that have become a growing concern in recent years. These molecules are now found in all environmental compartments and are suspected of being carcinogenic or endocrine disruptors, making them a threat from both an environmental and a public health perspective. Recent regulatory developments concerning the monitoring of PFAS in atmospheric emissions have led Ineris to organize one of the first inter-laboratory comparison (ILC) on the 49 semi-volatile PFAS substances listed in the french standard XP X43-126 and in OTM-45 method. Ineris proposes this ILC, covering only the analytical part, to give laboratories the opportunity to comply with the requirement of the EN ISO/IEC 170253 standard to participate in an ILC. Outside this regulatory context, participation in ILCs is an essential tool for monitoring and controlling the implementation of analytical methods (comparability between laboratories, assessment of operator's skills, method evaluation, compliance with quality requirement, accreditation…).

Materials and Methods

This proficiency testing program consisted in the analysis of three fractions provided by the sampling train described in the XP X43-126 and in OTM-45: (i) a particulate fraction captured on a filter, (ii) a gaseous fraction sampled on a dedicated resin, (iii) a gaseous fraction absorbed in deionized water, each one provided with its associated rinsing solution consisting of 5% ammonia in methanol. Participants were informed that the spiking level of each fraction was between 5 and 100 ng per fraction and were provided with duplicates of each testing material. Homogeneity and stability were monitored to ensure the validity of the proficiency test for all three fractions. Testing materials were sent to the 11 participants mid-October and participants were asked to submit their results within 6 weeks of reception.
Statistical processing of the results was carried out in accordance with the requirements of ISO 5725 series "Accuracy (Trueness and Precision) of measurement methods and results" and ISO 13528 "Statistical Methods for Use in Proficiency Testing by Interlaboratory Comparisons". The assigned values were based on the consensus of the results of the entire population participating in the test and calculated using robust statistical methods.

Results

Results show globally low dispersion between participants, both in terms of analyzed compounds and fractions though tendencies regarding some difficulties could be observed in some cases. Indeed, 8:2 FTCA and 10:2 FTCA systematically showed a standard deviation greater than 30% in all three fractions and 6:2 FTCA displayed standard deviations greater than 50% in all fractions. Participants also show some difficulties analyzing sulfonamides, though less obvious than x:2 FTCA. Those results are in accordance with current analytical knowledge as sulfonamides and FTCA have become more recently of interest and do not benefit from previous experiences in other types of matrices. In terms of fractions, the gaseous phase absorbed in deionized water showed 13 compounds with standard deviations greater than 50% (mainly x:2 FTCA, sulfonamides, long-chain PFCA). This observation could seem surprising as the matrix is mainly composed of water, which is one of the first matrix in which PFAS analysis were developed. However, the dispersion of the results in this fraction could be linked to the preparation step which differed between participants, especially in the sampling size (whole sample versus subsampling) and the corresponding subsampling process (homogenization, botlle rinsing, proportionality of the rinsing solution…).

Discussion and Conclusion

Overall, the results of this ILC based on standard method will make it possible for the laboratories to identify their weakness and take actions and improve their process. The study also shows that, despite the publication of standard methods, some difficulties are still to be overcome.

Progress in PFAS Analysis

C. Carrer & J. Focant

D41-537 Sodium-bound PFAS dimers as diagnostic features for improved confidence in non-targeted LC-IMS-MS identification

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are contaminants of emerging concern, with more than 7 million compounds currently listed according to the OECD definition. Non-targeted screening approaches are necessary for the identification of emerging PFAS. In this context, ion mobility spectrometry coupled with liquid chromatography-high resolution mass spectrometry (LC-IMS-HRMS) provides an additional dimension of separation based on ion gas-phase bulk density. The collision cross-section (CCS) values derived from IMS measurements can be used as molecular descriptors to improve confidence in PFAS annotation.
However, some PFAS remain difficult to identify because deprotonated ions ([M-H]-) may undergo in-source fragmentation or produce ambiguous CCS values due to the formation of aggregates or adducts1. Previous work has shown that proton-bound dimers can provide reliable CCS values2, but their formation depends on analyte concentration and pH3. To overcome these limitations, post-column dilution using sodium was investigated as a strategy to promote formation of more resilient sodium-bound PFAS dimers under LC(-IMS)-MS conditions.

Materials and Methods

To first assess the reliability of sodium-bound dimers ([2M-2H+Na]-), perfluorocarboxylic acid (PFCA) standards with different chain lengths were mixed with sodium-containing solutions and analyzed by direct injection using an electrospray source in negative ionization mode. Experimental CCS values were determined from three different IMS platforms: drift-tube IMS (DTIMS), trapped IMS (TIMS), and traveling wave IMS (TWIMS).
A proof-of-concept study was also conducted using the EPA 1633 PFAS mixture to evaluate sodium-induced dimer formation under LC(-IMS)-HRMS conditions, by adding sodium via a post-column dilution strategy before the electrospray source. Energy-resolved MS/MS experiments were also performed to investigate fragmentation pathways.

Results

Sodium-bound dimers were consistently observed across all three instruments, with CCS values agreeing within 2%, confirming their reliability as analytical descriptors.
Application to the EPA 1633 PFAS mixture demonstrated that sodium-induced dimer formation enabled both CCS determination and the identification of specific fragmentation pathway, thereby allowing carboxylic PFAS to be distinguished from sulfonic PFAS. Sodium doping increased the number of detected sodium-bound dimers, although some dimers were also detected without sodium addition, likely due to background sodium contamination. Sodium-bound dimers proved especially useful for PFAS that are unstable upon ionization or when monomeric ions were difficult to identify, particularly for short-chain carboxylated PFAS (Figure 1a).
Energy-resolved MS/MS experiments revealed class-dependent fragmentation channels, reinforcing the identification confidence. PFAS containing a carboxyl function generated characteristic sodium fluoride adducts ([M-H+Na+F]-) (Figure 1b), whereas those containing a sulfonic acid moiety predominantly formed deprotonated ions ([M-H]-).

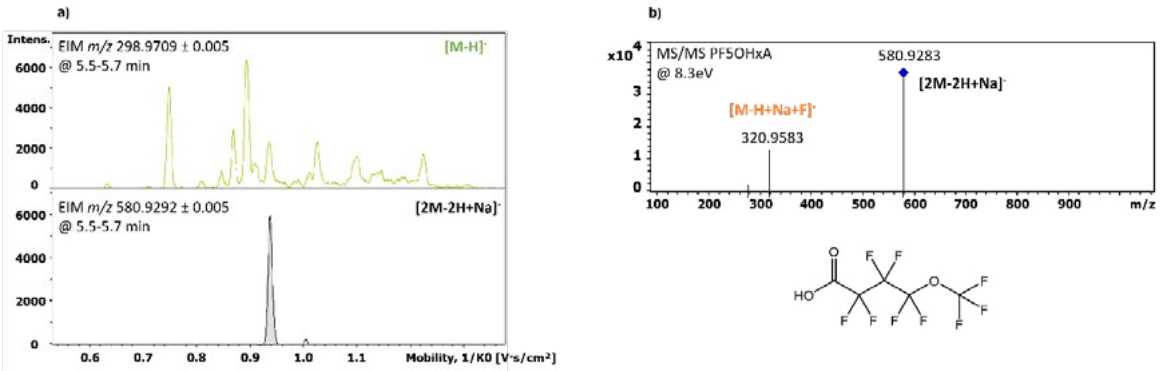


Figure 1: a) Extracted ion mobilograms (EIMs) of PF5OHxA ions (100 pg column injection with post-column dilution of sodium), whose structure is shown in the figure: $[M-H]^-$ (green trace) and $[2M-2H+Na]^-$ (black trace). b) MS/MS spectra of the $[2M-2H+Na]^-$ ion.

Progress in PFAS Analysis

C. Carrer & J. Focant

D41-537 Sodium-bound PFAS dimers as diagnostic features for improved confidence in non-targeted LC-IMS-MS identification

Discussion and Conclusion

Our results demonstrate that sodium-bound PFAS dimers provide additional analytical descriptors that may increase the confidence level in PFAS identification by LC-IMS-HRMS. Compared to proton-bound dimers, sodium-bound dimers may be readily observed due to the chemical background of sodium or easily produced through post-column dilution with a volatile buffer containing sodium, making them potentially more suitable for routine protocols.

The combination of consistent CCS values and class-specific fragmentation channels provides complementary criteria for distinguishing PFAS subclasses, especially for monomeric ions that undergo in-source fragmentation. Future work will evaluate this dimer-based strategy on real samples, including environmental samples and tissues collected from an orca that stranded on the Belgian coast in 2023.

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Progress in PFAS Analysis

C. Carrer & J. Focant

D41-577 Expanding PFAS Screening in Food Matrices using a Non Targeted Liquid Chromatography-Trapped Ion Mobility Spectrometry-High Resolution Mass Spectrometry Workflow

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are a highly diverse class of persistent anthropogenic contaminants of growing concern due to their widespread industrial use, environmental persistence, and potential adverse health effects. Consequently, PFAS have become an important focus of food safety and environmental monitoring. Routine monitoring strategies mainly rely on targeted liquid chromatography-mass spectrometry (LC-MS) methods focusing on a limited number of regulated and well-characterized compounds. Although these approaches provide robust quantification, they may overlook emerging, transformation, or previously unreported PFAS potentially present in complex food matrices. Therefore, non-targeted and suspect screening workflows based on high-resolution mass spectrometry are attracting growing interest to improve PFAS characterization and extend analytical coverage.

Materials and Methods

Food extracts previously analysed at Sciensano using a targeted LC-MS workflow were re-investigated using a non-target LC-TIMS-HRMS approach. Analyses were performed in PASEF mode on timsTOF Pro 2 and timsTOF fleX instruments (Bruker). Accurate mass measurements, isotopic profiles, retention times, MS/MS fragmentation patterns, and collision cross section (CCS) values were combined to support compound annotation. Kendrick mass defect analysis was applied to visualize homologous fluorinated series and facilitate PFAS-related feature detection.

Results

Preliminary results revealed several PFAS-related signals beyond those identified by targeted analysis. Kendrick mass defect analysis enabled the visualization of multiple homologous series consistent with fluorinated chemistries and facilitated the detection of recurring mass patterns characteristic of PFAS subclasses. Signals consistent with longer-chain perfluorocarboxylic acids (PFCAs) and perfluorosulfonic acids (PFSAs) were observed in mammal meat samples. Additional homologous series showed patterns compatible with hydrogen-substituted PFCAs and perfluorodicarboxylic acid compounds based on accurate mass measurements, chromatographic behaviour, ion mobility data, and characteristic fragmentation pathways.

A homologous series tentatively assigned to perfluorodicarboxylic acids ranging from perfluoroundecanedioic acid to perfluorononadecanedioic acid was detected. The proposed annotations were supported by accurate mass errors typically below 5 ppm for most detected features, characteristic neutral losses ([M-CO2-CO2HF]-), retention time trends, CCS agreement with published reference values ($\Delta CCS \leq 0.7\%$), which together strengthened annotation confidence and facilitated the differentiation of structurally related compounds within complex datasets.

Discussion and Conclusion

These observations highlight the complementarity of ion mobility spectrometry and high-resolution mass spectrometry for PFAS screening in food analysis. The tentative identification of long-chain perfluorodicarboxylic acids and hydrogen-substituted PFCAs illustrates the ability of non-target LC-TIMS-HRMS operated in PASEF mode to characterize PFAS-related compounds beyond conventional targeted workflows. Although further confirmation using analytical standards remains necessary, this preliminary work demonstrates the added value of ion mobility-enabled HRMS for investigating emerging fluorinated contaminants in complex food matrices.

Acknowledgment

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Environmental and Human Exposure to Consumer Products 2

V. Esposito & I. İmamoğlu

D43-628 A transparent hazard–exposure prioritization framework for plastic-related chemicals

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Introduction

The growing chemical complexity of plastic pollution presents a major challenge for environmental monitoring and risk assessment. Current chemical inventories are largely static and limited by severe regulatory data gaps, leaving the hazard profiles of thousands of substances unassessed. Furthermore, these inventories frequently lack multidimensional exposure metrics and dynamic analytical feedback loops. To advance beyond static lists, there is a critical need for an integrated, auditable approach that prioritizes chemicals for monitoring and suspect screening based on combined hazard and exposure evidence.

Materials and Methods

We developed an integrated prioritization workbench to systematically evaluate plastic-related chemicals. First, a recompilation layer was engineered to harmonize record-level information from 14 public databases into a unified, structure-resolved chemical infrastructure using standardized identifiers. Intrinsic hazard was assessed using a semi-quantitative PMBT (Persistence, Mobility, Bioaccumulation, Toxicity) scoring system. This system employs a "curated-database-first, QSAR-fallback" strategy, utilizing validated computational toxicology models to bridge empirical data gaps without overriding curated evidence. In parallel, we constructed a multi-proxy exposure framework that integrates production volumes, patent counts, literature frequencies, food contact migration, and human biomonitoring evidence. Hazard and exposure scores were combined into an overall priority ranking, and the framework was deployed as a public-facing interactive dashboard featuring an upload-driven suspect-matching workflow.

Results

Identity resolution successfully aggregated 92,371 database records into 16,328 unique standardized compounds while preserving source-level provenance for evidence auditing. The integrated framework stratified these chemicals, classifying 8,634 as low priority, 5,486 as moderate priority, and identifying a focused subset of 649 high-priority candidates. The underlying evidence profiles revealed substantial data gaps; although toxicity and mobility had broader coverage, persistence and bioaccumulation lacked evidence for over 12,600 compounds. Notably, regulatory context analysis showed that 391 of the 649 high-priority compounds remain outside existing global or regional regulatory coverage. The interactive dashboard's implementation enabled external suspect lists to be exactly matched to the prioritized inventory, allowing analytical chemists to instantly contextualize their targets.

Discussion and Conclusion

This study transitions plastic chemical inventories from opaque, static lists into a fully transparent, evidence-linked prioritization infrastructure. By retaining the provenance of each hazard and exposure score, the framework functions as an auditable decision-support tool. It highlights substantial mismatches between empirical evidence of concern and current regulatory frameworks. While not a replacement for quantitative risk assessment, this workbench establishes a new methodological baseline to identify chemicals of concern, contextualize non-target screening results, and guide dynamic environmental monitoring efforts for complex plastic mixtures.

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Advances in (Bio)remediation of POPs

S. Lomnicki & C. Carrer

D42-080 Integrating aeration soil washing and with plasma technologies for PFAS and precursor remediation in soil

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Introduction
Poly and perfluoroalkyl substances (PFAS) are raising significant environmental concerns due to their widespread occurrence and adverse effects. Their extensive use has resulted in considerable soil and groundwater contamination. Notably, PFAS precursors contribute to this problem, as they act as long term sources of 'hidden' PFAS and are often found at higher concentrations than the terminal PFAS themselves. Therefore, developing effective remediation strategies capable of simultaneously removing PFAS and their precursors is essential for achieving sustainable PFAS management.

Materials and Methods
Our study integrates aerated soil washing to remove PFAS and their precursors from soil by concentrating them into foam, followed by degradation using plasma technology. Laboratory scale tests at Lulea University of Technology, Sweden, were conducted to evaluate how surfactant type (anionic, cationic, and zwitterionic), solution pH, particle size, and liquid to soil ratio influence the transfer of PFAS and their precursors from soil into foam. Plasma based experiments are being carried out at the University of Padua, Italy, to assess how initial PFAS and precursor concentrations, aerating gas type, persulfate level, and the acid–base properties of the contaminated solution affect the degradation process.

Results
Preliminarily indicated that anionic surfactants had the highest ability to enhance the removal of regular PFAS from soil and to efficiently transfer them into the foam. Up to 90% removal was observed for PFOS, PFOA, PFHpS, and PFHxS initially present in the contaminated soil. In contrast, cationic and zwitterionic surfactants showed a higher capability to remove PFAS precursors, including 6:2 FTAB, N AP FHxSA, and N AP FOSA, into the foamate. Neutral and alkaline pH conditions provided the best performance for contaminant removal. Cationic and zwitterionic surfactants removed short chain PFAS from soil less effectively than anionic surfactants, but they efficiently extracted these compounds from the washing solution and transferred them into the foam. PFBS, PFPeA and PFHxA were no longer detected in the washing solution after aerated soil washing with either cationic or anionic surfactants. Overall, the findings support a sequential surfactant based approach to achieve effective removal of all PFAS categories from soil and their efficient concentration into foam. Applying atmospheric radial plasma effectively degraded the precursors, achieving more than 95% degradation within 10 minutes. Long chain PFAS, including PFOA and PFOS, were also efficiently degraded, with up to 99% removal in five minutes. Ongoing research is optimizing the treatment process to improve the removal of PFAS and precursors while avoiding the formation of degradation by products.

Discussion and Conclusion
Overall, the experience from this study demonstrates that combining surfactant enhanced aerated soil washing with plasma holds strong potential as an integrated remediation strategy capable of effectively removing and degrading both PFAS and their precursors from contaminated soil.

Acknowledgment
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Advances in (Bio)remediation of POPs

S. Lomnicki & C. Carrer

D42-096 Mechanistic insights into sorption and electrosorption of PFAS using functionalized carbon nanotubes

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Introduction

Short-chain per- and polyfluoroalkyl substances (PFAS), particularly perfluoroalkyl carboxylic acids, remain among the most difficult PFAS to remove from drinking-water sources because of their high mobility, low hydrophobicity, and sensitivity to water chemistry (Tshangana et al. 2025). As PFAS regulations increasingly target broader compound groups and ng/L-level concentrations (U.S. EPA 2024, Drinking Water Directive (EU) 2020/2184), remediation materials must be evaluated not only by removal efficiency, but also by their performance in complex water matrices. This study examined whether functionalized carbon nanotubes (CNTs), combined with applied electrical potential, can enhance short-chain PFAS uptake while revealing the interfacial mechanisms that govern adsorption and electrosorption.

Materials and Methods

Perfluorooctanoic acid (PFOA, C8) and perfluorobutanoic acid (PFBA, C4) were used as representative long- and short-chain PFAS. Pristine, aminated, and fluorinated multi-walled CNTs were evaluated as conductive adsorbents. Adsorption and electrosorption performance were further tested in variant environmental conditions, including contaminated real groundwater. Cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and Randles–Ševčík analysis were used to explore PFAS–CNT interfacial behavior.

Results

CNT–NH_2 showed the highest adsorption performance under controlled conditions, increasing PFOA and PFBA uptake by 11-fold and 92-fold, respectively, relative to pristine CNTs. However, PFBA adsorption decreased by 62-fold with increasing salt concentration, whereas PFOA was less affected. Applied potential further increased uptake, with CNT–NH_2 again performing best and PFBA uptake increasing up to 4-fold relative to open-circuit conditions. Nevertheless, PFBA removal plateaued beyond the optimum potential (750 mV). In contaminated groundwater, long-chain and sulfonated PFAS were removed more efficiently, whereas short-chain carboxylates remained treatment-limited, and applying potential further decreased PFBA uptake. Fluorinated CNT provided the most stable PFAS performance across experimental conditions. Electrochemical analysis revealed mechanistic differences that were not apparent from removal data alone. PFOA caused stronger suppression of electrochemical activity, higher charge-transfer resistance, and larger Warburg contributions than PFBA. Interfacial blocking was also governed by anion identity, following SO_4^{2-}> NO_3^- > Cl^-.

Discussion and Conclusion

The results show that fluorophilic interactions promote selective interactions for PFAS, whereas electrostatic interactions are critical for improving short-chain PFAS capture but also increase sensitivity to matrix composition. The electrostatic forcing alone cannot overcome competition from ions and co-contaminants. Therefore, short-chain PFAS remediation cannot be optimized using synthetic laboratory matrices, and requires hybrid or multifunctional materials that combine electrostatic attraction, fluorophilic selectivity, and resistance to matrix interference. Combined CV and EIS analysis provided molecular-level evidence that PFAS chain length, CNT functionalization, and electrolyte identity jointly control interfacial layer formation during adsorption and electrosorption. These interfacial structures highlight the central role of water chemistry in electrically assisted PFAS capture. Overall, this work provides a mechanistic framework for designing electrically responsive adsorptive systems for PFAS remediation in complex drinking-water sources.

Acknowledgment

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Advances in (Bio)remediation of POPs

S. Lomnicki & C. Carrer

D42-096 Mechanistic insights into sorption and electrosorption of PFAS using functionalized carbon nanotubes

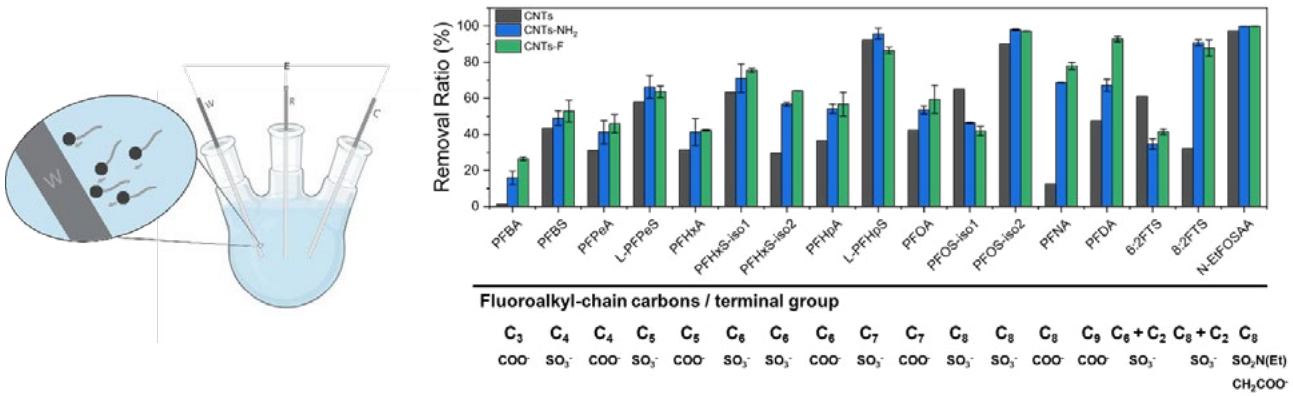


Figure 1. (a) Illustration of the experimental setup; (b) Electrosorption of various PFAS from real groundwater, using CNT-coated electrodes (pristine, -NH2, -F), under externally applied potential of 750 mV. The experiments were conducted for 48 hr at pH 7.5 ± 0.5 and 25 °C (n = 2).

Advances in (Bio)remediation of POPs

S. Lomnicki & C. Carrer

D42-106 High-performance adsorbents for rapid PFAS removal in aqueous systems: Sustainable synthesis of MCM-41 silica from rice husks

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Introduction

The global challenge of PFAS pollution, often referred to as "forever chemicals" due to their environmental persistence and associated health risks, requires the development of advanced water treatment technologies [1]. Current methods, such as granular activated carbon (GAC), are limited by slow adsorption kinetics and low efficiency in removing short-chain molecules [2].

Materials and Methods

To address this problem, it is necessary to develop next-generation materials that can rapidly remove various PFAS. In this work, rice husks, an abundant agricultural waste, were used as a sustainable source of biogenic silica for the synthesis of mesoporous silica MCM-41 [3]. Through a process called pseudomorphic transformation, the material retains the original "egg-box" morphology of the rice husk, resulting in large particles (50–250 µm) with optimal porosity that enables rapid mass transfer kinetics. Unlike conventional adsorbents, these materials are used in their "as-synthesized" form (as-MCM-41), where the surfactant phase remains confined within the pores, serving as a supported solvent. This enables a dual capture mechanism: electrostatic interactions with the surfactant head groups and C-H…F-C interactions with the alkyl tails.

Results

In tests using a complex mixture of 25 different PFASs, these adsorbents achieved 90% removal in just 15 minutes, significantly outperforming commercial GACs, which removed only 45% in the same time frame. Furthermore, targeted functionalization of MCM-41 allows modulation of both selectivity and adsorption kinetics, for example by enhancing the uptake rate of short-chain PFAS. The adsorption performance of these materials was further evaluated using natural water matrices.

Discussion and Conclusion

The results demonstrate that the efficiency of the base as-MCM-41 material is not adversely affected by the presence of competing anions such as bicarbonates or sulfates, confirming its robustness and suitability for real-world water treatment applications.

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Advances in (Bio)remediation of POPs

S. Lomnicki & C. Carrer

D42-063 Thermal destruction behavior of PFOA, PFOS, and PFNA in a commercial-scale melting separation plant

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Introduction

Per- and polyfluoroalkyl substances (PFAS) have been widely used in various industrial and commercial applications; however, growing concerns about their persistence, bioaccumulation, and toxicity have led to their regulation as persistent organic pollutants (POPs) under the Stockholm Convention. At the last conference, we reported that perfluorononanoic acid (PFNA) could be effectively destroyed in a commercial-scale melting separation plant. In the present study, we conducted destruction tests to examine whether the same process can destroy other regulated PFAS such as perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). In the test, solid, water, and gas samples were collected and analyzed using US EPA and Japanese methods to determine destruction efficiencies (DEs). Furthermore, the presence or absence of products of incomplete combustion (PICs) in the flue gas was evaluated using US EPA OTM 50.

Materials and Methods

Destruction tests were conducted at a melting separation plant (5 t/day). Two experimental runs were performed. RUN 1 was a blank test, where no PFAS were added to the feed material. The base feed material used in the tests was a glass powder with a particle size of 1-2 mm, primarily composed of silica. RUN 2 was a PFAS spiked test, prepared by premixing PFOA, PFOS, and PFNA with the base material prior to feeding. In RUN 2, the nominal concentrations of the added PFAS in the feed material were 125 mg/kg for PFOA and PFNA, and 4.5 mg/kg for PFOS. The temperatures of melting furnace and secondary combustion chamber were maintained over 1,350 °C and 1,030 °C, respectively.
Solid residues, processing water, and flue gas samples were collected at multiple sampling points to evaluate PFAS destruction. PFAS in solid and water samples were analyzed using US EPA Method 1633 and the Japanese technical considerations for PFOS/PFOA-containing waste management (JPN-TC) issued by the Ministry of the Environment of Japan. PFAS in flue gas were measured using EPA OTM 45 and the JPN-TC to evaluate DEs based on mass balances between PFAS input and output streams. In addition, the presence or absence of PICs in the flue gas were evaluated by EPA OTM-50.

Results

DEs for three PFAS calculated from the measurement results by the EPA methods were > 99.9995% for PFOA, > 99.9962% for PFOS, and > 99.9995% for PFNA. Similarly, DEs calculated according to the JPN-TC were 99.9992% for PFOA, >99.9994% for PFOS, and 99.9994% for PFNA. The symbol ">" indicates that the DE was calculated using the limit of quantification (LOQ) for output concentrations below the LOQ. These DE values demonstrate that the melting separation technology can safely destroy regulated-PFAS and suggest that there might be consistency between the US EPA methods and the JPN-TC.
Furthermore, the results for flue gas analysis using OTM 50 exhibit that the concentration of all 30 volatile PFAS compounds considered as PICs was below the LOQ. The absence of detectable PICs in the flue gas indicates that the melting separation process effectively decomposes PFAS to a high degree without forming measurable incomplete combustion products, or mineralizes PFAS.

Discussion and Conclusion

This study demonstrated that high DEs were achieved for multiple PFAS compounds, including PFOA and PFOS, in a commercial-scale melting separation plant. The JPN-TC was comparable to the US EPA analytical methods in terms of DE determination. In addition, the application of OTM 50 confirmed that PICs were not detected in flue gas. These findings indicate that the melting separation technology is useful for the effective decomposition and mineralization of PFAS, including potential PICs.

Acknowledgment

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Advances in (Bio)remediation of POPs

S. Lomnicki & C. Carrer

D42-061 Lewis acid-base coordination unlocks photochemical defluorination of perfluorocarboxylic acids

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are widely distributed and persistent in environmental water resources, posing serious environmental and human health threats. Existing degradation methods often rely on high energy UV irradiation, strong reductants, elevated temperatures, or complex catalytic systems, and exhibit nonselective reactivity while generating recalcitrant short chain byproducts. Moreover, many of these approaches are ineffective for treating the concentrated PFAS eluates generated during sorbent regeneration, further limiting their practical applicability.

In this study, we introduce a photocatalytic strategy that exploits the intrinsic Lewis basicity of the PFAS headgroup to coordinate with metal based Lewis acids, forming reactive metal-PFAS complexes. This coordination enables selective activation of PFAS through ligand to metal charge transfer (LMCT), allowing efficient and complete photochemical defluorination under mild near UV to visible light irradiation.

Materials and Methods

PFAS photodegradation was performed in a customized reactor equipped with either 365nm or 405 nm LED light source. Reactions were conducted in 40.0 mL quartz tubes placed 5.0 cm from the LED lamp, with temperature maintained at 23 ± 1 °C using an integrated fan cooling system. In a standard procedure, 0.2 mmol of a cupric or ferric source was added to 10.0 mL of MeCN or MeOH containing 0.1 mmol of the target PFAS. For comparative experiments in aqueous media, PFAS concentration was set to 240 µmol/L to accommodate solubility limits. The reaction mixture was equilibrated under air, sealed with a perforated cap to allow gas exchange, and stirred at 500 rpm in the dark prior to irradiation.

Results

We found that the head carboxyl groups of perfluoroalkyl carboxylic acids can coordinate with redox active metal ions (Cu2+ and Fe3+), forming metal-PFAS complexes that exhibit unique photochemical reactivity. Upon photoexcitation, ligand to metal charge transfer (LMCT) induces electron transfer from the perfluoroalkyl ligand to the metal center, generating reduced metal species and perfluoroalkyl radicals. These radicals undergo decarboxylation followed by oxidative chain shortening, ultimately leading to complete defluorination. This pathway offers several advantages: (i) selective activation of coordinated PFAS rather than indiscriminate radical attack; (ii) mild reaction conditions enabled by near UV to visible light excitation; (iii) compatibility with simple, commercially available metal salts; and (iv) potential for complete mineralization through iterative transformations.

The strategy proved effective across a broad range of PFAS, with degradation rates inversely correlated with chain length. Short chain species such as trifluoroacetic acid achieved >99% degradation within 60 min in the Cu2+ system and 240 min in the Fe3+ system, while long chain perfluorooctanoic acid was fully defluorinated within 300 min in the Cu2+ system and 420 min in the Fe3+ system. Both systems also efficiently degraded perfluoroalkyl ether carboxylic acids.

Furthermore, the Cu- and Fe based homogeneous system operates effectively in PFAS rich regenerant solutions, directly enabling integrated capture and destroy workflows for concentrated PFAS streams. This demonstrates that the chemical principles uncovered here can be translated into practical treatment strategies while maintaining strong mechanistic foundations.

Discussion and Conclusion

This study establishes that Lewis acid-base coordination as a robust and generalizable strategy for activating PFAS toward photochemical degradation. Upon formation of metal-PFAS complexes, LMCT initiates decarboxylation and oxidative chain-shortening of PFAS, leading to complete defluorination under mild near-UV to visible light in both Cu2+ and Fe3+ systems. The unified mechanistic framework established here explains the broad reactivity across PFAS structures and underscores the tunability of metal based LMCT pathways. Furthermore, the successful integration of this chemistry with adsorption based enrichment offers a practical route for treating concentrated PFAS eluates, addressing a key bottleneck in current remediation workflows. Collectively, these findings position LMCT driven metal activation as a promising foundation for scalable PFAS destruction technologies and for the future development of selective, energy-efficient remediation strategies.

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Environmental and Human Exposure to Consumer Products 2

V. Esposito & I. İmamoğlu

D43-259 Vacuuming up exposure: can robotic vacuums reduce exposure to semi-volatile organic compounds in the home?

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Introduction

Homes are a primary microenvironment for human exposure to semi volatile organic compounds (SVOCs), including legacy persistent organic pollutants (POPs) and emerging contaminants released from building materials, furnishings, and consumer products. Indoor dust acts as a reservoir for many SVOCs and a key exposure pathway. Studies report positive associations between SVOC concentrations in indoor dust and biomarkers of exposure, including serum levels of polybrominated diphenyl ethers (PBDEs)1 and urinary metabolites of organophosphate ester flame retardants (OPFRs)2.

Despite the large amount of time spent at home, practical and accessible strategies to reduce exposure remain limited. Cleaning is commonly recommended because dust serves as a reservoir for pollutants, however, results of cleaning studies have been mixed because they typically rely on homeowners to change their behaviors. Robotic vacuuming offers a consistent and increasingly accessible cleaning approach that may overcome this barrier. This study evaluated the effectiveness of frequent robotic vacuuming as an exposure reduction strategy.

Materials and Methods

Participants from the ongoing Project HOPE 1000 cohort in Durham, NC (n=48; Feb 2023–July 2024) were recruited for a robotic vacuuming intervention. Participants wore silicone wristbands for 5 days before the intervention to measure baseline exposures, then ran a robotic vacuum for ≥15 minutes daily, ≥5 days a week for 8 weeks. After vacuuming, they wore a second wristband to assess post intervention exposures. Wristbands were analyzed using gas chromatography – high resolution mass spectrometry (GC-HRMS) for 119 POPs and emerging contaminants.

Results

Thirty five compounds were detected in >70% of wristbands, including 15 flame retardants (FRs), 9 phthalates, 5 polycyclic aromatic hydrocarbons (PAHs), 3 pesticides, 2 industrial alkylphenols and one fragrance compound. To assess participant's total exposure burden, an exposure score was calculated using the sum of all chemicals on a z-scale. Overall, the vacuuming intervention was effective at reducing exposure across the cohort (paired t-test $p<0.001$, Cohens $d=-0.47$). On an individual level, 58% of participants experienced a meaningful reduction in exposure burden, while 20% showed a slight increase.

Nineteen chemicals were significantly reduced following the intervention (Wilcoxon signed rank test, $p<0.05$) including 12 FRs, 3 phthalates, 2 PAHs and 2 pesticides. The greatest reductions were observed for OPFRs including Triphenyl phosphate (51.8% reduction), Tris(2-butoxyethyl) phosphate (35.1% reduction) and Tri-iso-butyl phosphate (32.6% reduction). Brominated FRs were also significantly reduced, including 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (29.4% reduction) and Bis(2-ethyl hexyl)-2,3,4,5-tetrabromophthalate (26.5% reduction).

Predictors and modifiers of the intervention's effectiveness were also assessed. Behavioral and housing characteristics such as vacuuming frequency and floor type were not associated with the magnitude of change in chemical exposures. In contrast, physicochemical properties were strong predictors of effectiveness, with the largest reductions in exposure burden for chemicals with greater octanol-air partitioning coefficients (Koa) (Spearman's rank correlation $\rho=0.74$, $p < 0.001$).

Discussion and Conclusion

Frequent vacuuming with a robotic vacuum can be an effective way to reduce exposure to SVOCs, particularly those with high Koa values that are more likely to be sorbed to dust. By minimizing reliance on sustained behavioral changes, this study isolates the effect of vacuuming on exposure reductions in the home environment.

Acknowledgment

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Environmental and Human Exposure to Consumer Products 2

V. Esposito & I. İmamoğlu

D43-260 Screening of transformation products from legacy and emerging plasticizers during simulated gastrointestinal digestion

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Introduction

Plastic contamination has emerged as a major public health concern arising from multiple exposure pathways, including dietary intake. Previous studies have reported that ingestion of microplastics (MPs) may interact with the gastrointestinal tract and alter the human colonic microbiota [1]. However, there is a lack of studies focusing on chemical additives associated with plastics, which are potentially responsible for greater toxic effects. These additives can migrate into packaged foods, which may also become contaminated across the food chain, together contributing to potentially relevant dietary exposure and associated health concerns [2]. Moreover, plastic additives may be metabolized into transformation products (TPs) in the gut. Nonetheless, studies assessing plasticizers under simulated human digestion conditions remain scarce, limiting current knowledge of their fate and transformation pathways. The main goal of this study was to identify different TPs from legacy and emerging plasticizers at different stages of the gastrointestinal tract.

Materials and Methods

The legacy plasticizer di-(2-ethylhexyl) phthalate (DEHP) and the emerging alternatives acetyl tributyl citrate (ATBC) and 2-ethylhexyl diphenyl phosphate (EHDPP) were selected at concentrations similar to those previously reported in foodstuffs [2] to assess their behavior during in vitro digestion, according to INFOGEST methodology [3] and static batch fermentations using microbiota from healthy donors. For each plasticizer, duplicate experiments were conducted simulating the complete transit, including the oral, gastric, small intestine and colonic phases. Samples were diluted and injected in a liquid chromatography coupled to high resolution mass spectrometry (LC-HRMS) system equipped with a turbulent flow chromatography (TFC) module, which enabled on-line purification. Non-target analysis was employed as a screening approach to elucidate potential TPs.

Results

After gastrointestinal digestion, plasticizer levels exhibited a significant decrease, reaching values below 3 µM, which represents less than 5% of the initial concentration. Additionally, acetyl dibutyl citrate (ADBC) and dibutyl citrate (DBC) were identified as TPs of ATBC, while mono-2-ethylhexyl phthalate (MEHP) was identified as a metabolite of DEHP. For EHDPP, diphenyl phosphate (DPHP) and triphenyl phosphate (TPHP) were detected as the most abundant compounds (Table 1).

Table 1: Measured concentrations of plasticizers after gastrointestinal digestions and tentatively identified compounds.

Plasticizer	Initial concentration (µM)	Measured concentration (µM)	Tentatively identified compounds
ATBC	600	0.44	ADBC ($C_{16}H_{26}O_8$) DBC ($C_{14}H_{24}O_7$)
DEHP	60	2.85	MEHP ($C_{16}H_{22}O_4$)
EHDPP	60	1.97	DPHP ($C_{12}H_{11}O_4P$) TPHP ($C_{18}H_{15}O_4P$)

Discussion and Conclusion

Simulated digestion experiments revealed a substantial decrease in plasticizer concentrations immediately after the gastrointestinal digestion, indicating that the characteristic pH transitions along the gastrointestinal tract are sufficient to promote TPs generation. In addition, these findings provide insight into the behavior of different plasticizers along the human gastrointestinal tract, and thereby enhancing the understanding of their biotransformation mechanisms. Although legacy plasticizers are well-known as endocrine disruptors, long-term exposure effects caused by emerging compounds such as ATBC and EHDPP are currently under scrutiny. Hence, these results contribute to a better understanding of additive adsorption and fate within the digestive system.

Environmental and Human Exposure to Consumer Products 2

V. Esposito & I. İmamoğlu

D43-260 Screening of transformation products from legacy and emerging plasticizers during simulated gastrointestinal digestion

Acknowledgment

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Environmental and Human Exposure to Consumer Products 2

V. Esposito & I. İmamoğlu

D43-587 Behavior of Bisphenol A in Anaerobic Sludge Digestors and Its Influence on Methane Production

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Introduction
Bisphenol A (BPA), monomer in polycarbonate and epoxy resin production, is a widespread environmental contaminant with pronounced endocrine disrupting potential. Due to its lipophilic and hydrophobic nature, BPA heavily partitions onto organic matrices during wastewater treatment, resulting in elevated concentrations in sewage sludge (Hardegen et al., 2021). Although anaerobic digestion (AD) effectively stabilizes sludge while generating renewable biogas, the accumulation of such persistent pollutants poses critical operational challenges. High concentrations of BPA can negatively impact anaerobic metabolic pathways, causing process instability and decreased methane production. Therefore, this study aims to evaluate the concentration dependent impacts of varying BPA doses on biochemical methane potential (BMP) and methanogenic kinetics.

Materials and Methods
BMP reactors were operated for 60 days with food-to-microorganism ratio of 1 g VS of substrate/g VSS of inoculum and 2% total solids. The reactors were spiked with 5 BPA concentrations (2, 7, 15, 20, 25 mg/L) dissolved in methanol. Methanol controls (MEC) and seed control reactors were also established. Quantification of BPA was performed using gas chromatography coupled with mass spectrometry (GC-MS) following solids phase extraction (SPE).

Results
Initial analysis within 24 hours after spike indicated that an average of 86.3% of BPA sorbed onto the sludge, leaving a bioavailable aqueous fraction in the range of 349.4–4346.9 µg/L. Relative to these post-sorption concentrations measured at 24 hours, an additional 43.7% reduction was observed by day 60, with a mechanism governed by sorption (Figure 1a). In terms of process performance, intermediate BPA doses exhibited a statistically significant (about 21%) increase in net methane yield compared to the control, lowest, and highest dose groups (Figure 1b). Corroborating these experimental profiles, first-order kinetic modelling showed that the ultimate methane yields for intermediate doses exceeded those of the controls, while the highest BPA concentration decreased the overall methane production potential. These findings demonstrate that while moderate BPA concentrations can stimulate methanogenic activity, higher doses may have inhibitory effects on the anaerobic community.

Discussion and Conclusion
The increase in methane production is attributed to the capacity of moderate BPA doses to mitigate oxidative stress, thereby enhancing key enzymatic activities and overall methane production (Chen et al., 2023). These findings demonstrate that while moderate BPA concentrations can stimulate methanogenic activity, higher doses may have inhibitory effects on the anaerobic community. In conclusion, the evaluation of BPA in BMP assays revealed a clear impact on AD performance. BPA associates with the solid sludge matrix through rapid initial sorption. While moderate concentrations of BPA can potentially stimulate methanogenic activity, elevated exposure groups indicate possible inhibitory effects. These findings are crucial for predicting the behavior of endocrine disrupting compounds in AD and optimizing sludge management strategies.

Acknowledgment
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Environmental and Human Exposure to Consumer Products 2

V. Esposito & I. İmamoğlu

D43-378 Assessment of Polychlorinated Alkanes in Dust from E-waste Impacted Area in Thailand

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Introduction
Polychlorinated alkanes (PCAs), persistent organic pollutants from industrial applications (e.g., lubricants, heat transfer fluids), are emerging contaminants in e-waste regions. Thailand, a major informal e-waste processor, faces severe contamination due to poor recycling practices, releasing PCAs into soil, water, and air. Settled dust provides critical insights into localized pollution, reflecting both historical contamination and ongoing dispersion pathways. This study investigates seasonal PCA levels in settled dust across three seasons (summer, rainy, cool) to assess variability in deposition, transport, and re-suspension. By identifying contamination sources (e.g., e-waste dismantling, open burning) and spatial distribution, it supports risk assessment and mitigation strategies to address public health and ecological threats in vulnerable communities.

Materials and Methods
Settled dust samples were collected from indoor and outdoor in household environments in Kalasin, Northern Thailand, during three distinct seasons (summer, rainy, and cool) over a one-year period. Sampling sites were selected based on proximity to an e-waste disposal facility located within a 2 km radius of residential areas, ensuring direct spatial relevance to potential contamination sources. Indoor samples were collected from living rooms and bedrooms and mixed, while outdoor samples were gathered from open areas adjacent to households. Samples were then transported to the Toxicological Centre of the University of Antwerp. Samples were processed following a validated method [1]. PCAs (C8–36) were targeted in this UPLC-Q-TOF based instrumental analysis, and the peak identification was conducted using CP-Seeker 2.1.6[2].

Results
∑PCA measurements in settled dust demonstrated distinct seasonal patterns, with the highest levels observed during the rainy season across all categories. For ∑PCAs-C10-13, outdoor concentrations were marginally higher in the rainy season compared to cool season ($p = 0.063$) but showed no significant difference from summer ($p = 0.723$). However, indoor ∑PCAs-C10-13 concentrations during the rainy season (58.7 µg/g) were significantly elevated compared to both outdoor levels (5.95 µg/g) and other seasons. The ∑PCAs-C14-17 category showed similar trends, with rainy-season concentrations both indoors (95.7 µg/g) and outdoors (3.96 µg/g) exceeding other seasons. Statistical analyses indicated significant seasonal variations ($p < 0.05$) for most PCA categories, with rainwater-mediated deposition and enhanced indoor accumulation processes likely contributing to the observed patterns. These findings suggest that the rainy season poses the greatest exposure risk for PCA contaminants in residential environments. Congener patterns of the PCAs in dust exhibited distinct seasonal trends (Figure 1). Outdoors, PCAs-C14-17 consistently dominated across all seasons, while indoors, PCAs-C14-17 prevalence persisted during cool and summer months. Notably, indoor summer samples mirrored outdoor cool - season profiles, suggesting limited ventilation or human - mediated PCAs-C14-17 retention indoors. Indoors, this pattern persists during the cool and summer seasons, indicating stable retention of PCAs-C14-17 within indoor environments despite seasonal changes. This shift suggests enhanced environmental release or transport of longer - chain CPs under warmer and humid conditions. These patterns imply seasonal variability in PCA exposure, considering human activities were one of the major impact factors for PCA contamination indoors.

Discussion and Conclusion
This study highlights seasonal variations in PCA contamination in Kalasin, Thailand, with elevated levels during the rainy season, particularly indoors, posing significant public health risks. Seasonal shifts in PCA congener profiles suggest environmental release mechanisms influenced by weather and human activities. Future modeling efforts, informed by these data, could employ simple diffusion models to simulate PCA dispersion from identified sources and predict spatial contamination patterns, enhancing risk prioritization and mitigation planning in similar e-waste-impacted regions.

Acknowledgment
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Nano-Plastics: Sources, Transport and Environmental Fate

F. Corami & S. Lievens

D44-255 From Roads to Lagoon — Tire Wear Particle Transfer Across the Venice Lagoon Drainage Network

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Introduction
Tire-wear and road particles (TWRPs) are recognized as microplastics (MPs); they are considered a dominant source of MPs in the environment, being a road-derived contributor to urban microlitter and a potential source of polymeric and rubber-associated debris delivered to freshwater and coastal waters. In this study, the spatial distribution and seasonal variability of TWRPs in water samples across the Venice Lagoon and the rivers within its drainage basin were assessed.

Materials and Methods
Four sampling campaigns were performed at 24 sites (12 in the 3 hydrological bodies of the Venice Lagoon and 12 in the drainage basin) to capture contrasting hydrometeorological conditions from spring through winter. Samples were pretreated in a plastic-free clean room ISO 7. The QA/QC protocol was rigorous to detect potential contamination at each step; reagent blanks and procedural blanks were analyzed as samples. Oleo-extraction enabled the simultaneous extraction of MPS, TWRPs, plastic additives, and other microlitter components (MLCs). Oleo-extraction was followed by purification and filtration. Chemical characterization of TWRPs and of MLCs, in particular of additives related to tires, was performed via Micro-FTIR spectroscopy. Thanks to the Particles Analysis, a simultaneous quantification (via microscopic counting) was performed

Results
A dedicated reference library for TRWPs was implemented using a multi-technical approach (FTIR-ATR, Micro-FTIR, Pyr/GC-MS, and SEM-EDX). Across the network, TWRPs were consistently detected, indicating effective transfer along land-to-water pathways linking road runoff, tributary transport, and lagoon receiving waters. Clear seasonal trends were observed, with the highest TWRP occurrence in late summer, following a prolonged dry period and heavy rain events, highlighting the crucial role of wet deposition as a scavenger. It should be noted the presence of CCP accelerator, often employed together with another tire additive 6PPD, which has been added to the watch list as an indicator of the presence of tires in the environment.

Discussion and Conclusion
Overall, our results highlight season-dependent delivery mechanisms for TWPs to the Venice Lagoon system and support the need for mitigation strategies that account for both chronic accumulation and event-driven transport across the drainage basin.

Acknowledgment
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The authors also thank Elga Lab Water, High Wycombe, UK, for the pure water system used in this study.

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Nano-Plastics: Sources, Transport and Environmental Fate

F. Corami & S. Lievens

D44-445 PVC-plastic as a vector to bring chlorinated paraffins into the atmosphere

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Introduction

Atmospheric transport plays a key role in controlling the environmental fate and long-range transport of semivolatile organic contaminants. However, the influence of airborne micro- and nano-plastics (MNPs) on the atmospheric behavior of plastic additives remains poorly understood. Chlorinated paraffins (CPs), which are widely used as additives in polyvinyl chloride (PVC) products, are representative semivolatile contaminants with strong persistence and partitioning potential. In this study, we investigated the interactions between airborne MNPs and CPs in urban PM2.5 to evaluate whether plastics may act as overlooked particulate reservoirs that alter atmospheric partitioning, transport, and persistence of semivolatile contaminants.Atmospheric transport plays a key role in controlling the environmental fate and long-range transport of semivolatile organic contaminants. However, the influence of airborne micro- and nano-plastics (MNPs) on the atmospheric behavior of plastic additives remains poorly understood. Chlorinated paraffins (CPs), which are widely used as additives in polyvinyl chloride (PVC) products, are representative semivolatile contaminants with strong persistence and partitioning potential. In this study, we investigated the interactions between airborne MNPs and CPs in urban PM2.5 to evaluate whether plastics may act as overlooked particulate reservoirs that alter atmospheric partitioning, transport, and persistence of semivolatile contaminants.

Materials and Methods

PM2.5 samples were collected from five representative megacities in China during winter and summer campaigns using high-volume active air samplers. Micro- and nano-plastics were quantified by pyrolysis–gas chromatography–mass spectrometry (Py–GC/MS), while gaseous and particulate chlorinated paraffins were analyzed using comprehensive two-dimensional gas chromatography coupled with mass spectrometry (GC×GC–MS). Gas–particle partitioning behavior was evaluated using equilibrium and steady-state partitioning models. Positive matrix factorization (PMF) was applied to identify major sources of PM2.5-bound CPs. Atmospheric persistence and residence times were further evaluated by incorporating PVC-associated non-exchangeable fractions into atmospheric mass balance calculations.

Discussion and Conclusion

Airborne MNPs were widely detected in urban PM2.5 and contributed substantially to particulate organic matter. Among the detected polymers, PVC showed particularly strong associations with particle-phase CPs during winter. In contrast, no significant relationship was observed between PVC and gaseous CPs, suggesting that PVC-associated CPs may behave as non-exchangeable particle-bound reservoirs rather than following conventional gas–particle equilibrium partitioning.

Measured gas–particle partitioning of CPs deviated substantially from equilibrium predictions during winter. After accounting for PVC-bound fractions, agreement between measured and model-predicted partitioning behavior improved markedly, indicating that airborne PVC particles substantially influence the atmospheric partitioning behavior of CPs. PMF analysis further identified a distinct PVC-associated source factor contributing significantly to PM2.5-bound CPs, particularly during winter.

Atmospheric modeling suggested that PVC-associated transport can prolong particle-phase residence times of CPs from hours to several days and shift atmospheric removal pathways from rapid re-volatilization toward deposition. These findings indicate that airborne plastics may substantially alter the atmospheric persistence and transport behavior of semivolatile contaminants. The results highlight an overlooked role of atmospheric MNPs in regulating contaminant cycling and suggest that polymer-bound transport should be considered in future atmospheric partitioning models and exposure assessments.

Nano-Plastics: Sources, Transport and Environmental Fate

F. Corami & S. Lievens

D44-721 Investigating the Effect of Pressure and UV Radiation on Additives in Different Tire Particles

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Introduction

Tire wear particles are increasingly recognized as a major source of environmental contamination because they are continuously generated during vehicle use and can be transported into aquatic environments through runoff and drainage pathways. Against this background, we investigated whether particle size, prior weathering, UV radiation, and deep-sea pressure alter the presence on the particles surface expressed as extractability of selected tire-associated compounds under controlled laboratory conditions. The study was designed to clarify whether environmental exposure changes the availability of additives already present in tire particles and to evaluate the implications of these changes for pollutant release, transport, and ecotoxicological risk in marine systems.

Materials and Methods

Three particle types were compared: virgin crumb rubber (VCR), weathered crumb rubber (WCR), and cryo-milled tire tread mixture (TTM). The experimental design included two laboratory exposure systems intended to simulate contrasting marine conditions. In the hyperbaric experiment, the three particle types were incubated in Mediterranean seawater under either surface-water pressure or deep-sea pressure (200 bar), with parallel biotic and abiotic conditions. Samples were collected after 6 hours, 24 hours, 1 week, and 2 weeks. In the UV experiment, the same particle types were exposed to artificial daylight at controlled temperature and irradiance, with matched dark controls, to simulate approximately 1 week, 2 weeks, and 1 month of environmental sunlight exposure. Following treatment, particles were extracted with n-hexane using vortexing and sonication, and the extracts were analyzed by GC-HRMS. Targeted analysis included major tire-related compounds such as 6PPD, 6PPD-quinone, DPPD, CPPD, DTPD, TPPD, benzothiazole (BTH), fluoranthene, and pyrene. Suspect screening was additionally applied to detect recurring unidentified compounds.

Results

The findings indicate that extractability was governed primarily by compound identity rather than by particle size or age alone. Across all samples, 6PPD was the most abundant analyte, accounting for 64–97%. TTM exhibited the highest initial extractable concentrations of PPDs, followed by VCR and WCR, suggesting that smaller or less weathered particles contained a larger readily extractable fraction. In both experiments, PPD concentrations declined substantially over time, particularly during the earliest sampling intervals. Among the PPDs, 6PPD showed the smallest relative decrease, whereas DPPD and TPPD declined more markedly. 6PPD-quinone was detected in every rubber sample, demonstrating that this toxic transformation product persists even in aged materials. UV exposure reduced PPD extractability most clearly in TTM, whereas effects in larger crumb rubber particles were less consistent. Deep-sea pressure did not generate a uniform temporal response, although endpoint comparisons suggested that deep-sea-exposed samples more often showed higher extractability than surface-water controls. BTH was detected in all samples, including blanks and controls, complicating interpretation, while fluoranthene, pyrene, and several unidentified suspect compounds displayed more variable and substance-specific patterns.

Discussion and Conclusion

Overall, the results demonstrate that the effects of marine exposure on tire additives are complex and highly compound-specific. Most targeted additives were present in tire particles even after prolonged exposure to environmental stressors, readily available for surface extraction. Smaller particles generally displayed higher starting concentrations, whereas weathered particles often showed less decline over time, suggesting that prior environmental aging may deplete or stabilize the most accessible additive fraction. UV radiation appeared to exert a stronger influence than pressure, particularly for fine particles, and likely accelerated depletion or transformation of antioxidants at particle surfaces. The widespread detection of both 6PPD and 6PPD-quinone underscores their environmental relevance and supports concern about their persistence in marine systems. The study provides robust comparative evidence that tire particles remain ongoing sources of extractable additives and transformation products under marine conditions.

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Nano-Plastics: Sources, Transport and Environmental Fate

F. Corami & S. Lievens

D44-621 Evaluating Plastic-Related POP Exposure in Cory's Shearwater

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Introduction
Marine plastic ingestion is commonly reported in seabirds and it is known to cause multiple physical impacts. However, the extent to which ingested plastics contribute to the transfer of persistent organic pollutants (POPs) under environmentally realistic conditions is still not fully understood. In this work, POP occurrence and distribution were investigated in Cory's shearwater (Calonectris borealis) fledglings in connection with previously characterized plastic and microplastic particles recovered from their stomachs (proventriculus and ventriculus).

Materials and Methods
A total of 57 stranded fledglings collected during rescue campaigns carried out in Tenerife (Canary Islands, Spain) in 2022 and 2023 were included in the study. Concentrations of up to 53 target compounds, including polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and organochlorine pesticides (OCPs), were determined in ingested plastics, liver and selected adipose tissue samples. Analyses were performed using ultrasound-assisted extraction followed by gel permeation chromatography (GPC) clean-up and GC-qqq-MS/MS determination. Additional purification procedures based on the use of acidic silica gel and/or Florisil® were applied to biological tissues when necessary. The analytical methodology provided satisfactory recoveries (60–95%), good repeatability (RSD <8%) and quantification limits generally below 1 pg g^{-1}.

Results
POP concentrations were typically higher in ingested plastic particles than in liver samples when expressed on a fresh weight basis. Yet, differences between them decreased after lipid normalization. Distinct contaminant patterns were observed across matrices. Plastic particles were mainly characterized by PBDE-209 together with lower chlorinated PCB congeners, while liver samples showed a predominance of PCB-153/138, PBDE-47/99/100, and p,p'-DDE. These differences suggest the influence of selective uptake, metabolic transformation, and additional dietary exposure routes. A principal component analysis (PCA) clearly separated plastic and liver samples, with liver samples displaying higher variability than plastics and therefore further supporting the influence of multiple exposure routes and biological processes on tissue contamination patterns. Moderate correlations were found between POP burdens in plastics and ΣPCB concentrations in liver on a fresh weight basis, although these relationships disappeared after lipid normalization. In addition, a negative logarithmic association was observed between the mass of ingested plastics and ΣPCB levels.

Discussion and Conclusion
Overall, these results indicate that contaminant accumulation in Cory's shearwater cannot be explained by a simple direct transfer from plastics to tissues. Instead, multiple exposure pathways appear to contribute to the observed chemical profiles. This study further supports the relevance of Cory's shearwater as a bioindicator species for integrated monitoring of marine plastic litter and POP pollution in the Canary Current ecosystem.

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Nano-Plastics: Sources, Transport and Environmental Fate

F. Corami & S. Lievens

D44-090 Microplastic in Riverine Sediment in Diverse Ghana's Land-Use Areas

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Introduction

Plastics have become indispensable materials in daily life since Leo Baekeland's invention in 1907 [1]. Nevertheless, during the last century researchers have documented the increasing deleterious effect of plastic on the environment as they hardly degrade and can be fragmented into micro- and nanoplastics (MNPs), accumulating in the environment and resulting in effectively permanent plastic pollution. Ghana is a prominent example of an African country with a major plastic pollution problem, owing to its global plastic trade with high-income countries and the fact that a large share of Ghana's plastic waste is mismanaged, clogging up stormwater drains, rivers, and streams before eventually reaching the Gulf of Guinea.

Materials and Methods

In this study, a total of 49 sediment samples were collected during two sampling campaigns in 2022 and 2023 as described in Zhao et al. [2]. The sampling sites span three coastal administrative regions in Ghana, representing four land-use categories: agricultural, gold mining and municipal & e-waste area. Microplastics (MPs) composed of polyethylene terephthalate (PET) and polycarbonate (PC) were identified following the protocol of Zhang et al. [3].

Results

Table 1 shows that PET dominates the MPs assemblage in all types of land-use areas. Moreover, municipal & e-waste and agricultural areas are the most prominent in MPs pollution.

Table 1 Concentration of PC and PET at areas of different land-use types in Ghana.

Land-use type	PET (ng/g)	PC (ng/g)
gold mining area	309	25.9
municipal & e-waste area	3435	50.2
agricultural area	2425	40.5

Discussion and Conclusion

The distinction of MPs distribution due to land-use types has also been revealed by other studies [4, 5]. It is suggested that the occurrence of MPs in agricultural lands may be associated with the use of plastic film, while that in municipal & e-waste area can be a result of pertinent human activities including open burning and unregulated recycling [4, 5]. Further research is needed to understand the correlation between MPs occurrence and gold mining.

Acknowledgment

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PFAS Exposure 2

G. Becher & T. Webster

D45-687 Factors Influencing Concentrations of PFAS in Drinking Water: Implications for Human Exposure

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Introduction

Concentrations of ten per- and polyfluoroalkyl substances (PFAS) were measured in samples of tap water from the UK (n = 41) and China (n = 14) as well as in bottled water originating from 15 different countries (n=112). These data were used to evaluate possible factors influencing PFAS concentrations in drinking water and to estimate human exposure to PFAS via drinking water. Perfluorooctanesulfonate (PFOS) were the most frequently detected (>99%) and dominated in global bottled water, with other PFAS also highly detected (67%–93%). ∑10PFAS concentrations differed significantly in natural mineral vs purified, but not in glass vs plastic and still vs sparkling bottled water. Significantly higher mean Σ10PFAS concentrations were present in tap water from China (9.2 ng/L, with PFOS and perfluorobutane sulfonate (PFBS) dominant) than in UK tap water (2.7, in which PFBS and PFOA were dominant). The greater contribution of PFOS in tap water from China might be a result of the later implementation of regulatory bans on PFOS in China (2019) compared to the EU (2010). Except for PFOS in Chinese tap water, related target PFAS concentrations in all water samples were below the reference values. High detection rates of target PFAS in both tap and bottled water highlight necessity of monitoring a wide range of PFAS. Adult daily exposure to Σ10PFAS via tap water exceeded substantially that via bottled water in both the UK and China. Estimated exposure of Σ(PFOA+PFOS+PFNA+PFHxS) in all scenarios was below the group tolerable weekly intake (TWI) of 4.4 ng/kg bw/week promulgated by EFSA. Interestingly, boiling and activated carbon filtration can reduce substantially (50%–90%) concentrations of PFAS in water.

PFAS Exposure 2

G. Becher & T. Webster

D45-122 Concentrations and Profiles of Per- and Polyfluoroalkyl Substances (PFAS) in Dust and Drinking Water from the United Kingdom: Implications for Human Exposure

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Introduction

Per- and polyfluoroalkyl substances (PFAS) have found extensive application. The phase out of legacy PFAS has led to the introduction of a growing number of novel PFAS as substitutes. Several investigations have been conducted to monitor the levels of emerging PFAS and confirm their presence in the environment,[1,2] but have rarely been studied in indoor environments, particularly in the UK. Despite the global concern, the extent of PFAS exposure in the UK population and associated health risk remain poorly understood. Therefore, our study aims to measure concentrations of a suite of 44 PFAS in samples of indoor dust (n=50) and drinking water (n=50) collected in Birmingham, UK in 2025 and to conduct a preliminary assessment of the exposure of the UK population to PFAS via ingestion of indoor dust and drinking water.

Materials and Methods

Indoor dust and drinking water samples were collected from households and offices in Birmingham, UK. Dust samples and drinking water samples were extracted using methanol with ultrasonication and solid-phase extraction (SPE), respectively, and subsequently analysed on an ultra-performance liquid chromatography coupled to quadrupole time-of-flight mass spectrometry (UPLC-ToF-MS).

Results

PFAS in dust

PFAS were detected in all dust samples, at median SPFAS concentrations of 41.7 and 67.8 ng/g in home dust and office dust, respectively. This demonstrates the widespread presence of PFAS in UK indoor environments. Correlation analysis showed significant associations among 9 PFAS in dust from both microenvironments ($p < 0.05$), indicating those compounds may share similar sources.

PFAS in drinking water

PFAS were also detected in all water samples, showing median total concentrations of 2.27 ng/L in household tap water and 1.33 ng/L in office drinking water. Notably, concentrations of both PFOA and total PFAS in office water were observed to be significantly lower than those in household tap water ($p < 0.05$). The differences may be attributed to the use of purification systems in office drinking fountains, compared to direct tap water collection at homes, suggesting that filtration systems have the potential to remove certain PFAS from drinking water.

Exposure assessment

The exposure levels of PFAS via dust ingestion and water consumption were higher for toddlers than for adults in the UK. The median daily intakes under average exposure scenarios were 0.233 and 0.056 ng/kg bw/day for toddlers and adults, respectively. Based on these two exposure pathways alone, household tap water contributed 54.1% median daily PFAS intake for toddlers and 81.0% for adults, while home dust ingestion under the high exposure scenario was the dominant source for toddlers (71.8%). Differences in exposure levels and pathway contributions likely result from variations in body weight, ingestion rates and lifestyle behaviours.

Discussion and Conclusion

Our study provides the first integrated dataset on PFAS in indoor dust and drinking water in the UK. Results reveal the widespread occurrence of a range of PFAS in household and office dust as well as drinking water, narrowing the research gap on novel PFAS in these two environmental matrices in the UK. The exposure assessment reveals higher intake of toddlers compared to adults on a body weight basis. Further studies are needed for continuous monitoring and comprehensive assessment of PFAS risk via different exposure pathways, including diet and dermal uptake.

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PFAS Exposure 2

G. Becher & T. Webster

D45-476 Trifluoroacetic acid in Great Lakes waters

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Introduction
As the shortest perfluorocarboxylic acids (PFCAs), trifluoroacetic acid (TFA) can be generated from the photodegradation of PFAS precursors and hydrofluorocarbons. Atmospheric deposition is an important source of PFAS to the aquatic ecosystems. ~10% of the U.S. population and 30% of the Canadian population lives in the Great Lakes basin. However, data on PFAS, especially TFA levels in the Great Lakes aquatic ecosystems was reported ~20 years ago, so it is time to revisit the TFA levels in this region.

Materials and Methods
In 2021-2024, precipitation samples were collected every two weeks from five sites in the Great Lakes region. The IADN sites included two urban sites in Chicago, IL, and Cleveland, OH; one rural site at Sturgeon Point, NY; and two remote sites, one at Eagle Harbor, MI, and one at Sleeping Bear Dunes, MI (Figure S1). Samples were collected using an atmospheric precipitation sampler (ADS-120, NCON, GA, USA), equipped with a PFAS-free high-density polyethylene (HDPE) bucket and sensor that automatically opens the cover during precipitation events. Lake water samples were collected by the US EPA's Great Lakes National Program Office (GLNPO) in May 2022 aboard the R/V Blue Heron from Lakes Superior (n = 15) and Michigan (n = 11) and by Environment and Climate Change Canada (ECCC) between April and June 2022 aboard the CCGS Limnos from Lakes Huron (n = 21), Erie (n = 3), and Ontario (n = 13). Due to low sample size in 2022, ECCC collected additional samples from Ontario (n=12) and Erie (n=12) in April and May 2023, then from Superior (n=22) and Erie (n=16) in May 2024, respectively. The samples were collected at a 1-meter depth below the water surface. All samples were analyzed using a liquid chromatograph coupled to tandem mass spectrometer (LC/MS/MS).

Results
The median TFA concentration in precipitation (448 ng L-1; 369–737 ng L-1) was 1–2 orders of magnitude higher than Σ26PFAS (median 3.28 ng L-1). The median flux of TFA and Σ26PFAS was 311 and 2.25 μg m−2 year−1, respectively. Spatially, TFA and Σ26PFAS concentrations in precipitation were highest at urban locations with lower levels found at rural and remote sites. In open lake water, concentrations were highest in Lake Ontario and lowest in Lake Superior. TFA concentrations in precipitation increased significantly between 2021 and 2024 at all sites with doubling times of 1.4-2.3 years. Seasonal differences were pronounced, with significantly higher TFA concentrations in summer than in the other seasons, consistent with enhanced summertime atmospheric oxidation of volatile precursors.

Discussion and Conclusion
Our findings suggest that TFA is now a dominant pollutant in Great Lakes water bodies, and its concentration is rapidly increasing in precipitation with a doubling time of ~1.5 years. As part of ongoing efforts to understand the environmental fate and behavior of PFAS and related compounds, more intensive and robust atmospheric monitoring of these compounds are recommended. In parallel, targeted measurements of TFA in the atmosphere are needed to better characterize its sources, transport, and deposition.

Acknowledgment
U.S. domestic components of this study conducted by Indiana University were funded by the Great Lakes Restoration Initiative (Cooperative Agreement Number GL00E02730 (Derek Ager, Program ManagerTechnical Lead, and Ben AlsipNicole Singleton, Project Officer). This article has not been formally reviewed by EPAFinally, any use of trade, firm, or product names is for descriptive purposes only and the views expressed in this document are solely those of the authorsdoes not imply endorsement by the U.S. government. The findings and conclusions here do not necessarily reflect thoserepresent the views or policies of the U.S. Environmental Protection Agency. EPA does not endorse any products or commercial services mentioned in this publication.

PFAS Exposure 2

G. Becher & T. Webster

D45-207 Fate of per- and polyfluoroalkyl substances (PFAS) in a waste-to-energy plant: from atmospheric emissions to ambient air contribution

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Introduction
The atmospheric fate of per- and polyfluoroalkyl substances (PFAS) represents a very recent and challenging field of research. While widely accepted ISO or CEN standards are yet under development, PFAS have been quantified during the past years in emissions, ambient air and atmospheric deposition. Experimental evidence on atmospheric PFAS emissions is essential to (i) characterize the magnitude and composition of contemporary industrial releases, (ii) better understand the efficiency of thermal destruction technologies and (iii) create the evidence-base needed for proper mitigation strategies and air quality management in relation to PFAS.

Materials and Methods
This study reports flue gas emissions and resulting emission impact in the vicinity of a state-of-the-art waste-to-energy (WtE) plant under representative operational conditions. The study combines 7 repeated stack measurements using the Belgian emission standard LUC/VI/003 (Hofman et al., 2025a, Hofman et al., 2025b, VITO, 2025) with continuous 12-week ambient air monitoring on filter and PUF sorbent at 4 monitoring sites located in different wind directions around the WtE plant.

Results
Quantifiable PFAS emissions were observed with a distinct long-chain carboxylic acid (PFCA) fingerprint, contributing up to 57% of the total measurable atmospheric PFAS concentration at 450m downwind of the WtE plant. When modelling the emission impact using the Immission Frequency Distribution Model (IFDM), the observed emission levels never breached the temporary assessment framework for ambient air in Flanders (0.3 ng/m^3 for sum of PFHxS, PFOS, PFOA, PFNA). Moreover, optimization of AC dosage during flue gas treatment resulted in quantifiable emission reductions up to 95%, resulting in emissions approaching field blank levels.

Discussion and Conclusion
To our knowledge, our study is the first to experimentally evaluate the emission impact of a WtE plant by combining stack emission measurements of 50 semi-volatile PFAS with ambient air measurements in the vicinity. We quantified PFAS in the flue gas of 2 grate incinerator stacks under representative operational conditions to evaluate composition and concentration levels of the emissions and assessed the resulting impact at ambient monitoring locations in the vicinity of the WtE plant.The waste treatment sector represents a critical frontier for environmental management. Building experimental evidence on potential PFAS releases and remediation technologies will be key to ensure comprehensive strategies for responsible PFAS management in the years ahead.

Acknowledgment
Authors acknowledge the plant operators for pushing the bounderies on PFAS research.

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PFAS Analysis 3

K. Fernie & S. Harrad

D46-011 Rapid and sensitive screening of PFAS in surface water with large volume injection using a novel Ion Mobility-QTOF

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Introduction

PFAS are highly present in the public posing threats to mankind and nature. The comprehensive characterization of PFAS in environmental samples is often limited by their vast number, trace concentrations and matrix interferences. For less complex matrices like surface water, large volume injections can be a good option for fast analysis. LC-TQ approaches are mainly used for routine PFAS monitoring of a limited number of species due to their high quantitative sensitivity. However, a comprehensive characterization of the PFAS content in environmental samples requires smart non-targeted workflows. An ion-mobility QTOF is an ideal tool then because of acquiring fast full scan MS and MS/MS data in combination with the additional mobility separation capability. Moreover, the CCS (collision cross section) determination of the individual PFAS species can help to improve confidence in annotation and identification. In this study, we evaluate a novel, small-molecule LC-TIMS-QTOF platform for targeted and non-target screening of PFAS in surface water.

Materials and Methods

The samples were analyzed by a large-volume injection (100 µL) on an Elute+ SL UHPLC system (Bruker) with a fast 9.6min gradient on a Phenomenex Gemini 3 µm C18 column (50 × 2 mm). LOD were determined by using the TIMS-bbCID acquisition mode. We investigated the impact of key hardware and acquisition novelties from the instrument and their impact on sensitivity and mass/mobility range coverage, such as the Mobility Range Enhancement (MoRE) mode, a brighter ion beam and collision energy sweeping. For non-target analysis we have developed a complete non-targeted workflow using PASEF, with library search and suspect screening using the CompTox database as suspect list, and tools in MetaboScape (Bruker) for the annotations of true unknowns.
MoRE utilizes the full length of the dual TIMS tunnel through ion accumulation and mobility separation in successive stages. This expands the effective mobility range per scan and increases the ion throughput, particularly in the low m/z range. A glass capillary with a larger inner diameter increases the brightness of the ion beam compared to the previous timsTOF product line. The AIP, an additional RF/DC ion optics stage downstream of the collision cell, dynamically optimizes ion transfer to the TOF analyzer across the entire mass range, while the redesigned TIMS device enhances ion capacity and transmission.

Results

To determine the limits of detection and quantification, surface water samples were spiked with a mixture of 40 EPA 1633 regulated PFAS in a dilution range of 0.1 to 100 ng/L. Screening and quantification were performed using TASQ (Bruker) and a database containing all regulated PFAS, including retention times (RT), CCS values, and their fragments as qualification ions. For 16 PFAS, such as PFNA, we achieved limits of detection (LODs) of up to 0.1 ng/L, for 27 PFAS they were 0.3 ng/L or better, and for 36 they were 1 ng/L or better. The standard addition method has been used to quantify PFAS already in the blank surface water samples. By collision energy (CE) sweeping from 10 to 70 eV, significantly richer MS/MS spectra were obtained compared to the previous CE stepping method. This allows for more reliable annotations.

Discussion and Conclusion

For the pure surface water samples, over 60 PFAS could be annotated using the PASEF data acquisition mode and our non-targeted workflow.

PFAS Analysis 3

K. Fernie & S. Harrad

D46-024 Putting the (Atmospheric) Pressure on Forever Chemicals: A Targeted Analysis of GC Amenable PFAS using APGC–MS/MS

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Introduction

Analysis of per- and polyfluoro alkyl substances (PFAS) is routinely performed by laboratories around the globe using liquid chromatography coupled to mass spectrometry. This technique is sufficient to cover an extensive list of compounds, but is not well suited for analysis of more volatile classes of PFAS, such as fluorotelomer alcohols and acrylates, among others. As focus continues to expand beyond the routinely monitored compounds and matrices, the addition of gas chromatography coupled to mass spectrometry is becoming an important tool to get a more comprehensive overview of the PFAS composition of a sample. Many of the GC amenable PFAS can be present in a variety of sample types from environmental to food and food packaging.

A method was developed using atmospheric pressure gas chromatography (APGC) to chromatograph and ionize the GC amenable PFAS of interest. This technique uses nitrogen to ionize the compounds of interest, which is a soft ionization process, allowing for precursor ions to remain intact in the ion source. Ionization for the PFAS compounds covered in this method was aided by using water in the source, otherwise known as proton transfer. To simplify laboratory implementation, nitrogen was also utilized as the carrier gas for this separation. The method developed covers 35 different native PFAS compounds, plus four isotope labelled internal standard, covering PFAS compound classes including fluorotelomer alcohols, acrylates, methylacrylates, sulfonamides, sulfonamidoethanols, and acetates. The use of the APGC allowed for the precursor to remain as the intact [M+H]+ ion, increasing specificity, as compared to a harder ionization technique like electron ionization, in which these compounds are likely to easily fragment.

Environmental samples, previously extracted following EPA Method 1633 and characterized only using LC-MS/MS analysis, were analyzed using the APGC-MS/MS method to determine if any of the targeted GC amenable PFAS were present in the samples. Additionally, different types of food packaging materials were extracted for analysis using this method.

PFAS Analysis 3

K. Fernie & S. Harrad

D46-284 High-Throughput and Automated PFAS Analysis for Human Serum Samples

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are chemically stable compounds that have been widely detected in various environmental and biological matrices, including the human body. Public concern regarding PFAS exposure and their potential adverse health effects has increased over the past two decades. Large-scale epidemiological studies are essential for evaluating these health effects, and high-throughput, robust analytical methods are critical for accurate and reliable exposure assessment. In this study, we developed a high-throughput method for PFAS analysis in human serum using an automated liquid-handling system.

Materials and Methods
Serum samples were collected from 100 healthy Japanese adult volunteers (mean age: 22.3 ± 3.7 years) between 2020 and 2021, following approval by the ethics committees of the National Institute for Environmental Studies and Nagoya University. For sample preparation, 200 µL of 1% formic acid in acetonitrile/water (3:1, v/v) and 10 µL of an internal standard solution were dispensed into a 96-well deep-well plate, followed by aliquoting 50 µL of serum. After centrifugation, the supernatant was loaded onto a Captiva EMR-Lipid 96-well plate (Agilent) to remove phospholipids and other impurities. A total of 35 target PFAS in the final eluates were separated and quantified using liquid chromatography–tandem mass spectrometry (LC–MS/MS; 1290 LC–6495 TQ, Agilent) equipped with a Poroshell 120 EC-C18 column (2.1 × 50 mm, 2.7 µm).

Results
Sample transfer, addition of internal standards and dilution solvents, and loading onto the Captiva EMR-Lipid plate were fully automated using a liquid-handling machine (Microlab STAR, Hamilton), thereby minimizing human error and accelerating the sample preparation process. To reduce LC run time, a switching valve was installed immediately upstream of the analytical column, enabling alternating use of two columns. A dedicated gradient program was developed to wash one column while analysis was performed on the other. As a result, the entire process from sample preparation to data acquisition for one analytical batch (75 samples) could be completed within a single working day, corresponding to potential annual analytical throughput of more than 10,000 samples. The developed method was applied to human serum samples for biomonitoring purposes, and the validity and applicability of the method were evaluated. Among the 35 target PFAS, seven compounds—PFOA, PFNA, PFUnDA, PFTrDA, PFHxS, PFOS, and 9Cl PF3ONS—were detected in more than 50% of the samples, indicating widespread and continuous exposure to these chemicals. Median concentrations were highest for PFOS, followed by PFOA, PFNA, PFUnDA, PFHxS, PFTrDA, and 9Cl PF3ONS. These findings suggest that serum PFAS levels may reflect both current and historical production and usage patterns in Japan. Although the production and use of PFOS, PFOA, PFHxS, and long-chain PFCA have been regulated, continuous exposure may remain due to their long biological half-lives and the ongoing use of PFAS-containing products.

Epidemology and Exposome 2

Chairs: A. Covaci & T. Webster

D47-793 Prenatal PCB and DDT exposures in 1960's Oakland California are linked to neighborhood disparity, age of menarche, midlife obesity, allostatic load, and Alzheimer plasma markers in Black women through DNA methylation gene networks

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Introduction
The Developmental Origins of Health and Disease hypothesis posits that perinatal exposures have consequences on health that persist across the lifespan. Persistent organic pollutant (POP) exposures during pregnancy have been linked to obesity, age of menarche, and breast cancer risk. Black women in the US have historically had complex exposomes due to racial discrimination, segregated neighborhoods and occupations enriched for POPs, which are possibly linked to higher rates of obesity, earlier age of menarche, higher morbidity from breast cancer and higher rates of Alzheimer's disease (AD) than white women.

Materials and Methods
To explore these complex relationships, we examined the epigenetic mark of DNA methylation (DNAm) as an informative molecular phenotype linking complex exposure mixtures with disease-related outcomes. Genome-wide DNAm signatures can both reflect prior exposures and be predictive of future outcomes, making them ideal for intergenerational studies. Here we investigated adult midlife (mean age 49.5) blood DNAm signatures associated with perinatal exposome measurements. These included PCBs and DDTs, cumulative stress, race, and structural neighborhood disadvantage within the Child Health and Development Studies (CHDS) birth cohort from 1959-1967 in Oakland, California, that have been studied for 3 generations. Using Whole-Genome Bisulfite Sequencing data from a subset of 173 F1 daughters (59 Black and 114 White), we analyzed genome-wide methylation profiles with the comethyl bioinformatics pipeline to identify co-methylated networks of genes, called modules.

Results
33 modules were identified and examined for primary associations with race, neighborhood spatial polarity and disadvantage at birth using historical Index of Concentration at the Extremes (ICE) metrics, age at menarche, and midlife obesity. Strikingly, 27 of 33 comethylated modules were significantly correlated with black versus white race, with the yellow module showing the strongest relationship (bicor=0.82, $p<0.001$). Race was also highly correlated with the first 2 principal components in overall DNAm data (bicor=0.56, 0.77, $p<0.001$), together explaining 9.3% of the variance. 5 modules were significantly correlated with midlife obesity and were also the modules most strongly associated with race, ICE quadrant 1 vs 4 (most vs least spatially polar by race, income, and education attainment), and age of menarche. Within these 5 obesity-associated gene networks, 3 showed significant associations with one or more of DDT, o,p'-DDT, PCB 15, PCB 180, PCB 187, or PCB 203; 4 showed significant associations with one or more allostatic load markers (IL6, HDL, HBA1C, blood pressure, % body fat, white cell count); and 1 showed significant association with early AD plasma biomarkers (pTau217, pTau217/total Tau ratio, pTau 217/Aβ42 ratio) measured during midlife. In contrast, APOEα4 genotype was associated with one of the only modules not associated with race, suggesting that AD genetic risk altered DNAm of distinct genes from race and allostatic load. These 5 obesity-associated comethylated gene networks showed significant enrichment for neuronal, metabolic, and endocrine pathways, and genetic association with obesity.

Discussion and Conclusion
Together, these results suggest that race, structural neighborhood disadvantage, and lifetime stressors act as modifiers of POPs that alter methylation within neurologic, metabolic, and cancer-related pathways.

Acknowledgment
California Breast Cancer Research Program

Risk Assessment and Risk Management 2

L. Ramos Bordajandi & M. Rose

D48-662 Cumulative Health Risk Assessment of Dietary Exposure to Persistent Organic Pollutants (POPs) in Türkiye

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Introduction
Humans are generally exposed to complex mixtures of several POPs simultaneously through dietary intake, and such long-term exposure may cause cancer and non-carcinogenic health effects. This study aims to conduct a human health risk assessment of dietary exposure to POPs in Türkiye, utilizing an extensive national dataset to quantify cumulative carcinogenic and non-carcinogenic health risks.

Materials and Methods
In this study, a comprehensive database was constructed by compiling peer-reviewed literature data (2000-2025) derived from 43 independent studies investigating POP concentrations in food items in Türkiye. The integrated database compiles all available food concentration data reported across the literature, categorized into 8 major food categories spanning 24 distinct food items: dairy products (milk, butter, butterfat, and clotted cream), meat and poultry (meat, beef, chicken meat, and offal), seafood (fish and clam/mussel), eggs, plant-based foods (wheat, vegetables, fruits, dried fruits), processed snack products, (cake, chocolate, and crackers, chips), beverages (water, mineral water, and juice), and other commercial products (edible oil and honey). This compiled data encompasses 19 distinct POPs with aldrin, chlorpyrifos, and PCBs being the most heavily measured compounds across the evaluated food categories.
A human health risk assessment of both carcinogenic and non-carcinogenic risks was conducted by integrating pooled POPs concentrations with national food consumption rates in accordance with the latest risk calculation guidelines established by the United States Environmental Protection Agency (US EPA). For both assessments, a deterministic worst-case exposure scenario was implemented, presuming that individuals were simultaneously exposed to all identified POPs across all food categories via dietary intake. This approach was employed to determine upper-bound risk levels.

Results
The human health risk assessment showed that both carcinogenic and non-carcinogenic risks for certain food items exceeded the generic safety limits of 10-6 for cancer and 1 for the Hazard Quotient (HQ), which represents non-carcinogenic health effects due to exposure to a single chemical. While a wide range of food groups was evaluated, red meat and chicken meat were selected as representative food items highlighted here due to their high consumption rates and lipid-rich profiles. The Hazard Index (HI) for the adult population, calculated by summing the HQs of individual chemicals, was found to be 100.3 for red meat and 91.4 for chicken meat, pointing to a severe potential non-carcinogenic risk. Furthermore, the cumulative cancer risk, determined by summing the cancer risks of individual chemicals, was calculated as 6.5 × 10-2 for red meat and 5.9 × 10-2 for chicken meat. Although both meat samples contained a mixture of PFOA, PFOS, PCDD/Fs, and dioxin-like PCBs, the main contributor to the overall risk was PFOA. This is largely attributed to its high cancer slope factor and very low oral reference dose, which together drive both carcinogenic and non-carcinogenic risk estimates even at low exposure levels.

Discussion and Conclusion
The findings indicate that both carcinogenic and non-carcinogenic risk thresholds are exceeded across multiple food groups. Importantly, even in the absence of a worst-case scenario, the calculated risk levels remain notable. However, several limitations must be considered when interpreting these estimates. The dataset compiles independent studies conducted across different years using diverse analytical methods, which introduce uncertainty into the study. Establishing a long-term nationwide monitoring study would enable much more realistic estimations of human health risk from ingestion of POPs-containing foods. In the next phase of the study, a probabilistic risk assessment using Monte Carlo simulation will be conducted, in addition to the point estimate deterministic approach, followed by a comparative analysis of the outcomes from both methodologies.

Risk Assessment and Risk Management 2

L. Ramos Bordajandi & M. Rose

D48-779 Is the Planetary Boundary Concept Suitable for Dealing with Global Chemical Pollution?

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Introduction

The Planetary Boundaries (PB) concept focuses on a set of anthropogenic impacts on the global environment that are of particular concern because they have the potential to push the earth into new, less habitable states [1]. Postulating a safe operating space for humanity that extends to limits where the system may reach tipping points, the PB concept follows a similar logic as the Critical Loads concept developed in the 1980s. Among climate change, biodiversity loss and several others, the list of impacts also includes chemical pollution. Application of the PB concept to chemical pollution has been discussed extensively [2]. Specifically, Arp et al. mention plastic debris as a planetary boundary threat [3] and Cousins et al. highlight four perfluoroalkyl carboxylic acids as chemicals of global presence and with a potential for adverse effects on the global scale [4].

Results

The problem of chemicals causing global pollution ("global chemicals") has a long history, starting from Rachel Carson's "Silent Spring", published in 1962. From the 1960s on, two tracks of environmental chemistry looking into global chemicals developed: an "atmospheric" track dealing with chlorofluorocarbons and other ozone-depleting substances (ODSs), and an "aquatic-terrestrial and ecotoxicological" track addressing semivolatile persistent organic chemicals such as organochlorine pesticides, polychlorinated biphenyls, etc. Both tracks have led to multilateral environmental agreements addressing the two types of global chemical pollution, namely the Montreal Protocol on ODSs and the Stockholm Convention on Persistent Organic Pollutants. The two tracks intersected at two points: in the early 1970s, when research into the enzymatic defluorination of haloacetic acids in aquatic or terrestrial systems highlighted the problems that may be caused by the extraordinary strength of the carbon-fluorine bond [5], which was then found to be exactly the factor that makes CFCs so stable that they reach the stratosphere. The second intersection happened in the mid-1990s, when CFC replacements were found to form trifluoroacetic acid (TFA), which is transferred from the atmosphere back into aquatic and terrestrial ecosystems [6]. This concern was an early recognition of the large-scale problem caused by per- and polyfluoroalkyl substances (PFASs) that are now ubiquitous in the global environment, including nearly all humans living on earth.

Discussion and Conclusion

The rich track record of environmental chemistry over the last 60 years shows that chemical pollution is not a single, uniform impact like most others in the PB concept. Accordingly, more specific approaches than the PB concept may be more effective in dealing with global chemical pollution. These include: (i) Environmental persistence is the key property that causes chemical pollution problems of truly global scale and needs to be avoided with highest priority. (ii) To avoid regrettable substitution of one chemical with others of the same type, grouping approaches are needed in chemicals regulation. (iii) More extensive, detailed and effective pre-market assessments of chemicals are needed so that early technological lock-ins of problematic chemicals can be avoided. Up to now, the use and regulation of PFASs have violated all three of these aspects; the PFAS restriction proposal under discussion in the EU will hopefully change this.

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Risk Assessment and Risk Management 2

L. Ramos Bordajandi & M. Rose

D48-581 Decontamination dynamics of Mytilus galloprovincialis in a multi-stressed Mediterranean coastal site: implications for environmental management and public health

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Introduction
Taranto (Southern Italy) is characterized by a unique coastal ecosystem—the Mar Piccolo and Mar Grande basins—historically dedicated to Mytilus galloprovincialis farming. However, decades of intense industrial and military activity have led to significant environmental contamination by PCDD/Fs and PCBs [1], resulting in the site's designation as a Site of National Interest (SIN) for remediation [2]. Due to their high bioaccumulation potential, mussels in the Mar Piccolo 1st Inlet frequently exceed European safety limits [3], particularly during summer, leading to strict regional ordinances that restrict harvesting and mandate early relocation of juvenile specimens.

Materials and Methods
To mitigate the economic impact on local fisheries while ensuring food safety, this study evaluated the decontamination rates of mussel batches relocated from the Mar Piccolo 1st Inlet to the Mar Grande. A monthly monitoring program was established to compare initial contamination levels with those measured 15, 30, and 45 days post-transfer. Additionally, physical water parameters (temperature, pH, dissolved oxygen) and biometric indices (condition index, tissue weight) were recorded.

Results
Results demonstrate: a) significant decontamination within the first few days post-relocation; b) stabilization of pollutant levels approximately 30 days after transfer; and c) marked seasonality in contamination levels linked to the mussels' physiological state and lipid cycles.

Discussion and Conclusion
These findings suggest that correlating decontamination dynamics with reproductive cycles and environmental parameters could support a more flexible regulatory framework. Such an approach would allow for extended farming periods in the Mar Piccolo, safeguarding the local economy without compromising public health standards.

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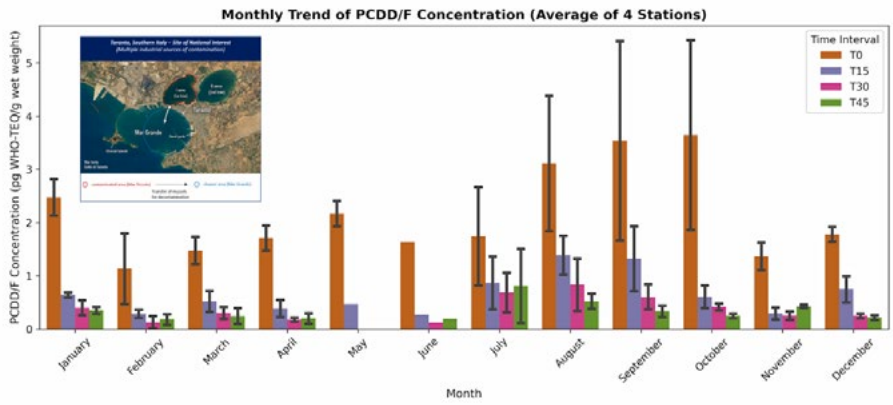


Figure 1. Study area in the Taranto coastal system (Southern Italy), including the Mar Piccolo and Mar Grande basins. Mussels from the contaminated Mar Piccolo 1st Inlet (red outline) were relocated to the cleaner Mar Grande area (blue outline) to evaluate natural decontamination dynamics of dioxins.

BFR Analysis

L. Leondiadis & H. Stapleton

BFR3-489 High levels of polybrominated dibenzo-p-dioxins (PBDDs) in fish from the North and Baltic Seas

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Introduction
Fish are frequently high contaminated with polyhalogenated compounds [1]. Several of these polyhalogenated compounds are persistent, bioaccumulative and toxic and some twenty compound classes were classified as persistent organic pollutants (POPs) by the Stockholm Convention on POPs.

Materials and Methods
Fish samples collected during a sea cruise at seven sites of the North or Baltic Sea were analyzed on polyhalogenated compounds. In the first part, different tissues (fillet, liver, and brain) of dab (Limanda limanda) were pooled (typically n=6) and analyzed from seven stations. Screening by GC/Orbitrap-ECNI-HRMS (and later by GC/Orbitrap-EI-HRMS) indicated that the three most abundant brominated compounds in one fillet sample were PBDD congeners.

Results
Since the corresponding PBDD standards were not available to us, the dibenzo-p-dioxin backbone was brominated according to the method described for polybrominated dibenzofurans (PBDFs) [2]. The purified synthesis mixture was fractionated by countercurrent chromatography (CCC) into 60 fractions. GC/MS analysis was used to select four CCC fractions containing PBDDs whose GC retention times matched those in the fish samples. These four CCC fractions were combined to give a standard mix with a total content of 75 ng PBDDs. This PBDD standard mix was calibrated by GC/FID since FID responses are only dependent on the carbon content and not the degree of halogenation with same responses for different isomers [3]. After calibration and correction by the carbon content, the PBDD amounts were determined in the dab samples. The (semi-) quantified PBDD levels in 12 dab samples (four fillets, livers, and brains, respectively) ranged between 2 – 1,100 µg/kg lipids. Especially, the highest level in the ppm-range was astonishing as it exceeded the highest level of PCB 153 by one order of magnitude. However, the distribution between the individual samples was highly varied and completely different to the PCBs. Both aspects produced strong evidence that the PBDDs in the fish samples were halogenated natural products (HNPs). These results were confirmed by previous findings of PBDDs in the Baltic Sea [5] and their formation from bromophenols in incubation experiments [4,5].

Discussion and Conclusion
Previous studies on the man-made 2,3,7,8-TBDD indicated much lower levels of <0.11 pg/g fat in cod livers from the Baltic Sea [1].
Subsequent analysis of mackerel (Scomber scombrus) fillet from the same locations verified the presence of the same di- to tetrabrominated PBDDs as found in the dab samples. This indicated that PBDDs are widely distributed in the North and Baltic Sea. This is of importance since PBDDs are candidates for being added to Annex C of the Stockholm Convention on POPs.

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Pathway of Exposure

J. De Boer & G. Rimkus

BFR4-625 Atmospheric Levels and Trends of Halogenated Flame Retardants at a High Mountain Site in the Northern Alps in Bavaria, Germany

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Introduction

The study presents concentrations of halogenated flame retardants (HFRs) in ambient air from a period of 11 years (2012-2023) from Mt. Zugspitze in the northern Alps in Bavaria, Germany. Measurements are performed within a close cooperation of the Bavarian Environment Agency and the Environment Agency Austria for monitoring persistent organic pollutants (POPs) in the Alps. The sampling site receives air masses from local and regional sources inside and north of the Alps as well as from long-range transport.

Materials and Methods

Active air sampling over periods of three months is performed at the Environmental Research Station Schneefernerhaus (Umweltforschungsstation Schneefernerhaus, UFS, 10.9850 E, 47.4211 N, 2650 m). The low volume sampler for monitoring HFRs is operated at 1.8 m^3/h with a cartridge containing a quarz glass fiber filter (QFF) and two polyurethane foam (PUF) plugs (d=50 mm, l=40 mm) according to guideline VDI 2464 part 3.
Accelerated solvent extraction of QFF and PUF plugs is done with n-hexane/acetone-(1:1). After addition of 13C-labelled quantification standards a three-step clean-up is performed with separation into two fractions. Analysis is done by gas chromatography-tandem mass spectrometry (GC MS/MS) with a 15 m Rxi-5HT-capillary column (0.25 mm ID, 0.10 µm f.t.). Measured values are accepted if they are at least two times higher than corresponding field blanks according to VDI 2464 part 3. Time series are analysed by using the statistic software R and are not corrected for outliers. Depending on the better fit, linear or exponential temporal trends are calculated which cover the full time series as well as the last 5 years. As minimum level of significance we accepted $p < 0.1$ due to high variability of atmospheric processes.

Results

Table 1 summarizes the results in pg/m^3. Trends are indicated by ¬an arrow up- or downwards¬ when p <0.1, otherwise →; Median, Q25 and Q75 are given for the total period starting from 2012-11-08; the trend for the last 5 years covers the period from 2018-10-02 to 2023-10-02.

Discussion and Conclusion

The concentrations of polybrominated diphenylether, which are regulated by the Stockholm Convention, show significant reductions over the whole series except for BDE 209. However, unregulated HFRs such as pentabromotoluene display increasing concentrations. A comparison with atmospheric deposition rates measured in parallel as well as ambient air concentrations at an urban background site will be presented.

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Compound	total n	n < LOQ	Q25	Median	Q75	total trend	trend 5a
BDE 100	35	19	0.0076	0.011	0.017	→	↓
BDE 153	35	9	0.0034	0.0039	0.013	↓	↑
BDE 154	32	21	0.0033	0.0041	0.0068	↓	→
BDE 183	33	14	0.0062	0.012	0.038	↓	↑
BDE 209	36	20	0.33	0.51	0.85	→	→
BDE 28	41	41	0.049	0.063	0.16	↓	→
BDE 47	42	26	0.079	0.12	0.15	↓	→
BDE 99	41	23	0.024	0.031	0.045	↓	→
BTBPE	13	3	0.013	0.014	0.014	→	n.a.
DBDPE	38	32	0.51	0.74	1.9	→	→
Dechlorane Plus anti	36	34	0.15	0.21	0.49	→	→
Dechlorane Plus syn	33	33	0.053	0.090	0.16	→	→
HBCD (sum)	31	18	0.24	0.32	0.43	→	→
Hexabromobenzene	43	40	0.13	0.23	0.46	↑	→
Pentabromoethylbenzene	29	29	0.021	0.033	0.080	→	↑
Pentabromotoluene	42	28	0.18	0.39	0.56	↑	↑
Tetrabromo-p-xylene	20	19	0.0064	0.0096	0.012	→	→
aCl11-Dechlorane Plus	19	13	0.0026	0.0031	0.0079	→	→

Table 1: Levels of HFRs in ambient air at Environmental Research Station Schneefernerhaus in pg/m^3 and temporal trends for the period 2012 to 2023 and 2018 to 2023, respectively.

Pathway of Exposure

J. De Boer & G. Rimkus

BFR4-472 Tracing Organophosphate Esters Across the Great Lakes Atmosphere: Spatial Patterns, Phase Partitioning, and Air Mass Transport

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Introduction

Organophosphate esters (OPEs) are a class of anthropogenic chemicals widely used as flame retardants and plasticizers in textiles, furniture, building materials, and electronic products(Marklund et al., 2003; Wei et al., 2015). OPEs comprise structurally diverse compounds that can be broadly classified as alkyl, aryl, or chlorinated species based on their side-chain composition. This structural variability leads to differences in physicochemical properties, such as volatility and partitioning behavior, complicating the interpretation of their environmental fate across different matrices. Following the restriction and phase-out of certain polybrominated diphenyl ethers (PBDEs), the use of OPEs has increased substantially. Because many OPEs are used as additive flame retardants and are not chemically bound to polymer matrices, they can readily migrate from products into the environment. Additionally, some OPEs exhibit sufficient persistence and mobility to undergo long-range atmospheric transport (LRAT), contributing to their regional and global distribution. Consequently, their widespread occurrence has raised concerns regarding potential risks to human and ecological health. Emerging evidence suggests that certain OPEs may exhibit persistence, bioaccumulation potential (Strobel et al., 2018), neurotoxicity (Patisaul et al., 2021), and reproductive toxicity (Zhu et al., 2015).

The Great Lakes represent the largest freshwater system in the world and have been the focus of extensive monitoring programs for environmental contaminants. The Integrated Atmospheric Deposition Network (IADN) is a long-standing U.S.-Canada program that measures atmospheric concentrations and temporal trends of priority pollutants using standardized sampling protocols and rigorous quality assurance/quality control (QA/QC) procedures. Air sampling at both urban and remote shoreline sites, with collection of gas and particle phases, enables evaluation of spatial patterns, seasonal variability, and long-term trends of atmospheric contaminants across the Great Lakes basin. These measurements are critical for assessing atmospheric inputs to the lakes and supporting science-based environmental management.

Pathway of Exposure

J. De Boer & G. Rimkus

BFR4-781 Temporal Trends in Halogenated Flame Retardants in Mixed Plastic Waste Derived from Television Casings in Japan

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Introduction

Information on POP concentrations in products and recycled materials in Japan remains limited, particularly for waste streams consisting of complex mixtures of products and components. To improve understanding of POP occurrence in domestic recycling systems, this study investigated mixed shredded plastic waste derived from end-of-life household appliances and generated a comprehensive dataset on POP concentrations in recycled materials.

Materials and Methods

To clarify the occurrence of intentionally added flame retardants and contamination associated with mechanical recycling, 12 regulated and unregulated halogenated flame retardants were analyzed in mixed plastic flakes derived from television casings collected at household appliance recycling facilities in Japan between 2016 and 2024. These included both currently regulated POPs and candidate POPs, such as decabromodiphenyl ether (BDE-209), Dechlorane Plus (DP), decabromodiphenyl ethane (DBDPE), and bis(2-ethylhexyl) tetrabromophthalate (BEH-TEBP). Target compounds were determined by gas chromatography–tandem mass spectrometry. Total bromine (Br) concentrations were also measured by combustion ion chromatography as an indicator of brominated flame retardant (BFR) content. A total of 20 samples were analyzed, including mixed plastic flakes from cathode-ray tube (CRT) television casings made of polypropylene (PP; n = 7) and polystyrene (PS; n = 7), and flat-panel display (FPD) television casings made of PS (n = 6). The samples represented different production periods, with PP CRT casings being the oldest, followed by PS CRT casings and, finally, PS FPD casings as the most recent products. In addition, Br concentrations in 68 individual end-of-life CRT television casings made of PP were screened using a handheld X-ray fluorescence (XRF) analyzer.

Results

The average Br concentration in PP CRT mixed flakes (1.6 wt%), representing the oldest product category, was significantly lower than those in PS CRT (8.9 wt%) and PS FPD (8.7 wt%) mixed flakes. XRF analysis of 68 individual end-of-life CRT television casings revealed a bimodal distribution of Br concentrations: approximately one quarter of the samples contained Br at levels of several percent, whereas the remaining samples contained 30 mg/kg or less. Among the 12 flame retardants analyzed, DBDPE and BDE-209 showed the highest concentrations and detection frequencies. DP was detected in six samples (30%) at concentrations up to 15 mg/kg, suggesting that it had not been intentionally added to television casings. Clear differences in BFR usage patterns were observed among product categories. TDBP-TAZTO and TBBPA-BDBPE were detected only in PP CRT mixed flakes, BDE-209 was the dominant BFR in PS CRTs, whereas DBDPE and TTBP-TAZ were used in combination in PS FPDs. Mass-balance estimation of Br sources indicated that approximately 70% of the Br in PP CRTs and 40% of the Br in PS CRTs could not be explained by the targeted BFRs analyzed in this study, suggesting the presence of unidentified brominated flame retardants.

Discussion and Conclusion

No clear temporal changes in BFR usage patterns were observed between products discarded in 2016 and those discarded in 2024. BDE-209 concentrations were highest in PS CRT mixed flakes, and these concentrations exceeded the low-POP-content (LPC) limits established under the Basel Convention, indicating that this material is not suitable for recycling into new products. Consistent with the more recent production period of PS FPDs, BDE-209 concentrations were low, whereas DBDPE concentrations were high. Given the possibility that DBDPE may be listed under the Stockholm Convention in the future, proactive policy measures and management strategies should be considered in advance to minimize potential impacts on plastic recycling systems. These findings highlight the importance of continuous monitoring of both regulated and emerging flame retardants in plastic recycling streams.

Acknowledgment

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Pathway of Exposure

J. De Boer & G. Rimkus

BFR4-407 Determination of the occurrence levels of PBDEs in feed materials in Greece

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Introduction

One pathway of human exposure to polybrominated diphenyl ethers (PBDEs) is through contaminated food. The safety of food derived from animals is closely linked to the quality of their feed. The latest scientific opinion by EFSA's Panel on Contaminants in the Food Chain (CONTAM) updates the risk assessment of PBDEs in food and covers the "feed-to-food" pathway as a relevant source of PBDEs in food of animal origin. Consequently, it is necessary to assess PBDE levels to gain clearer insight into contamination trends in feed, in line with the EU's recommendations for monitoring PBDEs (2014/118/EU). PBDE levels in feed materials have been monitored in numerous countries1-3; however, Greece hasn't reported any findings yet.

Materials and Methods

This preliminary study assessed contamination by eight PBDE congeners (BDE-29, -47, -49, -99, -100, -153, -154, and -183) in 38 feed samples classified into seven categories (277/2012/EU): feed materials of plant origin (4), vegetable oils (1), animal fat (5), fish oil (5), other products derived from fish and aquatic animals (10), compound feeds for fish (10), trace elements and premixtures (3). Solid samples were homogenized with sodium sulfate and extracted overnight using a Soxhlet apparatus, after the addition of a quantification standard (13C12 labeled PBDEs). The isolated lipid fraction was purified by column chromatography using 44% H2SO4-silica gel and alumina, evaporated and re-dissolved in n-nonane with a 13C12 PCB 80 injection standard for analysis. PBDE congeners were determined using a high-resolution mass spectrometry method based on the isotope dilution technique. Quality control included method blanks and reference samples in each batch of 10 samples. The laboratory is accredited under EN/ISO 17025 for PBDE analysis in feed, and method trueness is verified annually through inter-laboratory trials organized by the European Union Reference Laboratory for halogenated POPs in Feed and Food (EURL POPs).

Results

Concentrations of PBDE congeners were expressed in pg g-1 product, with a calculated LOQ of 5.00 pg g-1 product, and the sum of congeners was determined using the upper-bound approach, assigning the LOQ value to non-quantified congeners (2017/644/EU). The highest median Σ8PBDEs concentration was measured in "compound feed for fish" (2279.79 pg g-1 product), followed by "fish oil" (1539.03 pg g-1 product), consistent with EFSA's updated Scientific Opinion identifying food category "fish, seafood, amphibians, reptiles, and invertebrates" as a major PBDE contributor. The category with the highest Σ8PBDEs mean and max concentration in this study was "other products derived from fish and aquatic animals" (4139.72 and 21897.71 pg g-1 product, respectively). The most frequently detected PBDE congener was BDE-47, which also showed the highest concentrations and was the only congener detected above the LOQ in a barley sample from the "plant origin" category.

Discussion and Conclusion

These findings support the transfer of PBDEs through the feed-to-food chain and their potential accumulation in aquatic organisms, in agreement with previous studies included in the 2024 Scientific Opinion of the European Food Safety Authority (EFSA)1,4,5. Overall, the findings underscore the need for ongoing monitoring and emphasize the importance of the One Health approach, which recognizes the close interconnection between human, animal, and environmental health.

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Flame Retardants: Biotransformation and Toxicity

H. Moon & M. Petreas

BFR5-377 In-depth assessment of the metabolic fate and potential bioactivation pathways of halogenated bisphenols

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Introduction
Bisphenol A (BPA) is widely used in the production of polycarbonate plastics and epoxy resins to manufacture numerous consumer products, including food and beverage containers, lacquers and coatings. It is a well-known endocrine disruptor with adverse effects on human health, including reproductive and metabolic disorders. Notably, BPA is also used as a free monomer for manufacturing thermal papers and halogenated flame-retardant analogues.
Tetra-bromo bisphenol A (TBBPA) is employed to produce flame-proofed epoxy resins. It accounts for more than 50% of the worldwide production of brominated flame retardants (>230.000 metric tons/year). Human exposure to TBBPA has been demonstrated, based on different human samples (maternal and cord serum, maternal milk, hair), and is considered as a ubiquitous environmental contaminant, with different routes of exposure including diet, dust ingestion and inhalation. TBBPA can disrupt endocrine functions. It is an antagonist of hormone receptors including AR, GR, PR and TR. However, primarily, TBBPA as well as its major metabolite TBBPA-sulfate have both been demonstrated to be potent PPARα activators.
Tetra-chloro bisphenol A (TCBPA) production volumes are much lower (ca. 10.000 tons/year). However, human exposure to chlorinated BPAs may occur following BPA's chlorination under sunlight in saltwater, or during the recycling of wastepaper. TCBPA as well as mono-, di-, and tri-chloro-BPA are environmental contaminants which have been detected in wastewaters and surface salted waters. Several studies have demonstrated human exposure to chlorinated BPAs. For all halogenated analogues of BPA, major data gaps of knowledge remain, notably as regards their metabolic fate and potential bioactivation pathways.
Within the context of the Horizon Europe project "PARC" (Partnership for the Assessment of Risks from Chemicals) a series of BPA alternatives is currently studied with the aim of filling data gaps, to reach a better assessment of related hazards and risks. TBBPA and TCBPA are part of the prioritized BPA analogues list. In this study we present novel data obtained using in vitro human hepatic models, with the aim to better assess the metabolic fate and potential bioactivation pathways of these substances of high concern.

Materials and Methods
Following the synthesis of radio-labelled [14C]-TBBPA or [14C]-TCBPA and their radio-HPLC purification to reach a high degree of purity, full mass-balance studies were completed in HepaRG cells. For each substance, differentiated HepaRG cells were exposed for 24 hr to a range of 6 non-cytotoxic concentrations. All experiments were carried out in triplicate and included negative controls. At the end of the exposure period, radioactivity distribution was monitored in all compartments (culture media, cells, culture plates, washes). Complete radioactivity recovery (100 ± 10%) was assessed. Cell media were individually analysed by radio-HPLC to establish metabolic profiles and study the concentration-dependant formation of metabolites. Additional incubations using dedicated in vitro tools (human liver subcellular fractions) and enzymatic deconjugation were carried out to confirm the structure of major metabolites, in addition to LC-HRMS characterization. Finally, specific cytochrome P450 isoforms involved in TBBPA/TCBPA phase I biotransformation were screened using an extended set of human CYP-recombinant supersomes, to characterize specific associated enzymatic constants, in addition to the apparent kinetic constants calculated from HepaRG incubations.

Results
Despite the predominance of phase II conjugation pathways, phase I oxidative pathways were evidenced, involving ipso-substitution mechanisms, which remain extremely limited for non-halogenated BPA. The subsequent formation of several types of dimers and related structures were demonstrated.

Discussion and Conclusion
TBBPA and TCBPA's metabolic fate was investigated in the metabolically competent human hepatic HepaRG cell line, demonstrating the extensive biotransformation of both substances, which major metabolites were identified, and which kinetic of formation was characterized, providing critical data to achieve a better assessment of the hazards associated with these substances.

Flame Retardants: Biotransformation and Toxicity

H. Moon & M. Petreas

BFR5-828 Systemic and cerebral inflammation contribution to the emergence of Autism Spectrum Disorder induced by a developmental exposure to α-HexaBromoCycloDoDecane in rat

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Introduction
The worldwide increase in the prevalence of Autism Spectrum Disorders (ASD) has raised concerns regarding the contribution of environmental factors to their etiology. Among these factors, brominated flame retardants have emerged as potential neurodevelopmental toxicants and early-life exposure to α-hexabromocyclododecane (α-HBCDD), a widely used brominated flame retardant, has been suggested to contribute to ASD development. Previous work from our group demonstrated that maternal exposure to α-HBCDD during gestation and lactation induces ASD-like behavioral alterations in male offspring, closely resembling those observed in the well-established valproic acid (VPA)-induced ASD model. However, the biological mechanisms underlying these behavioral impairments remain poorly understood. Given the growing evidence implicating immune dysregulation and neuroinflammation in ASD pathophysiology, this study aimed to investigate the contribution of systemic and cerebral inflammatory processes to ASD-like phenotype induced by developmental exposure to α-HBCDD.

Materials and Methods
Pregnant Wistar rats were assigned to three groups (n = 6 dams/group): control, α-HBCDD (100 ng/kg/day, p.o., GD0–PND21), and VPA (500 mg/kg, i.p., GD12). Analyses were performed in male offspring from these dams. At postnatal day 50 (PND50), peripheral blood was collected to assess systemic immune alterations by flow cytometry immunophenotyping. Brain regions were microdissected and cortex were used to evaluate neuroinflammatory markers using cytokine arrays and RT-qPCR. Astrocyte and microglial activation were assessed through gene and protein expression analyses (RT-qPCR and Western blot), while glial morphology was characterized by immunofluorescence.

Results
Both α-HBCDD and VPA exposure induced similar systemic immune alterations, characterized by reduced natural killers (NK), Type 1 cytotoxic T cells (Tc1), and regulatory T-cell (Treg) populations. These changes may reflect either immunotoxic effects or infiltration of immune cells into the central nervous system. Supporting the latter hypothesis, marked neuroinflammatory responses were observed in both exposed groups. Increased microglial density in the cortex and hippocampus, astrocyte activation, and dysregulation of 26 inflammation-related markers were detected following α-HBCDD and VPA exposure. Pathway analyses highlighted alterations in JAK–STAT and PI3K–Akt signaling pathways, which have previously been implicated in ASD patients. More specifically, significant changes in the expression of metalloproteinase 2 and 3 (MMP-2, MMP-3), vascular cell adhesion protein 1 (VCAM-1), and osteoprotegerin (OPG) were identified at both transcript and protein levels. These mediators are involved in the initiation and maintenance of inflammatory responses through the modulation of cytokine and chemokine signaling and regulation of vascular endothelial function, potentially affecting blood–brain barrier permeability.

Discussion and Conclusion
Our findings demonstrate that developmental exposure to α-HBCDD induces systemic immune dysregulation and neuroinflammation in males exhibiting ASD-like behavioral phenotypes. These alterations closely mirror those observed in the VPA model of ASD and may contribute to neuronal network dysfunction underlying behavioral abnormalities. Overall, this study provides new mechanistic insights into the role of immune and neuroinflammatory processes in linking early-life α-HBCDD exposure to ASD-related neurodevelopmental outcomes.

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Flame Retardants: Biotransformation and Toxicity

H. Moon & M. Petreas

BFR5-013 Perinatal α-Hexabromocyclododecane exposure induces neurodevelopmental and synaptic alterations in female rats: comparison with the valproic acid model of Autism Spectrum Disorder

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Introduction
Hexabromocyclododecane (HBCDD) is a brominated flame retardant (BFR) consisting of a technical mixture of 3 diastereoisomers (α, β and γ). Until 2015, HBCDD was mainly used as an additive flame retardant in building insulation and household materials in Europe, and was restricted from this date for health concerns. HBCDD has been classified as Persistent Organic Pollutant and meets the PBT criteria (persistent, bioaccumulative, and toxic) with the α-isomer being the most abundant and persistent in environmental matrices. Although its use is now banned, HBCDD is still present in waste such as construction materials, plastics, textiles, and electrical and electronic equipment. This constitutes a major long-term source of contamination, and raises concerns about the effects of such exposure on human health. An increasing body of evidence suggests that early exposure to BFRs, among them HBCDD, contributes to the etiology of neurodevelopmental disorders, including autism spectrum disorders (ASD). We have previously demonstrated that perinatal exposure to α-HBCDD induces ASD-like disturbances in male offspring, mainly with social and repetitive deficits. However, ASD is characterized by differences in prevalence and symptoms between sexes, raising questions about the effects of the same exposure in female offspring, and the ability of this BFR to induce an ASD-related phenotype depending on the sex of the animal. The present study was designed to evaluate the neurotoxic and behavioral effects of perinatal exposure to α-HBCDD in females, which possibly indicate the onset of ASD. These effects were compared to those observed in a well-described rodent model of ASD consisting of a gestational exposure to valproic acid (VPA).

Materials and Methods
Pregnant Wistar rats were assigned to three experimental groups (n=6/group): control, α-HBCDD (100 ng/kg/day, p.o., GD0-PND21), and VPA (500 mg/kg, i.p., GD12). Female pups were evaluated for ultrasonic vocalizations (USV), olfactory discrimination, and eye opening during the first three weeks of postnatal life. After weaning, the females were assessed as juveniles for nociceptive sensitivity, anxiety, locomotor activity, repetitive behaviors, and social behavior. Expression of cortical markers of synaptic plasticity (synaptophysin, PSD95, SNAP25 and mTOR) was measured at PND50 by RT-qPCR, Western blot, and immunofluorescence.

Results
During the first 3 weeks of postnatal life, α-HBCDD exposure induced several disorders in female pups, some of which overlapped with those observed in VPA-exposed offspring. Females exposed to α-HBCDD showed delayed eye opening and increased latency to reach home bedding in the olfactory discrimination test, indicating impaired sensory maturation. USV were not altered in females exposed to α-HBCDD whereas VPA delayed the maximum vocalization peak, indicating an impairment in the dynamic of communication between dams and pups. During the juvenile stage, females exposed to α-HBCDD exhibited a thermal hyposensitivity, a mechanical hypersensitivity, and a higher anxiety level. However, their social behavior was unaffected, unlike the VPA group which showed reduced interest in social novelty. In the brain, both α-HBCDD and VPA induced alterations in cortical synaptic plasticity, as evidenced by significant changes in SNAP25 and synaptophysin mRNA and protein expression levels. Additionally, immunofluorescence analysis revealed elevated mTOR expression in α-HBCDD-exposed animals compared to the control and VPA groups.

Discussion and Conclusion
These results suggest that early exposure to α-HBCDD can induce an ASD-like phenotype in females, which is characterized by sensory and anxiety-related disturbances without any modifications of social behavior. The molecular alterations of synaptic plasticity observed in the cortex of the same animals are relevant to ASD physiopathology and could be one of the mechanisms responsible for these behavioral impairments. Differences in male and female behavior early exposed to a-HBCDD suggest the ability of this chemical to induce a sex-dependent ASD-like phenotype as described in humans and highlights the importance of including females in preclinical ASD research.

Flame Retardants: Biotransformation and Toxicity

H. Moon & M. Petreas

BFR5-014 Using in vivo and ex vivo brain imaging approaches to characterize neurodevelopmental impairments induced by early-life exposure to α-Hexabromocyclododecane in rats

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Introduction
Hexabromocyclododecane (HBCDD) is a brominated flame retardant (BFR) composed of three diastereoisomers (α, β, and γ), widely used as an additive in building insulation and household materials across Europe until 2015, when its applications were restricted following health concerns. Classified as a persistent organic pollutant fulfilling PBT criteria (persistent, bioaccumulative, and toxic), HBCDD (particularly its a-isomer, the most environmentally prevalent form) continues to represent a significant contamination source through its persistence in construction waste, plastics, textiles, and electronic materials. Accumulating evidence links early-life BFR exposure, including HBCDD, to the etiology of neurodevelopmental disorders such as autism spectrum disorder (ASD). Our previous studies demonstrated that early-life exposure to a-HBCDD induces an ASD-like behavioral phenotype in juvenile rats, similar to that observed following gestational exposure to valproic acid (VPA), a well-recognized idiopathic model of ASD. Notably, the expression of this phenotype was found to be sex-dependent, with male and female offspring displaying distinct behavioral profiles, highlighting the importance of considering biological sex as a critical variable in the neurotoxicological assessment of HBCDD. Given the critical role of cerebral energy metabolism in neurodevelopment, this study uses complementary in vivo and ex vivo approaches to investigate whether developmental α-HBCDD exposure perturbs brain glucose metabolism.

Materials and Methods
Pregnant Wistar rats were assigned to three experimental groups (n=3/group): control, a-HBCDD (100 ng/kg/day, p.o., GD0-PND21), and VPA (500 mg/kg, i.p., GD12). Following weaning, both male and female offspring underwent a behavioral battery encompassing anxiety-related responses (PND36, openfield test), stereotyped behaviors (PND39, marble burying test), social interaction (PND42, three-chamber social test), and thermal nociception (PND43, hot plate test). Subsequently, regional cerebral energy metabolism was evaluated through complementary in vivo and ex vivo approaches, combining [18F]-FDG PET-CT imaging withhistochemical quantification of cytochrome c oxidase activity. This metabolic characterization was further extended through LC-MS/MS quantification of Krebs cycle intermediates and molecular profiling of glucose metabolism markers, with mRNA and protein expression levels assessed by RT-qPCR and Western blot, respectively. This integrative approach was designed to bridge behavioral phenotyping with underlying neurobiological substrates, thereby contributing to a mechanistic understanding of environmentally induced ASD-like disorders.

Results
Our findings confirm an ASD-like behavioral phenotype in both a-HBCDD exposed and VPA treated animals, consistent with previous observations. In vivo [18F]-FDG PET-CT imaging revealed region-specific cerebral hypermetabolism in VPA treated rats, while no significant metabolic alterations were detected in a-HBCDD exposed animals. Complementary ex vivo analyses, however, uncovered regional metabolic imbalances in both groups, evidenced by differential cytochrome c oxidase labeling intensity across brain regions, suggesting localized disturbances in oxidative energy metabolism that may not be captured by PET resolution alone. LC-MS/MS quantification further identified significant perturbations in Krebs cycle intermediates, indicative of compromised mitochondrial function and altered oxidative phosphorylation capacity. RT-qPCR and Western blot analyses revealed dysregulation of key glucose metabolism markers at the mRNA and protein levels, collectively supporting a profound remodeling of cerebral bioenergetics that may underlie the observed behavioral disturbances.

Discussion and Conclusion
While the present study establishes a neurometabolic basis for α-HBCDD induced behavioral disturbances, key mechanistic questions remain. Future investigations will therefore focus on characterizing the developmental trajectory of brain-resident immunocompetent cells including microglia and astrocytes through the analysis of cytokine and chemokine signaling pathways. Particular attention will be given to astrocyte dependent metabolic support and its influence on synaptic plasticity, as disruptions in neuron-glia metabolic coupling may represent a critical, yet underexplored, mechanism in environmentally induced neurodevelopmental disorders. Collectively, this study aims to provide a comprehensive understanding of the cellular and molecular landscape underlying a-HBCDD induced neurotoxicity and its potential contribution to ASD pathogenesis.

Human Biomonitoring

K. Fernie & S. Harrad

BFR6-315 Hot spots of PBDD/F and BFRs contaminate chicken eggs leading to high human exposure

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Introduction
Currently, PBDD/Fs and brominated-chlorinated PXDD/Fs are being evaluated by the POPs Review Committee, which concluded that they meet the POP criteria of Annex D of the Stockholm Convention.1 Food is a major exposure pathway for dioxins to humans. Eggs from free-range chickens around a wide range of dioxin emission sources have been found to be a major pathway from contaminated soils to humans with relevant exposure levels.2,3

Materials and Methods
The International Pollutants Elimination Network (IPEN) and Arnika, in cooperation with many NGOs in developing countries sampled free-range chicken eggs from five continents for >20 years. Eggs were sampled at sites influenced by potential dioxin sources, including industrial and waste management sites. At these sites, between 2 and 6 eggs were pooled for analysis of flocks. Samples were analysed with DRCALUX for total dioxin-like toxicity and by HRGC/HRMS in ISO 17025-accredited laboratories with a resolution >10,000 using 13C isotope labelled standards following the EU methods for the control of levels of PCDD/Fs and dl-PCBs for levels in certain foodstuffs (Commission Regulation (EU) No 252/2012). Toxic equivalent quotients (TEQs) of PCDD/Fs based on WHO-2005 toxic equivalency factors (TEFs) were used to calculate TEQs for the corresponding PBDD/F as proposed by the WHO expert group. Also, major brominated flame retardants (BFRs) were measured in a wide range of pooled eggs.

Results
IPEN measured PBDD/Fs in 43 pooled egg samples from potentially polluted areas, in which the measured bio-TEQ was considerably higher as could be explained by PCDD/F and dl-PCB content. In 24 of the samples (56%), the PBDD/F-TEQ was above the EU maximum level for PCDD/Fs in eggs (2.5 pg TEQ/g fat). This shows that a significant proportion of free-range eggs from areas surrounding suspected contaminated sites had PBDD/F levels that would cause a child to exceed the EU Food Safety Authority tolerable weekly intake (EFSA TWI; 2 pg TEQ per kg body weight per week) if they were consumed in normal quantities. The highest PBDD/F-contamination in pooled eggs was 503 pg TEQ/g fat detected in the chicken flock at an e-waste and end-of-life vehicle dismantling site in Ghana (Agbogbloshie). Also, the second- and third-highest levels of PBDD/F-TEQ were found in eggs from an e-waste dismantling site in Thailand (81.3 and 30.4 pg TEQ/g fat). Additionally, pooled eggs from chickens in Bagong Silang, Philippines, that had access to a site where e-waste is dismantled, had a PBDD/F level of 13.9 pg TEQ/g fat. At plastic and e-waste sites in Nairobi, Kenya; Tangerang, Indonesia; Nong Khok, Thailand; and Guadalajara, Mexico, PBDD/F levels in egg samples were 10.8, 9.3, 8.4 and 6.2 pg TEQ/g fat, respectively. High PBDD/F levels were detected in eggs close to a waste incinerator in Wuhan, China (28.3 pg TEQ/g fat), where ashes were disposed of in the surrounding area. Eggs from lime kilns burning plastic waste in Indonesia had a PBDD/F level of 12.9 pg TEQ/g fat. Also, a range of BFRs were detected.

Discussion and Conclusion
Environmental pollution by BFRs and related PBDD/F contamination can occur along the life cycle of BFRs from production, use in production, and use of BFR-treated products, with particular hot spots in the end-of-life from frequent open burning of waste in low- and middle-income countries. The highest contamination was detected at e-waste sites involving open burning and at incinerators not applying Best Available Techniques (BAT) where ash residues can be contaminated with PBDD/Fs.

Acknowledgment
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Human Biomonitoring

K. Fernie & S. Harrad

BFR6-614 Decoding Chemical Footprint: Human Biomonitoring with Chromatography & Mass Spectrometry

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Introduction

Non-communicable diseases (NCDs) account for about 70% of deaths globally. Major risk factors are tobacco use, physical inactivity, the harmful use of alcohol and unhealthy diets. Additionally, known environmental risks (air pollution, occupational) are estimated to contribute around 25% of non-communicable diseases (NCDs). However, these estimates are likely to represent only the tip of the iceberg as the full impact of pollution, especially chemical pollution, on NCD development is not known or underestimated. One of the reasons for this is the absence of sufficiently robust evidence for many exposures and health outcomes. Human biomonitoring (HBM) of nutrients and environmental contaminants is emerging as an important tool to gain information about exposures to essential and toxic substances.

Materials and Methods

NIPH has thus established a platform to perform chemical analytical research on human exposure to persistent and non-persistent organic pollutants with a focus on biomonitoring of breast milk, blood and urine. All the methods available are using tandem mass spectrometry as the detection technique. State of the art instrumental methods available include pyrolysis GC-MS/MS, APGC-MS/MS, and several LC-MS/MS systems using online extraction and clean-up methods, as well as a LC-QToF that can be used both for targeted and non-targeted analyses. The platform provides high-throughput, high sensitivity assays to accurately measure exposure to a set of about 100 chemical compounds from different exposure families in human samples, i.e. Per- and polyfluoroalkyl substances (PFASs, including ultrashort PFAS), persistent organic pollutants (PCBs, organochlorine pesticides and flame retardants), environmental phenols (like bisphenols, parabens, triclosan), UV filters (benzophenones), plasticizers (phthalates, terephthalates, DINCH), polycyclic aromatic hydrocarbons (PAHs), glycol ethers, pesticides (organophosphates, pyrethroids, neonicotinoids), organophosphate flame retardants, micro- and nanoplastics. This targeted approach provides specific, validated detection and quality-assured quantification of chemicals present at very low concentrations. Limits of detection are usually in the low nanogram range.

Results

NIPH performs biomonitoring in large cohort studies linking exposure to chemicals to different health outcomes, and has been involved in several EU-funded projects e.g. HBM4EU (the human biomonitoring initiative for Europe) and the exposome projects Helix (the Human Early Life Exposome), Athlete (Advancing Tools for Human Early Lifecourse Exposome Research and Translation) and the ongoing PARC (Partnership for the Assessment of Risks from Chemicals).
We will present our biomonitoring platform and chemical exposure data from different biomonitoring/exposome projects.

Human Biomonitoring

K. Fernie & S. Harrad

BFR6-456 Establishing a Guideline for the Determination of PBDD/F in Emission Samples –Interlaboratory Comparisons and State of the Development

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Introduction

In connection with the combustion of brominated flame retardants, polybrominated dibenzo(p)dioxins and -furans (PBDD/Fs) recently came into focus and led to two German regulations for monitoring their emissions in different types of stationary plants, reflecting differing expected homologue profiles and levels. Based on that, the Association of German Engineers (VDI) established an expert working group in order to set up a national VDI-guideline for an analytical method in emission samples. As a part of this work, interlaboratory comparison studies were conducted to assess method quality and to address existing analytical challenges, for the analysis in flue gases from incineration plants, but also from non thermal stationary plants (e.g. shredder plants), where the thermolabile Hepta and OctaBDD/Fs may also occur.

Materials and Methods

The analysis is based on method EN1948 (isotope dilution GC/HRMS) and adapted for special requirements, e.g. 15-30 m GC-columns for determination of Hepta- and OctaBDD/Fs. For further details, the participating laboratories had the freedom to perform the analysis ad libitum. The scope was to analyse all 14 2,3,7,8-substituted Tetra- to OctaBDD/Fs for which reference substances are commercially available. A series of 3 interlaboratory comparisons were performed by 3-4 experienced laboratories on combustion related matrices viz. (a) a raw extract of ground cable shredder dust, (b) spiked XADs as emission samples and (c) a mineral residue. The materials were provided by and distributed to the participants.

Results

The results for the interlaboratory comparisons on 14 PBDD/Fs are shown in Table 1.
The analytical quality expressed as recovery of the internal standards were on average 77 % for Tetra- to HexaBDD/Fs and 74 % for Hepta- and OctaBDD/F. Furthermore, during the comparison, several problem categories were encountered with respect to GC and MS analyses, e.g. due to inhomogenities, adsorption effects and interferences. The determined LOQs per compound were in the range of 0.001-0.005 ng/sample for TetraBDD/Fs, 0.002-0.04 ng/sample for Penta- to HexaBDD/Fs and 0.005-0.25 for Hepta- and OctaBDD/Fs.

Discussion and Conclusion

Even with only small data sets, the analytical setup for the intended guideline appears to be robust. Especially for the flue gas sample setup, comparability and trueness proved to be sufficient, recovery rates of the internal standards were good or at least acceptable for the Hepta- and OctaBDD/Fs. Nevertheless, the analysis of the latter remains difficult and challenging. Acceptance criteria might be softened there, as long as background blank control is applied, GC columns of 15-30 m are used and PBDEs separated. The results especially reflect the need for more research, especially into GC-separation of PBDD/Fs and additional data, also for toxicological effects. This is especially necessary for possible calculations of TEQ-values, e.g. by using the TEFs for PCDD/Fs. Based on the LOQ values above, a hypothetic estimation of an "PBDD/F-TEQ-value" indicates that with the methods used here for guideline development, comparability with possible target values of maximum combustion plant emissions on PCDD/F-TEQ basis might be feasible.

Analysis of 14 Tetra-OctaBDD/Fs	Concentrations		Analyte recoveries (trueness)		Relative standard deviation of results (RSD)	
	min-max	Unit	min-max (%)	average (%)	min-max (%)	average (%)
Shredder extract	15.1-34319	ng/kg	-	-	15.6-79.6	40.7
Standard solution	25-145	pg/µL	77.2-120.3	88.6	4.0-53.1	14.4
XAD, spiked #1	4.0-25	ng/sample	92-123.9	103	4.3-25.8	9.5
XAD, spiked #2	1.0-6.3	ng/sample	95.6-129.4	109	3.3-16.2	8.8
mineral residue	2.9-72100	ng/kg	-	-	20.3-54.3	30.4

Table 1: Main results. Min/max – overall ranges of findings; recoveries compare against standard dotations

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Posters

P-00005 Metrology to support the analysis of per- and polyfluoroalkyl substances from industrial emissions

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Introduction
The EU's Zero Pollution action plan aims at reducing pollution in air, water and soil to levels no longer considered harmful to health and natural ecosystems. As part of this, the Industrial Emissions Directive was revised in 2024 which includes a magnitude reduction in the permissible associated emission level of a range of pollutants, affecting many industrial processes. Pollutants such as perfluoroalkyl and polyfluoroalkyl substances (PFAS) are increasingly causing concern. Up to now there is only little knowledge on which industrial processes emit PFAS, at what concentrations, and no European standard exists (only national standard in Belgium and France) for measuring PFAS emissions. Therefore, the Euramet project MetZeroPol (2026) will be develop methods to measure PFAS and use them to identify key PFAS species from real industrial processes.

Materials and Methods
The aim of the project is to develop sample approaches for PFAS from industrial plants. Currently, the OTM-45 (for semi-volatile polar PFAS) (EPA, 2025a) and OTM-50 (for volatile nonpolar PFAS) (EPA, 2025b) methods of the U.S. EPA are available for this purpose. However, the purpose of the Other Test Methods (OTM) is to promote discussion of developing emission measurement methodologies and to provide regulatory agencies, the regulated community, and the public at large with potentially helpful tools. However, what is needed is a harmonised European sampling approach.

Results
The developed sampling and analysis methods will be deployed at industrial installations (e.g. municipal waste incinerator, hazardous waste incinerator, sewage sludge incinerator, fluoropolymer plant) to sample PFAS. Evaluation of complementary sampling approaches targeting different sub-classes of PFAS (e.g. OTM-50 targeting, ultrashort-chain PFAS and PICs) will be considered. Moreover, also PFAS sum parameter techniques will be evaluated. Furthermore, several members of MetZeroPol are involved in the new CEN/TC 264 WG 48 - "Emissions and ambient air - Determination of PFAS" group in order to uniformly regulate the standardization of analysis methods for PFAS emissions from industrial plants.

Discussion and Conclusion
In addition to the development of LC/MS-MS (OTM-45) and GC-MS (OTM-50) methods, we will also develop instruments to continuously monitor (e.g. FT-IR spectroscopy, chemical ionization – time of flight - mass spectrometry (CI-ToF-MS)/ selected ion flow tube mass spectrometry (SIFT-MS)) volatile PFAS in-situ on stacks of industrial plants. In longer term it is likely that industrial process operators will be required to install in-situ analysers for continuous monitoring of PFAS emissions between formal compliance testings.

Acknowledgment
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P-00006 Mitigating Acetylene Inhibition in Trichloroethene Dechlorination: A Coculture Strategy with Syntrophotalea acetylenivorans SFB93 and Dehalococcoides mccartyi

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Introduction
Chlorinated ethenes (CEs) are persistent groundwater pollutants that pose significant environmental and health risks (Kueper et al., 2014). While bioremediation using Dehalococcoides mccartyi (Dhc) is an effective solution, its performance is often crippled by acetylene accumulation, which acts as a potent competitive inhibitor of reductive dehalogenases (Mao et al., 2017). This study proposes a novel co-culture strategy utilizing nitrogen-fixing Syntrophotalea acetylenivorans SFB93 to neutralize acetylene. These bacteria employ acetylene hydratase to degrade the inhibitor while simultaneously providing essential electron donors H2, acetate, and fixed nitrogen to support Dhc activity (Akob et al., 2022). By leveraging this metabolic complementarity, the proposed system enhances the resilience and sustainability of in situ TCE remediation in complex, nutrient-limited hydrogeological environments.

Materials and Methods
Dehalococcoides mccartyi strain FL2 and Syntrophotalea acetylenivorans SFB93 were co-cultured anaerobically using a bicarbonate-buffered mineral medium. Cultures were amended with 0.4 mM lactate as the carbon source and 100 µM TCE as the electron acceptor. Dechlorination was monitored using gas chromatography. Genomic DNA and RNA will be extracted from co-culture broths. Quantitative and relative quantitative PCR (qPCR/RT-qPCR) will be performed on extracted nucleic acids using target-specific primers and probes. These curves will be utilized to quantify the abundance of target genes, including 16S rRNA, dechlorination gene tceA and nitrogen fixation gene nifHDK. All experiments were performed in triplicate.

Results
D. mccartyi strain FL2 maintained dechlorination at 0.4 mM acetylene, whereas strain CWV2 was inhibited at >0.02 mM. RT-qPCR revealed acetylene suppressed tceA expression, indicating a dual impact on metabolism and transcription. In contrast, Syntrophotalea acetylenivorans SFB93 metabolized acetylene in 100 µM TCE with sustained nifHDK expression. To address co-contamination and nutrient deficiency, an SFB93-FL2 co-culture was established. Without exogenous nutrients, SFB93 simultaneously consumed acetylene to provide carbon, H_2, and fixed nitrogen, facilitating continuous dechlorination by FL2. These findings suggest the SFB93-FL2 system has significant potential for stable bioremediation in complex, nutrient-limited environments.

Discussion and Conclusion
This study underscores the critical importance of strain selection by demonstrating significant variations in acetylene sensitivity among Dehalococcoides mccartyi strains. To address the dual challenges of acetylene co-contamination and nutrient deficiency frequently encountered at TCE-polluted sites, we developed a novel co-culture system by pairing D. mccartyi strain FL2 with the Syntrophotalea acetylenivorans SFB93. This research represents the first integration of acetylene metabolism with the self-sustained supply of three essential resources—carbon, H_2, and fixed nitrogen—within a single co-culture to maintain dechlorination activity. Under nitrogen-purged conditions and in the absence of exogenous nutrients, SFB93 simultaneously consumed inhibitory acetylene while providing the necessary metabolic precursors to facilitate continuous dechlorination by FL2. By effectively overcoming the synergistic inhibition caused by acetylene accumulation and nutrient scarcity, this co-culture system offers a robust and cost-effective strategy for natural attenuation-based groundwater remediation. In conclusion, the SFB93-FL2 consortium provides a promising biotechnological approach for maintaining stable dechlorination performance in complex, multi-contaminant environmental matrices.

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PFAS Analysis

P-00010 Rapid PFAS Screening by Real-Time MS/MS

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Introduction
DART-MS/MS (Direct Analysis in Real Time) was introduced in the recent past as a technology capable of providing analysis time in seconds for MS and MS/MS data with quantitative results. Per- and polyfluoroalkyl substances (PFAS) are synthetic chemicals known as "forever chemicals" because they persist in the environment and accumulate in living organisms. The Environmental Protection Agency (EPA) and the European Union (EU) currently employ LC-MS/MS workflows and regulations for PFAS analysis in various matrices. However, high concentrations of PFAS in samples frequently cause carryover in LC-MS/MS, resulting in false-positive peaks in subsequent analyses. Eliminating these contaminants necessitates an extensive cleaning process and downtime of the instrument.

Materials and Methods
This study proposes the use of DART-MS/MS to pre-screen PFAS samples, thereby avoiding the contamination of precious LC-MS/MS setups with high concentrations of PFAS and reducing carryover. Following regulated preparation, samples are analyzed on a Bruker DART-MS/MS triple quad mass spectrometer. Individual sample analysis time is 20 seconds only. Since in DART only gaseous ions reach the source orifice – in contrast to solvent droplets in ESI – the ion source can be kept clean even at high PFAS concentrations.

Results
DART and triple quad parameters were optimized for selectivity, sensitivity, precision, and run time. Unique MS/MS transitions and collision energies were identified for all target compounds followed by optimization of scan time, cone temperature, and collision cell pressure. Optimized DART temperatures ranged from 250 to 350ºC, depending on the target analytes. Grid voltages were optimized to 50 V for all analytes. The resulting data was processed by standard MS quantitation software.

Discussion and Conclusion
Preliminary findings indicate that samples prepared according to the EPA Method 1633 can be rapidly analyzed by DART-MS/MS (run time per sample is 20 seconds). These results suggest that DART-MS may serve as an effective and rapid screening tool for identifying high-concentration samples prior to LC-MS/MS analysis, thereby minimizing carryover and contamination problems.

European POPs monitoring

P-00017 20 years of PFAS analysis, a long story that brought us to rule them

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Introduction
While we started testing PFAS in just water, today we test a wide variety of different matrices, each with its own regulations, targets and limits.
What do we mean when we talk about PFAS? Which technologies are involved in PFAS analysis other than LC and GC? Which instruments operate at the proper sensitivity?
Your mass detector is the starting point to understanding which analytical approach you should pursue. Here follows a practical approach guideline for PFAS analysis, basing the approach on your detector sensitivity.

Materials and Methods
Method for last generation triple quads Restek IBD column 100x2,1x3
Methos for owners of high resolution and not brand new mass detectors
Restek Polar X 50x2,1x2,7
Restek c18 50x2,1x1.8
Volatile PFAS in GC Restek RMX 5sil/ms

Results
Once you know your instrument, you have all the information you need to start solving the PFAS emergency at analytical level.
A single run to analyze all PFAS together? Separate runs to maximize sensitivity? Whatever your best practice, there's a way to make it happen.

Discussion and Conclusion
How can we easily develop an analytical method for PFAS? We'll discuss what is needed to evaluate your analytical approach, based on the sensitivity of your MS detector.
Do you own an older instrument or a high-resolution mass spectrometer? Then you'll need a different approach compared to people who are using a latest-generation triple quadrupole. We'll discuss both approaches, outlining the reasons behind our choices, ensuring that your analysis allows you to reach the required sensitivity.
What about PFAS that are best suited to analysis by GC? We're well-prepared for this as well, and we'll show you our most advanced PFAS GC method.
In addition to turnkey methods, Restek offers the EZ suite, a set of comprehensive free method development tools dedicated to the PFAS world. This means that you can create or modify your own method with your own list of analytes in just over 5 minutes at the computer before actually going to the instrument, saving you both time and expense

P-00018 PCDD/F emission characteristics from coal-fired boilers and cement rotary kilns co-firing solid recovered fuel in Taiwan

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Introduction
To support Taiwan's 2050 net-zero emissions target, solid recovered fuel (SRF) has been increasingly used as an alternative fuel in industrial coal-fired boilers and cement kilns. However, the heterogeneous nature of SRF and unstable co-firing conditions may promote the formation of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) (Kuo et al., 2021). This study investigated 14 SRF co-firing facilities in Taiwan to compare PCDD/F emissions across facility types and to evaluate the effects of SRF quality, operating conditions, and air pollution control devices (APCDs), with particular focus on Cl and Cu contents in SRF.

Materials and Methods
Fourteen SRF co-firing facilities were investigated, including pulp-and-paper mills (n = 8), cement plants (n = 3), cogeneration plants (n = 2), and one petrochemical facility. The units comprised 11 fluidized-bed boilers (5 BFBs and 6 CFBs) and 3 cement preheater–rotary kiln systems. During each campaign, SRF, stack flue gas, bottom ash, and fly ash were collected simultaneously. SRF was sampled according to ISO 21645, and its chlorine, sulfur, moisture, calorific value, and heavy metal contents were analyzed using EN 15408, ISO 21660-3, ISO 21654, and EN 15411. Stack PCDD/Fs were analyzed using USEPA Method 23, while heavy metals and PCDD/Fs in fly ash were determined by ICP-OES after acid digestion (USEPA Method 6010D) and isotope dilution HRGC/HRMS (USEPA Method 1613), respectively.

Results
The results showed substantial variation in SRF sources and composition across industrial sectors. Most SRF samples met Taiwan's current quality standards, although chlorine contents in Plant C (1.59%) and Plant M (1.77%) exceeded the regulatory limit of 1.5%. A relatively high Cu concentration was also observed in cement plant L (243 mg/kg). Although Cu is not currently regulated under Taiwan's SRF standards, it is recognized as an important catalyst for the low-temperature de novo synthesis of PCDD/Fs. In this study, SRF chlorine and fly ash Cu were positively associated with PCDD/F concentrations in stack flue gas, suggesting that these parameters may serve as practical indicators of emission potential. PCDD/F concentrations in stack flue gas ranged from 0.0006 to 0.338 ng-TEQ/Nm3. Emissions from boilers in pulp-and-paper mills and cogeneration plants were generally low, and all complied with the emission standard of 0.1 ng-TEQ/Nm3. In contrast, cement rotary kilns showed greater variability, with one facility exhibiting markedly elevated emissions during start-up. Emission factors ranged from 0.005 to 0.697 μg-TEQ/ton-fuel for the 11 boilers (mean: 0.182 μg-TEQ/ton-fuel), whereas those of the three cement kilns were higher and more variable, ranging from 0.012 to 5.960 μg-TEQ/ton-fuel (mean: 2.136 μg-TEQ/ton-fuel). Congener profiles in most boiler samples were dominated by OCDD and HpCDD/HpCDF, whereas cement kilns showed more heterogeneous patterns, with TCDF dominance under non-steady-state conditions. These findings suggest that minimizing PCDD/F formation and emissions requires SRF with low chlorine (<0.4%) and low Cu (<150 mg/kg), a lower co-firing ratio (<20%), and effective APCDs, such as SCR, catalytic filters, and activated carbon injection followed by bag filters.

Discussion and Conclusion
Overall, the results indicate that PCDD/F emissions from SRF co-firing systems are governed by facility type, operating stability, and SRF quality, particularly chlorine and Cu contents. Stable combustion, proper control of SRF quality, and the use of appropriate APCDs are therefore critical to minimizing PCDD/F formation and emissions. These findings provide a scientific basis for optimizing SRF quality management and emission control strategies in Taiwan.

Acknowledgment
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P-00021 Biological effect on earthworm of arsenic-contaminated soil from tailing area in China

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Introduction
Arsenic (As) is a metalloid with significant biological toxicity that can accumulate in soil organisms and be harmful to crops and human health. In order to study the biological effects of arsenic in soil with its biotoxicity, especially to address the importance of arsenic fractions, we collected the arsenic-contaminated soil around tailing area in Guangxi Zhuang Autonomous Region, China, which followed by the extraction and analysis of its arsenic fractions and biotoxicity with earthworms. The biological effects were expressed with the survival rate, growth rate, oxidative stress index and arsenic enrichment of earthworms.

Materials and Methods
In this study, we collected arsenic-contaminated soil from a tailing site in Guangxi Zhuang Autonomous Region, followed by the extraction and analysis of its arsenic fractions and biotoxicity with earthworms. The arsenic fractions were extracted following the modified BCR sequential extraction technique which was proposed by the European Community Bureau of Reference. The biological effects were expressed with the survival rate, growth rate, oxidative stress index and arsenic enrichment of earthworms.

Results
Our results showed that the mean value of total arsenic concentration in the collected soil samples was 626 mg·kg–1. Herein, the proportion of water soluble fraction (F0) and weak-acid extractable fraction (F1) accounted for 2% - 5%, where residual fraction (F4) dominated for more than 50 %. Arsenic concentration in earthworms increased with total arsenic concentration in soil and exposure time, which inhibited their survival and growth or caused oxidative stress. The correlation analysis showed that each arsenic fraction in soil was negatively correlated with survival and growth rate, while positively correlated with toxicity indexes (especially with ROS and CAT, $p < 0.01$).

Discussion and Conclusion
Our study provides the fundamental research for the importance of arsenic fractions in the consideration of biotoxicity related to arsenic, further to help reveal the biological effects of arsenic-contaminated soil on earthworm Our findings provide research basis for the arsenic control strategy around tailing area.

Acknowledgment
This study was supported by National Key Research and Development Program of China (2020YFC1807804).

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P-00028 Dietary TCDD and PCB-126 activate AhR signaling without affecting sperm quality or oxidative stress in the epididymis of peripubertal mice: limited modulation by fish oil

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Introduction
Dioxin-like compounds (DLCs), including TCDD and PCB-126, are potent aryl hydrocarbon receptor (AhR) agonists potentially linked to impaired male reproductive function. However, the relationship between AhR activation in reproductive tissues and functional sperm outcomes remains unclear. At the same time, fish oil from fish consumption represents both a major exposure route for DLCs and may interact with DLC toxicity or affect reproductive function independently. The aim of this study was to investigate the effects of subchronic dietary exposure to TCDD and PCB126 on sperm quality and epididymal gene expression in peripubertal mice, and to assess whether fish oil could modulate these responses.

Materials and Methods
Male C57BL/6J mice (4 weeks old) were exposed for 13 weeks in a factorial design combining purified dietary fish oil (0%, 1%, 5%) and contaminant exposure (TCDD or PCB-126) at low (0.07 µg TEQ-05/kg bw per week) or high (5 µg TEQ-05/kg bw per week) dietary doses. Sperm concentration, motility and morphology were assessed using computer-assisted sperm analysis (CASA). AhR induction (Ahr, Cyp1a1, Cyp1a2) and oxidative stress (Cat, Gpx4, Sod1 and Gst) were assessed using gene expression analyses by real-time quantitative PCR (RT-qPCR) in the epididymis.

Results
Both TCDD and PCB-126 induced upregulation of Cyp1a1 in the epididymis, confirming activation of AhR signaling in the male reproductive tract. However, no effects were observed on regulation of Ahr or Cyp1a2, nor on expression of any of the oxidative stress markers. Furthermore, no effects of contaminants were observed on sperm concentration, motility, or morphology across exposure groups. In contrast, high dietary fish oil reduced sperm motility and altered sperm morphology, indicating an independent dietary effect on sperm quality. Fish oil did not modify contaminant-induced effects on sperm endpoints, but attenuated Cyp1a1 induction in mice exposed to TCDD at high dietary levels. Fish oil did not affect any oxidative stress markers.

Discussion and Conclusion
Subchronic dietary exposure to TCDD and PCB-126 activates AhR-responsive pathways in the epididymis of peripubertal mice, without clear effects on sperm quality or oxidative stress markers. In contrast, dietary fish oil influences sperm parameters independently of DLC exposure and may modulate molecular responses to AhR agonists. These findings highlight a missing association between molecular (Cyp1a1 induction) and functional endpoints (sperm quality) and underscore the importance of dietary context in reproductive toxicology.

P-00030 Air–Water Exchange and Atmospheric Distribution of Persistent Organic Pollutants Along a Coastal–Oceanic Transect in the Southeast Pacific

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Introduction
Persistent organic pollutants (POPs) are degradation-resistant compounds that accumulate in the environment and undergo long-range transport. The oceans act as a major sink via atmospheric transport, deposition, and air–water exchange, governed by physicochemical and environmental factors (Pozo et al., 2022). Although Atlantic studies have improved understanding of POP distribution, data for the Pacific—especially along continent-to-island transects—remain limited, highlighting the need to better understand air–water exchange in the open ocean.

Materials and Methods
During the CIMAR 28 Oceanic Islands cruise, atmospheric samples (gas and aerosol phases; n = 9) were collected using high-volume air samplers (~40 m^3 h^{-1} for 24 h) aboard the research vessel. Meteorological parameters, including temperature and wind speed, were recorded simultaneously. Surface seawater samples (<5 m depth) were collected using the ship's underway system. The particulate phase was obtained using pre-combusted GF/F filters, and the dissolved phase was extracted using XAD-2 resin columns, with volumes exceeding 200 L. In the laboratory, samples were extracted by Soxhlet, followed by purification and fractionation using alumina and silica columns. Target compounds included PCBs, organochlorine pesticides (OCPs), polycyclic aromatic hydrocarbons (PAHs), and PBDEs, analyzed by gas chromatography coupled to mass spectrometry (GC-MS). Fugacity in air and water was estimated following established methods (Galbán-Malagón et al., 2012), and net air–water fluxes were calculated using the Whitman two-film model (Bidleman and McConnell, 1995).

Results
Atmospheric POP concentrations showed clear differences among compound groups. ∑PAHs were the most abundant in the gas phase (1.13–4.68 ng m^{-3}), whereas ∑OCPs were lower (0.0202–0.0385 ng m^{-3}). ∑PCBs ranged from 0.0047 to 0.0083 ng m^{-3}, and ∑PBDEs were detected at trace levels (0.0001–0.0002 ng m^{-3}). In surface seawater, ∑PAHs also dominated (4.33–9.11 ng m^{-3}). ∑OCPs ranged between 0.0165 and 0.0338 ng m^{-3}, while ∑PBDEs (0.0003–0.0016 ng m^{-3}) were consistently higher than in air. ∑PCBs showed the greatest variability (0.0119–1.6383 ng m^{-3}), with localized peaks.

Discussion and Conclusion
PAHs dominated in both compartments, with higher dissolved concentrations indicating net atmospheric deposition. OCPs showed similar levels in air and water, suggesting near-equilibrium conditions. PBDEs accumulated in seawater despite low atmospheric concentrations, reflecting their physicochemical properties. In contrast, PCBs exhibited strong variability in water, likely driven by oceanic and biological processes rather than direct atmospheric inputs. Overall, these patterns highlight the importance of partitioning behavior and environmental conditions in controlling POP distribution. This study provides new insights into POP dynamics along a Pacific Ocean transect, emphasizing the ocean's role as both a sink and a dynamic reservoir, and the need to consider coupled atmospheric and oceanic processes to better understand their environmental fate.

Acknowledgment
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P-00031 Analysis of Dioxins Using H_2 and N_2 as Carrier Gases

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Introduction
Dioxins are characterized by persistence, bioaccumulation, long-range environmental transport, and toxicity, and are therefore regulated as persistent organic pollutants (POPs) under the Stockholm Convention on Persistent Organic Pollutants.Conventionally, the analysis of dioxins has been performed using double-focusing high-resolution gas chromatograph mass spectrometer (GC-HRMS) with helium as the carrier gas. However, recent helium supply shortages and rising costs, along with the discontinuation of HRMS instrument production, have created a need for alternative analytical approaches and carrier gases.In this study, we investigated the use of hydrogen and nitrogen as carrier gases for dioxin analysis, an approach that has seen little application to date. We also compared the separation performance and detection sensitivity with conventional helium-based methods.

Materials and Methods
Dioxin standard solutions (CS1H–5H) were purchased from Cambridge Isotope Laboratories, Inc. The standard solution was analyzed using GC-MS/MS (H2) (Shimadzu GCMS-TQ8040NX) and APGC-MS/MS (N2) (Agilent 8890 GC coupled with Waters Xevo TQ-XS)1,2. Hydrogen and nitrogen were used as carrier gases, and the GC columns employed were Rxi-5Sil MS (Restek, 40 m × 0.18 mm) and BPX-DXN (Trajan Scientific, 60 m × 0.25 mm). Measurement conditions were optimized to achieve maximal separation of dioxin congeners and sufficient sensitivity. Quantitative performance was evaluated using calibration curves prepared from standard solutions at multiple concentrations. Linearity was assessed by the coefficient of determination (R^2), reproducibility was evaluated by relative standard deviation (RSD), and instrument detection limit (IDL) and instrument quantification limit (IQL) were calculated to assess the analytical reliability.

Results
Calibration curves prepared using standard solutions at multiple concentrations exhibited excellent linearity, with R^2 greater than 0.99. RSDs were below 10%, indicating good reproducibility. IDLs and IQLs were determined by measuring the lowest calibration concentration (0.1–0.3 ng/mL) five times and calculating the standard deviation of these measurements. As a result, IDLs and IQLs ranged from 0.2–3 pg for GC-MS/MS (H_2) and 0.01–0.1 pg for APGC-MS/MS (N_2), demonstrating that the nitrogen-based conditions provided higher sensitivity, comparable to that achieved under helium carrier gas conditions. Notably, under hydrogen carrier gas conditions, certain analytes exceeded the specified IDLs, suggesting the need for optimization of analytical parameters. Overall, these findings confirm the feasibility of dioxin analysis using nitrogen carrier gas. However, potential matrix effects in environmental samples should be carefully considered, and further validation using real environmental matrices is planned.

Acknowledgment
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P-00034 Paternal exposure Decabromodiphenyl ether affects spermatogenesis in mouse offspring and and its related mechanism

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Introduction
Decabromodiphenyl ether (BDE-209), a prevalent brominated flame retardant, is widely distributed in environment, including quatic systems, soil, and atmospheric particulates [1].Some studies found that BDE-209 may pose risks to the male reproductive system, resulting in permanent harm even after exposure has ended[2,3]. The previous study showed that prenatal exposure to BDE-209 leads to spermatogenesis disorders. BDE-209 has been recognized for its adverse effects on the male reproductive system [4,5]. The underlying mechanisms through which BDE-209 impacts the reproductive function of offspring are not yet fully understood.

Materials and Methods
The present study classiffed institute of cancer research (ICR) mice into control and BDE-209 treatment groups, administering doses of 0 and 75 mg/(kg ·day), respectively. After 50 days of exposure, normal female mice were co-housed with the male mice, and their male offspring were sacriffced at 2 and 12 months of age.

Results
The results showed that paternal BDE-209 exposure decreased both sperm quantity and quality in offspring. Furthermore, exposure to BDE-209 resulted in DNA damage and the upregulation of the cyclic GMP-AMP synthase (cGAS)–stimulator of interferon genes (STING) DNA-sensing and inffammatory signaling pathways. The activation resulted in Z-DNA binding protein 1 (ZBP1) binding to the mitochondrial antiviral signaling protein (MAVS), subsequently activating mitochondrial apoptosis in the testes. The activation of the cGAS-STING pathway inhibited mitophagy, leading to senescence in the testes of male offspring. In vitro studies indicated that the cGAS inhibitor RU320521 (RU.521) effectively reversed the cGAS-STING pathway activation, alleviated the mitophagy inhibition, and decreased apoptosis and senescence in mouse spermatocyte line GC-2spd cells treated with BDE-209.

Discussion and Conclusion
The results suggested that paternal BDE-209 exposure might affect spermatogenesis in mouse offspring by activating the cGAS-STING pathway and inhibiting mitophagy. This study provided valuable insights into the mechanisms underlying BDE-209-induced male reproductive toxicity, and had important scientiffc and practical implications for maintaining biodiversity and population health in general

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P-00037 Mixture effects of an emerging contaminant (ibuprofen) and fungicides: implications for pharmaceutical accumulation and plant responses

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Introduction
Pharmaceutically active compounds are increasingly recognized as pervasive environmental contaminants, with ibuprofen (IBU) being one of the most frequently detected nonsteroidal anti-inflammatory drugs in agroecosystems. This study investigated the accumulation, translocation, and physiological and biochemical effects of IBU and co-applied fungicides (Benlate, Daconil, Validacin, and Oryzemate) in Cucurbita pepo cv. Soraya.

Materials and Methods
Plants were cultivated under controlled conditions in soil spiked with IBU (10 mg kg^{-1} d.w.), and responses were assessed at biochemical, physiological, and chemical levels.

Results
IBU accumulation was significantly higher in roots than in leaves across all treatments, with fungicide co-application markedly influencing uptake patterns. In particular, Benlate and Validacin enhanced root accumulation while limiting translocation, whereas Daconil and Oryzemate promoted root-to-shoot transport. IBU alone induced only minor physiological changes, including a slight, non-significant reduction in biomass and increased chlorophyll content, suggesting a hormetic response. In contrast, combined treatments, especially with Benlate and Daconil, resulted in pronounced reductions in biomass and photosynthetic pigments, indicating synergistic stress effects.
Biochemical analyses revealed substantial modulation of antioxidant and detoxification systems. Combined treatments increased activities of ascorbate peroxidase, peroxidase, and glutathione S-transferase, while catalase activity declined, reflecting altered reactive oxygen species management. Elevated lipid peroxidation and α-tocopherol levels in selected treatments further confirmed enhanced oxidative stress.

Discussion and Conclusion
These results demonstrate that fungicides strongly modulate IBU behavior and toxicity in zucchini, leading to interaction-specific responses. These findings highlight the importance of considering mixture effects in environmental risk assessment of pharmaceuticals, as co-occurring agrochemicals can significantly alter contaminant uptake, translocation, and plant stress responses.

Acknowledgment
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P-00038 Remote but not pristine: pharmaceutical contamination of soils in a high-elevation tepui ecosystem

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Introduction
Remote ecosystems are often assumed to be insulated from chemical contamination; however, our results show that measurable pharmaceutical pollution can occur even in the absence of permanent human settlement. We evaluated the occurrence, spatial distribution, and ecological implications of pharmaceutical active compounds (PhACs) in soils from the summit of Roraima-tepui, a high-elevation "sky island" in the Guiana Shield subjected to unregulated tourism and lacking sanitation infrastructure.

Materials and Methods
Surface soils from anthropogenically influenced and naturogenic zones were analysed for 98 pharmaceuticals using HPLC–MS/MS, and potential risks were assessed using environmental risk quotients (RQenv), cumulative and mixture-based approaches, and antimicrobial-resistance-specific thresholds (RQAMR).

Results
Eleven pharmaceuticals were detected, including antibiotics, antifungals, analgesics, and psychoactive compounds. Compounds associated with direct human use (e.g., ciprofloxacin, clarithromycin, acetaminophen) were primarily confined to high-use areas, whereas others (notably fleroxacin, thiabendazole, pregabalin, and sulfadimethoxine) were detected more widely, including in naturogenic zones. These patterns indicate that intense rainfall and shallow sandstone soils facilitate redistribution of contaminants beyond their initial points of introduction. Ciprofloxacin reached concentrations up to 186 ng g^{-1} and was a major contributor to cumulative environmental risk estimates. Several compounds exceeded predicted no-effect concentrations, and cumulative RQenv values indicated elevated potential ecological risk. Antimicrobial resistance screening suggested strong selection potential for ciprofloxacin in tourist-impacted areas.

Discussion and Conclusion
These findings demonstrate that tourism can introduce and redistribute pharmaceutical contaminants across remote high-elevation landscapes, highlighting the vulnerability of hydrologically connected systems and the need to consider emerging contaminants in environmental assessment of protected areas.

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P-00041 Identification of persistent mobile chemicals and ultrashort chain perfluoroalkyl substances in full-scale drinking water treatment plants by target and suspect screening analysis

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Introduction
Persistent, mobile, and toxic (PMT) substances are increasingly detected in aquatic environments, posing emerging threats to drinking water safety. However, comprehensive monitoring of these compounds in full-scale drinking water treatment plants (DWTPs) remain limited. This study addresses that gap by analyzing paired raw and treated water samples from 28 DWTPs along two major river basins in Korea. T

Materials and Methods
Four US-PFASs and 14 other PMCs (all classified as vPvM, PMT, or both) that are frequently detected in aquatic environments were analyzed in this study. Paired raw and treated drinking water samples were collected from 28 full-scale DWTPs across areas with diverse anthropogenic activities, including large cities and major industrial complexes (E.g. chemical and textile facilities for plastics and rubber resin, and oil refining). In addition, suspect screening analysis using LC-HRMS was performed to identify unknown compounds in raw and treated drinking water.

Results
Trifluoroacetic acid (TFA) was detected in 100 % of raw water samples with an average concentration of 3365 ng/L, followed by metformin (DF: 85.7 %; mean: 294 ng/L), acesulfame (64.3 %; 144 ng/L), and melamine (39.3 %; 719 ng/L). Industrial sites exhibited significantly higher raw water contamination (mean: 6237 ng/L) than urban (5409 ng/L) and rural areas (3426 ng/L). In treated water, TFA, metformin, perfluoropropanoic acid (PFPrA), and acesulfame were detected in over 40 % of samples with concentrations ranging from 55.2 to 3629 ng/L, highlighting their persistence through treatment. Notably, PFPrA significantly increased post-treatment ($p < 0.01$), suggesting precursor degradation. This is the first study to report the occurrence of ultrashort-chain PFASs (US-PFASs) in Korea's drinking water systems. Additionally, suspect screening tentatively identified seven compounds at confidence levels (CL) 2 – 3, including industrial additives and pharmaceutical intermediates. These findings underscore the widespread occurrence, persistence, and potential health relevance of PMT and very mobile pollutants in DWTPs, emphasizing the need for improved monitoring, treatment strategies, and regulatory oversight.

P-00045 Assessing the health risks from inhaled airborne PCDD/Fs in Phu Cat

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Introduction
During Operation "Ranch Hand" from 1961 to 1971, the US military used approximately 80 million liters of herbicides, of which 61% was Agent Orange containing about 366 kg of dioxin, to spray over South Vietnam. Phu Cat, Bien Hoa, and Da Nang airports, where herbicides were stored, were dioxin hotspots [1]. Agent Orange/dioxin has long-term effects, seriously impacting human health; causing cancer, skin damage, liver damage, thyroid damage, diabetes, hypertension; damaging the respiratory, circulatory, digestive, endocrine, and nervous systems; causing gene and chromosome mutations, thereby causing congenital disabilities and reproductive disorders [2,3].

Materials and Methods
This study was conducted from 2015 to 2022 in the vicinity of Phu Cat (PC) former hotspot, in Vietnam. High-volume air samplers were used to monitor airborne PCDD/Fs. PCDD/Fs were analyzed by high-resolution gas chromatography coupled with high-resolution mass spectrometry. The average daily doses through inhalation (ADDI) were calculated [4].

Results
The risks of exposure to airborne PCDD/Fs are summarized in Table 1.
Table 1. ADDI for residents in Phu Cat between 2015 and 2022

Age group (year)	Birth to <1	2 to <3	3 to <6	6 to <11	11 to <16	16 to <21	21 to <31	31 to <41	41 to <51	51 to <61	61 to <71	71 to <81	≥ 81
Average	55.0	50.0	38.3	28.1	21.2	21.7	18.8	18.9	18.7	18.8	16.0	14.6	13.8
Min	5.66	5.15	3.94	2.89	2.18	2.24	1.94	1.95	1.93	1.94	1.65	1.51	1.43
Max	279	253	194	142	107	110	95.3	95.7	94.8	95.3	81.0	74.2	70.2

Discussion and Conclusion
There are three routes of PCDD/F exposure: about 90% of the PCDD/Fs entering the human body comes from foods, through the food chain; approximately 10% from inhalation; and less than 1% from contact. The WHO has recommended a tolerable daily intake (TDI) value of 1000-4000 fg TEQ/kg BW/day [4]. Thus, the TDI for airborne PCDD/Fs extrapolated from WHO corresponds to 100-400 fg TEQ/kg BW/day. ADDI values (Table 1) for adults in PC ranged from 1.43-110 fg TEQ/kg BW/day, with average values from 13.8 to 21.7 fg TEQ/kg BW/day, remaining below and only slightly above the lower threshold of 10% TDI extrapolated from WHO recommendations. For children, ADDI values (2.18-279 fg TEQ/kg BW/day, mean: 21.2-55 fg TEQ/kg BW/day) also remained below the lower threshold and within the 10% TDI threshold. Overall, the risk of PCDD/F exposure in PC (1.43-279 fg TEQ/kg BW/day, with an average of 52.8 fg TEQ/kg BW/day) was lower than in the areas surrounding the Bien Hoa hotspot during the social distancing period for Covid-19 prevention in 2020-2022 (14.6-208 fg TEQ/kg BW/day, average: 59.4 fg TEQ/kg BW/day) [5]. However, these levels were higher compared to the west (13-123 fg TEQ/kg BW/day, average: 38.8 fg TEQ/kg BW/day) and the south (6.2-107 fg TEQ/kg BW/day, average: 28.2 fg TEQ/kg BW/day) around the dioxin-treated areas in Da Nang [6].

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P-00046 Lipid modifications associated with dioxins contamination in cheeses: a case study

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Introduction
Dioxins and furans are persistent organic pollutants characterised by strong lipophilic properties and resistance to metabolic degradation. Due to their affinity for lipids, these contaminants accumulate preferentially in animal fatty tissues, reaching particularly elevated concentrations in high-fat food products of animal origin. Cheese is a complex dairy product whose lipid composition is influenced by animal species, geographical origin, and farming practices. Lipids in cheese include glycerolipids, phosphatidylcholines, phosphatidylethanolamines, phosphatidylinositols, phosphatidylserines, sphingomyelins, and free fatty acids, collectively representing key quality markers. Dioxin exposure activates the aryl hydrocarbon receptor (AhR) (1), a ligand dependent transcription factor that, upon binding dioxins, translocates to the nucleus and modulates genes involved in xenobiotic metabolism, immune regulation, and epithelial barrier integrity (2). This AhR-mediated signalling alters the intestinal immune environment by influencing host fermentation processes and lipid metabolism; consequently, the lipid profile of animal-derived food products, such as milk and cheese, could be influenced by changes in lipid metabolism and fermentation processes. Despite the well-documented toxicological relevance of dioxins, their specific effects on the lipid profile of food products remain poorly characterized. This study aims to evaluate the influence of dioxin contamination on the lipidomic profile of different cheese varieties using advanced analytical and chemometric tools.

Materials and Methods
Six cheese types were analysed, including two bovine, three caprine, and one ovine variety. Lipid extraction was carried out using a modified Folch protocol and the resulting extracts were analysed by UHPLC-Q Orbitrap MS for comprehensive lipid characterization. The collected data, including lipid identification were processed by LipidSearch™ v4.2.2.7 and Compound Discoverer 3.3 SP2 softwares. Dioxin and furans levels were quantified by isotope dilution analysis using GC-HRMS. Statistical evaluation of the lipidomic data was conducted through Principal Component Analysis (PCA) and Hierarchical Clustering Analysis (HCA).

Results
Detectable dioxin levels were found exclusively in one bovine cheese sample (upper bound sum 0.76 pg-WHO TEQ/g fat). Comprehensive lipidomic profiling identified multiple lipid classes, including glycerolipids, phospholipids, sphingomyelins, free fatty acids, and additional minor subclasses. PCA and HCA revealed that oxidized triacylglycerols (OxTG) and diacylglycerols (DG) were the lipid class most markedly differentiated in the dioxin-contaminated sample. The other lipid classes, particularly the polar species, contributed mainly to the discrimination of the samples based on animal species and geographical origin, rather than on the contamination status.

Discussion and Conclusion
Dioxin contamination is associated with alternations for important lipids in energy storage and metabolism (3). The elevated levels of OxTG detected in the contaminated bovine cheese suggest a potential pro-oxidative effect of dioxins on the lipid content of dairy products. This finding is consistent with the known capacity of dioxins to induce oxidative stress via reactive oxygen species generation, which may promote lipid peroxidation. On the other side, the observed down-regulation of DGs that serve as substrates for TG biosynthesis and as catabolites of TGs, it can suggest that metabolism of TG was disturbed by dioxin contamination.The ability of other lipid classes to differentiate samples based on species and geographic origin confirms the utility of lipidomics as a tool for cheese authentication and traceability (4). The lipidomic approach adopted here may be a useful tool for detecting contamination-related changes in the lipid composition of dairy products. Future studies should expand the sample set and integrate metabolomic and chemometric analyses to comprehensively characterize the effects of dioxin exposure on the quality and safety of dairy products.

Acknowledgment
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Levels and Trends (Abiotic)

P-00048 Combined fluorotelomer Alcohol/8270 Analysis using GC-MS/MS

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Introduction
The analysis of PFAS compounds in environmental samples has traditionally focused on ionic, non-volatile PFAS analyzed by LC-MS/MS. Many PFAS compounds, such as the fluorotelomer alcohols (FTOH), are neutral and semi-volatile and can be better analyzed by GC-MS/MS.

Results
While no EPA methods have been published, labs have analyzed these compounds with a variety of preparation techniques and column selections, including liquid/liquid extractions, headspace, and sorbent-based extractions on both volatile and semi-volatile type columns.
In this presentation we'll explore a combined 8270/FTOH method, focusing on small volume liquid/liquid extractions and GC-MS/MS using the new RMX-5Sil MS column. This workflow would allow labs to incorporate neutral PFAS compounds into their existing semi-volatile workflows, streamlining laboratory operations.

P-00050 Polycyclic Aromatic Hydorcarbons and other emerging chemicals of Arctic concern in permafrost: spatial and vertical distribution in the Canadian lowland tundra (Northwestern Territories, CA)

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Introduction
Permafrost has acted as a long-term sink for contaminants released since the beginning of the industrial era (Miur et al., 2025). Ongoing Arctic warming and increasing human activities may enhance the remobilisation of these pollutants through permafrost thaw and coastal erosion (Vonk et al. 2015). This study investigates the occurrence, spatial variability, and vertical distribution of polycyclic aromatic hydrocarbons (PAHs) and chemicals of emerging Arctic concern (CEACs) in tundra soils and permafrost sediments from the western Canadian Arctic. The work represents one of the first integrated assessments of legacy and emerging contaminants in the lowland tundra of the Northwestern Territories, Canada.

Materials and Methods
A total of 209 soil and permafrost samples were collected during field campaigns in August 2024 and 2025. Active layer thickness was measured in excavated soil pits, while deeper permafrost sediments were retrieved using a permafrost corer to target depths of up to 100 cm or until massive ground ice or bedrock was encountered. Sampling was coordinated with vegetation and berry collection campaigns. Quantitative analyses of 22 PAHs were performed using Accelerated Solvent Extraction (Thermo Fisher Scientific Dionex ASE 350) followed by Gas Chromatography–Triple Quadrupole Mass Spectrometry (Trace 1310 GC coupled with TSQ9000 TQMS, Thermo Fisher Scientific) at CNR-ISP, Venice, Italy. Where thirteen bisphenols and eight benzothiazoles were analysed using high-performance liquid chromatography coupled with tandem mass spectrometry (HPLC-MS/MS). Additional environmental parameters, including elemental and isotopic carbon and nitrogen composition, texture, organic matter, water content, and mercury species, are currently under investigation.

Results
PAHs were detected across both active layer and permafrost samples, showing strong spatial heterogeneity and variable vertical trends. Total PAH concentrations ranged from non-detectable values to >700 ng g^{-1}, with the highest concentrations associated with organic-rich horizons and buried permafrost layers. Low- and medium-molecular-weight compounds, particularly Naphthalene, Phenanthrene, and Retene, dominated the PAH profiles, while several high-molecular-weight PAHs, including benzo(b)fluoranthene and benzo(e)pyrene, were also frequently detected. The presence of Retene suggests an important contribution from natural pyrogenic sources linked to boreal vegetation burning. Among CEACs, Bisphenol A (BPA) was the most abundant bisphenol, although concentrations were generally low and highly variable. Other bisphenol analogues (BPF, BPAF, BPS) occurred sporadically and mostly near method detection limits, while BPAP showed occasional enrichment in selected horizons. In contrast, Benzothiazole compounds were more consistently detected throughout the soil profiles. Benzothiazole (BTH) was the dominant compound, reaching concentrations above 250 ng g^{-1} and displaying a relatively uniform vertical distribution compared with bisphenols. Episodic enrichments of BTH-SH and BTH-MeS were observed in selected permafrost intervals.

Discussion and Conclusion
The results demonstrate that Arctic permafrost stores both legacy contaminants and emerging industrial chemicals, with distinct vertical distribution patterns reflecting differences in transport pathways and environmental persistence. The widespread occurrence of PAHs and benzothiazoles highlights the potential for contaminant remobilisation under accelerating permafrost degradation. This study provides a first baseline dataset for the western Canadian Arctic and contributes to ongoing efforts to understand contaminant cycling and release in rapidly changing polar environments.

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P-00052 Removal of 6:2 FTOH from Water by MCM-41: Adsorption Performance and Analytical Method

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are persistent organic pollutants widely detected in environmental and drinking waters due to their extensive industrial use and extreme resistance to degradation. Their environmental persistence has been linked through epidemiologic and basic science research to a variety of adverse health outcomes, including endocrine disruption, immune and hepatic toxicity, impaired metabolism, and increased risks of cancer and other chronic diseases [1].
Among them, fluorotelomer alcohols (FTOHs) are of particular concern as volatile precursors capable of transforming into persistent perfluoroalkyl acids (PFAAs). 6:2 fluorotelomer alcohol (6:2 FTOH) can undergo oxidative degradation pathways leading to both long-chain perfluoroalkyl carboxylic acids (e.g., PFHxA, PFOA) and ultra-short-chain products such as trifluoroacetic acid (TFA), which exhibit high mobility and environmental persistence [2].
The widespread occurrence of PFAS precursors in aquatic systems highlights the need for effective materials capable of targeting not only perfluoroalkyl carboxylic and sulfonic acids (PFCAs and PFSAs), but also volatile precursors such as FTOHs. Conventional adsorbents, including activated carbon and ion-exchange resins, often show limited affinity toward FTOHs because of their distinct polarity and physicochemical properties.

Materials and Methods
In this study, MCM-41 was synthesized starting from a waste-derived silica source and subsequently functionalized with different surface modifiers to improve its stability in aqueous environments and enhance its affinity toward fluorinated compounds. Different functionalization degrees were investigated to optimize the balance between surface modification and accessibility of adsorption sites, while a non-functionalized material was used as reference [3,4].
Adsorption isotherms of 6:2 FTOH were determined in batch experiments to evaluate the uptake capacity of the prepared materials from aqueous matrices. Equilibrium concentrations were measured by headspace gas chromatography-mass spectrometry (HS-GC-MS), an analytical technique suitable for the quantification of volatile PFAS precursors.
The method exhibited excellent linearity (R^2 > 0.999) within the 0-200 ppb range, enabling reliable trace-level determination of 6:2 FTOH.

Results
Functionalized MCM-41 materials showed significantly enhanced adsorption performance compared to as synthesized, confirming the key role of surface modification in promoting interactions with neutral and hydrophobic PFAS precursors.

Discussion and Conclusion
These findings highlight the potential of waste-derived mesoporous silica as a sustainable material for the removal of volatile PFAS precursors from contaminated water systems.

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P-00053 Gendered exposure to persistent pollutants in Arctic food systems: insights from dietary patterns and food contamination

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Introduction
Arctic populations experience elevated exposure to environmental contaminants through the consumption of local foods, which remain deeply embedded in cultural identity, traditional practices, and food security. This contribution explores how the interplay between dietary habits and food contamination shapes exposure to persistent organic pollutants (POPs), with a specific focus on gender-related differences.

Materials and Methods
An online survey on food consumption habits was designed and disseminated between December 2024 and February 2025 among populations in Iceland and Greenland to identify major consumption trends, cultural practices and the most relevant food items to be collected for subsequent analysis and potential dietary exposure to organic contaminants.A set of representative locally sourced foods has been characterized for a broad range of POPs, including dioxins, PCBs, brominated flame retardants (BFRs), organochlorine pesticides, and PFAS.

Results
The data highlight strong differences in contamination levels across food types, with the highest concentrations observed in lipid-rich matrices such as fish liver and shark, reflecting the well-established bioaccumulative behavior of these compounds in Arctic food webs [1].

Discussion and Conclusion
Traditional diets, particularly those based on marine mammals and fatty fish, remain a cornerstone of Arctic food systems, food security and cultural identity, but also constitute a major pathway for exposure to lipophilic contaminants. Ongoing dietary transitions towards more westernized habits, combined with gender-specific consumption patterns, contribute to differences in exposure profiles, with women generally exhibiting lower contaminant burdens than men. These differences are further influenced by physiological elimination processes unique to women [2, 3].
Together, these findings highlight the multifaceted nature of contaminant exposure pathways in Arctic communities and underscore the importance of integrating food contamination data, traditional dietary practices, and gender-specific physiological and behavioral determinants into exposure assessment, food sufficiency and public health strategies.

Acknowledgment
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Progress in non-polar POPs Analysis

P-00055 Development of an Ultra Sensitive APGC MS/MS Analytical Method for POPs Pesticides Employing Nitrogen as the Carrier Gas

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Introduction
Japan, similar to the EU, has adopted a positive list system for pesticide residue regulations. For pesticides without individually established MRLs, a stringent default limit of 0.01 mg/kg is enforced. However, the inherent complexity of food matrices often leads to analytical interference. One approach to reducing matrix interference is to add sample pretreatment steps, although this requires comprehensive knowledge of pesticide and matrix properties. Another approach is to dilute the analytical solution, but this demands instruments with sufficient sensitivity to detect pesticides at lower concentrations.
In gas chromatography mass spectrometry (GC-MS) analyses of pesticide residues, helium has traditionally been used as the carrier gas. However, the rapid increase in global helium demand, particularly driven by semiconductor manufacturing, has resulted in supply shortages and substantial price escalation. Consequently, the use of alternative carrier gases such as hydrogen or nitrogen is being considered in Japan. Despite this shift, several challenges remain, including reduced analytical sensitivity, diminished chromatographic separation, and potential chemical reactivity between the analytes and the alternative gases.
The APGC ion source developed by Waters is classified as an atmospheric pressure ionization modality. Because its ionization process proceeds via nitrogen facilitated chemical ionization, employing nitrogen as the carrier gas does not incur the substantial sensitivity deterioration commonly associated with electron ionization (EI) systems. Furthermore, because it constitutes a softer ionization technique compared with conventional EI, the molecular structure of analytes can be preserved during ionization, thereby enhancing selectivity and suppressing interference peaks as well as baseline elevation. This study describes the development of an ultra-high sensitivity APGC MS/MS method for the determination of POPs pesticides using nitrogen as the carrier gas, and presents the results obtained from its application to food samples.

Materials and Methods
APGC MS/MS (Agilent 8890 GC – Waters Xevo TQ Absolute) was used as the analytical instrument with nitrogen as the carrier gas. An Rxi 5Sil MS column (Restek, 30 m × 0.25 mm I.D. × 0.25 µm film) was utilized, and the injection volume was set to 0.5 µL. The target analytes included the POPs pesticides α endosulfan, β endosulfan, and heptachlor epoxide. Green coffee beans and eel were selected as representative food matrices for method evaluation.

Results
Sensitivity was evaluated using standard solutions with 0.5 µL injection. α and β endosulfan were detectable at 0.02 ng/mL, while heptachlor epoxide was detectable at 0.05 ng/mL. Reproducibility was assessed at 0.05 ng/mL for α and β endosulfan and at 0.1 ng/mL for heptachlor epoxide, and satisfactory performance was achieved for all analytes. Quantification of the samples was performed using the standard addition method. As a result, quantification limit was achieved at levels several to several tens fold lower than those attainable with existing EI-GC-MS/MS method.

Discussion and Conclusion
These findings demonstrate the potential of the APGC MS/MS system using nitrogen as the carrier gas for highly sensitive quantification of POPs pesticides in food matrices.

Per and polyfluorinated substances (PFAS): Toxicity

P-00056 Synthetic phenolic antioxidants and per- and polyfluoroalkyl substances in dog's – reason for concern for pet and human health?

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Introduction
A rather new group of chemicals of concern, with high-production volume, are the synthetic phenolic antioxidants (SPAs). These compounds are scavenging radicals to increase the shelf-life of products and food. SPAs are used in cosmetics, preservatives, food-contact materials (FCM), plastics and rubber, glues and adhesives (ECHA Chemical Database). Due to their phenolic structure, they are also potential endocrine disruptors. Unexpectedly high levels of certain SPAs were recently found by us in human serum from Stockholm, such as mean levels of 500 ng/mL serum of the FCM chemical A022461.
Together with PFAS levels, SPA levels have been analyzed in three different dog cohorts, seminal fluid (unpublished) and blood serum2 from Swedish Bernese Mountain dogs (n=66)), saliva and blood serum from Spanish dogs (n=30, mix breed and sex)3 and maternal blood plasma from pregnant Swedish bitches (n=84) (unpublished). These data will be presented at the conference.

Materials and Methods
A multi-target analytical method has been developed and validated for >40 organic phenolic contaminants1. The same method has now been validated for PFAS analysis and used here for the analysis of dog serum, seminal fluid and saliva. In short, distilled acetonitrile was used for denaturation and extraction of ca 200 mg of fluids. Bond-Elute EMR-Lipid (Agilent) was used for sample cleanup and the extracts analyzed using complementary gas and liquid chromatography coupled to a high-resolution mass spectrometer (Q Exactive HF hybrid Orbitrap, Thermo Fisher Scientific Inc.).

Results
PFAS levels in both Swedish and Spanish dogs had serum levels similar to human levels, in the range of 1-10 ng/mL. The high levels of SPAs reported in Swedish population could be confirmed in both Swedish Bernese Mountain dogs and Spanish dogs, being in the range of 10-1000 ng/mL. The cohort of the pregnant bitches is being analyzed and will be reported at the conference.

Discussion and Conclusion
PFAS have been regulated due to their ubiquitous presence and toxic effects. Here we highlight the presence of another group of potentially harmful group of chemicals, at levels far above the PFASs. The commonly used preservatives BHA and BHT were found in similar levels in dogs and humans, but the transformation products of BHT were ten times higher in dogs blood compared to humans. These metabolites are often more toxic than the parent compound4. Maternal transfer of SPAs to the developing child has been reported5. This together calls for further investigating the exposure to these SPAs, both for pet animal and human health concern.

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P-00057 Proteomic profiling of acute ozone exposure-induced myocardial injury: ferroptosis as a major regulator

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Introduction
Surface ozone pollution has become a major global public health issue. Increasing epidemiological studies have shown that either short- or long-term exposure to ozone is positively correlated to the risk of hospitalization and mortality for cardiovascular diseases. Nevertheless, the experimental evidence of myocardial toxicity of ozone exposure was limited, and the underlying mechanisms remain incompletely understood. Thereby, this study aims to explore the cardiotoxicity of acute ozone (03) exposure in mice and clarify its mechanisms by using proteomics, which provides a comprehensive framework for identifying molecular mechanism and major cellular processes involved.

Materials and Methods
Eight-week-old male C57BL/6J mice were randomly divided into four groups: control and low-, medium-, and high-dose O_3-exposed groups, with 10 mice per group. Mice in O_3-exposed groups were dynamic inhaled O_3 at the concentrations of 0.25, 0.5, and 1.0 ppm, respectively, for 6 hours daily over 7 days, while control mice inhaled filtered air. Myocardial pathological alterations were observed using HE staining, and serum cardiac troponin T (cTnT) levels were measured by ELISA to assess myocardial injury. Proteomics was then performed to identify differentially expressed proteins in myocardial tissue in response to O_3 exposure, followed by GO and KEGG enrichment analyses. The protein expression levels of hypoxia-inducible factor (HIF)-1α, heme oxygenase-1 (HO-1), ferritin (heavy chain FTH and light chain FTL), glutathione peroxidase 4 (GPX4), and acyl-CoA synthetase long-chain family member 4 (ACSL4) were detected by Western blotting.

Results
Compared with the control group, O_3-exposed mice exhibited inflammatory cell infiltration in the myocardium. The high-dose O_3-exposed mice showed disorganized myocardial fiber arrangement and elevated serum cTnT levels. Proteomics analysis revealed that O_3 exposure induced significant alterations in cardiac protein expression profiles, involving 565 differentially expressed proteins. These proteins were significantly enriched in pathways including complement and coagulation cascade, HIF-1 signaling pathway, and ferroptosis. To verify the role of ferroptosis in ozone-exposed myocardial tissue, ferroptosis-related protein expressions and iron level were measured in mice heart. In line with the interconnection of HIF-1 signaling and ferroptosis as indicated by proteomic analysis, ozone exposure significantly upregulated HIF-1α expression in mouse cardiac tissue, accompanied with the downregulation of GPX4 (a key ferroptosis molecule) and upregulations of FTH, FTL, HO-1 and ACSL4 expression in a dose-dependent manner.

Discussion and Conclusion
Acute ozone exposure could cause myocardial injury in mice, with its toxic mechanism associated with ozone-activated HIF-1α expression and ferroptosis.

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P-00058 Daphnia magna as a biological tool for managing microplastics and emerging contaminants in the wastewater systems

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Introduction
Emerging contaminants (ECs) are increasingly detected in wastewater streams. This group includes pharmaceuticals and personal care products, hormones, per- and polyfluoroalkyl substances (PFAS) and microplastics (MPs). Wastewater treatment plants (WWTPs) are essential for removing chemical pollutants and pathogens, ensuring the safe discharge of treated water into the environment. However, conventional processes often show limited efficiency in eliminating many ECs, resulting in their continued release into aquatic systems [1,2]. To address these challenges, several treatment strategies have been proposed, including molecularly imprinted polymers, nanocellulose-based absorbents and biological approaches based on algae and fungi [3].

Materials and Methods
In this context, the present study assessed a patented, biologically enhanced tertiary treatment strategy based on the filter-feeding activity of Daphnia magna [4]. This freshwater crustacean was employed as a living biofilter to evaluate its ability to reduce both ECs and MPs in treated wastewater. Monthly sampling was conducted over a five-month period (May-September 2025) at the UK National Trust wastewater facility. For each sampling event, influent and effluent (pre- and post-exposure to D. magna) samples were compared. Chemical contaminants were extracted using solid-phase extraction and analysed by ultra-performance liquid chromatography coupled with high-resolution mass spectrometry. MPs content was assessed through gravimetric measurement and further characterised using optical microscopy and μ-FTIR.

Results
A range of pharmaceuticals was detected, with tramadol and glyburide occurring most consistently across samples. Nevertheless, only clotrimazole and hydrocortisone demonstrated stable and repeatable removal over time. In contrast, a clearer reduction trend was observed for MPs, with outlet samples showing a consistent decrease in mass throughout the monitoring period. This suggests that D. magna can actively contribute to MPs retention, particularly for cellulose-based particles. Variations in removal performance were observed across months and appeared to correlate, at least partially, with rainfall events, indicating that environmental conditions may influence feeding and filtration efficiency.

Discussion and Conclusion
Overall, the results indicate that while D. magna shows a compound-dependent performance in the removal of dissolved ECs, while demonstrating a stronger and more consistent potential for MPs removal. These findings support the integration of biological filter feeders into nature-based solutions for advanced wastewater treatment applications.

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P-00059 Accumulation and temporal trends (2002–2023) of legacy and emerging persistent organic pollutants in common dolphins (Delphinus delphis) from Korean coastal waters

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Introduction
Elevated accumulation of persistent organic pollutants (POPs) in marine mammals remains a concern for the health and conservation of marine ecosystems. Cetaceans, such as dolphins and porpoises, are excellent sentinels for assessing POP accumulation in marine ecosystems due to their long lifespan, high lipid content, and slow metabolism. Among them, common dolphins (Delphinus delphis) are a widely distributed species inhabiting tropical to temperate waters worldwide. Long-term monitoring of POPs in marine mammals is essential to evaluate the effectiveness of regulations and to understand their environmental behavior in marine ecosystems. This study investigated accumulation patterns and temporal trends of legacy and emerging POPs in the blubber of common dolphins from Korean coastal waters over the past two decades (2002–2023).

Materials and Methods
Blubber samples of common dolphins (n = 160) were collected from individuals stranded or bycaught along Korean coastal waters between 2002 and 2023. Individuals were categorized into four groups according to sex and growth stage. Five contaminant classes, namely polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), polybrominated diphenyl ethers (PBDEs), novel brominated flame retardants (NBFRs), and dechlorane plus (DP), were determined using gas chromatography-mass spectrometry (GC-MS) and gas chromatography-triple quadrupole mass spectrometry (GC-MS/MS). Temporal trends were evaluated based on body length-adjusted concentrations derived from multiple linear regression (MLR) models to account for biological variability.

Results
In common dolphins, PCBs and DDTs were the dominant contaminants, whereas NBFRs and DP were detected at low concentrations and detection frequencies. Bioaccumulation of POPs was pronounced in mature male dolphins, whereas mature females exhibited lower concentrations, likely due to maternal transfer via placenta and lactation. Temporal trend analysis using body length-adjusted concentrations revealed that PCBs, DDTs, and PBDEs significantly declined over the study period. PCB concentrations decreased gradually, whereas PBDE concentrations exhibited the most rapid decline. Concentrations of BDE 184 showed an increasing trend, likely associated with debromination of highly brominated congeners. Unlike legacy POPs, NBFRs and DP did not show any significant temporal trends in dolphin tissues.

Discussion and Conclusion
This study determined the long-term accumulation profiles and temporal trends of legacy and emerging POPs in common dolphins from Korean coastal waters. Legacy and emerging POP concentrations showed age- and sex-dependent accumulation, implying long-term accumulation in males and maternal transfer in females. The significant declines of PCBs, DDTs, and PBDEs in dolphins over the last two decades reflect the effectiveness of regulatory actions, whereas NBFRs and DP showed no significant temporal trends. While PBDEs exhibited the most rapid decrease, the increasing signal of BDE 184 suggested ongoing reductive debromination of deca-BDE. Despite these overall declines, many dolphins still had PCB, DDT, and HCH concentrations above the thresholds for adverse effects, indicating ongoing ecotoxicological risks. These findings imply the need for long-term monitoring programs to track bioaccumulation and ecological risks of legacy POPs and their emerging substitutes in marine ecosystems.

Acknowledgment
This research was supported by the Korea Institute of Marine Science and Technology Promotion (KIMST) through a project entitled "Development of management technology for persistent organic pollutants (POPs) in the marine environment (RS-2024-00417889)" and funded by the National Institute of Fisheries Science (R2026004), Ministry of Oceans and Fisheries, Republic of Korea.

P-00060 Daily variations in atmospheric PFAS concentrations during transboundary and regional pollution episodes in Japan

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Introduction

The atmosphere serves as a major pathway for the spread of PFAS contamination and is also recognized as a reaction field for some PFAS that undergo modification. Therefore, monitoring various atmospheric PFAS is crucial for understanding their dynamics and behavior in the environment. We have conducted a survey of about 50 ionic and neutral PFAS in both the particle and gas phases of the atmosphere, elucidating the composition of atmospheric PFAS in Japan and the regional characteristics of their sources [1]. In this study, to gain deeper insights into the sources of atmospheric PFAS, we observed daily variations of their concentrations during transboundary and regional pollution episodes.

Materials and Methods

Atmospheric PFASs were collected using an FM4 (GL Science, Tokyo, Japan) air sampler, which combines a four-stage cascade impactor with polyurethane foam and activated charcoal fiber filters. Air sampling was conducted in Osaka for 24 hours at a flow rate of 20 L/min during a transboundary air pollution episode in February 2025 and a regional pollution episode in April 2025. Additionally, we sampled the atmospheric PFAS at a remote island in November 2024. Extraction and analytical methods were based on our previous report [2]. Native and labeled stock solutions of PFAS were purchased from Wellington Laboratories (Guelph, Ontario, Canada). We quantified 28 ionic PFAS and 18 neutral PFAS using LC-MS/MS and GC-MS/MS, respectively. We also performed non-target screening of neutral PFAS using GC-Orbitrap-MS [3]. The sum of the concentrations of PFAS (Σ46PFAS) was calculated by excluding data below the limit of detection.

Results

We detected 23 ionic PFAS and 9 neutral PFAS in the samples collected in Osaka and on the remote island. This is the first study to measure such a wide variety of PFAS on this remote island, with the Σ46PFAS ranging from 170 to 230 pg/m^3. The Σ46PFAS in Osaka City ranged from 930 to 2,400 pg/m^3 during the transboundary pollution episode and from 720 to 1,900 pg/m^3 during the regional pollution episode. The major components of atmospheric PFAS in Osaka were PFBA (240 pg/m^3), PFHxA (93 pg/m^3), PFBS (170 pg/m^3), and 6:2 FTOH (370 pg/m^3). Relatively higher concentrations of long-chain PFCA (PFNA: 180 pg/m^3, PFUnDA: 80 pg/m^3) and iodide PFAS (PFBuDiI: 800 pg/m^3, PFHxDiI: 160 pg/m^3) were observed during the transboundary pollution episode. Even during the regional pollution episode, there were days when PFNA (160 pg/m^3) and PFUnDA (230 pg/m^3) concentrations were significantly higher than on the previous or following day.

Discussion and Conclusion

Our 2022 study found that PFHxA concentrations in Osaka (annual average: 220 pg/m^3) were higher than in other regions of Japan, and it was estimated that the higher contribution of emissions from fluoropolymer manufacturers in Osaka. However, the average PFHxA concentration in Osaka in this study was 93 pg/m^3, which was comparable to that in other regions. Concentrations of FTOHs, one of the precursors of PFHxA, have not decreased. These results suggest that PFHxA concentrations have decreased over the past few years, indicating a possible reduction in PFAS emissions from fluoropolymer manufacturers. Whether the pollution episode is transboundary or regional, remarkable daily variations in the concentrations of some long-chain PFCA and iodide PFAS were observed. It would be desirable to identify the sources of these compounds, but this requires the accumulation of further data and analyses that take meteorological information into account.

Acknowledgment

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P-00062 Preliminary assessment of exposure of dogs and cats to dioxins and related compounds contained in pet food

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Introduction
Dioxins and PCBs are considered to be the most toxic compounds in the group of persistent organic pollutants. They are characterized by high stability in the environment and lipophilic properties, which causes their bioaccumulation in adipose tissue and biomagnification in the food chain. They enter the human and animal body mainly through food. The most common cause of contamination of food of animal origin is feeding farm animals with feed containing dioxins and PCBs. The problem of the presence of these chemical contaminants is well recognized in the food chain and human exposure. Feeding pets (dogs, cats) with appropriately composed feed is intended to provide them with a complete diet and support their health. However, in the case of persistent organic pollutants, the high lipid content in pet food makes it an ideal source of exposure to dioxins and PCBs for dogs and cats. Animal-derived materials added to feed, such as fish and fish meal, may be naturally contaminated with these compounds. Contamination of feed can also occur during production, processing, and transport.
Long-term exposure of pets to elevated levels of dioxins and PCBs in their food may be one of the reasons for the increased incidence of lifestyle diseases. Domestic animals are increasingly being diagnosed with cancer, metabolic diseases (diabetes), endocrine disorders (hyperthyroidism, hypothyroidism, Cushing's syndrome) or reproductive problems.

Materials and Methods
The research material consisted of purchased samples of various types of commercial dog and cat food. For each type of animal, 20 samples of dedicated food were tested, half of which were dry foods and the other half wet foods. The samples were analyzed using an accredited procedure based on gas chromatography coupled with high-resolution mass spectrometry (HRGC-HRMS).

Results
For all pet foods tested, the average concentrations of total PCDD/PCDF and PCDD/PCDF/dl-PCB were 0.11 ± 0.13 and 0.28 ± 0.42 ng WHO-TEQ/kg of feed at 12% moisture content, respectively, which represents approximately 6% and 6% of the maximum permissible level (ML). For dl-PCBs, the average concentrations were 1.24 ± 2.10 µg/kg of feed at 12% moisture content, which represents 3% of the ML.
The highest concentration of total PCDD/PDCF was determined in a sample of wet dog food at 0.82 ± 0.13 ng WHO-TEQ/kg, which represents 47% of the ML. The highest concentration of total PCDD/PDCF/dl-PCB was determined in a sample of wet cat food at 2.45 ± 0.68 ng WHO-TEQ/kg, which represents 49% of the ML. For ndl-PCBs, the highest concentration was also determined in a sample of wet cat food at 10.60 ± 2.40 µg/kg of feed at 12% moisture content, which represents 27% of the ML.

Discussion and Conclusion
Studies on the exposure of companion animals to POPs in food have been conducted only to a limited extent, which is why there are few publications on this issue in the literature. In Poland, this issue has not yet been studied either. Our preliminary studies revealed that the highest concentrations of the tested POPs occurred in wet food for both cats and dogs. In most cases, dry food samples were at the limit of quantification (LOQ). The concentrations of dioxins and PCBs in the samples tested did not exceed the maximum permissible limits for dioxins and PCBs. However, in wet pet food, we found concentrations of PCDD/F and PCDD/F/dl-PCB at half the maximum permissible limit. Further studies should therefore focus on this type of pet food and expand the scope of analysis to include other persistent organic pollutants.

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P-00064 Occurrence and source characterization of environmental contaminants in novel plant based foods

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Introduction
The market for novel plant based foods (NPBFs) has grown rapidly in recent years; however, data on their chemical food safety remain limited and so far focused on specific classes of chemical compounds, including organophosphate flame retardants, plasticisers and chlorinated paraffins (1, 2).

Materials and Methods
This study provides a comprehensive characterisation of chemical contaminants in NPBFs, with a particular focus on per and polyfluoroalkyl substances (PFAS) quantified via LC-MS/MS, metals quantified via HR-ICP-MS, and additional compounds identified using high resolution mass spectrometry (HRMS) based suspect screening. We analysed a total of 52 NPBF samples, including different types of PB meat , cheese , and fish alternatives, purchased in Belgium, Germany, and the United Kingdom.

Results
Targeted analysis revealed frequent detection of PFAS across all samples, albeit generally at low concentrations and mostly below defined maximum levels for food. Among the four priority PFAS, perfluorooctanoic acid (PFOA) and perfluorohexanesulfonic acid (PFHxS) were most prevalent, with higher levels observed in highly processed plant-based (PB) cold meat and sausage alternatives, suggesting industrial processing as a potential source for these chemicals. Metals were commonly detected in low concentrations across samples. The toxic metals arsenic and cadmium were found at the highest concentrations, predominantly in processed soy products highlighting the influence of product composition and agricultural pathways on the food contamination with metals.
Using HRMS based suspect screening, 65 compounds were annotated, mainly categorizable as industrial chemicals and plastic additives. Notably, the antioxidant 1,2 dihydro 2,2,4 trimethylquinoline, an antioxidant not permitted for use in food contact materials, was frequently detected across samples (detection frequency 48%), suggesting contamination related to industrial processing and further highlighting industrial chemicals as class of concern in NPBFs. Although suspect screening does not provide quantitative data, it is a valuable tool for identifying additional chemical classes of interest and prioritising future targeted analytes.

Discussion and Conclusion
Overall, contamination patterns of different contaminants varied between NPBF categories, indicating distinct contamination sources which might be linked to product composition and the degree of food processing. These findings demonstrate that NPBFs represent a relevant and distinct food category in terms of chemical contamination and underscore the need to incorporate these products into routine food monitoring programs and future regulatory frameworks to ensure consumer safety.

Acknowledgment
MSCA-FoodTraNet project (Grant agreement no. 956265); Exposome Centre of Excellence (Antigoon database number 50211)

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P-00065 Solving Analytical Challenges in PFAS Testing: Robust Calibration Data, Low Mass Confirmation and Isomer Quantification

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Introduction
Concern over the environmental and health impacts of long chain (≥C8) PFAS have driven their replacement with shorter chain PFAS, with EPA Method 1633 becoming the foundation for PFAS analysis in complex environmental matrices. However, challenges remain for laboratories using mass spectrometry.
Complex matrices which, even after solid phase extraction (SPE), can introduce unwanted ions into the detector, which can contaminate the quadrupole. Eventually this can affect signal response and therefore frequency of method calibrations.
Some short chain PFAS lack a confirmatory ion for multiple reaction monitoring (MRM)
Additionally, the diversity of PFAS, including branched and linear isomers, complicates accurate quantification
This study demonstrates solutions to these issues using new low mass transmission software settings on a high sensitivity tandem quadrupole mass spectrometer.

Materials and Methods
Sample extraction for domestic sludge (5 g), landfill leachate (50 mL), and environmental water (50 mL) followed the procedures outlined in EPA Method 1633. Extract cleanup was performed using weak anion exchange (WAX) solid phase extraction cartridges containing graphitized carbon black (GCB). An aliquot of the SPE eluate was acidified to pH < 5 using formic acid prior to analysis. Each sample matrix was injected 30 times per day over several weeks, with solvent quality control (QC) samples analysed at regular intervals throughout the analytical sequence.
Analyses were performed using a compact, high performance tandem quadrupole mass spectrometer with a slotted bandpass ion guide, featuring software enhanced low mass transmission.

Results
The system was run continuously for several weeks with challenging matrices, selected to test the robustness of the ion guide, alongside solvent calibration and QC checks. The new ion guide filters high m/z ions, preventing them from building up on the quadrupole and affecting robustness. System performance was evaluated for 42 PFAS analytes, during which quality control checks remained within ±30% tolerance, all quantified against a single calibration curve over the course of 5 weeks.
Looking into the leachate samples showed the presence of PFBA and PFPeA, compounds traditionally considered challenging to confirm due to the lack of identifiable product ions for confirmation. The enhanced low mass transmission settings allow for the selection of the m/z 19 fluoride ion, as a confirmatory product ion for these analytes. The ion ratio remained stable within a ±30% tolerance over the five-week study.
Some PFAS were detected in both branched and linear form, like PFOS and PFHxS. These were quantified against concentration calibrations created for each isomer and then reported as a total, helping to capture the full extent of PFAS contamination in the landfill leachate extract.

Discussion and Conclusion
This study demonstrates exceptional robustness, calibration longevity, and analytical confidence for PFAS analysis in complex environmental matrices. Collectively, these capabilities reduce the need for frequent recalibration, secondary confirmation methods, and unscheduled maintenance, improving laboratory efficiency and reducing consumable costs.

P-00069 Assessment of Dietary Exposure to PFAS in Foods of Animal Origin in Poland

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Introduction
Perfluoroalkyl substances (PFASs) constitue a persistent class of pollutants characterized by environmental durability, bioaccumulation, and long-range transport, posing risk to human and ecological health. The study aimed to determine the level of exposure to PFAS in food of animal origin among Polish adults and children.

Materials and Methods
The assessment was based on data regarding weekly consumption of eggs, meat, milk and fish, as well as the average concentrations of ∑4 PFAS (PFOS, PFOA, PFNA, and PFHxS) in these products. The concentrations of the analytes were determined by LC-MS/MS on a Sciex Triple Quad 7500 system. The analysis covered 26 egg samples, 61 samples of meat from farm animals, 22 milk samples and 25 fish samples.

Results
The concentarations of ∑4 PFAS measured in the food ranged from 0 µg/kg to 6.37 µg/kg (values below the LOQ were replaced with 0). The hierarchy of concentrations was as follows milk<meat<eggs<fish. The calculations were based on estimated weekly consumption for the following products: 3 eggs, 1250 g of meat from farm animals, 675 g of milk and 63 g of fish. To assess potential health risk, the calculated intakes were expressed as a percentage of the TWI (4.4 ng/kg body weight per week) and average concentration values for specific matrix groups were used in the calculations. For adults, the contribution of individual products to the TWI was as follows: fish 25%, eggs 0,6%, meat 0,3%, milk 0,1%. Total intake of ∑4 PFAS accounted for less than 26,0% of the TWI, indicating moderate exposure, with fish being the dominant source. For children, the TWI values for individual product groups were significantly higher: 76% for fish, 1.8% for eggs, 1,0% for meat and 0.27% for milk. Total intake was below 79% of the TWI. As with adults fish was the dominant contributor.

Discussion and Conclusion
Based on the obtained data, it can be concluded that consumption of the analysed animal-derived products does not result in the TWI being exceeded for either adults or children. The data presented relates to PFAS found in unprocessed products (samples of which were collected from livestock farms or slaughterhouses). In practice, exposure levels may be higher, as PFAS can migrate into food during processing or from packaging materials.

P-00072 Regulatory Evidence, Monitoring and Risk Management of PFAS in England

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Introduction

Abstract: Per and polyfluoroalkyl substances (PFAS) are a large and diverse group of synthetic fluorinated chemicals widely used in industrial applications and consumer products. They represent one of the most complex classes of environmental contaminants, characterised by extreme persistence, high environmental mobility, and the potential to bioaccumulate in humans and wildlife.
A robust evidence base is fundamental to supporting an effective regulatory response. Building on earlier work1, we have continued to expand our understanding of PFAS sources, uses, and environmental pathways in England. Data from our national monitoring network demonstrate widespread PFAS occurrence across groundwater, surface waters, estuaries, sediments, and biota. Long and short chain perfluoroalkyl acids are most frequently detected in groundwater and freshwater systems, while long chain compounds, particularly PFOS and related substances, tend to dominate in biota in England. PFAS measurements within the monitoring programme are undertaken using accredited high performance liquid chromatography coupled with triple quadrupole mass spectrometry (HPLC–QQQ), following methodologies described in Patel et al., 20262.
The Environment Agency, in collaboration with regulatory partners including the Health and Safety Executive (HSE), has implemented a coordinated programme of regulatory activity to support PFAS risk management. Key elements include:
A GIS based source risk screening tool has been developed to support targeted investigation and prioritisation of sites with the highest potential environmental risk.
Regulatory reviews of priority sectors including aviation, fire training sites, metal plating, textiles, paper and chemical manufacturing.
Integrating this monitoring evidence with data on UK REACH registrations, identifying data gaps relating to use patterns, releases and hazards. Emission estimates indicate the largest contributions arise from fluorinated gases, textiles and upholstery1,3.
Consultation on a UK REACH restriction on the manufacture and use of PFAS in Aqueous Film-Forming Foam (AFFF)4.
The regulatory evidence base will continue to evolve as analytical techniques advance, emissions and risks are further characterised, and regulatory interventions and treatment technologies are developed. This work integrates environmental chemistry, monitoring data, and regulatory decision making for highly persistent substances.
Key Words: Per and polyfluoroalkyl substances, PFAS, organofluorine

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Determination of PFAS in emissions and ambient air

P-00075 Thermal treatment tests for the removal of PFAS in emissions and residues from sewage sludge

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Introduction
The activities carried out included an experimental analysis aimed to evaluate the thermo-chemical degradation of a PFAS contamination in sewage sludge after thermal treatment, by characterization of input and resulting output materials. Emissions and residues.

Materials and Methods
All tests were conducted at the laboratories of Free University of Bozen-Bolzano located at NOI Techpark, Bolzano. To ensure maximum reliability of the analyses, UNIBZ relied on the support of the Eco Research for the development of the flue gas sampling line and the execution of the tests. Eurolab Srl performed all the characterization analyses of the input materials and of the products generated during the tests. The client supplied two sludge samples from a municipal wastewater treatment plants. In both cases, the material was not collected in its raw state but had been partially dried by the client to a specific moisture level. The sludge samples were characterized by UNIBZ in terms of moisture content and ash content, while the PFAS content was analysed by Eurolab. The two sludge samples had the following characteristics: Sludge_1: humidity 81.8% and Sludge_2: with humidity 60.0% The PFAS content in the two sludge samples was below the limit of quantification (LOQ) of 5 µg/kg),. For this reason, in order to proceed with the planned experimental campaign, a known quantity of PFAS were added to the sludge samples, to spike it, in order to obtain samples suitable for combustion testing. After spiking the resulting PFAS concentration was approximately two orders of magnitude higher than the LOQ and around 500 µg/kg for each PFAS compound: PFOS, PFOA, FOSA, 4:2FTS, 6:2FTS and 8:2FTS. The sludge samples were subjected to combustion in a laboratory-scale batch reactor. The reactor consists of a steel cylinder with an internal diameter of 4.5 cm and a length of 30.0 cm. Laboratory-scale combustion tests were performed in duplicate at two different furnace temperatures: At 900 °C and 1100 °C. In each test, 10 g of material was used with an air flow rate of 2.0 L/min. In order to maintain the positioning of the material bed — characterized by a thickness of approximately 2 cm — and to ensure air diffusion within it, the material was placed inside the reactor between two layers of quartz wool. To ensure the fastest possible heating rate, the reactor was positioned horizontally, allowing insertion into a preheated tubular furnace. Inside the reactor, specifically within the material bed, a K-type thermocouple was installed to monitor the temperature profile. The oxidizing flow (air) was controlled through a thermal mass flow controller, while downstream of the reactor the gas stream was continuously sampled through a dedicated line composed of tubing and conditioned glass collection devices, in order to "trap" all PFAS released during the combustion reaction. The sampling systems consisted of a condenser maintained at -10 °C for cooling the outlet gases, an impinger bottle containing NaOH solution (0.1 N) and a XAD2 trap with a glass wool filter.

Results
The test results clearly showed that, under the experimental conditions adopted, All added PFAS compounds were destroyed.

Discussion and Conclusion
We observed complete thermo-chemical degradation of the added PFAS in sewage sludge after combustion. Specifically, no traces of the added PFAS were detected in the emissions or in the combustion residues at 1100°C or at the lower temperature of 900°C.

Acknowledgment
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PFAS Analysis

P-00077 Development of a reference PFAS database for physicochemical, analytical, and bioanalytical characterization

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Introduction
Per- and polyfluoroalkyl substances (PFAS) constitute a class of thousands of anthropogenic compounds whose widespread presence in the environment raises serious health concerns. Their chemical structures, characterized by carbon chains of varying lengths where hydrogen atoms are replaced by fluorine, create extremely stable C-F bonds. Such stability gives PFAS thermal and chemical resistance, but also makes them highly persistent in the environment, earning them the label of "forever chemicals". Historical compounds such as PFOA and PFOS are associated with endocrine disruption, immune system impairment, or increased risk of certain cancers and are thus subjected to strict regulations. Nevertheless, a significant portion of PFAS remains insufficiently characterized. The challenge, therefore, lies in the understanding of their behavior and how their physicochemical properties determine their biological effects.

Results
Classical target analysis is currently used to obtain precise quantification of PFAS in different environmental compartments. However, neither does it provide information on the bioactivities of those compounds, nor can it help to uncover the thousands of other existing PFAS.This work aims to address this gap by developing a reference database for over 150 PFAS. Analysis is carried out with gas chromatography coupled with time-of-flight mass spectrometry as well as liquid chromatography coupled with high-resolution quadrupole-time-of-flight mass spectrometry to obtain spectral signatures that could be used for subsequent suspect screening analysis. Simultaneously, bioanalytical activity is evaluated through the capacity of PFAS to bind to thyroxine-binding protein, thus affecting the thyroidal system. Combining those new data with physicochemical parameters (vapor pressure, solubility, log Kow…), this approach will improve the identification and characterization of these compounds, particularly those that are still poorly documented or not documented at all.

Discussion and Conclusion
This database will serve as a key decision-making tool by strengthening environmental monitoring capabilities but also provide essential data for bridging chemical and bioanalytical information on PFAS.

P-00078 Emission Characteristics of 17 PCDDs/Fs from Waste Treatment and Non-ferrous Metal Facilities under the Integrated Pollution Prevention and Control (IPPC) System in Korea

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Introduction
Workplace environmental management in Korea operates through the Integrated Pollution Prevention and Control (IPPC) System. It integrates multiple permits into one, unifying management. By April 2026, 1,326 facilities were permitted. Since 2021, 17 PCDDs/Fs have been measured at these sites. This study characterizes emissions by comparing congener profiles between the waste treatment (incineration) and non-ferrous metal (aluminum) industries using stack emission analytical results.

Materials and Methods
Flue gas sampling followed Korea's Official Testing Methods (ES 10101.a and ES 01112.d). Isokinetic sampling used a semi-automatic sampler (KXC-572-0, APEX) for over 4 hours at STP (≥3 m^3 dry gas). Analysis followed ES 10902.1b. Samples were cleaned with multi-silica gel and alumina columns, then analyzed via HRGC/HRMS (JMS-800D, JEOL) using SP 2331 and VF-Xms columns. Normal data ranges were defined using the Interquartile Range (IQR) method after log transformation for comparative analysis.

Results
Furans showed a higher detection ratio than dioxins in both industries. Waste treatment facilities exhibited higher ratios of highly chlorinated dioxins, whereas non-ferrous metal facilities showed more low-chlorinated furans. Higher PCDF formation implies a significant de novo synthesis contribution via fly ash surface reactions. Heating fly ash rapidly desorbs PCDDs/Fs at 250–350°C. Highly chlorinated PCDDs/Fs undergo dechlorination at high temperatures, yielding abundant low-chlorinated furans.

Discussion and Conclusion
Differences exist in typical air pollution control device (APCD) systems between the two industries. In targeted non-ferrous facilities, recycled scrap is melted at ≥750°C, and the flue gas, cooled to ~250°C, passes through a single bag filter system. We hypothesize that these operational factors cause the observed differences in emission characteristics. Consequently, these findings are expected to help propose optimal PCDD/F emission mitigation methods tailored to each industry's specific conditions.

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P-00079 Fast and Reliable Quantification of PAH and PCB Congeners by GC/TQ using Hydrogen as Carrier Gas

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Introduction
GC/MS is widely regarded as a gold standard analytical technique for quantifying PAH and PCB due to its high sensitivity, selectivity, and ability to resolve complex environmental mixtures like soil, water, air, biota. Hydrogen is increasingly used as an alternative carrier gas to Helium in GC/MS due to benefits in chromatographic efficiency, cost, availability, and faster separations, but its adoption comes with potential trade-offs in safety, reactivity, and MS compatibility. Shown here is a fast GC/TQ method for the reliable quantification of PAH and PCB congeners using H_2 as carrier gas.

Materials and Methods
50 uL of sample were injected into the GC, using a PTV injector equipped with a BR-5ms, 20 m x 0.18 mm, 0.18µm column (all Bruker). Hydrogen was used as the carrier gas at a constant flow rate of 1.25 mL/min. A temperature gradient was applied at a total run time of 20 min for a representative mix of compounds for both species. The EVOQ GC-TQ Speed (Bruker) was operated in MRM compound-based scanning mode with a minimum of 12 spectra per peak.

Results
All PAH and PCB compounds could be fully separated during the GC run. Isomers or highly related compounds like Benzo[b]fluoranthene and Benzo[k]fluoranthene or the PCB congeners 28 and 31 were close to baseline resolved on the GC column. All compounds could be successfully quantified across typical concentration ranges of 0.02 – 1 ppb for PAH and 0.01 – 2 ppb for PCB with R2 > 0.999 for all compounds.

Risk Assessment and Risk Management

P-00085 Heterogeneous Variations on Historical of Mercury, Dioxins, and CO2 emissions from Medical Waste Incineration Process in China

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Introduction

Medical waste incineration (MWI) is one of the important sources of carbon dioxide (CO_2) and hazardous air pollutants (HAPs), threatening the triple planetary environmental crisis of climate change, biodiversity loss, and environmental pollution. Utilizing the EMEP/EEA air pollutant emission inventory and the IPCC 2006 guidelines, this study develops a comprehensive inventory of anthropogenic mercury (Hg), dioxins (PCDD/Fs), and CO_2 emissions from the MWI process in China among 2014-2023, employing a bottom-up approach at the plant level. The findings indicate that national MWI emissions of Hg, PCDD/Fs, and CO_2 increased by 1.33, 2.23, and 1.17 times, respectively, across Chinese mainland from 2014 to 2023. Notably, the response to the COVID-19 pandemic has led to a sudden increase of both Hg and PCDD/Fs emissions in the MW incineration process in China, particularly in 2022. Random forest model analysis identifies GDP and total population as key determinants of MWI, with feature importance values of 0.617 ($P < 0.05$) and 0.100 ($P < 0.05$), respectively. Additionally, a geographical detector analysis reveals that GDP, openness, and urbanization significantly influence pollutant and CO_2 emissions, with temporal variations in significance. These results provide critical insights for formulating medical waste disposal policies, promoting sustainable management practices in China, and enhancing preparedness for future health emergencies.

P-00086 Catalytic Oxidation Performance and Mechanism of Fe-Pd/γ-Al2O3 for Trichlorobenzene Degradation

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Introduction
Dioxins (PCDD/Fs) are typical persistent organic pollutants (POPs) with high toxicity, strong environmental persistence, and significant bioaccumulation, which are easily generated and released during medical and solid waste incineration. Chlorinated aromatic compounds are important precursors for dioxin formation, among which trichlorobenzene (TCB) is highly toxic, persistent, and recognized as a key precursor. Thus, efficient TCB degradation is crucial for controlling dioxin formation and mitigating environmental pollution. Catalytic oxidation is an effective method for removing chlorinated organic pollutants due to its low reaction temperature, high efficiency, and minimal secondary pollution, but noble metal catalysts are prone to chlorine poisoning, leading to decreased activity and stability. Therefore, developing catalysts with high activity and strong chlorine resistance is an important research focus.
In this study, 1,2,4-trichlorobenzene (1,2,4-TCB) was used as the model pollutant, γ-Al2O3 as the support, and a Fe-Pd bimetallic catalyst system was constructed to investigate the regulatory effect of Fe on the catalytic oxidation performance and chlorine resistance of Pd-based catalysts. Pd/γ-Al2O3 and Fe-Pd/γ-Al2O3 catalysts with different Pd loadings were prepared by wet impregnation. Their structural characteristics and surface chemical states were analyzed via XRD, BET, SEM, and XPS. Catalytic oxidation performance was evaluated in a self-constructed fixed-bed reactor, and the effects of reaction conditions and TCB isomers on degradation were examined. NH3-TPD, O2-TPD, in situ FTIR, and density functional theory (DFT) calculations were used to explore surface acidity, active oxygen species, and molecular-level adsorption/activation behaviors.

The results showed that Pd/γ-Al2O3 had good TCB catalytic oxidation activity, and Fe introduction significantly enhanced low-temperature activity and stability. Fe-Pd0.3/γ-Al2O3 exhibited the best performance, with significantly lower T50 and T90 than monometallic Pd catalyst, indicating a strong Fe-Pd synergistic effect. Increasing temperature improved TCB degradation efficiency and promoted the reaction pathway from incomplete to deep oxidation. The Fe-Pd/γ-Al2O3 catalyst maintained high degradation efficiency for 40 h at 300 °C, showing excellent long-term stability. 1,2,4-TCB had a higher degradation rate than 1,3,5-TCB due to its asymmetric chlorine distribution.
Characterization and DFT results revealed that Fe regulated the catalyst's surface structure and electronic properties, increasing active oxygen species and weak/medium acid sites, and forming a Pd-O-Fe interfacial structure to enhance C-Cl bond cleavage. Fe also dispersed chlorine adsorption, reducing Cl coverage on Pd sites and alleviating chlorine poisoning.
In summary, Fe-Pd/γ-Al2O3 exhibits excellent catalytic activity, stability, and chlorine resistance for TCB oxidation. The Fe-Pd synergistic effect promotes active oxygen formation, regulates surface acidity, and mitigates chlorine poisoning. This study provides theoretical insights for efficient chlorinated aromatic pollutant removal and guidance for chlorine-resistant catalyst design.

P-00091 Analysis of Volatile PFAS in Water Using Head-Space Solid Phase Microextraction-Gas Chromatography/Mass Spectrometry (HS-SPME GC/MS)

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Introduction
This note presents a rapid, low contamination method for analyzing volatile PFAS in water using automated head space solid phase microextraction (HS SPME) combined with single quadrupole gas chromatography/mass spectrometry (GC/MS). Using a Shimadzu QP2020 NX with an AOC 6000 Plus HS SPME autosampler and a DVB/CAR/PDMS fiber, 13 volatile PFAS classes are extracted directly from 10 mL water samples (salted to 2% NaCl) and quantified by GC/MS SIM with mass labelled internal standards. The automated HS SPME workflow minimizes sample handling and PFAS contamination, delivers linear calibration to low ng/L (ppt) levels (R2 ≥ 0.993), and shows negligible carryover (<0.2%), providing a practical, cost effective complement to LC/MS for PFAS species that are difficult to analyze by electrospray techniques.

Materials and Methods
Targets: 13 volatile PFAS across PFIs, FTIs, FTACs, FTMACs, FTOHs and FASAs.
Standards: stock 1000 mg/L in methanol → intermediate 10 mg/L; working calibrators prepared in 10 mL water (typical levels 2000 → 2.5 ng/L). Mass labelled internal standards (FTOHs, FASAs, FTACs) spiked at 1000 ng/L.
Sample prep: 10 mL water, add NaCl to 2% (w/v), vortex 30 s. Use LC/MS grade solvents; store standards at 4 °C. Consumables: SH 1 624Sil MS column, 50/30 µm DVB/CAR/PDMS SPME fiber, 20 mL headspace vials.
Instrumentation: Shimadzu QP2020 NX GC/MS + AOC 6000 Plus autosampler (HS SPME).
SPME: DVB/CAR/PDMS fiber; incubate 5 min, extract 30 min at 50 °C, 300 rpm; desorb 7 min at 240 °C (splitless). Sample: 10 mL headspace vial, 2% NaCl.
GC/MS: Nexis GC 2030, SH 1 624Sil MS column; oven: 40 °C (7 min) → ramp to 188 °C → to 300 °C.

Results
A selective HS SPME GC/MS method was developed and validated for 13 volatile PFAS in water. Chromatographic separation was achieved for most targets, and where partial coelution occurred (10:2 FTOH and 6:2 FTAC) the compounds were resolved reliably by using distinct SIM m/z channels. Representative TIC and SIM chromatograms in the source document show clear, well defined peaks for each analyte at environmental concentration levels. Calibration performance was strong: each compound produced a linear calibration over its reported range with correlation coefficients R2 ≥ 0.993 and response factor (RF) %RSD values generally below 20%. Calibration ranges varied by analyte (see Table 4 in the source) but extended down to low ng/L (ppt) levels, enabling direct quantitation in the 10 mL sample aliquot without additional concentration or back calculation steps. Sensitivity and background control were excellent. The SIM HS SPME approach provided ppt level capability for the targeted PFAS. Laboratory blanks (ultrapure water with methanol) showed no quantifiable target PFAS, and carryover was negligible (< 0.2%) after the highest calibrator. Precision indicators (RF %RSD per compound) support reproducible quantitation when using the mass labelled internal standards specified in the method.

Discussion and Conclusion
Overall, the automated HS SPME workflow on the AOC 6000 Plus coupled to the Shimadzu QP2020 NX offered a robust, low contamination, and cost effective solution for analyzing volatile PFAS in water. The method is presented as a practical complement to LC/MS for PFAS classes that are difficult to analyze by electrospray techniques.

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Legacy and Emerging Flame Retardants: Occurrence and Exposure

P-00093 Determination of dechlorane plus and related chlorinated flame retardants in soil samples by gas chromatography - high resolution mass spectrometry

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Introduction
Flame retardant (FR) are a wide range of chemicals generally used in manufacture of electronic, textiles, plastics and building materials in order to inhibit the development and propagation of flames, increasing the safety of these products.1 Developed in the mid-20th century as a substitute for Mirex, Dechlorane Plus (DP) is a widely used chlorinated flame retardant. However, recent studies have shown that Dechlorane Plus is toxic to both humans and the environment.2.3 In addition to their toxicity, DP exhibit persistent behavior in the environment. DP is estimated half-life is more than 24 years in water.4 Furthermore, DP exhibits minimal to no degradation under anaerobic conditions. The European Union and the Stockholm Convention have added DP to its legislation on persistent organic pollutants (POPs) but can still be applied in aerospace and medical imaging. To better characterize the occurrence of these pollutants in Taiwan, this study established a simultaneous analytical method for the determination of Dechlorane 601 (Dec-601), syn -DP and anti-DP with a specific focus on their distribution across various soil samples.

Materials and Methods
We collected soil samples from southern Taiwan. Approximately 5.0 g of each sample was weighed and spiked with a 13C10-labeled internal standard solution, followed by Soxhlet extraction to extract the target analyte. Following the extraction process, the extract was purified sequentially using acid silica (40% w/w) followed by Florisil solid-phase extraction (SPE). The extract was then concentrated to dryness and spiked with a 13C10-labeled recovery standard solution. The samples were analyzed using gas chromatography - high resolution mass spectrometry (GC-HRMS). Quality control analysis(n=5) showed that the recovery of Dec-601, syn-DP and anti-DP averaged 96.4±6.12 %, 97.7±6.93 % and 101±11.0 %. Additionally, the recovery of the internal standards consistently were 62.0±5.34% and 57.6±6.03% for 13C10-syn-DP and 13C10-anti-DP.

Results
In the present study, syn-DP and anti-DP were detected in all samples. In contrast, Dec-601 was detected in only a single sample at a concentration of 0.295 ng/g. syn-DP ranged from 0.04 ng/g to 1.35 ng/g. anti-DP ranged from 0.14 ng/g to 4.25 ng/g. The isomer ratio of DP is commonly used to elucidate its environmental behavior distribution across various matrices. The fractional abundance of the anti-isomer (fanti) is calculated as the ratio of the anti-DP concentration to the total concentration of syn-DP and anti-DP [fanti = anti-DP / (syn-DP + anti-DP)]. The fanti value in this study ranged from 0.68 to 0.86 with an average equal to 0.77±0.06.

Discussion and Conclusion
A robust and sensitive method has been developed and evaluated for the simultaneous analysis of Dec-601, syn-DP and anti-DP in soil. syn-DP and anti-DP were detected in all samples. In contrast, Dec-601 was detected in only a single sample at a concentration of 0.295 ng/g. Furthermore, this chromatography condition can effectively separate Dec-601 and syn-DP to avoid interference from Dec-601 on the fanti, which is helpful for the determination of the sample matrix. The fanti value in this study ranged from 0.68 to 0.86 with an average equal to 0.77±0.06, which is similar to previously reported values for soil about 0.70.4 While this study provides a critical baseline, additional monitoring with a broader spatial and temporal scope is required to fully elucidate the contamination sources and their long-term environmental impacts.

Acknowledgment
We would like to thank for the financial support provided from Ministry of Environment, Executive Yuan of R.O.C. (Taiwan).

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P-00094 Source Apportionment and Chemical Oxidative Potential Analysis of Atmospheric PAHs and PFAS in TSP in Vietnam and Taiwan

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Introduction
The association ofpolycyclic aromatic hydrocarbons (PAHs) and per- and Polyfluoroalkyl Substances (PFAS) with total suspended particulates (TSP) has garnered increasing attention due to their combined carcinogenic, mutagenic, and endocrine-disrupting effects, making them a critical focus of contemporary environmental health research. This study aimed to elucidate the source contributions and chemical oxidative potential (OP) of PAHs, and PFAS in TSP, with a focus on exposure patterns and associated toxicity.

Materials and Methods
Ambient TSP samples were collected using a high-volume air sampler (Model HV-500R, Sibata, Japan) at a constant flow rate of 500L/min for 48h. TSP samples were collected from industrial sites in Vietnam and Taiwan. 27 of PAH compounds were quantified via GC-MS/MS analysis, 24 of PFAS compounds were quantified via LC-MS/MS analysis. To apportion sources, the study employed Positive Matrix Factorization (PMF), Principal Component Analysis (PCA), and diagnostic ratio methods. Oxidative potential was assessed using the dithiothreitol (DTT) assay. Regarding the development of sampling methods, different adsorption media such as XAD-2, PUF, and activated carbon fiber (ACF) were compared. Results showed that XAD-2 was prone to pressure drop under high flow rate sampling conditions, and after cleaning and reuse, severe background interference was observed

Results
TSP levels in industrial sites in Vietnam and Taiwan reached 170 ± 71.1 μg/m^3 and 51.2 ± 14.4 μg/m^3 respectively. PAH levels in industrial sites in Vietnam was 1.41 ± 2.2 ng BaPeq/m^3. In Vietnam, the volume-based OP (OPv) was 1.343 ± 0.642 nmol/min/m^3 and the mass-based OP (OPm) was 8.9 ± 4.7 pmol/min/μg. In comparison, these values in Taiwan were significantly lower, at 0.178 ± 0.072 nmol/min/m^3 and 3.3 ± 0.5 pmol/min/μg, respectively. ΣPAHs21 concentration was 2.26 ± 2.50 (ng BaPeq/m^3). The concentrations range from a maximum of 11.11 pg/m3 (PFBA) to a minimum of 0.0009 pg/m3 (HFPO-DA). Short-chain PFAS (specifically PFBA) is the dominant congener in this dataset. Most compounds are present at levels below 0.1 pg/m3, with several long-chain species (like PFTrA, PFDS) and precursors (FOSA) detected at trace levels (< 0.02 pg/m3).

Discussion and Conclusion
Among the detected PFAS compounds, PFBA is the most dominant congener, with a concentration significantly higher than the others, followed by PFHxA and PFHpS. Results regarding statistical analysis of the relationships are underway and are expected to be updated within a short period of time.

Acknowledgment
I am profoundly grateful to Professor Kai-Hsien Chi for his mentorship and for providing the necessary facilities to conduct this research. Special thanks are also due to the esteemed professors and industry experts for their scholarly guidance and practical assistance. Their expertise has been a constant source of inspiration and help in overcoming the technical challenges of this project.

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P-00095 Comparative study on the in vivo metabolism of 2,2',3,4,4',5'-hexachlorobiphenyl (PCB138) and 2,2',3,4,4',6'-hexachlorobiphenyl (PCB140) in rats

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Introduction
PCB138, along with PCB153 and PCB180, has a chemical structure containing a 2,4,5-trichlorine-substituted benzene (245-type), making it very difficult to metabolize. PCB138 is also well known as a highly persistent PCB isomer and is detected at high concentrations in human blood, adipose tissue, and liver 1,2. Our previous studies on the metabolism using rat liver microsomes of PCB140, PCB155, and PCB182 which contain the corresponding 2,4,6-trichlorine-substituted benzene (246-type), revealed that all three are significantly more easily metabolized than 245-type PCBs, primarily producing a 3'-hydroxy (OH) metabolite, and also that phenobarbital pretreatment significantly accelerated the formation of 3'-OH metabolite by 10 to 50 times compared to the corresponding 245-type PCBs 3-5. In this study, we compared the in vivo metabolism of PCB138 and PCB140 in rats, namely the distribution of unchanged PCB and its 3'-OH metabolites in the liver and blood, and the excretion in the feces and urine.

Materials and Methods
PCB138, PCB140, and their 3'-OH metabolites were synthesized by the Cadogan method. Each PCB was administered orally to five-six male Wistar rats (200g body weight) once at a dose of 50 mg/kg of body weight. Feces and urine were collected daily for 4 days. Rats were sacrificed on the 4th day and blood and liver samples were collected. Unchanged PCB and its metabolites were extracted from each sample with the organic solvent. The organic layers were evaporated to dryness. The residues were methylated and subjected to GC-ECD and GC-MS. PCB208 was used as an internal standard. Unchanged PCBs and their metabolites were quantified using a calibration curve for each unchanged PCB.

Results
Feces: Within 4 days after administration, approximately 15% of the administered dose of unchanged PCB138 was detected, indicating that the remaining 85% was absorbed from the small intestine. In contrast, only 5% of unchanged PCB140 was detected. Furthermore, 3'-OH metabolites of both PCBs were also detected. A metabolite of PCB138 accounted for 0.56% of the administered dose over the first 2 days after administration. In contrast, a metabolite of PCB140 accounted for 2.66%, which was 4.3 times higher than that of PCB138. Urine: Neither both unchanged PCBs nor their metabolites were detected in any of rat urine samples. Liver: On day 4 after administration, unchanged PCB138 and its metabolite in the whole liver accounted for 3.3% and 0.04% of the administered dose, respectively. In contrast, unchanged PCB140 accounted for 0.39% of the administered dose, and no metabolite was detected in the whole liver.

Discussion and Conclusion
The in vivo metabolites of PCB138 and PCB140 were 3'-OH-PCB, consistent with their in vitro metabolites, and were detected only in feces, not urine. These results indicate that the metabolites produced in the liver are excreted through the hepatic ducts with bile. On day 4 after administration, unchanged PCB138 in the whole liver accounted for 3.3% of the administered dose, while unchanged PCB140 showed only 0.39% of the administered dose. These facts suggest that PCB138 is more likely to accumulate in the liver than PCB140, supporting previous reports 1,2. In conclusion, it is clearly demonstrated that in PCB metabolism, metabolic efficiency correlates well with hepatic accumulation.

Acknowledgment
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P-00097 Twenty-five years of continuous sampling to monitor PCDDs and PCDFs emissions of municipal waste incinerators in Walloon region of Belgium

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Introduction
Belgium was a pioneer of continuous sampling for the monitoring of PCDD/F emissions from municipal solid waste incinerators. As early as 2000, Walloon environmental legislation had integrated the EU emission limit of 0.1 ng TEQ/m^3, mandating strict compliance across the region. Consequently, all incineration units were equipped with automated continuous sampling systems, creating a network overseen by ISSeP for the past 25 years.

Materials and Methods
Sampling System
The AMESA system (Environnement SA) is a fully automated device developed for sampling PCDD/F phases onto XAD-2 cartridges. To ensure representative collection of particulates from stack gases, sampling is performed under isokinetic conditions. Key physical parameters from the furnace, stack, and samplers are continuously recorded and are accessible via remote monitoring.
Analytical Procedure XAD-2 cartridges are spiked with 13C-labelled extraction standards and undergo a 24-hour toluene extraction in large-volume Soxhlet apparatus. Once concentrated, extracts are purified using the automated Power-Prep (FMS) multistep system. Finally, quantification is conducted by HRMS Autospec (WATERS) coupled with a HRGC 7890 (HP-Agilent), using the internal standard method. All procedures strictly adhere to the CEN/TS 1948-5 technical specification.

Results
Exceedances evolution
Within just four years, annual exceedances plummeted from dozens of occurrences to only a few out of more than 130 annual samples. This long-term dataset emphasizes the synergy between continuous sampling and transparent, rapid reporting [1]. Such monitoring has incentivized operators to refine process controls and drastically reduce abatement system failures. Twenty-five years later, results remain a valuable tool for early detection of process issues.

Emitted mass evolution
Despite the steady increase in incinerated waste over the years, the total mass of dioxins emitted by incinerators has remained stable and accounts for less than 1% of total dioxin emissions in Wallonia.
Implementation costs
The investment for samplers and HRGC-HRMS was subsidized by the Walloon region. Operating costs, estimated at less than €1 per ton of waste, are borne by plant operators, which is considered reasonable given the public health benefits.

Reference method
The Walloon PCDD/F monitoring network, with its dataset of more than 4,000 samples collected over 25 years, has contributed to the validation of the technical specifications of the upcoming European standard for continuous monitoring of dioxins from stationary sources [2].

Discussion and Conclusion
The Walloon network for continuous sampling of PCDD/Fs has provided more accurate estimates of annual emissions for inventories over the past 25 years and enabled early detection of issues in furnaces and flue gas abatement systems. Large sample volumes collected over four-week periods also minimize detection and quantification limitations.

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P-00099 A Sensitive UHPLC-MS/MS Method Validated for the Analysis of UCMR 5 PFAS in Water

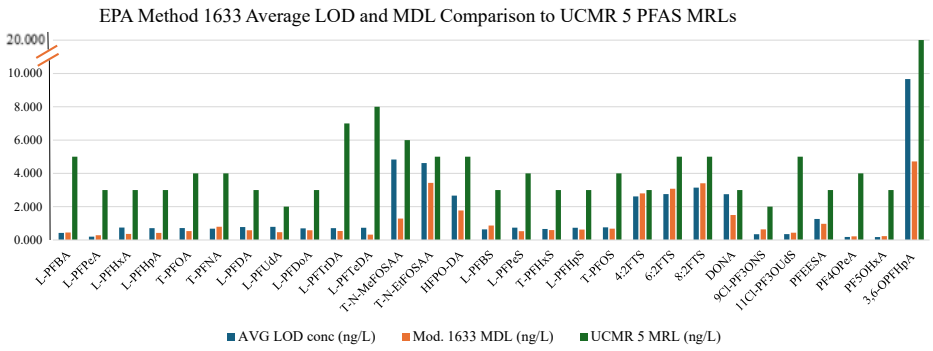
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Introduction
Increased concern over exposure to per- and polyfluoroalkyl substances (PFAS) and their associated negative health effects has resulted in regulatory bodies lowering the allowable limits in drinking water1,2. To monitor PFAS in drinking water at the levels required by newer regulations, highly sensitive and reliable analytical methodologies and instrumentation are needed. In this study, the performance of a modified U.S. EPA 1633 method for the analysis of PFAS in drinking water was evaluated in accordance with our ISO 17025 requirements for accuracy and precision. The detection limits of the developed method were also compared to the UCMR5 method reporting limits (MRLs) to assess method sensitivity.

Materials and Methods
All samples were analyzed for 1633 PFAS targets (40 total) using an ACQUITY™ UPLC™ I-Class PLUS System coupled to a Xevo™ TQ Absolute Mass Spectrometer. The 1633 calibration set was prepared with EPA-1633STK, MPFAC-HIF-ES and MPFAC-HIF-IS (Wellington Laboratories Inc.) to encompass a concentration range of 0.00400-0.156 ng/mL to 13.0-500 ng/mL and cover a dynamic range of 0.00625-0.500 ng/mL to 13.0-500 ng/mL. PFAS were extracted and cleaned up from water samples using Oasis™ WAX 200 mg/GCB 50 mg for PFAS cartridges.

Results
Method accuracy and precision were assessed by calculating the percentage error for eight replicate samples. Two of the replicates were extracts of ERA 404 (a reference material for PFAS in wastewater) and the remaining six replicates were ~ 500 g spiked blank (HPLC-grade) water. The average percent error was measured to be within ±20% of the reference or spiked values and replicates agreed within 20% RSD for all detected PFAS, demonstrating method trueness and consistency. MRLs are confirmed by fortifying and extracting seven replicate lab field blanks at or below the proposed MRL concentration, then verifying the reported concentrations are within the upper (≤ 150%) and lower (≥ 50%) prediction intervals (based on U.S. EPA Method 533)3. In this study, we applied the MRL confirmation calculations to seven limit of detection (LOD) replicates to verify the method's ability to meet the MRL requirement for the 29 UCMR 5 PFAS analytes. The method detection limits (MDLs) determined in our study were also compared to the UCMR 5 MRLs for internal method evaluation. The MRLs and MDLs calculated in this study were shown to be lower than the UCMR 5 MRLs for all the target PFAS.

Discussion and Conclusion
In this study, extension of the PFAS calibration standards to lower concentrations resulted in a 10-times increase in dynamic range for some PFAS



compared to the recommended calibration range used in EPA method 1633. PFAS were also accurately and reliably detected at lower levels in the water extracts, providing significantly improved detection limits. This study validates a modified EPA 1633 PFAS analysis method that provides the accuracy, precision, and increased sensitivity necessary to meet modern regulatory limits.

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Environmental and human exposure to plasticizers and other consumer product chemicals

P-00103 Chemical Exposures to Plastic Waste and Recycling Workers in Kenya and Thailand

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Introduction
Plastics contain over 16,000 chemicals, many of them endocrine-disrupting or otherwise hazardous, and most lack sufficient hazard data. Less than 1% of plastic chemicals are regulated under existing multilateral agreements. Workers engaged in plastic waste collection, sorting, shredding and recycling are believed to face elevated exposures, yet evidence from low- and middle-income countries remains scarce. The International Labour Organization has linked plastic-related occupational exposures to cancers, cardiovascular and respiratory disease. This study assessed personal exposures to plastic-associated chemicals among plastic waste workers, plastic recyclers and a control group without occupational plastic exposure in Kenya and Thailand, using silicone wristbands as passive samplers.

Materials and Methods
Personal exposure was assessed among 55 participants in Thailand and Kenya, divided into groups: plastic waste workers, recyclers, and reference, non-plastic related workers (7–10 participants per group; office/administrative staff reflecting regional baseline contamination). Participants wore silicone wristbands continuously for 120 hours and completed daily activity logs. Analysis was performed at the University of Chemistry and Technology, Prague. Polar analytes (OPFRs, phenols, and bisphenols) were extracted with basic methanol and quantified by UHPLC-MS/MS. Non-polar analytes (phthalates, alternative plasticizers, PAHs, and UV stabilizers) were extracted in hexane:dichloromethane (1:1, v/v), and if needed the extracts were purified via silica SPE and analyzed using GC-MS/MS and UHPLC-MS/MS. In total, 73 target chemicals across six categories were monitored.

Results
All six chemical groups were detected in every wristband, with 11 chemicals ubiquitous across all 55 participant´s wristbands. Plastic waste workers and recyclers consistently carried a higher chemical burden than control groups. Phthalates dominated the exposure profile; DEHP reached the highest concentrations of any analyte, with median levels of ~50,700 ng/g in Kenyan waste workers and a peak of 157,142 ng/g in waste workers in Thailand. Generally, exposures in Kenya were higher than in Thailand for the same occupational groups.
PAH concentrations were significantly elevated in workers; Kenyan waste workers showed a sum-PAH median of 388 ng/g, with phenanthrene levels four-fold higher than controls. While Thai recyclers showed the strongest OPFR signal (71 ng/g median), exposure in Kenya was widespread across all groups. Evidence of "regrettable substitution" was prominent: phthalate alternatives (DEHA, TOTM) and bisphenols (BPA, BPS) were detected in nearly every sample, with Thai controls surprisingly showing the highest DEHA median (3,946 ng/g), likely due to non-occupational sources.

Discussion and Conclusion
Plastic waste workers and recyclers are an occupationally vulnerable group with significantly higher chemical burdens. However, even control groups face exposure to EDCs like DEHP, DiBP, and DBP—phthalates restricted in the EU but largely unregulated in Africa and Asia. The prevalence of DEHA, TOTM, and BPS confirms that 'regrettable substitution' persists without group-based regulation. Since national laws cannot curb global chemical trade, the Plastics Treaty must mandate binding global controls, ban toxic recycling, and ensure full chemical transparency and worker protection.

Acknowledgment
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Progress in non-polar POPs Analysis

P-00105 Analysis of 2,3,4,7,8-pentachlorodibenzofuran in the blood of examinees collected during medical check-up for Yusho by GC-MS/MS coupled with boosted efficiency ion source (BEIS)

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Introduction

Yusho is the name given to a food poisoning incident that occurred in 1968 in western Japan. Blood level of 2,3,4,7,8-pentachlorodibenzofuran (2,3,4,7,8-PeCDF) is a primary diagnostic criterion for Yusho. For a long time, analysis of 2,3,4,7,8-PeCDF was done with gas chromatography coupled with magnetic sector-type high-resolution mass spectrometers (GC-HRMS). However, in recent years, the performance of triple quadrupole mass spectrometers (MS/MS) has improved significantly. In addition, the development of the boosted efficiency ion source (BEIS) offers sensitivity up. In this study, we analyzed 2,3,4,7,8-PeCDF in the blood of examinees collected during medical check-up for Yusho using a GC-MS/MS coupled with BEIS, and quantitation performance was evaluated by comparing the analytical values obtained by GC-HRMS.

Materials and Methods

Materials

The blood samples examined in this study were collected from 56 examinees during medical check-up for yusho from 2024 through 2025. All of these examinees gave informed consent to participate in this study.

Analysis of 2,3,4,7,8-PeCDF

Analysis of 2,3,4,7,8-PeCDF was performed using a Nexis GC-2030 (Shimadzu, Kyoto, Japan) gas chromatograph interfaced with a GCMS-TQ8050 (Shimadzu, Kyoto, Japan) triple quadrupole mass spectrometer coupled with BEIS. The separation was conducted on BPX-DXN, 60 m×0.25 mm i.d. (TRAJAN, Victoria, Australia).

Results

When analyzed using a GC-MS/MS coupled with BEIS, quantification was impossible for some samples due to sensitivity limitation. In particular, for samples with a concentration less than 3 pg/g lipids, 89% of the samples could not be quantified. Next, for the samples that could be quantified, ratios of analytical values by GC-MS/MS coupled with BEIS and GC-HRMS were calculated, and 97% of the samples had a ratio between 50% and 200%. In addition, a coefficient of determination (R2) was calculated between the analytical values obtained by the two methods. The R2 value was 0.84, and that showed a good agreement between the two methods.

Acknowledgment

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P-00110 Transport mechanisms of per- and polyfluoroalkyl substances via xylem sap of plants

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Introduction
Per- and polyfluoroalkyl substances (PFAS) have been widely used because of their useful industrial properties, including water and oil repellency and high chemical stability, such as resistance to heat and chemical degradation. More than 10,000 PFAS have been identified, with varying chain lengths and functional groups, resulting in substantial variation in their physicochemical properties. PFAS have attracted global attention because they persist in the environment once released and can be taken up by humans through drinking water and food; some compounds are also associated with adverse health effects.
Highly water-soluble PFAS are known to be transported to the aboveground parts of plants via transpiration, where they accumulate1. As a result, PFAS have been detected in the edible parts of a wide range of crop species. In contrast, in cucurbit plants such as zucchini, a protein known as major latex-like proteins (MLPs) acts as a transport factor for hydrophobic organic pollutants, leading to the accumulation of highly hydrophobic substances, such as dioxins and dieldrin, in aboveground tissues2,3.
In this study, we aim to clarify differences in PFAS accumulation patterns and concentrations by quantifying PFAS in the xylem sap of various crops. Furthermore, we will examine whether transport proteins such as MLPs contribute to PFAS transport to aboveground tissues by comparing accumulation patterns and concentrations between Cucurbitaceae species and plants from other families.

Materials and Methods
Eleven plant species from six families were cultivated for 3–4 weeks. Four kinds of PFAS with different chain lengths and functional groups—PFOA, PFNA, PFHxS, and PFOS—were applied either individually or as a mixture. Xylem sap was collected from stems, and PFAS concentrations were quantified using LC-MS/MS. Protein analyses, including SDS-PAGE, PFAS-binding assays, and in silico modeling, were conducted to investigate PFAS transport-related proteins.

Results
When applied individually, PFAS detection in xylem sap was largely reflected by their water solubility, with concentrations decreasing in the order PFHxS > PFOA > PFNA > PFOS. Similar trends were observed in mixed treatments, although overall concentrations were higher than in single-compound applications. Total PFAS concentrations were particularly high in Cucurbitaceae and Brassicaceae species. In spinach, a high proportion of PFHxS was attributed to active transpiration. Although PFOS is less water-soluble and generally detected at low levels, it was detected at relatively high concentrations in zucchini and pumpkin, species known for accumulating hydrophobic pollutants. MLPs in these plants showed favorable binding free energy with PFOS, suggesting their involvement in PFOS transport. Furthermore, PFOS-bound MLPs were detected in xylem sap, supporting this mechanism.

Discussion and Conclusion
PFAS concentration in plant xylem sap is influenced by their water solubility and varies among species. In Cucurbitaceae, MLPs appear to play a key role in transporting less soluble PFAS such as PFOS to aboveground tissues. Understanding these mechanisms could enable the development of crop cultivation strategies that minimize PFAS accumulation. Additionally, PFAS detection in xylem sap may serve as a simple method for estimating their concentrations in edible plant parts.

Acknowledgment
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P-00113 Does dietary marine fish oil supplementation mitigate TCDD and/or PCB-126 hepatotoxicity in male C57BL/6 mice?

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Introduction
Fish and seafood are, among other nutrients, valuable dietary sources of the long-chain ω3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), nutrients known to support metabolic and hepatic health and suggested to reduce oxidative stress–mediated toxicity. However, fish and seafood are also the primary contributors to human exposure to persistent organic pollutants (POPs) including dioxins and dioxin-like PCBs (dl-PCBs), which pose well-established risks to liver health, including inflammation, oxidative stress, and altered metabolic regulation. As a result, risk–benefit assessments of fish consumption, weighing the protective effects of ω3 fatty acids against contaminant-driven toxicity, are increasingly emphasized. Understanding how these nutritional and toxicological factors interact at the hepatic level is therefore critical. This study investigated whether dietary intake of purified fish oil modifies the hepatotoxicity of sub-chronic dietary exposure to TCDD or PCB 126. The study focused on hepatic physiology and toxicity markers in peripubertal male mice.

Materials and Methods
A total of 126 male C57BL/6 mice were assigned to diets in a fractional factorial design containing low (0.07 µg TEQ-05/kg bw per week) or high (5 µg TEQ-05/kg bw per week) doses of TCDD or PCB-126 for 90 days. Diets were supplemented with 0%, 1% or 5% purified fish oil (Atlantic mackerel and herring oil). Physiological parameters, including body weight, body composition, and hematological markers, were recorded throughout the study. At termination, organ weights, liver histology, plasma biochemical markers, and hepatic gene expression of detoxification-, oxidative stress- and inflammatory markers (real-time quantitative PCR) were assessed.

Results
High-dose exposure to TCDD induced pronounced adverse effects, including increased liver weight and reduced body weight. PCB-126 also affected liver endpoints, though less severely. Plasma hypoglycemia and depletion of hepatic lipid stores on histological assessment indicated a profound catabolic state following exposure to 5 µg TEQ-05/kg bw per week of TCDD. Hepatic Cyp1a1 gene expression reflected the relative magnitude of effects, with stronger induction following high dose (5 µg TEQ-05/kg bw per week) TCDD compared to the same dose of PCB 126. Liver gene expression analyses further indicated effects on hepatic lipid metabolism, inflammatory responses, oxidative stress, and evidence of hepatocellular damage, including cell death, with the strongest effects observed following exposure to 5 µg TEQ-05/kg bw per week of TCDD. However, fish oil supplementation did not attenuate the toxicological effects of TCDD or PCB-126.

Discussion and Conclusion
Sub chronic dietary exposure to a high dose of TCDD caused significant hepatotoxicity in peripubertal male mice, while PCB-126 had a more moderate impact. Simultaneous intake of dietary fish oil did not attenuate contaminant induced metabolic nor redox disturbances, suggesting that this oil, rich in ω3 fatty acids, may provide primarily nutritional benefits rather than protective effects against dioxins and dioxin like toxicants. As the intervention consisted of a complex oil matrix, effects could not be attributed specifically to DHA or EPA, but rather to the combined fatty acid composition.
Ongoing analysis of the liver proteome aims to clarify whether the included sub toxic doses (0.07 µg TEQ-05/kg bw per week) initiate early adaptive or pre pathological changes preceding overt adverse effects.

Environmental and human exposure to plasticizers and other consumer product chemicals

P-00114 Persistent organic pollutants in plastic products in the automotive sector

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Introduction
Persistent organic pollutants (POPs) are organic substances that persist in the environment, bioaccumulate in living organisms, and exhibit long-range transport, posing a risk to human health and the environment. Because of their adverse effects on humans and the environment, POPs are regulated worldwide by the Stockholm Convention. As part of the UNEP initiative on POPs-free plastics in Africa, there was a desire to establish baseline concentrations of POPs in components of equipment used in different sectors. The current study focuses on the automotive sector.

Materials and Methods
A 100 µg/L technical standard of SCCPs (51.1 % and 55.5 % each) and an internal standard (1, 5, 5, 6, 6,10 -hexachlorodecane) were purchased from Dr Ehrenstorfer GmH (Augsburg, Germany). Silica gel, sulphuric acid, ultrapure water, LC/MS grade solvents, methanol, acetonitrile, hexane, dichloromethane, and ammonium acetate were purchased from Sigma Aldrich. Individual α-, β-, and γ-HBCD standards were purchased from Wellington Laboratories. Pure standards of BDEs- –47, –99, –100, –153, –209 and 13C12BDE-139, –77 and –209) were purchased from Wellington Laboratories. Nitrogen gas (99.999% purity) was supplied by Afrox (Pty.). UV-328 and UV-234 (purity 97-98%) were purchased from Sigma-Aldrich. Dechlorane Plus: Anti-dechlorane plus (anti-DP) and syn-dechlorane plus (syn-DP) were purchased at>98% purity from Cambridge Isotope Laboratories. Scrap vehicle headliners, textile covers, upholstery and paints from various types of vehicles were collected from scrap vehicle yards. Thereafter, the samples were ground into powder, stored in brown bottles and kept in a cold room until use. A total of 56 samples were collected. A surrogate standard was added to validate the extraction method. Thereafter, the analytes were sonicated in DCM and quantified using LC-MS/MS (PFAS, HBCD, SCCPs, and UV382) and GC (PBDEs and DP).

Results
The concentrations of PFOA ranged from 11.3-4440 ng/kg, 26.8-963.0 ng/kg, and 2.9-56.2 ng/kg for textile, headliners, and upholstery, respectively, whereas those of PFOS ranged from nd-708 ng/kg and 68.5-1325 ng/kg, respectively. HBCD concentrations in upholstery/textile, EPS/XPS and headliners ranged from nd-4387 ng/g, nd-4346 ng/g and nd-1,938 ng/g, respectively. The concentrations of PBDEs ranged from 6,018-738,395 mg/kg, 16-1630 mg/kg, 21-1,679 mg/kg, 304-1494 mg/kg and 20-146 mg/kg for BDE-47, -100, -99, 154 and -209, respectively, in upholstery/textile, headliners and PUR foam. The concentration order is as follows: BDE-47>BDE-99>BDE-100>BDE-154>BDE-209. The concentrations of liquid and solid paints in Low Duty Vehicles ranged from 642-93348 ng/mL and from 136-15, 271 ng/g, respectively. DP concentrations ranged from 1 to 180 mg/kg in PVC components from low-duty vehicles.

Discussion and Conclusion
All the POPs were detected in most of the samples. Since these POPs are added to automotive plastics, drivers and passengers may be well exposed to them, particularly under warm conditions

Acknowledgment
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P-00119 Rapid and simultaneous determination of volatile and semi-volatile organic compounds using passive sampling methods

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Introduction
Chemicals can be unintentionally released into the environment during emergency situations. In such situations, the concentrations of chemicals in the environment can vary both temporally and spatially. Rapid and multipoint measurement of chemicals is essential for accurate assessment of chemical exposure risks. Passive sampling methods are expected to be useful in emergency situations because passive samplers are inexpensive, compact, and require no electric power. In this study, we assessed the collectable compounds by two types of passive samplers and determined their sampling rates (SR) for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs).

Materials and Methods
A carbon bead passive sampler (CBP) and an ultrahigh-purity silicone sheet were used as passive samplers for VOCs and SVOCs, respectively. Recoveries from the CBP were determined for 50 VOCs, including esters, ethers, alcohols, chlorinated compounds, aromatic compounds, and ketones. The log KOA of the 50 VOCs ranged from 2.15 to 6.00. Recoveries from the silicone sheet were determined for 27 polycyclic aromatic hydrocarbons (PAHs), 46 halogenated PAHs, and 111 per- and polyfluoroalkyl substances (PFAS). The log KOA of the 27 PAHs, 46 halogenated PAHs, and 111 PFAS ranged from 6.27 to 13.6, 6.38 to 12.9, and 3.52 to 16.9, respectively.
Passive sampling using the CBP and silicone sheet was conducted simultaneously with active sampling using a mini pump to determine the SRs of 57 VOCs, 21 PAHs, and 3 halogenated PAHs.

Discussion and Conclusion
Good recoveries of all target VOCs were obtained using the CBP. The recoveries of target PAHs, halogenated PAHs, and PFAS from the silicone sheet ranged from 0.873% to 122%. The relationship between the recoveries of PAHs, halogenated PAHs, and PFAS from the silicone sheet and their log KOA was fitted using a sigmoid non-linear regression model. According to the non-linear regression, the compounds with log KOA greater than 4.04 were collectable by the silicone sheet, assuming that the compounds with recoveries exceeding 60% were effectively collectable. Simultaneous air sampling using both the CBP and silicone sheet enabled the assessment of organic compounds with a wide range of physicochemical properties.
The SRs of target compounds are essential for estimating individual exposure concentrations from the amounts collected by passive samplers. The SRs on the CBP ranged from 0.0450 L min-1 (5%ile) to 0.0689 L min-1 (95%ile), with an error of 0%–69%, derived from meteorological factors1). In contrast, the errors associated with the SR on the silicone sheet ranged from 4.11% (5%ile) to 281% (95%ile); however, these errors were reduced to 2.94% (5%ile)–148% (95%ile) by correcting for wind speed effects based on the sampling mechanism2). The SRs on the silicone sheet ranged from 0.342 L min-1 (5%ile) to 3.49 L min-1 (95%ile). The relatively low SRs of the CBP and their small associated errors were attributed to the presence of a diffusion layer surrounding the adsorbent in the CBP. These results suggest that, for compounds collectable by both the CBP and silicone sheet, the CBP enables exposure assessment with reduced influence from meteorological conditions, whereas the silicone sheet, whose SRs are approximately two or three orders of magnitude higher than those of the CBP, enables the detection of a larger number of compounds during short-time sampling. Combining the CBP and silicone sheet therefore enables flexible individual exposure assessment depending on the physicochemical properties of the target compounds and the objectives of the investigation.

Acknowledgment
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P-00123 Characteristics and Human Exposure Assessment of PFAS in Car Dust from the United Kingdom

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Introduction
Per- and polyfluoroalkyl substances (PFAS) have gained worldwide attention due to their persistence and potential toxic implications for human health. Indoor dust has been established as important vector of human exposure to organic pollutants. Numerous studies have documented the ubiquitous presence of PFAS in indoor dust, mainly in home and office microenvironments [1]. Nowadays, growing daily commute times have turned cars into an important source of indoor exposure. However, few studies have investigated the occurrence and profiles of PFAS in cars and implications for human exposure remain limited, especially in the United Kingdom (UK). Therefore, the objective of this study is to characterise the occurrence of 44 PFAS in automotive dust and estimate the daily intake for the UK population.

Materials and Methods
Car dust samples were collected from 25 private cars in the West Midlands, UK. Dust samples were extracted using 0.1% ammonia in methanol with ultrasonication and subsequently analysed via ultra-performance liquid chromatography coupled to quadrupole time-of-flight mass spectrometry (UPLC-ToF-MS).

Results
PFAS were detected in all car dust samples, with a median concentration of 64.6 ng/g. A total of 18 PFAS were detected in >50% of samples, with median concentrations ranging from 0.06 to 8.60 ng/g. Perfluorooctanoic acid (PFOA) and 6:2 polyfluoroalkyl phosphate diester (6:2 diPAP) emerged as the predominant pollutants across all car dust samples, with high detection frequencies of 96.0% and 88.0% and median concentrations of 6.25 and 8.60 ng/g, respectively, indicating their ubiquitous presence in the vehicle environment. The estimated weekly intakes of PFAS via dust ingestion in cars were 0.07 and 0.01 ng/kg body weight/week for toddlers and adults, respectively; both of which were well within the tolerable weekly intake of 4.4 ng/kg bw/week set by The European Food Safety Authority (EFSA).

Discussion and Conclusion
This study provides first information on PFAS in UK car dust, highlighting the widespread presence of PFAS in UK cars and bridging the knowledge gap concerning PFAS within the UK automotive microenvironment.

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Screening and identification of novel contaminants

P-00125 Extending a dioxin-oriented nitrogen carrier gas APGC-MS/MS method to emerging dioxin-like halogenated PAHs

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Introduction
Atmospheric Pressure Gas Chromatography coupled with mass spectrometry (APGC-MS) has emerged as a powerful soft-ionization technique for the analysis of organic contaminants, providing enhanced molecular-ion information and improved selectivity compared with conventional electron ionization methods 1. Recent studies have demonstrated the applicability of APGC-MS/MS to the analysis of dioxins and related compounds, achieving analytical performance comparable to that of conventional high-resolution mass spectrometry 2. Halogenated polycyclic aromatic hydrocarbons (XPAHs), including chlorinated (ClPAHs) and brominated PAHs (BrPAHs), are unintentionally formed during combustion and industrial processes 3. Several XPAHs have been reported to exhibit mutagenic, carcinogenic, and dioxin-like activities, with some congeners showing toxic potencies comparable to those of mono-ortho PCBs. Although environmental occurrence and toxicological concern regarding XPAHs have increased, analytical methods capable of comprehensively determining a wide range of XPAHs remain limited.
In this study, a nitrogen carrier gas APGC-MS/MS method originally established for dioxin determination 2 was extended to the analysis of XPAHs and parent PAHs, and its applicability was evaluated for 68 target compounds.

Materials and Methods
A total of 68 compounds were investigated, including 27 ClPAHs, 29 BrPAHs, and 12 parent PAHs. Standard solutions were analyzed using an APGC-MS/MS (Xevo TQ Absolute, Waters) equipped with an Rxi-5Sil MS column (40 m × 0.18 mm, 0.18 µm film thickness) and nitrogen carrier gas. Product ion and precursor ion scans were performed to determine optimal MS/MS transitions. Cone voltage and collision energy were optimized individually for each analyte. Calibration performance, chromatographic separation, and instrumental detection limits for the target chemicals were evaluated.

Results
Optimized MS/MS conditions were successfully established for all 68 target compounds. Chromatographic separation of most XPAHs was achieved under the GC conditions originally developed for dioxin analysis. Although several structural isomers were adequately resolved, incomplete separation was observed for a limited number of compounds, including 1,9-dichlorophenanthrene and 9,10-dichloroanthracene. Excellent linearity was obtained for the majority of analytes over the concentration range of 0.1–100 ng mL^{-1}, with coefficients of determination (R^2) greater than 0.995. Instrumental detection limits derived from repeated measurements of low-concentration standards were below 0.1 pg for XPAHs.

Discussion and Conclusion
The present study demonstrates the feasibility of extending a nitrogen carrier gas APGC-MS/MS method originally developed for dioxin analysis to emerging dioxin-like contaminants, including a broad range of XPAHs and parent PAHs. The method provided high sensitivity and satisfactory chromatographic performance for most target compounds while maintaining analytical capabilities comparable to, and in some cases exceeding, those reported for double-focusing high-resolution mass spectrometry.
Given the increasing concern regarding emerging dioxin-like contaminants, the developed method offers a practical and cost-effective alternative for comprehensive XPAH analysis. In addition, the use of nitrogen as a carrier gas reduces dependence on helium, supporting more sustainable analytical operations. The developed method may support future monitoring and risk assessment of emerging dioxin-like contaminants in environmental matrices.

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Environmental and human exposure to plasticizers and other consumer product chemicals

P-00126 Organic UV filters in indoor dust: multi-environment distribution and human exposure assessment

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Introduction
Organic ultraviolet (UV) filters have recently emerged as contaminants of concern for both the environment and human health. Within these chemicals, benzotriazole UV stabilizers (BUVSs) are extensively used as additives in plastic manufacturing to prevent UV-induced photodegradation and preserve material integrity. Consequently, the manufacture, use, and disposal of these products may result in the release of UV filters into different environmental compartments, where their presence can threaten ecosystem health. BUVSs have recently gained attention as emerging pollutants, particularly following the inclusion of UV-328 in Annex A of the Stockholm Convention in 2023 as a persistent organic pollutant (POP) and the increasing interest in their toxicological effects (Ling et al., 2025). In this context, the present study performed a quantitative assessment of eight BUVSs in indoor dust from different environments.

Materials and Methods
A total of 84 indoor dust samples were collected from various locations across Spain during 2022, including urban residential settings and public spaces such as offices and educational environments. In the latter sites, both settled and airborne dust were collected. Samples were processed using a modified QuEChERS procedure (Navarro et al., 2023). Instrumental analysis was performed by gas chromatography coupled with tandem mass spectrometry (GC-MS/MS). Additionally, human exposure was assessed by calculating Estimated Daily Intakes (EDIs) via dust ingestion, dermal contact, and inhalation across different age groups.

Results
BUVSs were quantified in all dust samples, with quantification frequencies (Qf) ranging from 46% to 99%. The pollution profile was dominated by UV-329 (95 ng/g, median; Qf = 99%), UV-328 (90 ng/g, 98%), and UV-P (68 ng/g, 99%), while other compounds, such as UV-320 and UV-234, were detected less frequently (46-79%) and at lower concentrations (6-15 ng/g). Residential environments showed the highest median concentrations, whereas educational settings and offices generally exhibited lower levels. Nevertheless, statistically significant differences were observed only between household dust and high school samples. Exposure assessment identified dust ingestion as the primary exposure pathway, with toddlers experiencing the highest EDIs due to their lower body weight and higher dust ingestion rates. In addition, UV-329 and UV-328 showed the highest EDIs, reaching 0.6 and 0.4 ng/kg bodyweight/day for toddlers in residential environments, respectively, consistent with their concentration values. As people spend most of their time indoors, the ubiquitous presence of organic UV filters in enclosed locations underscores the importance of these environments in shaping human exposure to emerging contaminants and their potential health impacts.

Acknowledgment
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P-00132 Fate and Transformation of Legacy and Novel PFAS in Wastewater Treatment Plants Using Target, Suspect and Non-Target Analysis

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Introduction
Per- and polyfluoroalkyl substances (PFASs) have been widely used since the 1950s. Due to their persistence, bioaccumulation, and toxicity, certain legacy PFASs, including PFOS and PFOA, have been regulated worldwide. Regulatory restrictions have driven the use of alternative PFASs. However, these compounds can be transformed into terminal PFASs (e.g., PFBA and PFBS) during wastewater treatment. Due to limited removal and transformation, Wastewater treatment plants (WWTPs) may serve as significant sources of terminal PFASs, such as C4-C10 PFCAs and PFSAs, to the environment. This study aims to evaluate PFASs removal efficiency in WWTPs, investigate their fate across treatment processes, and propose transformation pathways.

Materials and Methods
Samples were collected from five WWTPs in April, July, and September 2024. Following filtration, samples were spiked with internal standards and adjusted to pH prior to extraction using solid-phase extraction with a multi-layer cartridge (HLB, WAX, WCX and, ENV+). Extracts were then concentrated and reconstituted before LC-HRMS analysis. PFASs characterization was conducted ustin integrated target, suspect, and non-target analysis (SNTA) combined with a Random Forest-based semi-quantification method, with Tracefinder 4.1 used for target and suspect analyses and Compound Discoverer for non-target analysis.

Results
Among the 37 target compounds, 17 PFASs were detected at least once across the five WWTPs, and their composition varied markedly depending on industrial sources. In textile dyeing and Printed circuit boards manufacturing (A), 6:2 FTS (210–1,400 ng/L) and PFBS (30–280 ng/L) were dominant. Textile processing and energy-related industries (B), PFBS (1.7–38 ng/L) and PFOS (1.2–130 ng/L) were the major compounds. In paper, metal, and plastics industries (C), PFBS (5,600–63,000 ng/L) and PFEESA (7-200 ng/L) were prominent. Electronic component manufacturing (D) showed PFBA (0–18 ng/L) and PFOA (4.4–7.5 ng/L), whereas chemical manufacturing (E) exhibited several alternative PFASs, including GenX (290–690 ng/L), PFBA (35–230 ng/L), and PF4OPeA (40–180 ng/L).
PFASs removal efficiencies varied across the five WWTPs. PFHpS and 6:2 FTS were completely removed (100%), whereas PFBA exhibited negative removal (–560%), indicating that precursor transformation during treatment contributes to PFBA formation and its increased concentrations in the effluent. SNTS identified a total of 12 PFASs, including precursors, intermediates, terminal PFASs, and alternative compounds. At WWTP A, the precursor 6:2 FTS decreased during treatment, while intermediates such as 6:2 FTUSA and Ketone-6:2 FTSA increased. In addition, short-chain PFCAs showed higher concentrations in the effluent, indicating the transformation of 6:2 FTS to terminal PFASs via intermediate products. PFHpS and 6:2 FTCA were completely removed, whereas PFPrA showed strongly negative removal (–11000%). These results support the transformation of precursors into terminal PFASs during wastewater treatment processes. Integrated target and SNTS results suggested transformation pathways from precursors (6:2 FTS) to intermediates (6:2 FTCA, 6:2 FTUCA) and terminal PFASs (PFCAs) during wastewater treatment.

Discussion and Conclusion
This study suggests that, despite regulatory efforts, legacy PFASs like PFOA and PFOS are still present in WWTPs and can be newly formed through the transformation of alternative PFASs during treatment processes. These findings indicate that PFASs may still pose long term risks to the environment. Therefore, effective PFAS management requires integrated monitoring approaches that include terminal, alternative and their intermediates supported by advanced analytical techniques such as SNTA.

Acknowledgment
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P-00134 Occurrence of organofluorine in river water from 11 prefectures in Japan assessed by EOF analysis and TOP assay

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Introduction
Targeted analysis is widely used for PFAS monitoring. However, it covers only a limited subset of PFAS present in the environment. Complementary approaches are needed for a more comprehensive characterization of organofluorine compounds. Extractable organofluorine (EOF) analysis measures the amount of organofluorine that can be extracted from a sample, whereas the total oxidizable precursor (TOP) assay estimates precursors oxidizable to PFCA. In this study, EOF was measured in river water samples in Japan. In addition, 30 PFAS based on ISO 21675 and ultra-short-chain PFAS were quantified in the EOF extracts to identify compounds contributing to EOF. The TOP assay was also applied to evaluate the presence of oxidizable precursors.

Materials and Methods
River water samples were collected from 11 prefectures in Japan. For EOF analysis, 100 mL of each sample was acidified with acetic acid and loaded onto an Oasis WAX cartridge. The cartridge was washed with 20 mL of 0.01% ammonia solution, 30 mL of ultrapure water, and 4 mL of acetate buffer at pH 4, followed by centrifugation to remove residual water. The retained compounds were eluted with 5 mL of methanol and 5 mL of 0.1% ammonia in methanol. The eluate was concentrated to 1 mL under a nitrogen stream and used for EOF determination and individual PFAS quantification. EOF was measured by combustion ion chromatography (CIC; DIONEX Integrion HPLC with AQF-2100F combustion unit). The 30 PFAS in the EOF extracts were quantified according to ISO 21675. Trifluoroacetic acid (TFA), PFPrA, and PFMS were separated using an RSpak JJ-50 2D column, analyzed by LC-MS/MS. For the TOP assay, 50 mL of river water collected in a 100 mL polypropylene bottle was mixed with 50 mL of ultrapure water, followed by the addition of potassium persulfate and sodium hydroxide. The samples were heated at ≥85°C for 6 h, cooled, and adjusted to pH<3 with hydrochloric acid. The river water samples and oxidized samples were extracted by solid-phase extraction and analyzed for the 30 PFAS according to ISO 21675. All individual PFAS were quantified by LC-MS/MS (Sciex, TQ4500).

Results
EOF concentrations ranged from 190–2,800 ng F/L, with relatively high concentrations observed at several urban sites. Previous studies reported EOF concentrations of 40–580 ng F/L in German rivers and 1,700–3,500 ng F/L in Austrian wastewater treatment plant effluents [1,2]. EOF concentrations in this study fell within these ranges. TFA accounted for 8.8–107% of EOF and was one of the major contributors to EOF at most sites. In contrast, PFPrA and PFMS accounted for only 0.3–3.3% and 0.1–1.6% of EOF, respectively. The 30 PFAS also made only a minor contribution, accounting for 0.2–4.1% of EOF, consistent with previous reports [1,2]. In the TOP assay, PFCA concentrations did not increase markedly after oxidation at most sites.

Discussion and Conclusion
Differences in EOF concentrations were observed among river water samples from Japan, indicating regional variation in the occurrence of organic fluorine compounds. TFA was identified as a major contributor to EOF at many sites. However, the 30 PFAS, TFA, PFPrA, and PFMS could not fully account for EOF. This result suggests that other untargeted organofluorine compounds were present in the river water samples. The TOP assay results indicated that oxidizable precursors of PFCA were not abundant in the examined river water samples. These findings show that EOF analysis and TOP assay are useful for evaluating organofluorine compounds in river water.

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P-00136 High serum concentrations of perfluoroalkyl substances (PFAS) in Norwegian infants, teenagers and adults are associated with unfavorable cardiometabolic profile.

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Introduction
Objective: To study if PFAS exposure of Norwegian children and adults was associated with various cardiovascular risk factors.

Materials and Methods
The results of the following studies were included: the Bergen study of infants (n=94, age 6 months), the Fit Futures study of teenagers in Troms county (n=905, age 15-19 years,) and the Tromsø 6 study of adults (n=3508, age 30-86 years). PFAS were measured by ultrahigh-pressure liquid chromatography tandem mass spectrometry at the Environmental Pollutant Laboratory, Department of Laboratory Medicine, University Hospital of North Norway.

Results
Observed detection rates for perfluorooctanoate (PFOA), perfluorooctane sulfonate (PFOS) perfluorohexane sulfonate (PFHxS) and perfluorononanoate (PFNA) were 100% in infants, teenagers and adults. Altogether 78% of the six-month-old infants, 87% of the teenagers and 98.9% of adults had sum concentrations of these four PFAS (∑4 PFAS) above the EFSA 2020 limit for maternal blood of 6.9 ng/mL.

Table: Serum concentrations of perfluoroalkyl substances in Norwegian children and adults.

∑4 PFAS ng/ml	Infants Bergen (n=94)	15–19 years old Tromsø (n=905)	30-86 years old Tromsø (n= 3508)
Median (25-75 percentile)	9.32 (7.35; 12.8)	9.90 (7.99; 21.7)	30.2 (21.3; 42.7)
Maximum	20.4	192	277

In infants, higher PFAS concentrations were correlated with an unfavourable cardiometabolic profile with higher low-density-lipoprotein (LDL)- and total cholesterol. In teenagers, PFAS exposure was associated with dyslipidaemia (elevated LDL and total cholesterol), as well as with hypertension, and obesity. In adults, several PFAS were also associated with dyslipidaemia, hypertension, overweight and obesity, and with being at increased risk of liver fibrosis (defined by the FIB4-score).

Discussion and Conclusion
The majority of Norwegian infants, children and adults had ∑4 PFAS serum concentrations above the suggested EFSA-limit of 6.9 ng/mL. PFAS exposure was associated with unfavorable cardiometabolic profile in infants, children and adults.

Acknowledgment
The authors are grateful for the contribution of the participants in the Bergen study of infants, the Fit Futures study and the Tromsø study. We are also grateful for the financial subsidies of the University Hospital of North Norway for PFAS analyses.

P-00138 Free-Range Hen Eggs as Bioindicators of PFAS and BFR Contamination at a Former Industrial Site (Central Italy): PNRR-PNC Project INSINERGIA preliminary data

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Introduction
Organic contaminants can bioaccumulate in animal tissues and transfer along the food chain. Free-range hens are particularly exposed to environmental contaminants through soil, water, and feed ingestion, making their eggs valuable bioindicators of environmental contamination and potential sources of human exposure [1]. PFAS (perfluoroalkyl substances) and BFRs (brominated flame retardants) are widely used industrial chemicals characterized by high thermal, chemical, and biological stability, leading to strong persistence, bioaccumulation potential, and possible adverse effects on human health and environment [1]. Italian Sites of National Interest (SINs) are areas affected by historical or ongoing industrial activities that compromised soil and groundwater quality. This study aims to evaluate the impact of the Papigno SIN area (Terni, Central Italy) on surrounding environment using free-range hen eggs.

Materials and Methods
Twenty-five free-range eggs were collected from the SIN of Papigno in the frame of INSINERGIA Project. Twenty-four PFAS, 9 PBDE congeners, 3 HBCD isomers and 9 emerging BFRs (eBFRs) were analysed [2]. Statistical elaborations were performed using the lower bound approach. Limits of quantification were 0.010 µg/kg except for PFBA=0.20, PFOSA=0.025, Gen-X=0.20 µg/kg [2].

Results
The median concentration of ∑24PFASs was 0.19 µg/kg (from <LOQ to 1.6 µg/kg), while the sum of the four regulated PFAS (PFOA, PFNA, PFHxS, PFOS) showed a median of 0.19 µg/kg (<LOQ–0.64 µg/kg) [3]. PFOS and long-chain PFASs (C8-C14) were the most frequently detected compounds, whereas short-chain and emerging PFASs were not quantified. Regarding BFRs, eBFRs were generally not detected, with only traces of PBT and BTBPE found in few samples. PBDEs were below LOQs in 11 of 25 samples; in the remaining, the median ∑9PBDEs was 0.052 µg/kg (<LOQ-0.56 µg/kg). The most frequently detected congeners were PBDE-47, -99, and -100 (frequencies of 53%, 56%, and 26%, respectively). The three HBCDs isomers were detected in several samples, with a median of 0.031 µg/kg (<LOQ–5.8 µg/kg) and α-HBCD was measured in 85% of samples, while β- and γ-HBCD were detected in the most contaminated eggs only.

Discussion and Conclusion
PFAS levels measured in all the samples were below the maximum limits set in eggs [3]; the sum of the 4 regulated compounds accounts for more than 60% of the total PFAS burden, estimated as sum of all the 24 PFASs included in the study, indicating that regulated substances represent, in this specific commodity, the dominant contribution to overall contamination. To date, no maximum limits have been issued for BFRs in food, despite their documented occurrence in eggs across Europe. The PBDE levels observed in the present study are consistent with those reported for eggs from Italian and UK markets, whereas HBCD concentrations are generally higher [4]. Conversely, HBCD levels reported in eggs from Netherlands and Belgium are more aligned with our findings [5]. HBCD concentrations deserve particular attention, although, the current available data are still limited to support definitive conclusions. The observed levels may not be unambiguously linked to emissions from the SIN area but originate from other unidentified sources. Additional sampling is ongoing to better elucidate the origin and distribution of the contamination.

Acknowledgment
Italian Ministry of Health through the PNRR-PNC Project INSINERGIA (CUP H79D23000110001) and the public health authorities for sampling

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P-00140 Per- and Poly-Fluoroalkyl Substances in Food: Dietary Patterns as Modulators of Human Exposure

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are persistent synthetic chemicals whose widespread industrial use has led to ubiquitous contamination of the food chain [1,2]. Dietary intake is the main exposure route for the general population, with higher concentrations reported in animal-derived products: fish (2–12 ng/g), shellfish (3–15 ng/g), liver (15–50 ng/g), eggs (>100 ng/g PFOA), and bovine milk (~16 ng/g) [2,3]. However, less attention has been paid to how dietary composition, i.e., the relative contribution of different food categories, shapes individual internal PFAS burden.

Discussion and Conclusion
Animal-based foods, particularly seafood, meat, eggs, and dairy products, often represent major contributors to dietary PFAS intake, reflecting bioaccumulation along the trophic chain [2,3]. Dietary patterns characterised by a higher proportion of animal-derived foods are therefore associated with greater exposure to long-chain legacy PFAS such as PFOS and PFOA, which have strong bioaccumulative potential due to their affinity for proteins and lipids in animal tissues [1,3]. Studies comparing internal PFAS concentrations across dietary groups support this hypothesis, showing higher serum PFAS levels in omnivorous diets, particularly those with high fish and processed meat intake, compared with diets lower in animal-derived foods [4]. This picture is complicated by next-generation PFAS. Ether-based compounds (such as GenX and ADONA) were introduced as substitutes for legacy PFAS due to their lower bioaccumulation in animal tissues. However, being more water-soluble and less adsorbed to soil, they are preferentially taken up by plants via the xylem [3]. As a result, plant-based diets are not necessarily associated with lower exposure when crops are irrigated with contaminated water. PFBA, a short-chain PFAS that shares the low-bioaccumulation profile of next-generation substitutes, has been detected at concentrations up to 140 ng/g in vegetables from industrial areas [2].These dynamics are particularly relevant to vulnerable groups: infants and young children exhibit disproportionately high dietary exposure relative to body weight, while pregnant women face additional concerns as PFAS accumulate in maternal serum, bind extensively to plasma proteins, and cross the placental barrier, with transfer efficiency varying by chain length; breast milk represents an additional postnatal exposure route for neonates [1,3]. Current regulatory frameworks, based on average adult exposure scenarios, may not fully capture heterogeneity across population subgroups and dietary patterns, nor do they account for the growing presence of next-generation PFAS. Developing unified, dietary pattern-stratified exposure frameworks that integrate both legacy and emerging compounds is therefore a priority for protecting the most at-risk groups.

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P-00142 Semiquantitative sum parameter screening of polychlorinated alkanes (ΣPCAs-C10-17) in food using GC-MS/MS for routine monitoring

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Introduction
Polychlorinated alkanes (PCA), particularly compounds with chain lengths from C10 to C17 (short- and medium-chain chlorinated paraffins), are increasingly recognized as persistent environmental contaminants with potential relevance for food safety. Due to their complex technical mixtures, unresolved chromatographic patterns ("humps"), and the limited availability of congener-specific standards, their analysis in food remains challenging. In anticipation of a forthcoming EU monitoring recommendation for PCA in food planned for 2026, there is a growing demand for analytical methods that are fit-for-purpose in routine laboratories and suitable for large-scale monitoring.

Materials and Methods
A semiquantitative screening method for the determination of PCA as a sum parameter (ΣPCAs-C10-17) was developed. The method is specifically designed for efficient routine application, focusing on robustness, simplicity, and high sample throughput rather than congener-specific resolution. The analytical workflow is based on established POP methodologies and covers different food matrices, such as milk powder, oils and fats. Samples are dried using sodium sulfate and extracted with cyclohexane/dichloromethane (1:1, v/v). Depending on matrix characteristics and fat content, extraction and clean-up are performed either sequentially or in a combined approach. Matrix interferences are removed using sulfuric acid-modified silica, followed by Florisil clean-up. Final extracts are concentrated prior to instrumental analysis. Isotopically labelled internal standards (^{13}C-labelled PCA) are added prior to sample preparation to check losses during extraction and clean-up, while injection standards are used to correct for variations in instrumental analysis. This approach improves the accuracy and robustness of the method and enables reliable semiquantitative determination despite the complexity of PCA mixtures. GC-MS/MS analysis is performed using a programmed temperature vaporization (PTV) inlet and a low-polarity capillary column. A fast temperature program (total runtime 18 min) enables efficient elution of the unresolved PCA hump signal corresponding to ΣPCAs-C10-17. Detection is carried out in MS/MS mode using characteristic transitions. Quantification is performed semiquantitatively based on ΣPCAs-C10-17 signal without differentiation of individual chain lengths or degrees of chlorination.

Results
The method enables reliable detection and semiquantitative estimation of ΣPCAs-C10-17 across defined food matrices. It shows consistent performance with respect to repeatability and matrix tolerance, allowing the identification of samples with elevated PCA levels. The simplified workflow, combined with short analysis times, supports high sample throughput and makes the method suitable for routine screening applications.

Discussion and Conclusion
The approach provides a practical alternative to complex congener-specific methods, which are often unsuitable for routine analysis due to analytical limitations. By using a sum parameter and characteristic MS/MS fragmentation, it is well suited to support upcoming EU monitoring activities and to contribute to harmonized data generation for exposure assessment and regulatory evaluation of PCA in food.

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P-00145 PFAS Occurrence in Freshwater Fish from Lake Varese: Regulated Compounds and Emerging Contaminants

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Introduction
Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a class of synthetic chemicals characterized by fully or partially fluorinated alkyl chains. The strength of the carbon-fluorine bond confers high chemical and thermal stability, resulting in marked environmental persistence[1,2]. Their widespread use has led to diffuse contamination of surface and groundwater, soils, and biota[1,3]. The European Union has progressively tightened regulatory limits for PFAS in food through Regulation (EU)2023/915[4], which establishes maximum levels for the sum of PFOS, PFOA, perfluorononanoic acid (PFNA), and perfluorohexanesulfonic acid (PFHxS), while Recommendation (EU)2022/1431[5] encourages monitoring of emerging PFAS.

Materials and Methods
This study, conducted within the "One Health - Fish as a Water Quality Indicator" project funded by ATS-Insubria, evaluated PFAS occurrence in five commercially relevant freshwater fish species collected from Lake Varese, a highly anthropized lake in Northern Italy. A total of 59 specimens, pike (Esox lucius), pikeperch (Sander lucioperca), perch (Perca fluviatilis), tench (Tinca tinca), and catfish (Silurus glanis), were collected between 2024 and 2025 during routine commercial net fishing activities. Muscle tissues were extracted using solid-phase extraction (SPE-WAX) and quantified via liquid chromatography-tandem mass spectrometry (LC-MS/MS). Target analytes comprised the four regulated PFAS (PFOS, PFOA, PFNA, PFHxS) and 31 emerging compounds listed in Recommendation (EU)2022/1431.
In accordance with Regulation (EU)2023/915, species were evaluated within two regulatory groups: Group1 (pike, catfish, tench): PFOS 7.0µg/kg, PFOA 1.0µg/kg, PFNA 2.5µg/kg, PFHxS 0.20µg/kg, sum of PFOS, PFOA, PFNA and PFHxS limit 8.0µg/kg; Group2 (pikeperch, perch): PFOS 35µg/kg, PFOA 8.0µg/kg, PFNA 8.0µg/kg, PFHxS 1.5µg/kg, sum limit 45µg/kg. The limit of quantification (LOQ) for all analyzed compounds was 0.10µg/kg.

Results
No specimen exceeded the legal limit for the sum of the four regulated PFAS. PFOA and PFHxS were never detected. PFNA was below LOQ in 37% of samples; where quantifiable, mean concentrations were below legal limits in both groups. PFOS was the dominant compound, detected in 100% of samples with an overall mean of 5.2µg/kg. In Group1, pike showed the highest contamination, with a mean sum of 5.45µg/kg (range: 3.3-8.0µg/kg); one specimen reached the regulatory threshold for the sum of the four PFAS (8.0µg/kg), and three individuals slightly exceeded the PFOS limit of 7.0µg/kg. Catfish and tench showed lower mean values of 1.33µg/kg (range: 0.6-3.3µg/kg) and 1.75µg/kg (range: 0.8-2.7µg/kg), with no exceedances. In Group2, pikeperch and perch reached mean sums of 8.73µg/kg (range: 2.2-19.8µg/kg) and 8.42µg/kg (range: 4.6-17.9µg/kg), respectively; no sample exceeded the sum limit or any individual threshold.
Among the 31 emerging PFAS monitored, most were absent or present at trace levels. Long-chain perfluoroalkylcarboxylic acids (C10-C13) were the most frequently detected, consistent with their bioaccumulation potential and environmental persistence. Pikeperch exhibited emerging PFAS concentrations approximately one order of magnitude higher than the other species. Precursor compounds such as perfluorooctanesulfonamide (PFOSA) and N-ethylperfluorooctanesulfonamidoacetic acid (N-EtFOSAA), capable of biotransforming into regulated PFAS, were occasionally detected and warrant attention in future monitoring.

Discussion and Conclusion
Fish from Lake Varese are currently compliant with EU food safety regulations. Nevertheless, the contamination profile of pike, with individual PFOS exceedances and sum concentrations approaching regulatory thresholds, and the elevated PFAS burden in pikeperch indicate that targeted surveillance is warranted. The emerging PFAS dataset constitutes a valuable baseline for future environmental monitoring and cumulative risk assessment within a One Health framework.

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P-00149 PFAS and arsenic species in Adriatic Sea clams (Chamelea gallina): regulated and emerging contaminants for compliance assessment and food safety evaluation

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Introduction
Clams are nutritionally valuable and widely consumed seafood but, due to their filter-feeding behaviour, can accumulate environmental contaminants such as PFASs and inorganic arsenic (iAs). PFASs are persistent fluorinated compounds of growing concern for human health, while iAs is a renown carcinogenic. Maximum levels for PFASs (PFOS, PFOA, PFNA, PFHxS and their sum) and iAs in bivalve molluscs were recently fixed in European Union [1;2].

Materials and Methods
Thirty-five samples of Chamelea gallina, collected between January and February 2026 along the Adriatic Sea coast of Veneto, Marche, and Abruzzo, were analyzed for PFASs and arsenic. Nineteen legacy PFAS (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, and PFDoS) were quantified by LC-MS/MS using isotopic dilution, with PFOA, PFNA, PFHxS, and PFOS reported as the sum of linear and branched isomers. Five emerging PFASs (PFOSA, GenX, ADONA sodium salt, F53 minor, and F53 major) were also included [3]. The same samples were analyzed for total arsenic (tot-As) and four arsenic species: i-As (expressed as sum of As(III) and As(V)), monomethyl arsonic acid (MMA), dimethylarsinic acid (DMA), and arsenobetaine (AB) [4]. Limits of quantification were 0.010 µg/kg for PFASs (except PFBA=0.20, PFOSA=0.025, Gen-X=0.20 µg/kg.), 0.020 mg/kg for tot-As and 0.010 mg/kg for As species.

Results
PFASs concentrations were almost comparable in all the samples analyzed, with no significant regional differences. ∑24 PFASs was 0.21±0.10 µg/kg with linear-PFOS and the long-chain carboxylic acids (C8-C14) detected in all samples. PFOS and PFOA (linear form) were the most abundant compounds (25% and 23% of ∑24 PFASs), followed by C9-C14 acids (contributing 7-12% each). Shorter-chain, long-chain sulfonic and emerging PFASs were not quantified. Tot-As was quantified in all samples (2.3±0.4 mg/kg) mainly as AB (1.59±0.03 mg/kg) and DMA (expressed as DMA+other unidentified As organic forms: 0.187±0.043 mg/kg). MMA was never measured. The toxic iAs form was present in all samples at 0.057±0.026 mg/kg (As(III)+As(V)).

Discussion and Conclusion
None of the clams samples exceeded the maximum limit for the four regulated PFASs [1] which accounted 0.13±0.05 µg/kg, on average 60% of the ∑24 PFASs. PFOS and PFOA are useful PFAS contamination indicators in clams contributing equally to the total levels. To the best of our knowledge, data on PFASs in European shellfish are available for mussels and oysters, but not for clams, including C. gallina. Regarding As, AB was the main contributor (70% of tot-As), followed by DMA (8%). Although quantified in all samples, the more toxic iAs represented only 2.6% of the tot-As, and remained always below regulatory limits [2]. To date no arsenic speciation data are available for C. gallina. These findings align with previous studies on seafood from the Belgium market, where AB was the dominant species and iAs was quantified only in shellfish (mussels) [5]. Although based on limited samples, this study provides the first insight on PFASs and arsenic speciation in clams collected in Italy and, likely, in Europe. Further research is needed, but these results support ongoing PFASs monitoring and future regulatory assessments of inorganic arsenic.

Acknowledgment
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Legacy and Emerging Flame Retardants: Occurrence and Exposure

P-00150 PBDEs in Food: insights from Official Italian Monitoring Plans on Dietary Exposure Assessment

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Introduction
PBDEs are brominated flame retardants widely used in consumer products. Since they are not chemically bound to the polymeric matrices to which are added, they are readily released into the environment. They bioaccumulate in adipose tissue and biomagnify through the food chain, making dietary intake the primary route of human exposure. PBDEs are included in the Stockholm Convention elimination list (1) and Commission Recommendation 2014/118/EU requested monitoring to EU member states. In absence of maximum levels, systematic data collection is essential to support risk assessment and future regulatory measures. This study reports preliminary PBDE levels in eggs, milk, meat, and anchovies across Italy, with an initial dietary exposure assessment.

Materials and Methods
Samples were collected in the frame of National Monitoring Plan for Environmental and Industrial Contaminants, issued by the Italian Ministry of Health. Seventy-five samples (bovine = 8, swine = 2, eggs = 17, milk = 11 and anchovies = 37) were collected between 2022-2025. Nine PBDEs (BDE-28, -47, -49, -99, -100, -153, -154, -183, -209) were analysed by isotope dilution in GC-MS/MS (2). Limits of quantification (LOQs) were 0.005 µg/kg (BDE-47: 0.015 µg/kg; BDE-209: 0.100 µg/kg); only in eggs were 0.010 µg/kg (BDE-47: 0.030 µg/kg; BDE-209: 0.200 µg/kg). Estimated Daily Intake (EDI) was calculated multiplying lower bound concentration by the mean daily consumption for a 70 kg body weight. Risk was characterised using the Margin of Exposure (MOE), defined as the ratio between a toxicological reference point and EDI. EFSA reference points were applied: 168 ng/kg bw/day and 1096 ng/kg bw/day for reproductive and neurodevelopmental effects respectively. MOE < 25 was indicative of a potential health concern (3).

Results
PBDEs were <LOQs in all the samples of eggs, muscles and milk, only in anchovies they had a mean sum concentration of 0.035 ± 0.044 µg/kg (0.0 - 0.164 µg/kg). BDE-47 was the dominant congener (37% of the total contamination), followed by BDE-100 (14%), -49 (11%), -154 (5%) and -99 (5%) (4). Remaining congeners were all <LOQs. The EDI of BDE-47 from anchovy consumption was 0.016 ng/kg bw/day. MOE (calculated against the reproductive Reference Point) was 10,500.

Discussion and Conclusion
In the absence of regulatory limits, results were compared with available literature. Meat, eggs and milk showed negligible levels across all samples, while anchovies were the only matrix with quantifiable PBDE concentrations, confirming fish as primary source of persistent organic pollutants exposure (3). PBDEs accumulate in anchovies due to their hydrophobicity by branchial uptake, non-selective feeding, and limited efficiency of reductive debromination, the main metabolic elimination pathway in fish (4). The predominance of BDE-47 in biological organisms is the result of BDE-99 conversion, in addition to the use of commercial penta-BDE mixture (dominated by BDE-47) (5). The MOE, calculated for BDE-47 in anchovies, largely exceeded the EFSA threshold, excluding health concerns for both reproductive and neurodevelopmental endpoints, consistent with EFSA opinion (3). However, EFSA concluded that, considering the entire group of PBDEs, cumulative dietary exposure in the European population may raise public health concerns, highlighting the need for risk assessment of the total burden of relevant congeners in food. MOE values suggest no health concern also for fish, although it showed the highest PBDE contamination; though further studies are needed to enrich the data set, given the limited sample size.

Acknowledgment
We thank the public health authorities for sampling.

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Fate, Detection and Analysis of Chlorinated Paraffins

P-00156 Metabolism of short-chain chlorinated paraffins by cytochrome P450 monooxygenases: An integrated in vitro and in silico studies

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Introduction
Cytochrome P450 (CYP, P450) monooxygenases are membrane proteins that are widely distributed among living organisms. P450s catalyze hydroxylation and dehalogenation of hydrophobic compounds, thereby increasing their water solubility and facilitating excretion from the body. Accordingly, P450-mediated metabolism plays a critical role in the expression of xenobiotic toxicity. In human, CYP3A4 has the largest portion of metabolic activities toward marketed drugs (3). In contrast, bacterial P450BM3 from Bacillus megaterium exhibits exceptionally high catalytic activity toward various substrates among P450s, including C12–18 saturated fatty acids (2).
Chlorinated paraffins (CPs) are chlorine-substituted n-alkanes consisting of complex mixtures of congeners with varying carbon chain lengths and degrees of chlorination. CPs have been widely used as flame retardants and plasticizers in industrial products. CPs are classified by carbon chain length as short-chain CPs (SCCPs, C10–13), medium-chain CPs (MCCPs, C14–17) and long-chain CPs (LCCPs, C18-30). Due to their persistence, long-range transport potential, and bioaccumulation, SCCPs and MCCPs were listed under the Stockholm Convention on Persistent Organic Pollutants in 2017 and 2025, respectively.
Previous studies showed that CYP3A4 is involved in the metabolism of CP mixtures in humans (4); however, the metabolic sites and pathways are unclear. In addition, P450BM3 metabolizes 2,3',4,4',5-pentachlorobiphenyl (CB118), a type of polychlorinated biphenyls (1), although its metabolic activity toward CPs has not yet been elucidated. Therefore, this study performed in vitro metabolic assays using 5 individual CP congeners and in silico docking simulations to investigate CP metabolism by human CYP3A4 or bacterial P450BM3.

Materials and Methods
In metabolic assays, five congeners were each incubated with either human CYP3A4 or bacterial P450BM3 in reaction mixtures containing NADPH and NAPDH-regenerating system. Reactions without NADPH were served as controls. After incubation at 37°C for 2 hours, acetonitrile containing 1% formic acid and the internal standard d18-HBCD were added, followed by centrifugation. The residues were sequentially extracted with acetonitrile and acetone, and the combined extracts were filtered and concentrated under nitrogen. CPs and their metabolites were identified and quantified using Liquid Chromatography – Time of Flight Mass Spectrometry (LC-TOF/MS). In docking analysis, 3D structures of P450s and CPs were constructed, and docking simulations were performed using AutoDock Vina to calculate binding free energies. The distance between the catalytic center of P450s and the nearest carbon atom of CPs was measured. If the distance was within 6 Å, the substrate was considered easily to be metabolized by P450s (5).

Results
In metabolic assays, human CYP3A4 reacted with CPs in NADPH-dependent manner, producing dechlorinated and hydroxylated metabolites, dechlorinated metabolites, and hydroxylated metabolites. In contrast, bacterial P450BM3 mainly produced hydroxylated metabolites. In docking simulations, the terminal or subterminal carbon atoms of CPs were positioned closest to the active center of both human CYP3A4 and bacterial P450BM3. In these orientations, the shortest distance between the active center and CP carbon atom was within 6 Å for all CP congeners.

Discussion and Conclusion
The metabolic assays suggested that CP metabolic pathways differ depending on the P450 isoforms. In addition, the degree of chlorination and chlorine substitution position of CPs affected metabolites amounts. The in silico analysis suggested that P450s preferentially metabolize the terminal or subterminal positions of CPs.
Our research provide important insight into the metabolic sites and pathways of CPs by P450s and may contribute to understanding the environmental fates of pollutants in humans and soils.

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Progress in non-polar POPs Analysis

P-00157 Tailored design of hollow spheric Eu-Luminol/ZIF-8 mixed matrix membranes for ratiometric sensing of tetracyclines

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Introduction
The increasing concern about tetracyclines (TCs) contamination brings out the development of multifunctional materials to sensitively detect TCs. Herein, a novel Eu-Luminol/ZIF-8 (Eu-L/ZIF-8) heterojunction is rationally designed for the simultaneous capture and ratiometric sensing of TCs. The large specific surface area, hollow and multiple pore structure of Eu-L/ZIF-8 boost the enhanced adsorption for tetracycline (TC, 1115.3 mg g-1), oxytetracycline (OTC, 869.6 mg g-1) and doxycycline (DOX, 862.1 mg g-1). Meanwhile, sensitive ratiometric sensing of TCs is realized by gathering TCs around the sensing center of Eu-L to induce the fluorescence turn-on of Eu3+ (615 nm) and quenching of luminol (435 nm). The detection limit is 5 nM for TC and OTC, 10 nM for DOX, respectively. Furthermore, Eu-L/ZIF-8 is fabricated to mixed matrix membranes (MMMs) for the portable visual sensing of TCs. The portable sensing of TCs is conducted by a homemade testing kit within 10 min in real wastewater. The results demonstrate that Eu-L/ZIF-8 MMMs is a powerful tool for the portable sensing of TCs.

P-00161 Investigation of Pretreatment Methods for the Simultaneous Analysis of Methoxychlor and Chlorpyrifos in Products Using an LPGC Column

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Introduction
Methoxychlor and Chlorpyrifos were used as insecticides. However, due to concerns about their persistence, toxicity, etc., they have been regulated under the Stockholm Convention on Persistent Organic Pollutants (POPs) and the establishment of analytical methods for these substances is urgently needed. Meanwhile, in GC/MS, which is commonly used for POPs analysis in products, the development of methods capable of analyzing multiple components in a short time has also become a critical challenge against the backdrop of recent helium supply shortages. Against this backdrop, at Dioxin 2024, we presented a method for the simultaneous analysis of Dechlorane Plus and UV-328 using Low-Pressure GC (LPGC) column1, which has been successfully applied in PCB analysis2. The use of LPGC columns enables a significant reduction in measurement time compared to general capillary columns, and is expected to increase sample throughput while reducing helium gas consumption. Therefore, in this study, we investigated a method for the simultaneous analysis of Methoxychlor and Chlorpyrifos in products using an LPGC column and GC/MS/MS, and also evaluated sample pretreatment methods using actual samples.

Materials and Methods
Methoxychlor and Chlorpyrifos (Fujifilm Wako Pure Chemical) were used as standards. Internal Standard Mixture Solution 3 (Kanto Chemical Co., Ltd.) was used as the internal standard (Chrysene-d12). During GC/MS/MS measurements, variations in the peak sensitivity were observed due to the sample matrix; therefore, a pseudo-matrix (PEG300) was co-injected. PVC, PS, ABS resin, and commercially available products were used as samples. For pretreatment, toluene was added to the cut sample, which was then subjected to ultrasonic treatment to obtain the extract. For samples made of PS and ABS that had dissolved in toluene, hexane was added to precipitate the polymer components, which were then filtered through a 0.45 μm filter (precipitation purification process), and the filtrate was concentrated. An internal standard solution was added to the filtrate (or the extract if not purified), and the resulting solution was concentrated to the required volume and analyzed by GC/MS/MS.

Results
Co-injection of a pseudo-matrix suppressed variations in peak sensitivity caused by the sample matrix between the standard solution and the actual sample. In the measurement, samples dissolved in toluene exhibited high viscosity in the extract, raising concerns about measurement issues and interference from polymer components; however, we confirmed that measurements could be performed without such interference by incorporating precipitation. Furthermore, it was confirmed that the recovery rates of the target substances during the precipitation purification process for PS and ABS resins were good, ranging from 106% to 114%.

Discussion and Conclusion
We investigated a method for the simultaneous analysis of Methoxychlor and Chlorpyrifos in products using an LPGC column and showed that co-injection of a pseudo-matrix suppresses fluctuations in peak sensitivity caused by matrix effects, thereby enabling reliable analysis. Furthermore, we confirmed that this analytical method is applicable even to toluene-soluble samples by incorporating a precipitation purification process as needed. Therefore, this analytical method is expected to significantly reduce measurement time and minimize helium gas consumption compared to conventional methods, while increasing sample throughput. Future challenges include improving the method to reduce analysis time and increase the number of substances that can be analyzed simultaneously, thereby enhancing measurement efficiency and aiming to further reduce helium gas consumption.

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P-00167 Dietary PFAS exposure in companion dogs and cats in Japan: pet food contamination and serum evidence

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Introduction
Companion dogs and cats share household environments and food-related exposure pathways with humans, but dietary exposure to per- and polyfluoroalkyl substances (PFAS) remains poorly characterized. This study integrated commercial pet-food monitoring with serum biomonitoring of privately owned pets in Japan to evaluate pet food as a source of internal PFAS exposure.

Materials and Methods
We quantified 34 PFAS in 100 commercial dog and cat food products sold in Japan. In parallel, 38 PFAS were targeted in serum from dogs and cats (n = 53) collected in Hokkaido, Osaka, and Ehime. Paired dry pet foods consumed by the Ehime animals were also analyzed (n = 22). PFAS were determined by LC-MS/MS after matrix-appropriate extraction and cleanup. Dietary intake, hazard quotients, and species-stratified serum-food associations were evaluated.

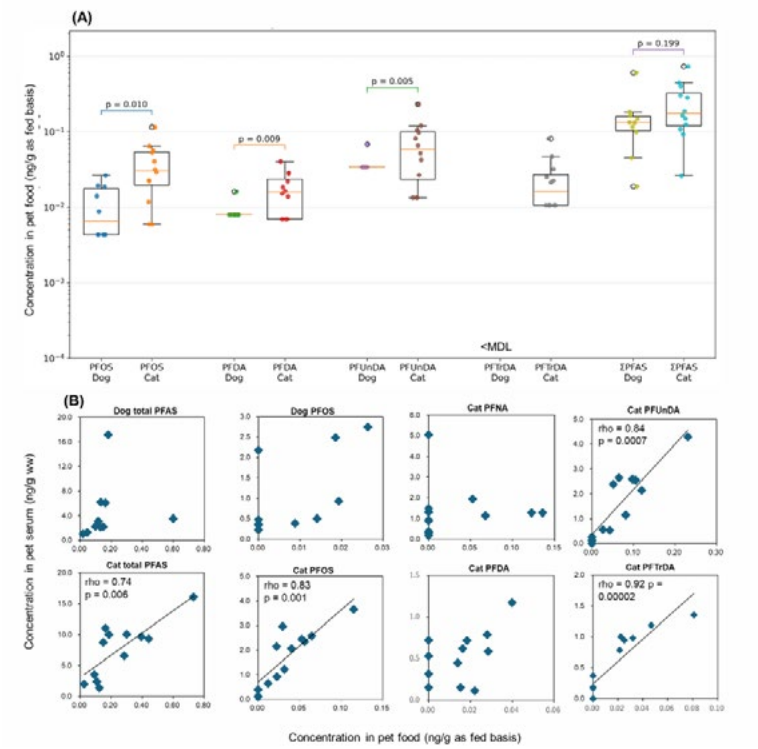


Figure 1. PFAS concentrations in paired dry pet food and serum-food relationships in the Ehime cohort. (A) PFOS, PFDA, PFUnDA, PFTrDA, and ΣPFAS concentrations in paired dry pet food samples consumed by dogs and cats. (B) Relationships between pet food and serum concentrations of PFAS in the corresponding animals. Dogs are shown for PFOS and ΣPFAS, whereas cats are shown for PFOS, PFNA, PFDA, PFUnDA, PFTrDA, and ΣPFAS. Boxes indicate the interquartile range, center lines indicate medians, and whiskers indicate the range excluding outliers. Each point represents one paired serum-food sample from the same animal. Spearman's rank correlation coefficients and p values are shown in the correlation panels.

Results
PFAS were frequently detected in pet foods and pet serum. In pet foods, concentrations differed by product type, ingredient category, and country of origin. Fish-based products showed elevated PFOS, PFUnDA, and PFTrDA, whereas meat-based products generally contained lower concentrations. Asian-manufactured wet foods tended to show long-chain PFCAs, and the F-53B-related compound 9Cl-PF3ONS was detected in several products. Preliminary hazard quotients exceeded 1 for several products, indicating that chronic dietary intake may be relevant for companion-animal health, although species-specific toxicokinetic uncertainty remains.

P-00167 Dietary PFAS exposure in companion dogs and cats in Japan: pet food contamination and serum evidence

Serum profiles differed clearly between species. Cats had significantly higher concentrations of long-chain PFCAs, including PFNA, PFDA, PFUnDA, PFDoA, and PFTrDA. In the paired Ehime cohort, cat foods contained higher PFDA, PFUnDA, PFTrDA, and total PFAS than dog foods. Cats also showed stronger positive serum-food relationships for PFOS, PFUnDA, PFTrDA, and total PFAS, whereas the corresponding relationships in dogs were weaker. These results suggest that feline enrichment of long-chain PFCAs is shaped by fish-associated dietary exposure and species-specific retention.

Discussion and Conclusion

Pet food represents an important PFAS exposure pathway for companion animals in Japan. Fish-derived ingredients and Asian-relevant emerging PFAS signatures should be considered in exposure assessment. Companion animals may serve as practical sentinels linking food-chain contamination, household co-exposure, and One Health-oriented risk assessment.

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P-00170 Development of a method for the analysis of microplastics in clam Chamelea gallina with Py-GC/MS

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Introduction

Microplastics (MPs) are increasingly recognized as emerging contaminants in marine environments, raising concerns about their occurrence in seafood and potential implications for human exposure. In 2016, the European Food Safety Authority (EFSA) highlighted the presence of MPs and nanoplastics (NPs) in food and pointed out that the lack of validated analytical methods still limits the acquisition of reliable data for risk assessment.1 More recently, European regulatory efforts have started to address the need for harmonized methodologies for MP analysis.2 Within this evolving framework, the development of robust approaches for complex biological matrices remains a key challenge. Among available techniques, pyrolysis coupled with gas chromatography–mass spectrometry (Py-GC/MS) is gaining relevance due to its high sensitivity and ability to provide mass-based information on polymer composition, even in complex organic matrices.3 This analytical technique also offers the potential to have information on polymer-associated chemical species, such as plastic additives, degradation products, and co-occurring organic contaminants,4 which are increasingly recognized as relevant in the assessment of MP-related pollution.

In this study, a protocol for the determination of MPs in the striped venus clam Chamelea gallina was developed using reactive Py-GC/MS and tetramethylammonium hydroxide, targeting nine common polymers, including PE, PP, PS, PET, PVC, PC, PA6, PMMA and MDI-PUR. MP analysis and mass quantification based on the detection of characteristic pyrolysis products related to the respective homopolymers which also serve as the basis for quantification. Results are expressed in terms of defined base polymer clusters (C-) related to the specific polymer building blocks and include copolymers on a proportional basis.5 This study focuses on sample preparation and organic matrix removal, including a combined chemical-enzymatic digestion followed by Fenton oxidation, and a multi-step filtration procedure with 10 µm stainless steel followed by 1 µm glass fiber filter. This last one is directly introduced into the pyrolysis cup. The analytical procedure was applied to real samples. Results show that most of the targeted polymer-clusters can be identified in variable amounts across samples, with some polymers (e.g., C-PET, C-PP and C-PS) more consistently detected at low µg range per sample, while others (e.g., C-PMMA and MDI-PUR) were found less frequently, but in notable quantities, in some cases > 10 µg/sample. No signals attributable to C-PC and C-PA6 were detected in the analyzed samples. The data provide valuable insight into key methodological aspects, heterogeneous distribution of MPs within the samples, and matrix-related interferences with certain characteristic pyrolysis products will be elucidated.

These findings are crucial for interpreting the results, as they address the influence of background signals typical of complex biological matrices and the heterogeneity of the samples. In this context, the data primarily indicate the presence of specific polymer type clusters as described above. This work underlines the potential of Py-GC/MS for MP analysis in seafood, while emphasizing the necessity for rigorous background contamination control and methodological refinements to ensure robust and reliable MP quantification.

Keywords: Microplastics, Py-GC/MS, seafood, complex matrices

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P-00171 Ten-Year Surveillance of PCDDs/Fs and PCBs in Foods from Central Italy (2016–2025): Contamination Trends and Dietary Exposure

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Introduction
This study assessed contamination by polychlorinated dibenzo-p-dioxins (PCDD/Fs), dioxin-like polychlorinated biphenyls (dl-PCBs), and non-dioxin-like PCBs (ndl-PCBs) in food samples from Central Italy (Latium and Tuscany) over a ten-year period (2016–2025). A total of 1,756 food samples, including meat, fish, milk and dairy products, eggs, vegetable oils, and baby foods, were analysed by high-resolution gas chromatography–high-resolution mass spectrometry (HRGC-HRMS). Contamination levels are expressed as WHO-2005 toxic equivalents (WHO05-TEQ).
Overall, contamination levels were consistently low across all food categories, with higher levels observed in game meat and sheep products and lower levels in pork and poultry. These patterns reflect known bioaccumulation mechanisms and are consistent with previous national findings [1]. Although occasional higher values were observed within certain categories, nearly all samples remained compliant with current regulatory limits of Commission Regulation (EU) 2023/915.

Results
The relative contribution of contaminant classes varied depending on the food type. PCDDs/Fs were most abundant in eggs and dairy products, whereas dl-PCBs accumulated mainly in dairy products. Ndl-PCBs showed the highest concentrations in marine oils and dairy products and high inter-sample variability, particularly in marine oils and eggs. Plant-based foods showed lower contamination levels, likely due to contaminant biomagnification in animal-derived foods. Over the 10-year period, only one yoghurt sample (2016) exceeded the regulatory limit, driven by dl-PCB congeners, consistent with congener patterns previously reported in milk from dairy cows exposed to contaminated feed [2].
Compared with Italian monitoring data from 2013–2016 [1], mean concentrations in major food groups, such as meat, milk, and eggs, were approximately 2–4 fold lower. Contamination levels in Central Italy were markedly lower than those reported in Southern Italy [3,4], with ndl-PCB concentrations and WHO05-TEQ values lower by up to one order of magnitude. These discrepancies may be attributed to differences in environmental contamination, animal feeding practices, and sampling strategies, including narrow monitoring windows [3,4] and proximity to industrial sites [4].
Preliminary dietary exposure estimates, based on measured contaminant concentrations and average daily food consumption data from two national databases, were 2.31 and 2.52 pg WHO05-TEQ/kg bw/week, respectively. These values are slightly above the tolerable weekly intake established by EFSA in 2018 (2 pg WHO05-TEQ/kg bw/week) but substantially lower than previous national estimates [1]. Fish and cheese were the main contributors to exposure, together accounting for approximately 67–71% of the estimated total intake.

Discussion and Conclusion
The results, representing a subset of a larger dataset reported in a recently published study[5], demonstrate a significant reduction in contamination levels in foods from Central Italy compared with previous monitoring periods, consistent with the effectiveness of current EU and national risk management strategies. However, the observed variability across food categories underscores the need for continued systematic surveillance, particularly for high-risk products such as game meat, marine oils, and dairy products, to ensure long-term food safety and promptly detect emerging contamination trends.

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PFAS Analysis

P-00174 Development and validation of an analytical method for determination of PFAS in honey: a biomonitoring study in the Czech Republic

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are a diverse group of anthropogenic contaminants characterised by their extreme persistence, bioaccumulation potential, and toxicity. Honey bees (Apis mellifera) are widely recognised as effective bioindicators of environmental contamination due to their extensive foraging activity, during which they collect nectar, pollen, and water that may contain pollutants, including PFAS, which generally occur at concentrations in the range of tenths to units of nanograms per gram (ng/g). These substances can subsequently be transferred to the hive and accumulate in honey, representing a potential route of human exposure. The European honey bee, responsible for approximately 35% of global crop production, is currently declining due to agricultural intensification and chemical contamination. Reduced EU honey production and increased imports (by up to 40%) highlight the need for stricter controls on honey quality and safety. As part of COST Action CA22105 (BeSafeBeeHoney), this study focuses on the development, optimisation, and validation of a robust analytical method for the simultaneous determination of 43 PFAS compounds in honey.

Materials and Methods
Sample preparation is based on a modified QuEChERS extraction procedure followed by dispersive solid-phase extraction (d-SPE) using a mixture of primary–secondary amine (PSA), Envi-Carb, and Z-Sep+ sorbents to remove potential matrix co-extracts. An additional advantage of the proposed approach is its compatibility with the simultaneous isolation of more than 400 pesticide residues, representing another target group within the project scope, which are determined directly in the primary acetonitrile extract prior to clean-up. Instrumental analysis was performed using UHPLC–MS/MS (XEVO-TQ Absolute, Waters).

Discussion and Conclusion
Method performance showed recoveries (at concentration levels of 0.01 and 0.1 ng/g) in the range of 77–120%, repeatability below 20%, and limits of quantification ranging from 0.001 to 0.01 ng/g. The validated method was applied to a comprehensive set of 100 honey samples collected between 2020 and 2024, covering all regions of the Czech Republic and various botanical origins (floral, honeydew, and mixed) across different seasons. The results provide the first systematic data on PFAS occurrence in Czech honey. These findings contribute to the assessment of environmental contamination and support future regulatory efforts, as no specific maximum limits for PFAS in honey are currently established in the EU.

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P-00176 Exposure to PFAS and eggshell features in an arctic seabird

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Introduction
Environmental pollution affects all ecosystems, and the Arctic is no exception. Arctic top predators, such as seabirds, at a high trophic level and generally long-lived, are particularly contaminated. But the effects of certain contaminants, such as PFAS (per-polyfluoroalkyl components, also called 'forever chemicals', used as surface-active agents and water repellents in a wide range of industrial and commercial applications) are still poorly documented. Some studies showed that PFAS can affect survival and reproduction, can disturb some physiological mechanisms, and can be transferred from the mother to their eggs. In many seabird species, eggs exhibit variations in colour, maculation and shape. Several hypotheses have been suggested to explain this variation. One of them is that these patterns may reflect the quality of the female. For instance, the two main pigments involved in egg patterning are also involved in the immune system and oxidative balance. Other studies observed that some contaminants can affect the appearance of eggs, but the effect of PFAS has never been investigated so far.

Materials and Methods
Our study tested if PFAS levels can be associated with egg parameters (spottiness, Hue, Saturation, Value, shell thickness, egg volume) derived from measurements and egg picture analyses, in an arctic population of black-legged kittiwakes (Rissa tridactyla), located in Svalbard.

Results
Links have been found between PFAS levels in females and in eggs, and certain parameters related to egg colouration (Hue, Value) and morphology (shell thickness and volume).

Discussion and Conclusion
This could affect hatching success, chick survival and, in fine, could disrupt the dynamics of this black-legged kittiwakes population. This study is part of a bigger research project which aims to better understand the consequences of this global PFAS contamination on wildlife.

Acknowledgment
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P-00177 Influence of inorganic matrices on the analytical pyrolysis of polymers: towards a validated multi-analytical workflow

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Introduction
Analytical pyrolysis coupled with gas chromatography and mass spectrometry (Py-GC/MS) is a cornerstone technique for the identification and quantification of polymers in complex environmental samples. As the analytical community moves towards more comprehensive characterization, there is a growing interest in developing multi-analytical workflows that combine non-destructive techniques, such as micro-Fourier Transform Infrared (μ-FTIR) spectroscopy, with destructive thermo-analytical methods [1,2]. The success of such sequential approaches relies on the ability to analyze the sample on the same physical support across different platforms to minimize sample loss and contamination. However, this integration introduces inorganic substrates directly into the pyrolysis environment. The influence of these inorganic phases on the resulting analytical signal is a factor that is often underestimated in current literature.

Materials and Methods
This study investigates the potential "matrix effect" exerted by inorganic materials. Alumina and silica were selected as representative substrates for this assessment. The choice of alumina is dictated by its widespread use in μ-FTIR filtration (e.g., Anodisk filters), representing a key step for integrating spectroscopic and pyrolytic analyses. Similarly, silica is evaluated to assess the direct analysis of polymers collected on quartz fiber filters, such as those typically used in atmospheric aerosol sampling. The experimental design involves a systematic comparison of the Py-GC/MS response for a selection of target polymers in the presence and absence of these inorganic phases, simulating "direct-filter" pyrolysis conditions.

Results
The qualitative assessment focuses primarily on verifying the stability of the pyrolytic profile, with particular attention to potential shifts in retention times and the identification of matrix-induced artifacts. From a quantitative perspective, the investigation involves a rigorous comparison of peak areas; the precision of the analytical signal is further assessed, ensuring that any fluctuations in the pyrolytic response are statistically significant. Preliminary observations aim to determine whether the inorganic support exerts a physical or catalytic effect capable of altering the degradation pathways or the reproducibility of the polymer's fingerprint.

Discussion and Conclusion
By addressing these fundamental analytical questions, the work aims to establish the degree of interference of inorganic supports on the polymer's thermal degradation. These findings provide the essential methodological basis for validating "direct-filter" pyrolysis, ensuring that the analytical output remains accurate and reproducible within integrated multi-analytical framework, in view of developing a robust multi-analytical workflow specifically tailored for the comprehensive analysis of environmental samples.

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P-00179 Atmospheric levels, sources and risks of PCBs in Brazilian Industrial Cities

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Introduction
Polychlorinated biphenyls (PCBs) are priority chemicals known for environmental and human health impacts. They are classified as persistent organic pollutants (POPs) under the Stockholm Convention. Key sources of PCBs have been identified as dielectric fluids/coolants in electric transformers and capacitors in closed applications. Leakages of these oils were mostly associated with environmental contamination of PCBs. Current PCB data in Brazil are skewed to specific micro-environments with wide range data limited, particularly in industrial locations. This study is therefore aimed at: (1) understanding the current level of PCBs in outdoor air of the industrial cities of Sorocaba, Votorantim, and Itu; (2) assessing possible sources by exploiting the surrounding soil compartments; (3) evaluating the human exposure risks; and (4) proffering relevant recommendations in line with the current policy formulation/enhancement.

Materials and Methods
Annual sampling was conducted with bi-monthly sample collections for soil and outdoor air samples using passive air sample - polyurethane-foam (PAS-PUF). 30 samples were collected each for soil and air, alongside the blank samples. Approx. 20g of the soil samples (<2mm) and air samples were subjected to exhaustive Soxhlet extraction using 200 mL dichloromethane (DCM) (DCM;hexane (1:1, v/v) for soil) for 24 hrs. Each sample was spiked with internal standards (IS) comprising 20 ng each of labelled PCBs -28, 52, 101, 118, 153, 138, and 180 prior to sample extraction. The extract was subsequently blown down under gentle nitrogen gas flow and then solvent exchanged to 2 mL hexane. The hexane extract was digested with conc. H2S04 (95% w/w) and further cleaned up on silica (deactivated at 3.3%) column (diameter = 7mm) using 15 mL DCM;hexane (1:1, v/v) solvent. Following further blown down and recovery in Toluene solution comprising 20 ng labelled PCB -70 as recovery determination standard, the extract was analysed for the seven indicator PCBs (PCBs -28, 52, 101, 118, 153, 138, and 180) on Agilent GC-MS. Inhalation risk was assessed for the PCBs in the air. All sample analyses followed stringent quality assurance/quality control protocols. Data analyses were performed on OriginPro v2026 and Microsoft Excel (v 2023). For statistical purposes, non-detect was set at 0.5 × LOD. Statistical data were considered significant at $p<0.05$.

Results
The average PCB concentration in the air samples was found as 65 pg/m3, in the order of: UNESP (89 pg/m3) > ETEC (79 pg/m3) > IUTP (53 pg/m3) > FATEC (52 pg/m3) > PARQT (52 pg/m3. The concentrations indicated significant negative correlations with the wet precipitations. PCBs – 28, 52, and – 138 were the only congeners detected above 50%.

Discussion and Conclusion
The average concentration found is within the mid-range of the global data but topping those of South America (Akinrinade and Rosa, 2025). The prevalent PCBs-28, 52 and 138 are consistent with the literature data. Atmospheric scavenging from wet precipitation played a significant role in air PCB levels with air concentration depreciating by factors upto ~4 to ~24. The impact of wet precipitation did not transform to any meaningful increase in soil level. With the highest concentrations found in industrial locations with active construction activities, the PCB sources were likely related to industrial and construction activities. No influence of volatilisation of secondary sources from soil was observed. Exposure to PCBs in the air samples was significantly low. In relation to continuous global efforts targeting the eradication of persistent organic pollutants (POPs)/ PCBs, broad public sensitisation is recommended.

Acknowledgment
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P-00181 Perfluoroalkyl substances (PFASs) in Italian Food: Insights from Three Years Official Controls (2023–2025)

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Introduction
PFAS are widely used in many industrial applications; they are toxic, persistent, and bioaccumulative in biota and humans with diet representing the main route of exposure [1]. In 2020, EFSA set a group Tolerable Weekly Intake (TWI) of 4.4 ng/kg body weight for the combined exposure to the four PFAS of greatest toxicological relevance: PFOA, PFOS, PFNA, and PFHxS. Regulation (EU) 2023/915 set maximum limits for these PFAS in food, while Recommendation (EU) 2022/1431 encourages the monitoring of other PFASs including emerging compounds [2,3]. Official laboratories are required to analyse food for compliance. This study reports official control data (2023–2025), to establish baseline levels and identifying emerging issues.

Materials and Methods
Samples were collected in 2023-2025 across Northern and Central Italy (Piemonte, Lombardia, Emilia-Romagna, Marche, Umbria) within Italian Official Monitoring Plans. 553 samples were analysed: 180 meat and meat product, 23 liver, 13 baby-foods, 16 milks, 76 eggs, 95 fishery products (74 fish, 3 cephalopods, 10 crustaceans and 8 gastropods) and 151 bivalve molluscs (60 mussels, 6 oysters, 81 raw clams and 4 cooked clams). Nineteen PFAS (PFBA-PFPeA- PFHxA-PFHpA-PFOA-PFNA-PFDA-PFUdA-PFDoA-PFTrDA-PFTeDA-PFBS-PFPeS-PFHxS-PFHpS-PFOS-PFNS-PFDS-PFDoS) were included in the LC-MS/MS method and PFOA, PFNA, PFHxS, and PFOS were reported as sum of linear and branched isomers [4]. Limits of quantification (LOQ) were 0.010 µg/kg (0.20 for PFBA) [2].

Results
The mean Σ19 PFASs was 0.24±0.77 µg/kg and the highest levels were observed in liver (except chicken offal). Ovine livers had the highest concentration (4.7 ± 4.9 µg/kg), followed by swine and bovine (0.63 ± 0.45 and 0.60 ± 0.95 µg/kg). Fishery products showed the highest mean values: 0.34 ± 0.56 µg/kg in fish, 0.23 ± 0.13 µg/kg in mussels, and 0.45 ± 0.38 µg/kg in clams. Higher concentrations, although based on few samples, were found in cephalopods (from 0.072-3.3 µg/kg), and cooked Paphia textile (0.040-6.6 µg/kg). Occurrence in eggs was limited (11% of samples) and at low levels (0.014 ± 0.052 µg/kg). Among meat, ovine showed the highest level 0.17 ± 0.59 µg/kg) and detection frequency (53%), whereas bovine, swine, and poultry exhibited negligible amounts.

Discussion and Conclusion
Food matrices highlighted important differences in PFAS patterns. In liver, PFOS was dominant accounting for 85% of the total contamination, with a branched-to-linear isomer ratio included in 31-61%. In meat, marine fish, and eggs, linear PFOS was also the most abundant (74%, 52%, and 39% of total PFASs) followed by long-chain acidic PFASs (C8–C14), accounting for 3–16% each. Different patterns were observed in other fishery products, likely reflecting different metabolic behaviours: PFOS contributed around 13% of Σ19PFASs, while C11–C14 acids predominated: PFTrDA (36%), PFUnDA (14%), PFTeDA (11%), and PFDoA (7%). In clams, PFOS and PFOA contributed similarly (25% each of Σ19PFASs). Short-chain PFASs and sulfonic compounds were generally <LOQ in all the samples. Heterogenous contamination patterns across different food commodities significantly influence compliance with maximum limits. Only one ovine liver and one cooked clam sample had tot-PFOS (12 µg/kg), tot-PFOA (4.6 µg/kg) respectively, and the sum of the four regulated PFASs (12 µg/kg in liver and 1.7 µg/kg in cooked clam) exceeding maximum limits. The Σ4 regulated compounds contribute significantly to overall PFAS contamination (87 - 50%) in meat, liver, eggs, fish, and clams, whereas in mussels, cephalopods, crustaceans, and gastropods they account for only 21–31% of Σ19 PFASs. Monitoring is recommended to collect more data and better understand the contribution of other not yet regulated PFAS.

Acknowledgment
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Progress in non-polar POPs Analysis

P-00191 Interlaboratory study on polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and polychlorinated biphenyls (PCBs) in cooked beef

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Introduction
Sample preparation in food analysis is a critical step that extends beyond achieving homogeneity to include effective conditioning of the matrix for subsequent extraction. Matrix-specific factors and structural variability can strongly influence the accessibility of target analytes, necessitating a detailed understanding of sample characteristics. The analytical determination of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and polychlorinated biphenyls (PCBs) requires effective removal of water from sample matrices to ensure accurate and reproducible results. Various approaches for matrix dehydration are available, each differing in efficiency and applicability. Commonly used techniques include mechanical homogenization in combination with drying agents, which facilitates simultaneous disruption and moisture binding, as well as freeze-drying methods that remove water under reduced pressure while preserving the structural integrity of the analytes. These preparation steps are critical for optimizing extraction efficiency and minimizing analytical interferences in subsequent determination procedures. Despite this, the influence on matrix properties should not be underestimated. In this interlaboratory study, the effect of freeze-drying on cooked beef was investigated, alongside the development of a robust and quantitative extraction method for PCDD/Fs and PCBs in this specific context. The study was initiated by the National Reference Laboratory for Halogenated Persistent Organic Pollutants in Feed and Food (NRL POPs) in Germany following observed differences in analytical results for these contaminants, which were found to correlate with differences in sample preparation approaches across laboratories. An initial preliminary study involving three laboratories has been completed. Its results demonstrate that freeze-drying can significantly influence analytical outcomes, particularly when extraction methods have not been validated for this specific matrix and preparation technique. Striking under-recoveries were observed across all laboratories when freeze-drying was applied. This suggests that structural changes in the matrix substantially impair the extractability of the congeners. Notably was that, for PCDD/Fs and dioxin-like PCBs (dl-PCBs), lower-chlorinated congeners were affected more strongly than higher-chlorinated ones. This is particularly critical, as the lower-chlorinated congeners contribute the most to the World Health Organization Total Toxic Equivalents (WHO Total TEQ) due to their higher toxicity. In contrast, it appears that the freeze-drying process has a negligible effect in the case of non-dioxin-like PCBs (ndl-PCBs). Building on these findings, an interlaboratory study on the analysis of PCDD/F and PCB in cooked beef with the participation of fourteen official laboratories (OFLs) in Germany is currently ongoing. The results obtained so far highlight the urgent need for harmonization of sample preparation protocols, or at minimum increased awareness among laboratories, to prevent underestimation of contamination levels and to ensure reliable detection of contaminated samples.

P-00192 Approaching micro- and nanoplastic mass fractions in apple orchard soils under different management systems via TED-GC-MS/MS

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Introduction
Intensive agriculture is one of the most important sources of plastic pollution of soils: recent studies estimate that accumulation levels in agricultural soils may be up to 20 times higher than those found in oceans [1]. This significant impact is primarily driven by the extensive use of plastic materials for crop protection (mulching films and anti-hail nets) and irrigation infrastructure (pipes and drip systems) aimed at increasing production efficiency. Additionally, disposable plastic materials, including packaging and other agrochemical applications, further contribute to this environmental burden [2.] In this context, Clim00 [3] project, funded by "South Tyrol Climate Plan 2040", investigates micro- and nano-plastic (MP, NP) contamination in agricultural soil and related interconnections with climate change. Our primary focus is on apple production fields. As part of the project strategies, farmer surveys are used to identify barriers to more sustainable agriculture, while a parallel review of current methods for assessing climate and sustainability impacts supports the development of a coherent framework and a reference ontology. The present study aims to assess the plastic occurrence and distribution in apple orchard soils within different agricultural management systems, contributing to a better understanding of the possible contamination patterns.

Materials and Methods
The sites included in this study were selected from those located in the main apple-growing regions across South Tyrol, meeting the same criteria, including crop configuration (e.g., the predominant slender spindle tree training system) and the availability of general management and site-specific information. A total of ten apple orchards, including both integrated production (IP) and organic systems (OS), were selected for randomized [4] soil sampling and subsequent analysis. Sampling spots were selected from both intra-row and inter-tree spaces, picked up with a soil auger to 10 cm depth avoiding areas that could bias the results (such as at the ends of the rows and places near public roads), and stored into glass jars.
An aliquot of each soil was subjected to the density suspension and organic matter removal procedure [5] for the extraction of plastics, optimized for the matrix. After the addition of aliquots of high-density saline solution (~1.6 g/cm3) plastic particles were separated from the sample solid matrix by floating. Supernatant liquid, once pooled, was digested following Fenton's procedure to allow the removing of precipitated reaction product. The solution is then filtered and analysed by TED-GC-MS/MS. Analytical standards of PE, PP, PS, PET, PVC, PU purchased by Microplastic Solution, were used to build the calibration curves and to identify the plastic materials.

Results
The better procedure to matrix handling to extract plastics from the collected soils is under evaluation at the moment.
Results of TED-GC-MS/MS determinations will be analysed to determine whether the current situation indicates widespread and overall contamination across sites with different management systems and whether there are differences between the age groups. We will also test whether the source of contamination is correlated with the level of contamination to indicate the accumulation trend and explore links between polymers composition and the potential sources of contamination.

Discussion and Conclusion
The findings of this study aim to enhance the understanding of MP and NP accumulation in agricultural soils, promoting more informed and responsible management of plastic use in farming.

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P-00194 An algae-based air purifier that removes various pollutants while simultaneously producing oxygen

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Introduction
Air pollution poses a critical global health threat, causing millions of deaths each year through exposure to TVOC, HCHO, particulate matter (PM2.5/PM10), CO_2, NOx, SOx, and Bioaerosols. It accelerates climate change, disproportionately affecting urban populations exposed to industrial, transportation, and energy sector emissions. Conventional purification technologies, such as HEPA filters, activated carbon, chemical absorption, and ionisers, address limited pollutant spectra while generating secondary waste and consuming substantial energy. This study presents a novel algae-assisted microbial fuel cell (MFC) prototype capable of simultaneously capturing multiple pollutants, producing oxygen, and generating valuable biomass byproducts, offering a sustainable, circular-economy alternative to existing remediation strategies.

Materials and Methods
An algal-MFC prototype was constructed incorporating multiple algae strains, with Chlorella vulgaris selected as the primary species based on its established CO_2 fixation efficiency. The bioreactor chamber maintained controlled light intensity (150 µmol photons/m^2/s), temperature (25±2°C), and airflow rate (2 L/min). Pollutant-laden air simulating indoor conditions was continuously passed through the algal chamber. CO_2, NOx, SOx, TVOC, HCHO and PM2.5/PM10 concentrations were measured using calibrated gas analysers and optical particle counters at inlet and outlet ports. Biomass productivity was quantified gravimetrically at 72-hour intervals. MFC electrodes were integrated to monitor bioelectricity generation. All experiments were conducted in triplicate, and removal efficiencies were calculated as the percentage reduction in inlet-to-outlet concentrations. Harvested biomass was analysed for suitability as biofertilizer and biofuel using elemental and calorific value analyses.

Results
Chlorella vulgaris demonstrated CO_2 capture exceeding 90% under optimized light and airflow conditions. NOx and SOx removal efficiencies exceeded 80%, while PM10 concentrations were significantly reduced via biofilm filtration. VOC and bioaerosol reductions were observed, attributed to metabolic assimilation and physical entrapment within the algal matrix. Algal biomass increased by 78% over the experimental period, confirming robust growth supported by pollutant-derived nutrients. Concurrent oxygen production maintained indoor O_2 levels above ambient baselines. The integrated MFC component generated measurable bioelectricity, demonstrating the system's multifunctional energy recovery potential. Harvested biomass exhibited nutrient profiles consistent with biofertilizer applications and sufficient calorific values for biofuel conversion.

Discussion and Conclusion
The algae-assisted MFC system successfully addressed limitations inherent to conventional purification methods by simultaneously targeting multiple pollutant categories without generating secondary waste. The >90% CO_2 capture by Chlorella vulgaris aligns with and exceeds previously reported phycoremediation efficiencies, while the>80% NOx/SOx reduction demonstrates competitive performance relative to chemical scrubbing technologies. The 78% increase in biomass confirms operational sustainability, enabling circular valorisation into biofertilisers and biofuels and enhancing economic viability. Oxygen co-production represents an additional indoor air quality benefit absent in conventional systems. Future research should investigate scalability, long-term performance stability, diverse pollutant mixtures, and outdoor deployment under variable environmental conditions. This prototype establishes algae-based MFC systems as promising, sustainable, and multifunctional solutions for next-generation air purification.

Acknowledgment
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P-00200 Emergent Toxicity Pathways in Complex Environmental Mixtures Characterized by Informatics Entropy of AhR-AOPN

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Introduction
Complex environmental mixtures represent one of the major unresolved challenges in aquatic toxicology because their biological effects are rarely driven by single chemicals, but instead emerge from dynamic interactions among multiple contaminants, pathways, and biological states. Traditional risk assessment frameworks remain largely compound-oriented and therefore have limited capability to explain how weak or individually insignificant perturbations collectively induce observable toxic outcomes. To address this limitation, we constructed an aryl hydrocarbon receptor-centered adverse outcome pathway network (AhR-AOPN) integrating high-resolution mass spectrometry screening, bioassay-guided effect profiling, transcriptomic responses, and network-based mechanistic inference to characterize emergent toxicity processes in the Pearl River sediment samples in China.

Materials and Methods
The AhR-AOPN framework was designed to connect chemical features, molecular initiating events, signaling cascades, and downstream biological responses into a unified mechanistic network. Multiple layers of evidence, including known AhR-active contaminants, predicted pathway interactions, and transcriptomic perturbations, were integrated to reconstruct toxicity propagation across interconnected biological processes. Beyond conventional pathway enrichment analysis, we further introduced an information entropy-based strategy to quantify pathway emergence within the AOPN. Entropy variation was used to evaluate how distributed low-intensity perturbations converge into organized toxicity states, thereby providing a quantitative explanation for the transition from "nothing to something," where individually weak molecular signals collectively produce detectable adverse biological outcomes.

Results
Application of the framework to environmentally relevant mixtures revealed that AhR-associated responses were not dominated by a single canonical pathway, but instead emerged through coordinated interactions among xenobiotic metabolism, oxidative stress regulation, inflammatory signaling, mitochondrial dysfunction, and developmental toxicity pathways.

Discussion and Conclusion
Entropy analysis identified several high-information-flow nodes that functioned as emergent regulatory hubs within the AOPN, despite showing only moderate perturbation intensity individually. Transcriptomic validation further confirmed the coordinated activation of these pathways and supported the existence of non-linear toxicity emergence under mixture exposure conditions.

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P-00213 Exploring the human environmental and dietary chemical exposome through the prism of rat and hedgehog as liminal sentinel species

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Introduction
Lifelong human exposure to a wide range of chemical pollutants constitutes a global public health concern. As diet represents a major route of human exposure to these contaminants, developing early detection strategies targeting this pathway is essential. However, the characterization of chemical hazards in food remains challenging due to their presence at trace levels. The use of sentinel animal species, whose diet is assumed to be similar to that of humans, appears to be an interesting approach for assessing contaminants that bioaccumulate. This strategy enables the detection at higher concentrations and facilitates access to biotic matrices in which pollutants tend to accumulate. In this project, we investigate the relevance of two commensal species of humans, the rat and the hedgehog, for assessing human exposure to known pollutants: per- and polyfluoroalkyl substances (PFAS), mixed halogenated dioxins (PXDD/Fs), pesticides, and to potentially emerging chemical ones.

Materials and Methods
Liver samples, a relevant matrix for the bioaccumulation of the compounds of interest [1], were collected from distinct biotopes (urban and rural) and from regions characterized by diverse activities (agricultural and industrial). Rat sampling sites close to Lyon (Southeastern France) were characterized using land-use mapping resources and classified into three distinct zones: urban, agricultural, and industrial. Composite samples were established from urban (n=18), agricultural (n=7) and industrial areas (n=12). Hedgehog sampling sites close to Nantes (Northwestern France) were previously characterized in another project using QGIS-based mapping with 10-hectare buffers around collection sites. Based on this classification, hedgehog individuals in the present study were assigned to two zones: urban (n=26) and rural (n=17). For PFAS analysis, liver samples from rats and hedgehogs were prepared using solid-phase extraction (SPE) and analysed by liquid chromatography coupled with high-resolution mass spectrometry (LC-HRMS).

Results
So far, results are available for a total of 61 PFAS in rat. Sixteen of them were detected with a detection frequency (DF) exceeding 50% across all study areas, while 23 additional PFAS showed moderate to low DFs (3-46%). Among the 16 most frequently detected PFAS, so-called "legacy" PFAS as well as "emerging" ones such as fluorotelomer sulfonates 8:2 and 10:2 were observed. Total PFAS concentrations were up to dozens ng/g wet weight. No significant differences were observed between the three studied areas for this group of compounds according to Kruskal-Wallis test ($p>0.05$).

Discussion and Conclusion
These preliminary results demonstrate the occurrence of various PFAS in rats. The absence of significant differences between the studied areas supports the hypothesis of diffuse contamination. Ongoing analyses in hedgehogs will provide further insight into interspecies variability. Expanding the analysis to additional pollutants (pesticides and dioxins) will broaden the assessment of hedgehogs and rats as sentinel species for human exposure.

Acknowledgment
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Per and polyfluorinated substances (PFAS): Toxicity

P-00219 It Takes Two to Tango: Investigating the Interaction of PFAS and Cr(VI) in Liver Disease

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Introduction
Per- and polyfluoroalkyl substances (PFAS) and h chromium [Cr(VI)] are environmental contaminants of major public health concern. PFAS are widespread, synthetic chemicals linked to various negative health outcomes. Cr(VI), a known human carcinogen, ranks as a "Top 20 Hazardous Substance". Both are commonly found together in contaminated drinking water and are used together in the same industries. Although co-exposures are common, no studies have considered their concomitant health effects. The lack of data is remarkable considering they have distinct, yet complementary mechanisms of toxicity. PFAS cause lipid accumulation and cell proliferation while Cr(VI) potently induces chromosome instability. Notably, PFAS does not appear to induce chromosome instability and Cr(VI) does not induce lipid accumulation. Thus, when exposure to both occurs, it is likely that PFAS will stimulate cells with Cr(VI)-induced chromosome instability to survive and grow causing worse disease outcomes. To study this toxic interaction, we focus my work on chronic liver disease, a top 10 cause of death worldwide, because both Cr(VI) and PFAS, independently, accumulate in and target the liver toxicity. We will focus on how Cr(VI) and PFAS interact in Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD), the most rapidly growing contributor to liver mortality and morbidity. Recent epidemiological data show MASLD severity correlates with worse chromosome instability suggesting the expected mechanistic interaction of PFAS-enhanced lipid accumulation and cell proliferation enhancing Cr(VI)-induced chromosome instability has the potential to significantly worsen MASLD progression.

Materials and Methods
Thus, in order to test the hypothesis "Cr(VI)-induced chromosome instability interacts with the PFAS-induced steatotic microenvironment to drive MASLD severity and progression' we are first establishing a Cr(VI)-PFAS interaction using a standard toxicological tool, chinese hamster ovary (CHO) cells, which have a stable karyotype. Cells were treated for 24 hours with sodium chromate +/- perfluorooctane sulfonate (PFOS). Cytotoxicity was determined using a clonogenic assay and genotoxicity was assessed with a chromosome aberration assay (a direct measure of chromosome instability).

Results
PFOS was minimally cytotoxic at the concentrations used (1-500 uM) whereas, as expected, sodium chromate induced a concentration-dependent decrease in survival with 1, 2.5, 5, and 7.5 uM Cr(VI) inducing 102.6, 85.4, 53.8, 17.5% relative survival, respectively. PFOS co-treatment (500 uM) altered Cr(VI) cytotoxicity, reducing survival to 70.8 and, 74.7%, respectively at the two lower concentrations and increasing survival to 60.7 and 29.6%, respectively, at the two higher concentrations. Preliminary data shows that PFOS exacerbates Cr(VI)-induced chromosome aberrations, without inducing chromosome aberrations on its' own.

Discussion and Conclusion
Thus far, we have shown PFOS alters Cr(VI)-induced cytotoxicity and genotoxicity after acute exposure. We will build on this pilot data, investigating longer exposure times and translating these results to primary human liver cells. Future studies include establishing a novel in vivo guinea pig model to demonstrate Cr(VI)-induced chromosome instability interacts with PFAS-induced fat accumulation to drive liver disease progression.

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P-00221 Target PFAS in edible invasive and native crabs from the Comacchio Lagoon

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are persistent anthropogenic contaminants of concern in transitional aquatic environments because of their chemical stability, mobility, bioaccumulation potential and relevance for seafood safety. This study focused on PFOS, PFOA, PFNA and PFHxS because these compounds are included by the European Food Safety Authority in the group-based tolerable weekly intake established for dietary risk assessment (EFSA, 2020). Two edible decapod crustaceans from the Comacchio Lagoon, Italy, were investigated: the invasive blue crab Callinectes sapidus, increasingly considered as a food resource in the northern Adriatic, and the native green crab Carcinus aestuarii.

Materials and Methods
Biological samples were processed by alkaline digestion with methanolic KOH, centrifugation, dilution with ultrapure water and clean-up by solid-phase extraction using weak anion exchange Oasis WAX cartridges, following approaches applied to PFAS determination in aquatic biota (Giari et al., 2023). Extracts were concentrated and reconstituted before instrumental analysis. Target PFAS were quantified by high-performance liquid chromatography coupled to tandem mass spectrometry, using negative electrospray ionization and multiple reaction monitoring for selective trace-level determination in complex biological matrices. The analytical method was validated for the selected analytes, confirming suitable sensitivity, linearity and reliability.

Results
In C. sapidus, PFAS showed marked tissue-dependent distribution, with total PFAS levels ranging from 0.69 to 85.22 ng/g wet weight. The highest concentrations were observed in the hepatopancreas, followed by gonads, gills and stomach, whereas muscle generally showed lower levels, in agreement with previous evidence of higher PFAS occurrence in internal crab tissues than in muscle-rich portions (Nobile et al., 2024). PFHxS was the dominant compound, while PFOS occurred at lower concentrations and PFOA and PFNA were generally close to or below detection limits. In C. aestuarii, analysed as pools of internal organs, total PFAS concentrations ranged from 16.99 to 118.04 ng/g wet weight, with PFHxS and PFOS as the main contributors. Principal component analysis highlighted differences in PFAS profiles among tissues and suggested a possible influence of biometric factors on contaminant distribution in blue crabs.

Discussion and Conclusion
The observed distribution is consistent with the role of internal, metabolically active organs in contaminant uptake and storage, as previously reported for PFAS accumulation in aquatic organisms and crab tissues (Marín-García et al., 2023; Nobile et al., 2024). These findings support the use of crabs as sentinel organisms for PFAS monitoring in lagoon and coastal ecosystems (Groffen et al., 2024). An exposure estimate based on blue crab muscle consumption indicated a weekly intake of 3.72 ng/kg body weight for the sum of PFOS, PFOA, PFNA and PFHxS, remaining below to the EFSA tolerable weekly intake of 4.4 ng/kg body weight (EFSA, 2020). Overall, this study combines validated target analysis and environmental chemistry with an ecotoxicological perspective based on tissue-specific bioaccumulation, highlighting the need to consider tissue distribution and realistic consumption scenarios in seafood safety assessments.

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P-00222 Presence and atmospheric transport of Persistent Organic Pollutants (POPs) through an altitudinal gradient in the Tarapacá region

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Introduction
Atmospheric data on Persistent Organic Pollutants (POPs) such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and organochlorine pesticides (OCPs), as well as emerging contaminants like phthalates (PHTs), are essential for efforts to reduce emissions and minimize human and environmental exposure1. In northern Chile, a potential emission source for these contaminants arises from the inadequate management of plastic and textile waste, which is disposed of in illegal landfills and subjected to open-air burning.

Materials and Methods
Passive air samplers were deployed in three different areas of Tarapacá region along an altitude gradient: Alto Patache (AP, 750 meter above sea level (m.a.s.l)), Mamiña (MA, 2750 m.a.s.l) and Alto Hospicio (AH, 610 m.a.s.l). The chemical analysis was conducted for PCBs, PBDEs, OCPs, PHTs by gas chromatography-mass spectrometry, and expressed in pg/m3. PHTs were expressed in ng/m3. Quality assurance and control (QA/QC) were also performed using three blank types (transport, field and laboratory, n=20).

Results
Σ7PCBs: 0.23±0.44 for AP, 9.31±11.97 for MA, and 6.15±5.04 for AH. Low molecular weight PCBs (e.g., PCB28 and 52) predominated compared to high molecular weight PCBs (e.g., 101 and 118); the latter were not detected in AP. Σ10PBDEs: 0.49±0.71 for AP, 1.49±1.92 for MA, and 13.77±9.87 for AH. PBDE209 was the most abundant (up to 84.1%, AH), followed to a lesser extent by PBDE47 (13.2%, MA). Σ12OCPs: 32.9±42.9 AP, 81.3±51.7 for MA, and 66.6±30.5 for AH. In AP (77.0%) and AH (89.5%), chlorobenzenes (e.g., PeCB and HCB) predominate, while in MA, gamma-HCH (52.6%) is followed by HCB (16.2%). Σ7PHTs: 3.5±2.9 for AP, 134.4±150.3 for MA, 70.8±110.6 for AH. Bis-2-ethylhexyl phthalate (DeHP) is the most abundant, ranging from 45.4% in AH to 85.3% in AP.

Discussion and Conclusion
PCBs and OCPs levels were lower than those found in Concepción (Chile) up to 24 pg/m3 and 110 pg/m3, respectively2. Although PBDEs are prohibited flame retardants, they persist in the environment. In northern Chile, the levels detected at AP and MA were lower, while concentrations at AH were higher compared to the study of nearby areas of the Santa Marta landfill in Santiago de Chile (10.2±1.4 pg/m3)3. PHTs are a group of semi-volatile organic compounds, widely used as plasticizers, showed levels higher than those reported in other urban areas, such as Toronto, Canada (up to 5.3±5.9 ng/m3)4. POPs continue to be detected in the Chilean environment, while emerging contaminants such as PHTs were found at elevated levels. This study provides critical information to support future environmental management and public health initiatives.

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P-00225 Development of a Fully Automated PAL-Based Sample Preparation Method for Simultaneous Analysis of PCDDs/PCDFs, 209-PCBs, PBDEs, and PCNs

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Introduction
Laboratory automation using robotic systems has rapidly advanced in chemical and clinical laboratories, driving cost reduction through decreased labor demands and improved operational efficiency. However, automation in environmental chemical analysis remains limited. In dioxin analysis in particular, sample preparation remains complex and labor-intensive, typically relying on multi-step cleanup procedures as described in standard methods such as U.S. EPA Method 1613B (1), and requiring extensive manual handling. As a result, many laboratories still depend on labor-intensive procedures that are time-consuming and susceptible to human error. Critical steps such as sample loading onto columns and concentration are often performed manually under operator supervision. To overcome these limitations, we are developing a fully automated robotic system capable of eliminating manual intervention and standardizing sample preparation across diverse sample matrices. In this first phase, we developed a novel PAL-compatible module and workflow that enables seamless automation from post-extraction sample preparation to GC-MS injection. Using this system, we demonstrated the feasibility of fully automated, simultaneous analysis of POPs including PCDDs/PCDFs, PCBs, PBDEs, and PCNs.

Materials and Methods
Three soil samples were used as environmental matrices, and sunflower oil was selected as a representative food sample. Soil samples (10 g) were dried, Soxhlet-extracted, adjusted to 10 mL with toluene, and transferred to 20 mL headspace vials with 2.5 mL of n-decane. Cleanup internal standards were added after extraction to evaluate the performance and reliability of the fully automated PAL-based sample preparation process. All subsequent procedures were fully automated using the PAL system. Soil extracts were evaporated to remove toluene and loaded onto a multi-layer cleanup column (silver nitrate silica, sulfuric acid silica, carbon, and zirconia). Analytes were fractionated into carbon and zirconia fractions, followed by addition of recovery standards, n-decane as a keeper solvent, and final concentration. Total processing time was ~1 h for environmental samples. GC-MS injection was performed using an Agilent autosampler. GC-HRMS measurements were conducted on a JMS-800D UltraFOCUS (JEOL Ltd.) using a DB-5HT column for PBDEs, DB-5ms column for PCNs, a VF-Xms column for PCDDs/PCDFs, and an HT8-PCB column for PCB analysis.

Results
In this study, method performance was first evaluated using internal standards only (blank samples) for PCDDs/PCDFs and 209-PCBs. The recoveries for PCDDs/PCDFs ranged from 72 to 99%, while those for 209-PCBs ranged from 59 to 97%. For PBDEs and PCNs, recovery tests were conducted using native standards. Recoveries for PBDE congeners ranged from 41 to 104%, whereas those for PCNs ranged from 63 to 84%. In soil samples, recoveries of PCDDs/PCDFs ranged from 61 to 97%, those of 209-PCBs ranged from 65 to 99%, those of PBDEs ranged from 57 to 106%, and those of PCNs ranged from 61 to 97%.

Discussion and Conclusion
Although this study represents an initial validation, the method achieved satisfactory recoveries and reproducibility across the target analytes. In soil samples, approximately 20% of 2,3,7,8-TeCDF was detected in the zirconia fraction, likely due to insufficient adsorption by carbon optimized for food matrices and partially inhibited by soil matrix components. This indicates that slight adjustment of the adsorption strength is required for environmental samples. In addition, further optimization of the hexane elution volume is necessary for PCNs in environmental samples. Future work will focus on tuning both the adsorption capacity of carbon and the elution conditions to improve performance. The developed PAL-based workflow enables fully automated sample preparation from post-extraction solutions by simply placing samples in 20 mL vials, eliminating manual intervention through to final concentration. This approach will be extended to a broader range of POPs analyzed by GC-MS, with future integration enabling automated injection and measurement scheduling.

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P-00227 Reduction of Matrix Effects in Automated PFAS Analysis Using the PAL System for Food Samples

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are persistent, bioaccumulative chemicals with potential toxicity to humans and the environment. Due to their widespread presence in food and environmental matrices, sensitive and reliable analytical methods are required for regulatory monitoring and risk assessment. Conventional PFAS analysis involves labor-intensive sample preparation steps, such as solid-phase extraction (SPE) and cleanup procedures, which are time-consuming and prone to variability. Therefore, automation strategies are needed to improve reproducibility and analytical efficiency. The PAL (Preparation and Liquid Handling) system is an XYZ robotic platform that enables automated sample preparation. In our previous work, a PAL-based PFAS analytical method was developed and compared with EPA1), FDA2), and methods developed by LABERCA3,4). While the PAL method showed the most stable recovery, its purification efficiency was lower than that of the EU guidance-based method. Therefore, this study aims to improve the purification efficiency of the established automated PAL method.

Materials and Methods
Sample preparation and automated PAL procedures were performed according to the method previously reported in poster #P-33 (Abstract #2618) at the 2025 Dioxin Symposium. Briefly, homogenized food samples (egg, salmon, and bovine liver) were extracted under alkaline conditions using acetonitrile/methanol and hexane, followed by centrifugation. The extract was transferred to a PAL vial, and then isotopically labeled PFAS standards specified in EPA Method 1633 and ISO 21675 were added prior to analysis. Automated solid-phase extraction (SPE) was carried out using a weak anion exchange (WAX) column followed by purification with a cleanup column. PFAS were eluted with ammonium hydroxide in methanol and analyzed by LC–MS/MS after addition of native internal standards (NIS). Total PAL processing time was approximately 40 min per sample. For purification optimization, ten sorbent materials were evaluated based on recovery in real samples, matrix-matched standards, and total scan chromatograms.

Results
Recoveries were evaluated specifically for the PAL cleanup procedure, excluding variability and losses from the extraction step, using matrix-matched standards prepared by spiking EIS and NIS into non-spiked, purified extracts obtained with the PAL system. These results were compared with observations from SCAN chromatograms. Using the conventional graphitized carbon black (ENVI-Carb) column, ionization enhancement and/or suppression in LC–MS/MS were observed due to co-eluting interferences, particularly for fluorotelomer sulfonates (FTSs), neutral PFAS, and long-chain PFAS. In contrast, these matrix effects were reduced when the new purification column was applied. Furthermore, SCAN measurements showed a significant reduction in baseline levels with the new purification column, indicating improved removal of interfering components.

Discussion and Conclusion
In conventional methods, ENVI-Carb is commonly used for purification. However, significant matrix effects, particularly for FTSs, long-chain PFAS, and neutral PFAS, were observed in high-fat samples. Although increasing the amount of ENVI-Carb reduced matrix effects, it also increased elution volumes, leading to more complex post-treatment procedures. The newly developed purification column demonstrated superior purification performance compared to ENVI-Carb. The baseline observed in SCAN chromatograms was comparable to that obtained using a method based on EU guidance, while matrix effects were substantially reduced. These results indicate that the new purification column improves removal of co-extracted interferences and overall analytical performance.

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P-00231 Toward Next-Generation Dioxin Monitoring: Interlaboratory Performance Assessment of Multiple MS Platforms Versus GC-HRMS under Japanese Regulations

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Introduction
Because dioxins in environmental samples occur at ultra-trace levels, their measurement requires not only high sensitivity but also high selectivity to minimize matrix interferences, and sufficient chromatographic and mass-spectrometric performance to separate and quantify numerous congeners/isomers. When the official Japanese manual was first established in the early 2000s, gas chromatography–high-resolution mass spectrometry (GC HRMS) operated in selected ion monitoring (SIM) was essentially the only approach that simultaneously satisfied these requirements. Although the manual has been revised several times since then, the recommended measurement instrumentation has not been revisited. Recently, however, concerns have emerged regarding the supply and long-term availability of GC HRMS systems. In addition, while the helium supply disruption that became a major issue around 2019 has largely stabilized, global supply-chain uncertainty remains and helium prices continue to rise, raising questions about the sustainability of the current analytical infrastructure. Meanwhile, high-performance instruments such as GC MS/MS and GC TOF/MS have become increasingly widespread, and efforts to explore alternatives to GC HRMS for dioxin analysis are growing both in Japan and internationally. Nevertheless, reports on method comparability remain limited, and few studies have thoroughly evaluated whether these approaches can provide sensitivity and reproducibility (stability) comparable to GC HRMS and yield consistent analytical values across different matrices (1. Here, we report the analysis and evaluation of results from an interlaboratory comparison study for "next-generation dioxin analysis," in which multiple organizations measured dioxins using GC MS/MS, GC TOF/MS, and other MS formats.

Materials and Methods
Three matrices—soil, sediment, and fly ash—were evaluated. For each matrix, three samples were prepared (nine samples in total), selected to cover, as far as possible, different concentration ranges and contamination profiles. Each distributed sample was extracted and cleaned up in accordance with the official method, solvent-exchanged to hexane, aliquoted (1 mL) into ampoules, and sent to participating laboratories. Multiple domestic institutions were recruited for each anticipated measurement approach, aiming to include instruments from different manufacturers. For GC TOF/MS, three laboratories were initially planned; however, due to instrument failure, only one laboratory provided two datasets. To reduce variability arising from steps other than instrumental analysis, internal standards were added by each laboratory immediately before measurement (after sample distribution). For participating GC MS/MS laboratories, use of the same GC column was requested and MS/MS transitions were shared in advance. Laboratories reported results for the same target analytes as in the official method. To enable detailed evaluation of inter-instrument compatibility, they also submitted instrument specifications, analytical conditions, chromatograms, calibration data, and instrument detection limits (IDLs).

Results
Comparison of IDLs showed that, among 11 submitted datasets, 8 met the official required detection limits for all isomers. Of the three datasets that did not meet the requirements, two were generally close to the target limits; the exception was one laboratory using hydrogen carrier gas with GC MS/MS. Reported values generally agreed with GC HRMS results, with some exceptions. Greater variability was observed for low-level isomers such as 2,3,7,8 TeCDD and 1,2,3,7,8,9 HxCDF. Increased scatter was also seen in some hydrogen-carrier GC MS/MS data and in GC TOF/MS results. For PCDD/F homolog groups, results were broadly consistent regardless of matrix. For DL PCBs, variability similarly increased for low-concentration congeners.

Discussion and Conclusion
This interlaboratory comparison indicates that GC MS/MS using helium or nitrogen carrier gas, as well as APGC MS/MS, can potentially generate data comparable to GC HRMS. In contrast, hydrogen-carrier GC MS/MS and GC TOF/MS require further work: issues should be clarified, measurement conditions re-optimized, and continued evaluation conducted with increased numbers of datasets.

Acknowledgment
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Biomonitoring/Human Exposure/epidemiology

P-00236 Multivariate optimization of SPE extraction for 7 priority organophosphate ester metabolites in human urine

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Introduction
Human biomonitoring of organophosphate esters (OPEs) is essential due to their widespread use as flame retardants and plasticizers. However, optimizing multi-residue extraction methods from complex matrices like urine is heavily hindered by the conflicting physicochemical properties of the metabolites. Traditional "one-factor-at-a-time" approaches are resource-intensive and fail to evaluate critical combinations of variables. This study aimed to implement a multivariate Design of Experiments (DoE) strategy to systematically evaluate and optimize the solid-phase extraction (SPE) efficiency for seven priority OPE metabolites (BCEP, BCPP, BDCIPP, DEP, DMP, DnBP, and DPHP) using Oasis HLB cartridges (200 mg).

Materials and Methods
A 3-factor Face-Centred Central Composite Design (CCF) consisting of 17 experimental runs (including 3 centre points for pure error estimation) was successfully executed. The investigated independent variables were sample pH (2.0–5.0), wash solvent composition (5–20% MeOH), and ionic strength (0–200 mg NaCl per 2 mL of urine). Samples were analysed via UHPLC-QTOF-MS in full-scan ESI-mode. To ensure modelling precision and account for matrix effects, DPHP-d10 and BDCIPP-d10 were utilized as internal standards. Response surface methodology (RSM), analysis of variance (ANOVA), and canonical optimization were performed using the rsm package in RStudio.

Results
The CCF mathematical models demonstrated varying degrees of sensitivity depending on analyte polarity. For the highly polar dimethyl phosphate (DMP), a statistically significant quadratic model was established ($R2 = 0.86$, $p = 0.028$), showing that a significant MeOH:NaCl interaction ($p = 0.043$) is required to prevent early breakthrough on the sorbent. For the chlorinated species BDCIPP, the ANOVA revealed a significant synergistic interaction between sample pH and ionic strength ($p = 0.038$), mathematically proving that the salting-out effect is strictly dependent on the ionization state of the analyte. In contrast, the lipophilic DPHP exhibited extreme analytical robustness, resulting in a non-significant model ($R2 = 0.21$, $p > 0.05$) with a stationary ridge situation, indicating stable recoveries across the entire experimental domain. By applying the Global Desirability Function to aggregate all seven responses, the comprehensive process optimum was mathematically calculated at the coded coordinates corresponding to pH 3.5, 13.3% MeOH in the wash solution, and 100 mg NaCl.

Discussion and Conclusion
The application of a Face-Centered Central Composite Design enabled the rapid, seamless mapping of extraction dynamics with a minimal laboratory workload. By identifying critical, non-linear interactions between pH, salinity, and organic modifiers, this chemometric approach provided a deeply rationalized and optimized sample preparation framework necessary for high-throughput human biomonitoring.

Acknowledgment
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2. Generation EU (Class: 643-02/23-01/00016, Reg. no. 533-03-23-0006, BioMolTox).

P-00246 Evaluation of SPE Based Sample Preparation for Ultra-Trace PFAS Analysis in Wastewater

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are a large group of persistent organic pollutants characterised by extreme persistence, bioaccumulation, and toxicity. Wastewater serves as a critical entry point for these substances into the environment, as conventional wastewater treatment plant technologies are currently unable to eliminate them effectively. Determining PFAS in wastewater presents a specific analytical challenge due to high matrix complexity, suspended solids, and the requirement for low detection limits ranging from ng/L to pg/L. Key critical points of the analysis include the elimination of background contamination and cross-contamination, as PFAS are ubiquitous in laboratory equipment and fluoropolymer-based materials, such as polytetrafluoroethylene (PTFE). Another significant risk is the non-specific adsorption of PFAS to glass surfaces and, to a lesser extent, to various plastics, leading to analyte losses during sample preparation.

Results
The objective of this work is to evaluate the efficiency of various types of SPE cartridges designed for the extraction of a wide spectrum of PFAS, encompassing: 13 perfluorocarboxyl acids (C4-C16 PFCAs), 12 perfluorosulfonic acids (C3-C13, PFSAs) and ether-PFAS (e.g. HFPO-DA, NaDONA, 6:2 FTS). This comprehensive strategy enables assessment of SPE cartridge efficiency across substances with widely differing hydrophobicity and environmental mobility within wastewater matrices. Sorbents based on weak anion exchange (WAX) and hydrophilic-lipophilic balance (HLB) were tested as standards. Particular attention was paid to dual-phase (stacked) cartridges that combine WAX with graphitised carbon black (GCB), which ensures interference removal and high recovery even for long-chain PFAS. The EPA 1633 methodology also recommends this strategy.

Discussion and Conclusion
For sample preparation, the FREESTYLE XANA PFAS TableTop robotic system (LCTech, Germany) was utilised, which was specifically modified for this application by replacing all fluorocarbon components with polyethylene and polypropylene-based materials to ensure a "PFAS-free" environment. This system enables fully automated processing of water samples using pressurised loading of SPE cartridges, ensuring precise flow control even for matrices with higher suspended solids content. For method development and optimisation, commercially available wastewater with precisely defined concentrations of the target PFAS compounds was used. To evaluate the performance of SPE cartridges for PFAS analysis in wastewater, samples of different volumes (10 and 100 mL) were analysed, focusing on recovery, accuracy, reproducibility, and matrix effects associated with potential interferences.
The final PFAS analysis was conducted using the ultra-performance liquid chromatography coupled to tandem mass spectrometry (UHPLC-MS/MS). The developed method will be used as part of regular wastewater monitoring to identify primary sources of PFAS contamination in the Czech Republic.

Acknowledgment
The work used [data/tools/services/facilities] provided by the METROFOOD-CZ Research Infrastructure (https://metrofood.cz), supported by the Ministry of Education, Youth and Sports of the Czech Republic (Project No. LM2023064).

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P-00254 Strategies to Enhance Detection and Selectivity of PFAS Using Cyclic Ion Mobility

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Introduction
Polyfluorinated alkyl substances (PFAS) are environmental contaminants that have been linked to increased risks of cancer and other diseases in humans. Monitoring PFAS concentrations in human biofluids and environmental samples is essential for understanding exposure levels and pathways. However, accurately identifying PFAS at extremely low concentrations (ng/L) remains challenging. To address this, a quadrupole-Cyclic ion mobility-time-of-flight (cIM-ToF) mass spectrometer equipped with Wideband Enhancement (WBE) can be programmed to target characteristic PFAS drift time trendlines and synchronize them with the time-of-flight (ToF) pusher.[1] This acquisition mode improves the ToF duty cycle and lowers detection limits. Use of a UniSpray™(US) can provide enhanced sensitivity compared to electrospray. [2] Analysis using a quadrupole-cIM-ToF mass spectrometer with Wideband Enhancement and UniSpray ionisation provides enhanced selectivity, sensitivity, and collision cross section (CCS) measurements, which serve as complementary descriptors for PFAS identification.

Materials and Methods
LC Cyclic-IMS MS-ESI- and LC Cyclic-IMS US^{-} (negative ion mode) analyses were performed using a quadrupole-cIM-time-of-flight mass spectrometer (cIM resolution (R ≈ 65 to 160)). A mixture of 48 PFAS native standards, native standard mix PFAC30PAR (Wellington Laboratories) and river water extracts were analysed, using reversed phase separation LC (A: 95:5 water:MeOH with 2 mM ammonium acetate) and B: (MeOH with 2 mM ammonium acetate) comprising a 22-minute gradient (0.3 mL/min), using a C18 (100 mm × 2.1 mm, 1.8 µm) column at 35 °C. Injection volumes were 10 µL. The modified LC used a PFAS conversion kit.

Discussion and Conclusion
The environmental impact of PFAS exposure is influenced by isomeric distribution, as both linear (L-PFAS) and branched (br-PFAS) forms have been associated with specific health risks, including increased infant burden during pregnancy. Enhanced sensitivity in the WBE analytical method for precursor ions enables the detection of PFAS at lower concentrations compared to conventional ion mobility acquisition modes. The WBE acquisition strategy allows targeting of mass/CCS trendlines for PFAS, with potential to reduce false detections caused by isobaric interferences. PFAS molecules exhibit distinct ion mobility drift time trendlines due to their unique CCS-to-mass ratios, a result of their fluorinated structures. This property causes PFAS to appear "denser" than hydrocarbon-based molecules, shifting their drift time trendline downward relative to molecules of similar m/z.[3] A dilution series of PFAC30PAR was used to compare LC-Cyclic-IMS-DIA-MS (HDMS) and WBE LC-Cyclic-IMS-MS, LC- Cyclic-IMS-MS/MS, LC- Cyclic-IMS-DIA-MS responses for PFAS. The WBE mode was calibrated to optimize drift time alignment for PFAS constituents of PFAC30PAR. Detection for the PFOS homologous series (0.4 ng/L) has been achieved with RMS S/N 194:1. Improved detection limits of PFOS, br-PFOS byproducts (P5MHpS and P6MHpS), have been achieved for a small cohort of river water samples compared to using conventional HDMS. LC-Cyclic-IMS-MS with Wideband Enhancement and UniSpray thus provides a highly selective, sensitive strategy for PFAS identification.
"For Research Use Only. Not for use in diagnostic procedures."

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P-00264 Automation of sample preparation and analysis of SVOCs in water based on EPA 8270E+EPA 3510C method

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Introduction

Environmental laboratories face pressure to expand semivolatile organic compounds (SVOC) coverage while lowering quantitation limits, shortening turnaround, and reducing solvent use and waste, especially methylene chloride.

In this presentation, we will discuss an EPA 8270E+EPA 3510C based SVOCs workflow that replaces manual sample preparation with a rail robotic platform integrated with a GC triple quadrupole (GC/TQ) system. The method automates acidified and basified aliquots and executes a miniaturized, single vial extraction of 5 mL water using only 400 µL DCM, followed by cooled inlet solvent vent sandwich injection (2 µL sample + 0.2 µL ISTD). This approach reduces open handling and total DCM usage, lowers waste, and improves analyst safety and reproducibility.

The automated workflow covers 192 SVOCs in one method – including PAHs, PCBs, pesticides/OPs, PBDEs, chloronaphthalenes, phthalates, phenols, and amines, over a 20-1000 ppt calibration range with accuracies of 80–120%. Replicate spike studies in surface water (10, 50, 100 ng/L; n=10) delivered RSDs ≤10–15% for the majority of analytes, and for priority classes (PAHs/PCBs) precision remained ≤15% at 5 ng/L (n=5). LOQs down to 0.02 ppb (20 ng/L) were achieved for multiple classes, supporting regulatory relevant reporting. The selectivity of the method was enabled by the GC/TQ system and high sensitivity was achieved though using a high-efficiency electron ionization source as well as the optimized GC injection parameters.

The automated workflow's robustness was demonstrated over extended operation with routine liner changes and minimal column maintenance. Collectively, these results show that Autosampler enabled automation coupled with GC/TQ delivers broad SVOCs coverage with low ppt quantitation and meaningful reductions in solvent usage, sample handling, and waste – providing an immediately adoptable path for high throughput environmental testing labs. This is a demonstrated approach how laboratories can materially reduce methylene chloride use and exposure while achieving low ppt quantitation and efficient in high throughput SVOCs testing.

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P-00268 Environmental impact of textile waste on soils in northern Chile: evidence of microplastics, chemical additives and ecological risk

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Introduction
Plastic pollution in the arid soils of northern Chile has become an environmental and public health concern, reflecting the gaps between consumption patterns, waste management, and ecological fragility. The study area is characterized by low humidity and limited biological degradation capacity. The presence of illegal dumps containing textile and plastic waste has intensified this problem, turning desert areas into pollution hotspots. However, the problem is not limited to the physical accumulation of plastics; these materials contain a wide variety of chemical additives, such as plasticizers1, which can be progressively released into the environment. In extreme conditions such as those in northern Chile, where solar radiation is intense and temperature variations are marked, fragmentation processes favor the formation of microplastics and their release. The soils then act not only as receptacles for waste but also as matrices for the accumulation of potentially toxic.

Materials and Methods
The methodology involved the systematic collection of i) textile waste and ii) soil samples, obtained using 1 × 1 m^2 grids defined in representative areas of the region. In the laboratory, the textiles underwent a mechanical washing process with Milli-Q water to remove unwanted particles, followed by controlled drying. Subsequently, a 1 cm^2 fragment was cut from each textile for analysis. For the soil samples, they were lyophilized (OPERON model) and weighed into 50 g. They were then digested to remove interfering substances and subsequently filtered to separate potential plastic particles using fiberglass filters previously calcined at 450 °C in a muffle furnace (Furnace 1400)2.The materials were analyzed using a Jasco 4600/ATR Fourier Transform Infrared Spectrometer and a Perkin Elmer Spectrum Frontier/Spotlight 400 microscope (μFTIR FT-IR), a technique that allowed for the identification of the textile's polymer composition and additives. Quality control and assurance procedures included background spectra between samples using a diamond prism (ATR crystal) and reference spectra to account for instrumental response and any residual signals.

Results
The results for textiles showed that 21 out of 46 samples were synthetic fibers (3.67 ±6.53) per m^2. Additives were detected in 20% of the textiles. For soils, the abundance of particles per m^2 was 0.9 ± 0.83 per m^2. A predominance of microplastics was observed, corresponding to fibers less than 5 mm in length. The main polymers identified were polyethylene terephthalate (PET) at 50–67%, polyester (PE) at 40–50%, and polypropylene (PP) at 0–20%. Plasticizers and additives in textile were also identified, particularly di(2-ethylhexyl) phthalate (DEHP) (12%), followed by polybutylene terephthalate (4%) and polycaprolactone (4%). The Contamination Load Index (PLI) for plastic polymers, calculated for the soils, was 34, placing the study area at Risk Level IV. This index reflects severe contamination and a significant impact of plastic polymers on local biodiversity and, likely, on the entire food chain.

Discussion and Conclusion
The data obtained confirm that the accumulation and improper disposal of textile waste in arid zones of northern Chile constitute an active source of soil contamination, not only due to the presence of microplastics but also due to the chemical additives associated with synthetic fibers. In this context, it is necessary to strengthen textile waste management by promoting prevention, recovery, and effective regulation.

Acknowledgment
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P-00272 An innovative multi-technical study regarding small microplastics (SMPs), plastic additives (PAs) and perfluoroalkyl compounds (PFAS) in the Antarctic plateau: the PASSPORT project

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Introduction
Antarctica, often considered as a pristine wilderness, is increasingly recognized as a sink for global pollutants. Despite its isolation, Antarctic region can act as a "cold trap", accumulating in snow and ice chemicals that reach this latitude via the atmospheric long-range transport and the oceanic currents. Polar areas, due to the limited presence of local pollutant sources, represents unique natural laboratories to understand the environmental fate of persistent pollutants in changing polar ecosystems. Recently, the presence of plastic fragments and small microplastics (<100 µm, SMPs) has been observed in polar areas. Plastic items are composed of plastic polymers and additives (PAs) mixed at various stages of the production process. The European Chemicals Agency (ECHA), through its initiative on PAs, has characterized over 400 additives, which can be inorganic or organic compounds, added to polymers to modify, protect or enhance the properties of the final material (e.g. light stabilisers, antioxidants, plasticisers, pigment agents, antistatics, flame retardants…). During their aging and weathering, plastics are exposed to sunlight (ultraviolet radiation), wearing and other environmental conditions, resulting in fragmentation into smaller particles of different sizes and in the release of PAs, potentially posing a risk for the environment and the human health. Therefore, it is important to assess the presence of these emerging persistent organic contaminants in sensitive environment as polar regions, in order also to study their transport mechanisms and environmental fate. In this work the preliminary results of the project "microPlastics, plastic Additives and plastiSphere in Antarctic continental Snow: transPORT mechanisms and biotransformations study" (PASSPORT are presented, with the aim to address a critical knowledge gap regarding the presence, transport, and environmental fate of SMPs, PAs and PFAS in the remote Antarctic Plateau.

Materials and Methods
The methodology integrates cutting-edge analytical techniques to ensure high-resolution data and prevent sample contamination. First-year sampling has been carried out during the XLI Italian Expedition in Antarctica, during austral summer 2025/2026. Surface snow has been collected in 10 locations around the Concordia Scientific Station at Dome C, considering the main wind direction, the presence of human activities, the distance from the scientific station. The samples were analysed through a combined approach including Pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS), liquid chromatography-high resolution mass spectrometry (HPLC-HRMS), and microscale Fourier transform infrared spectroscopy (micro-FTIR) to comprehensively characterize samples for the presence of MPs and PAs and PFAS both in the dissolved and in the particulate forms.

Results
This innovative approach permits the identification of all the plastic-related components in the samples, identifying correlations among the polymers and additives and cross-validating the obtained results. The method showed to be effective in the discrimination of plastic sources. The collected snow samples reflected the contribution of different aerosol sources: the "local" contamination, leading to activities related to the Antarctic area, and the long-range contamination, deriving from lower latitudes and constituting the background levels.

Acknowledgment
This research was financially supported by the MUR (Ministry of University and Research) – Call PNRA 2024 (National Antarctic Research Program) through the project PNRA0000005 "PASSPORT - MicroPlastics, plastic Additives and plastiSphere in Antarctic continental Snow: transPORT mechanisms and biotransformations study".

Flame Retardants: Biotransformation and Toxicity

P-00285 Rapid determination of seven priority OPE metabolites in human urine using UHPLC-QTOF-MS: a direct approach without enzymatic hydrolysis

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Introduction
Human biomonitoring of organophosphate esters (OPEs) requires sensitive and high-throughput analytical tools. Conventional methods often rely on time-consuming enzymatic hydrolysis, which limits sample throughput and increases the risk of analyte degradation during extended incubation times.This study aimed to develop, optimize, and validate a rapid multi-residue UHPLC-QTOF-MS method for the simultaneous determination of seven priority OPE metabolites (BCEP, BCPP, BDCIPP, DEP, DMP, DnBP, and DPHP) in human urine, completely eliminating the enzymatic hydrolysis step to maximize laboratory efficiency.

Materials and Methods
Sample preparation was based on a direct solid-phase extraction (SPE) protocol using Oasis HLB cartridges (200 mg). The extraction dynamics were thoroughly evaluated by testing critical combinations of sample pH (2.0–5.0), ionic strength (0–200 mg NaCl), and wash solvent compositions (5–20% MeOH) to balance the recovery of chemically diverse compounds. Chromatographic separation was achieved within a 12-minute gradient on a Zorbax RRHD SB-C18 column (1.8 µm) using a mobile phase consisting of 10 mM ammonium acetate in water (A) and methanol (B). Detection was performed using high-resolution QTOF-MS in full-scan ESI- mode. To compensate for matrix-induced ionization effects and extraction variations, DPHP-d10 and BDCIPP-d10 were utilized as internal standards. Data processing, calculation of analyte responses, and global optimization modeling were conducted using RStudio.

Results
The direct SPE-UHPLC-QTOF-MS method successfully handled the wide polarity range of the target compounds. A strong synergistic effect between sample pH and ionic strength was observed for the chlorinated species BDCIPP, proving that matrix modification via salting-out is strictly pH-dependent for these compounds. Conversely, DPHP demonstrated high analytical robustness, showing stable recoveries across all tested variations. To achieve the best analytical performance for all seven metabolites simultaneously, the final optimized operating conditions for the method were mathematically established at pH 3.5, 13.3% MeOH in the wash step, and 100 mg of NaCl per 2 mL of urine. Under these conditions, the method provided excellent peak shapes, high sensitivity, and outstanding mass accuracy (<5 ppm) for all target analytes.

Discussion and Conclusion
By eliminating the enzymatic hydrolysis step and operating at the mathematically derived optimum of pH 3.5 with moderate salinity and wash stringency, sample preparation time was drastically reduced. This direct analytical protocol offers a robust, sensitive, and high-throughput framework ideal for large-scale epidemiological exposure assessments.

Acknowledgment
The study is funded by the Croatian Science Foundation (grant HRZZ-IP-2024-05-8815, PlastRepRisk) and European Union – Next Generation EU (Class: 643-02/23-01/00016, Reg. no. 533-03-23-0006, BioMolTox).

P-00291 Study on the Phosphorylation of Carbon Materials' Surfaces by Dimethyl Methylphosphonate and their Adsorption Mechanism for Typical VOCs

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Introduction
Dimethylphosphonic acid (DMMP) is an organic phosphorus-based flame retardant. In this study, DMMP was used as P-donor to introduce P onto carbon surface. While activated carbons are predominant VOCs adsorbents, they frequently suffer from performance degradation under high humidity due to competitive water adsorption.

Materials and Methods
P-doped hierarchical porous carbons were individually engineered from corncobs using dimethyl methylphosphonate (DMMP) as heteroatom sources. Crucially, XPS and TGA-MS analyses confirmed that DMMP decomposition triggered in situ deoxygenation of the carbon surface, which significantly reduced oxygen-containing functional groups and enhanced hydrophobicity.

Results
This engineered surface effectively inhibited water competition, enabling the low-dose P-doped carbon (PAC-0.2) to exhibit an exceptional styrene capacity of 1327.3 mg·g-1 with 92.6% retention even at 80% relative humidity. GCMC and DFT calculations elucidated the synergistic mechanisms of pore-size and electronic structures during competitive adsorption.

Discussion and Conclusion
This work provides a microscopic-level understanding of moisture resistance and offers a robust strategy for designing high-performance carbonaceous adsorbents for industrial air purification.

Acknowledgment
This work was financially supported by the Fujian Provincial Science and Technology Program (Grant No. 2025T4041).

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P-00293 Beyond target PFAS analysis: Monitoring water contamination by adsorbable organic fluorine using combustion ion chromatography — A pilot study in the Czech Republic

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Introduction
Per- and polyfluoroalkyl substances (PFAS), commonly known as 'forever chemicals', are a large group of synthetic compounds distinguished by an exceptionally stable carbon–fluorine bond. This structure gives PFAS unique physicochemical properties, including resistance to both water and oils and high thermal and chemical stability. Since the mid-20th century, PFAS have been widely used in industrial applications and consumer products, such as firefighting foams, water-repellent textiles, non-stick cookware, cosmetics, and food contact materials (FCMs), where they act as barriers against grease and moisture. PFAS monitoring is essential due to their extreme environmental persistence, tendency to accumulate in ecosystems and living organisms, and associated toxic effects.
PFAS are released into the environment from various industrial applications and, depending on their solubility, are primarily transported via surface water and groundwater. Industrial sources, including textile manufacturing, firefighting foams, and the paper industry, may discharge substantial amounts of these substances into wastewater. Water, particularly drinking water, along with contaminated food, represents one of the major pathways of human exposure to these toxic compounds. Due to their high mobility in aquatic environments and the limited efficiency of conventional wastewater treatment processes in removing them, continuous monitoring and analysis of PFAS in water are essential. This need for monitoring is also reflected in recent legislation, such as the European Drinking Water Directive, which introduces parameters for the monitoring of total PFAS content.
Analytical methods have traditionally focused on the targeted determination of major PFAS compounds using liquid chromatography coupled with tandem mass spectrometry (LC–MS/MS). However, as this class comprises more than 10,000 substances and analytical standards are available for only a limited fraction, targeted analysis alone is insufficient. Current analytical trends, therefore, increasingly focus on the determination of organically bound fluorine using combustion ion chromatography (CIC). In water analysis, the monitored parameter is adsorbable organic fluorine (AOF), where fluorinated compounds are adsorbed onto activated carbon. As CIC cannot inherently distinguish between inorganic and organically bound fluorine, the activated carbon must be washed with a sodium nitrate solution prior to analysis to remove inorganic fluoride. The retained organic fluorine is then determined by CIC.

Materials and Methods
The aim of this study was to develop and validate a method for the determination of AOF in water samples. The method was validated using deionised water spiked with 4-fluorobenzoic acid at two concentration levels, 5 and 20 µg/L.

Results
Method recoveries were 76% and 92%, with repeatability (RSDs) of 12% and 11% at the lower and higher concentration levels, respectively. The method limit of quantification (LOQ) was established at 0.5 µg/L. The applicability of the method for the determination of AOF in water was verified by successful participation in an interlaboratory proficiency test organised by the Association Générale des Laboratoires d'Analyses et d'Essais (AGLAE).

Discussion and Conclusion
The developed method was applied to a set of real surface water samples. AOF concentrations ranged from <0.5 to 2.6 µg/L. Targeted analysis of 43 PFAS by LC–MS/MS in the same samples revealed total fluorine concentrations equivalent to 5.8–15.2 ng/L, corresponding to only 0.4–5.5% of the AOF determined by CIC. This pronounced discrepancy between AOF analysis and targeted PFAS determination indicates the presence of additional organofluorine compounds not covered by routine targeted PFAS analysis. These compounds may include polymeric PFAS, PFAS precursors, ultrashort-chain PFAS (e.g. trifluoroacetic acid), and fluorinated pharmaceuticals.

Acknowledgment
The work used [data/tools/services/facilities] provided by the METROFOOD-CZ Research Infrastructure (https://metrofood.cz), supported by the Ministry of Education, Youth and Sports of the Czech Republic (Project No. LM2023064).

P-00298 Occurrence of PCDD/Fs and PCBs in Ukrainian Pork Fat (Salo), a Traditional National Food Product: Assessment of Background Contamination and Congener Profiles

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Introduction
Persistent organic pollutants (POPs), particularly polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and polychlorinated biphenyls (PCBs), are among the most toxic, persistent, and bioaccumulative environmental contaminants. Owing to their strong lipophilicity, these compounds accumulate in animal lipids and enter the human food chain through foods of animal origin.
Pork fat (salo), a traditional Ukrainian food product, is a relevant matrix for monitoring environmental contamination, as it reflects long-term exposure and integrated background pollution from atmospheric deposition, combustion processes, industrial emissions, and contaminated feed.
In Ukraine, systematic data on POPs in food of animal origin remain limited. This study aimed to determine concentration levels, toxic equivalent (TEQ) values, and congener profiles of PCDD/Fs, dioxin-like PCBs (dl-PCBs), and indicator PCBs in pork fat samples collected from different regions of Ukraine.

Materials and Methods
Twelve pork fat (salo) samples collected across Ukraine were analyzed. Samples were homogenized and spiked with 13C-labelled internal standards for isotope dilution quantification. Lipid extraction was performed using an automated accelerated solvent extraction system (EXTREVA ASE).
Cleanup and fractionation were carried out using a DexTech Heat system with multilayer silica, alumina, and activated carbon columns to effectively remove matrix interferences and separate PCDD/F and PCB fractions.
Instrumental analysis was performed using a Thermo Scientific TSQ 9610 triple quadrupole mass spectrometer equipped with a NeverVent Advanced Electron Ionization (NVAEI) source, coupled to a TRACE 1610 gas chromatograph. A total of 17 2,3,7,8-substituted PCDD/F congeners, 12 dl-PCBs, and 6 indicator PCBs (PCB 28, 52, 101, 138, 153, 180) were quantified.
Toxic equivalents (WHO-TEQ, 2005 TEFs) were calculated using lower-, middle-, and upper-bound approaches.

Results
Total WHO-PCDD/F-TEQ (upper-bound) concentrations ranged from 0.055 to 0.4065 pg WHO-TEQ/g fat, with most samples falling between 0.10 and 0.26 pg WHO-TEQ/g fat, indicating generally low background contamination levels. The observed variability suggests heterogeneous environmental exposure influenced by local emission sources and differences in feed composition.
The PCDD/F congener profile was dominated by OCDD, OCDF, and 2,3,7,8-TCDF. The predominance of OCDD is consistent with diffuse background contamination typically observed in terrestrial food chains. Elevated TCDF levels in selected samples may indicate contributions from combustion-related sources, including biomass burning, domestic heating, and small-scale industrial activities.
WHO-dl-PCB-TEQ values were substantially lower, ranging from 0.0007 to 0.0452 pg WHO-TEQ/g fat. The dl-PCB profile was dominated by mono-ortho congeners, particularly PCB 118, PCB 105, and PCB 156. Non-ortho PCBs (PCB 126 and PCB 169), which have the highest toxic potency, were mostly below detection or quantification limits, indicating limited exposure to highly toxic PCB congeners.
Indicator PCB concentrations ranged from 0.0932 to 0.6393 ng/g fat. The dominance of PCB 118, PCB 105, and PCB 153 suggests historical, weathered contamination rather than recent industrial inputs. Overall, PCB levels are consistent with diffuse background exposure in agricultural environments.
All samples complied with current European Union maximum levels for PCDD/Fs and PCBs in food of animal origin, with no regulatory exceedances observed.

Discussion and Conclusion
Pork fat (salo) samples from Ukraine exhibited low levels of contamination with PCDD/Fs and PCBs. Congener patterns indicate predominantly diffuse environmental sources, including atmospheric deposition and contaminated feed, rather than direct industrial emissions. The absence of regulatory exceedances confirms compliance with current EU food safety standards and indicates an overall acceptable contamination status. These findings provide valuable baseline data for future monitoring of persistent organic pollutants in traditional Ukrainian food products.

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P-00306 Basic Study on Dioxin Formation in Water under High Chlorine Conditions

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Introduction
The Ministry of the Environment, Japan's Study Group on Unregulated Sources of Dioxins previously reported elevated dioxin concentrations in wastewater from hypochlorous acid-based oxidative cleaning processes. This study investigates dioxin formation under high chlorine conditions to elucidate the underlying mechanism.

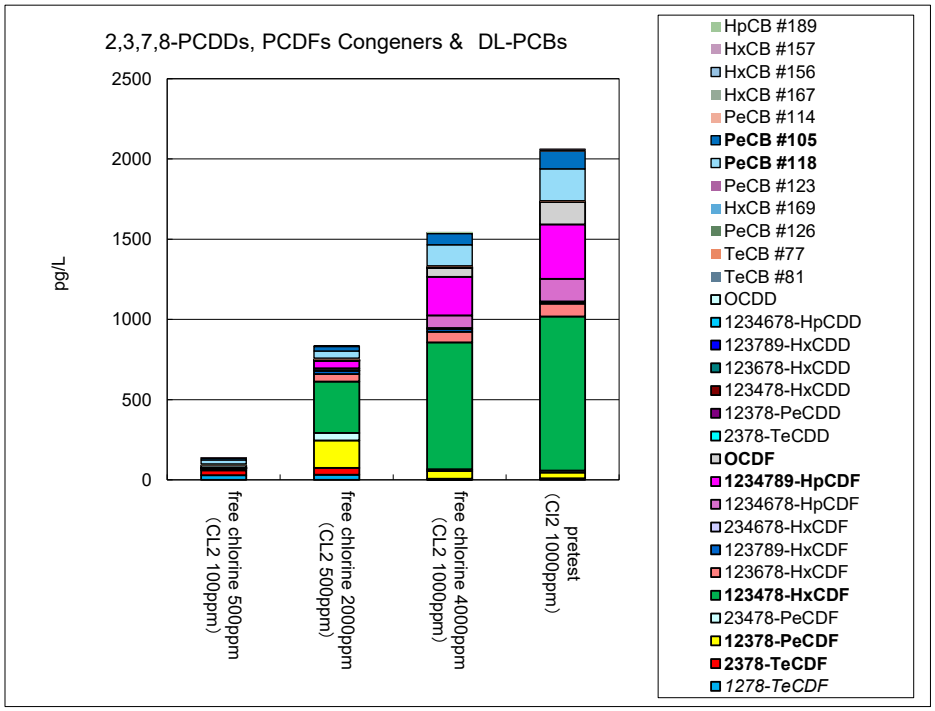
Materials and Methods
Chlorine gas, generated by reacting sodium hypochlorite with hydrochloric acid, was introduced into water samples. Preliminary experiments optimized chlorine generation and measurement, evaluated dioxin formation across chlorine concentrations, and confirmed the stability of residual chlorine.
Tap water from three locations was used. Samples (1–3 L) were reacted in sealed glass containers at room temperature for 24 hours with controlled chlorine concentrations. Reactions were quenched with sodium thiosulfate. Dioxins were extracted with dichloromethane and quantified by official JIS methods; other compounds were analyzed using the same extract. Residual chlorine was maintained throughout.

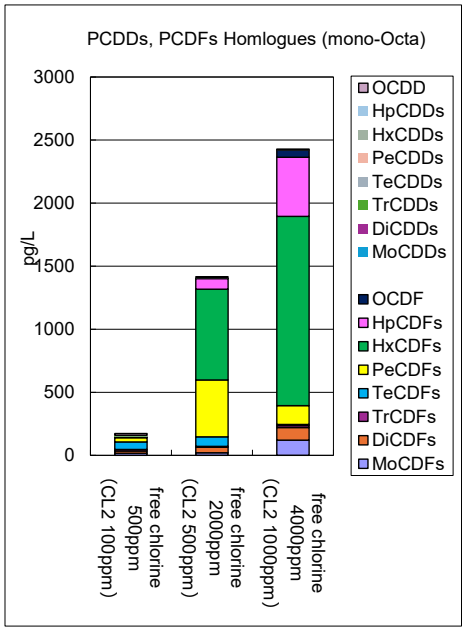
Results
Dioxin formation and TEQ dependence
Dioxin formation increased proportionally with chlorine concentration, yielding TEQ values of 5.5, 76, and 100 pg-TEQ/L at 500, 2000, and 4000 ppm free chlorine respectively (≈100, 500, and 1000 ppm Cl_2). Reproducibility was confirmed under high chlorine conditions.
Congener concentrations and distribution
PCDD/DF (mono- to octa-chlorinated congeners) concentrations increased significantly with chlorine concentration, reaching 170, 1400, and 2400 pg/L at ≈100, 500, and 1000 ppm Cl_2, respectively. PCDFs predominated, and congener profiles shifted toward higher chlorinated species as chlorine concentration increased. Lower chlorinated congeners, including MoCDFs to PeCDFs, were dominant at lower chlorine levels, whereas PeCDFs, HxCDFs, and HpCDFs became predominant at higher concentrations. Notably, low-chlorinated PCDFs were detected under all conditions.
PCDF isomer distribution and chlorination behavior
The dominant PCDF isomers varied systematically with chlorine concentration. At 100 ppm Cl_2, 2,3,7,8-TCDF was predominant; at 500 ppm, 1,2,3,4,7,8-HxCDF followed by 1,2,3,7,8-PeCDF; and at 1000 ppm, 1,2,3,4,7,8-HxCDFs and 1,2,3,4,7,8,9-HpCDF were dominant. Early-stage markers (1,2,7,8- and 2,3,7,8-TCDF) were consistently detected.
DL-PCB formation
Selective formation of dioxin-like PCBs (DL-PCBs) was observed, particularly congeners 2,3',4,4',5-PeCB(#118) and 2,3,3',4,4'-PeCB(#105), indicating preferential generation under high chlorine conditions.

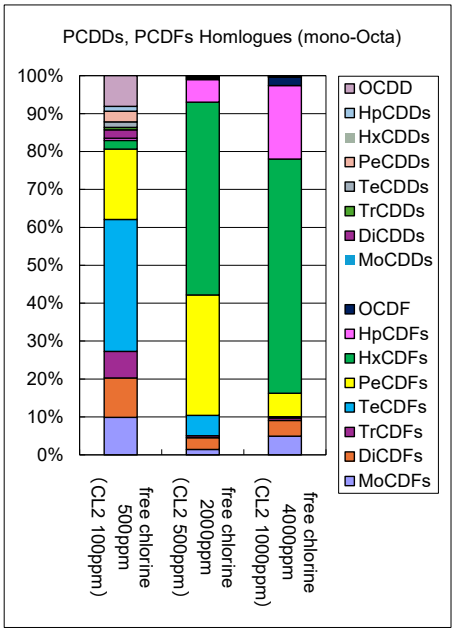
Discussion and Conclusion
Effect of water matrix
Dioxin formation was strongly influenced by the water matrix. At 4000 ppm free chlorine (1000 ppm Cl_2), dioxin levels in tap water ranged from 19 to 96 pg-TEQ/L, whereas purified water showed minimal formation (2.9 pg-TEQ/L), highlighting the critical role of organic matter.
Chlorination pathways insights
The results suggest a sequential chlorination pathway in which lower chlorinated PCDFs are progressively converted into higher chlorinated congeners: 1,2,7,8- / 2,3,7,8-TCDF → 1,2,3,7,8-PeCDF → 1,2,3,4,7,8-HxCDF → 1,2,3,4,7,8,9-HpCDF. Notably, 1,2,3,4,7,8,9-HpCDF—typically unfavorable due to steric constraints—was preferentially formed, suggesting a reaction mechanism specific to highly chlorinated conditions.
Overall conclusion
Dioxin formation under high chlorine conditions proceeds via systematic chlorination pathways influenced by organic matter and likely shares a common mechanism with that observed in hypochlorous acid cleaning wastewater.

Acknowledgment
This study forms part of the findings of the Ministry of the Environment, Japan's FY2002 Study Group on Unregulated Sources of Dioxins and Furans.

P-00306 Basic Study on Dioxin Formation in Water under High Chlorine Conditions







P-00310 Comprehensive assessment of small microplastics and plastic additives in surface sediments of Kongsfjorden from Svalbard

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Introduction

Comprehensive assessment of small microplastics and plastic additives in surface sediments of Kongsfjorden from Svalbard
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Small Microplastics (SMPs<100µm) and other microliter components, such as plastic additives (MLCs) have emerged as persistent tracers of anthropogenic impact even in remote Arctic environments. As part of the ICEBERG project, different surface sediment samples were collected during the 2023–2024 period along the Kongsfjorden land–ocean transect. This study aimed to elucidate the complex dynamics between local pollution sources and long-range transport, evaluating the role of marine currents and atmospheric deposition in the accumulation of these emerging contaminants.
Various procedures were implemented to minimize contamination throughout sampling, transport, pretreatment, and analysis. The samples were processed in a plastic-free ISO 7 Clean Room employing a strict QA/QC protocol. The samples were pretreated in duplicate, using an optimized oleoextraction procedure, followed by purification and filtration. Chemical characterization and simultaneous quantification were performed using Micro-FTIR with particle analysis section (employing the microscopic counting). A cross-validation approach was employed, and selected filters were also analyzed using Pyr/GC-MS.
For the first time, an extensive monitoring of small microplastics (SMPs < 100 µm) and MLCs was conducted in this area, revealing a diverse contamination profile. Analytical results confirmed the presence of over 25 different plastic polymers and copolymers, with a predominant concentration of particles smaller than 100 µm. Polyethylene High Density (HDPE), Polyamide 6 (PA6) and Polypropylene (PP) were the most abundant SMPs analyzed in all samples. Besides SMPs, several plastic additives such as vulcanizing agents and tyre wear particles were characterized as well. The spatial distribution and varying size classes observed across the fjord suggest a clear distinction between pollution drivers. Variations in particle size distributions indicate a differentiation between local inputs, potentially linked to research infrastructure and long-range transport mechanisms influenced by Atlantic water inflow and atmospheric pathways. The high diversity of polymers identified highlights the complexity of plastic reaches in the Arctic. This research provides a fundamental baseline for understanding the flux of emerging contaminants in Arctic fjords. By integrating data on SMPs and MLCs, the study confirms that Kongsfjorden acts as a crucial sink for emerging contaminants. These findings support the necessity for integrated monitoring strategies to assess the environmental risks posed by plastic pollution to fragile polar ecosystems and to inform international policies on long-range contaminant transport.

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Screening and identification of novel contaminants

P-00312 Small Microplastic analysis using FT-NIR spectroscopy in wet depositions and seawater from the Venice Lagoon: an integrated and cross-validation approach

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Introduction

Small Microplastic analysis using FT-NIR spectroscopy in wet depositions and seawater from the Venice Lagoon: an integrated and cross-validation approach

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Small microplastics (SMPs < 100 µm) have become a significant environmental concern due to their widespread presence in aquatic, terrestrial environments and in the atmosphere, posing a potential threat to biota and human health. However, due to the lack of standardized procedures for sampling, pretreatment, and analysis, research on SMPs remains inconsistent. Hence, accurate chemical identification and quantification are crucial for assessing environmental impacts and require robust cross-validation protocols capable of identifying successfully polymer types with high confidence. This study explores the application of Fourier Transform Near-Infrared (FT-NIR) spectroscopy for the detection of SMPs in seawater samples collected from the Venice Lagoon and wet depositions, focusing on the advantages of this technique for rapid screening, allowing for precise identification in higher resolution approach. This technique can support, enhance and confirm the SMPs identification via conventional Micro-FTIR techniques. In this work, environmental samples from wet depositions and the Venice Lagoon were processed through oleo-extraction and purification methodology previously developed (Corami et al., 2021). Then, selected seawater samples and wet depositions were analyzed employed a Thermo Scientific Nicolet RaptIR+ FTIR Microscope with Anodisc filters in the NIR range. This transparency allows for the acquisition of high-quality spectra with less organic interferences, enabling the identification of characteristic bands for plastic polymers such as polyethylene (PE), polyamide (PA6), and polyethylene terephthalate (PET).The results indicate that FT-NIR provides a robust, time-efficient alternative for monitoring SMPs, facilitating the processing of large datasets and providing a scalable solution for long-term environmental monitoring (Rosso et al., 2025). Comparing with Micro-FTIR analysis in the MIR range, most of the particles successfully characterized were < 100 µm and the same polymer types were successfully identified across both spectral regions. When integrated together, these techniques offer a distinct advantage by providing a more comprehensive and validated monitoring of plastic pollution dynamics in the real environmental samples. This synergistic approach facilitates the cross-validation of analytical methods for emerging contaminants, ensuring high-resolution datasets for long-term environmental risk assessment.

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P-00327 Adolescent exposure to polychlorinated biphenyls dysregulates cerebrovascular functions and primes for depression

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Introduction
Depression (major depressive disorder; MDD), is one of the most prevalent diseases, with a staggering lifetime prevalence of 21% in women and 11% in men in the United States and globally. Worldwide, approximately 350 million people are affected by this condition. Depression is characterized by disturbances in sleep, appetite, concentration, ability to experience pleasure, and psychomotor alterations. It is also associated with an increased risk for suicide, and several comorbid medical disorders, which shorten life expectancy. There is currently little understanding of the causes of depression; however, strong evidence indicates a role of environmental factors that interact with genetic susceptibilities. This is highly significant, because environmental factors are modifiable, and identification of their contribution may provide novel, data-targeted approaches for the prevention and treatment of depression. Thus, there is a critical need to evaluate how environmental toxicants affect the susceptibility to and the development of depression.
Emerging evidence indicates that exposure to polychlorinated biphenyls (PCBs) influence the risk of developing depression. PCBs are highly pervasive in the environment and biota due to their past widespread use, careless disposal, and resistance to degradation. Moreover, recent data demonstrates widespread human exposure to "contemporary" PCB congeners that are unintentional byproducts of current manufacturing processes. A widespread PCB contamination was identified in schools, which is especially alarming because children and adolescents are particularly vulnerable to health impact of environmental exposures.
While PCBs have been identified as potential carcinogens in humans, there is still an existing gap of knowledge on the impact of PCBs on psychiatric diseases, including depression. Taking into consideration PCB contamination in schools and the prevalence of depression in school children, a potential impact of PCBs on depression is an emerging and alarming health problem. Therefore, our studies focused on the hypothesis that PCB exposure in adolescence primes for depression.

Materials and Methods
Adolescent, 5-week-old male and female mice were exposed to an oral dose of a human-relevant dose of PCB mixture (PCB-138/-153/-180; molar ratio 1.7:3.2:1) dissolved in tocopherol-stripped safflower oil. PCBs were administered by oral gavage at 20 mg/kg daily, at the same time each day to minimize variability due to circadian effects.

Results
Behavioral analyses from a 10-day PCB exposure model revealed cognitive, social, and emotional deficits in 5-week-old male mice. In memory assays (novel object recognition and Y-maze), PCB-treated mice failed to show expected novelty preferences, suggesting deficits in recognition and working memory, despite no difference in total time spent with familiar and novel objects or arms between groups. In the sociability assay, PCB-treated mice showed reduced social interaction with a naïve mouse, despite similar total time spent in chambers, suggesting selective disruption of social interaction. Emotional behaviors were also affected, as PCB-treated mice showed increased immobility in the tail suspension test and a positive trend in escape failures in the learned helplessness test, both indicative of depressive-like behavior.
Additional molecular analyses indicated that PCB exposure can disrupt systemic inflammatory signaling, circadian regulation, and barrier integrity across brain and gut samples. Systemically, PCB-treated mice exhibited increased disruption in circulating inflammatory cytokine profiles, a prominent circadian rhythm dysregulation, and alterations of barrier function integrity.

Discussion and Conclusion
Together, these results demonstrate that PCB exposure results in disruption of multiple behavioral domains and establishes early vulnerability to exposure-driven mood dysregulation. Moreover, PCB exposure affects the molecular pathways regulating immune signaling, circadian timing, and barrier integrity, supporting an early mechanism of neuroimmune disruption involved in mood dysregulation.

Acknowledgment
Support for this work was provided by the University of Miami Team Science Award, Executive Dean for Research Office, and the National Institutes of Health ES036983

P-00339 The importance of Proficiency Test Providers (PTPs) for performance evaluation of laboratory proficiency testing using natural matrices (Test InterCinD Emissions – Proficiency Test - QA/QC Study).

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Introduction
InterCinD is a division and brand of LabService Analytica[1] that is Accredited ISO/IEC 17043:2023[2] (ACCREDIA Nr 01145 PTP) from February 2015 and it's a worldwide recognized PTP for POPs schemes. Essence of InterCinD are the materials used, all REAL MATRIX available in NATURE, prepared and characterized according to the international guidelines. These materials have the necessary characteristics of homogeneity and stability that they can be used in the round robin tests. The InterCinD is organized in conformity with international guidelines UNI CEI EN ISO/IEC 17043:2023, including the statistical analysis of data for evaluating laboratory performances through the z-scores (accuracy) and measures of dispersion (precision). The Accreditation certifies the technical competence of the organization as reported in Accredited Schemes details. The samples used in InterCinD QA/QC study are stored and therefore they provide an archive of test samples for scientific and research purposes, which are available upon request and could be used by laboratories for further testing their performances. Every Lab that requires an International PT with these samples features is welcome in its participation. In order to ensure confidentiality and privacy, participant Laboratories to the Scheme are identified by an ID number only. Random assignment of this ID number enables results to be reported without divulging the identities of participant Laboratories.

Materials and Methods
Here we present the importance of the InterCinD methodological of PTPs for performance evaluation of laboratory proficiency testing using natural matrices and using a methodological approach and the three main methods suggested in ISO 13528/2022 [3] (Test InterCinD EMISSIONS – Proficiency Test - QA/QC Study).

Results
This edition employed the comprehensive and robust InterCinD methodology, fully compliant with the UNI CEI EN ISO/IEC 17043:2026 standard, and involved a total of 12 participating laboratories. However, only 11 laboratories submitted valid and complete datasets.

Discussion and Conclusion
The results showed substantial variability and an overall performance that was not fully satisfactory. This variability is likely attributable to the limited number of participating laboratories and to the very low concentrations of congeners present in the natural matrix. Such ultra trace levels introduce significant analytical challenges and magnify the impact of even minor inter laboratory differences. The small number of valid data points, combined with the wide dispersion of results, resulted in an uncertainty associated with the assigned value that was not negligible relative to the standard deviation used for performance assessment; consequently, the required relationship was not fulfilled. Increasing the number of participants could improve statistical robustness, although this must be balanced against the physical constraints of the available sampling platforms. Additionally, the ability to verify the actual homogeneity and stability of the stack flow prior to the PT would help ensure more uniform sampling conditions for all operators.
The decision to rely on a single accredited reference laboratory proved appropriate, as it minimizes
additional and avoidable sources of error in the evaluation of analytical results.

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P-00340 The importance of Proficiency Test Providers (PTPs) for performance evaluation of laboratory proficiency testing using natural matrices (Test ICPFAS-waste waters).

C.C. Carrer[1], A. Battaglia[1], L.G. Gallocchio[1], M.T. Palermo[1], C. Carbone[2], I. Battaglia[1]
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Introduction
InterCinD is a division and brand of LabService Analytica[1] that is Accredited ISO/IEC 17043:2023[2] (ACCREDIA Nr 01145 PTP) from February 2015 and it's a worldwide recognized PTP for POPs schemes. Essence of InterCinD are the materials used, all REAL MATRIX available in NATURE, prepared and characterized according to the international guidelines. These materials have the necessary characteristics of homogeneity and stability that they can be used in the round robin tests. The InterCinD is organized in conformity with international guidelines UNI CEI EN ISO/IEC 17043:2023, including the statistical analysis of data for evaluating laboratory performances through the z-scores (accuracy) and measures of dispersion (precision). The Accreditation certifies the technical competence of the organization as reported in Accredited Schemes details. The samples used in InterCinD QA/QC study are stored and therefore they provide an archive of test samples for scientific and research purposes, which are available upon request and could be used by laboratories for further testing their performances. Every Lab that requires an International PT with these samples features is welcome in its participation. In order to ensure confidentiality and privacy, participant Laboratories to the Scheme are identified by an ID number only. Random assignment of this ID number enables results to be reported without divulging the identities of participant Laboratories.

Materials and Methods
Here we present the importance of the InterCinD methodological of PTPs for performance evaluation of laboratory proficiency testing using natural matrices and using a methodological approach and the three main methods suggested in ISO 13528/2022 [3] (Test ICPFAS-waste waters).

Results
In this fourth PFAs edition, the InterCinD method has been fully implemented in accordance with UNI CEI EN ISO/IEC 17043:2023. The InterCinD ICPFAS edition involved a total of 21 laboratories worldwide: 6 from Italy, 8 from China, and 7 from other EU and non-EU countries. Out of the 21 laboratories, only 20 submitted valid data. Participating laboratories received a set consisting of 3 bottles, each containing approximately 250 ml of wastewater sample. We strongly believe that this new area of application adds value to InterCinD proficiency test
projects and provides laboratories with an opportunity to refine their analytical performance for the determination of emerging pollutants. As always, the InterCinD team extends its gratitude to all the laboratories for their efforts and trust.

Discussion and Conclusion
The InterCinD proficiency tests, laboratories are not required to follow a specific method, there are 6 different methods used among the 20 participants. The homogeneity and stability check were performed according to the procedure identified by the ISO 13528. The matrix WASTE WATER (contaminated environmental matrix collected by a licensed testing laboratory) was selected and for 8 analytes out of 12. For those 8 analytes a good performance in terms of accuracy and precision has been achieved by most participants. Data analyses did not highlight significant differences between direct injection or not, probably due to the low number of laboratories adopting this technique.

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P-00343 Optimized dTOP Assay with suspect and non-target screening reveals PFAS precursor underestimation in hotspot soils

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Introduction
Per- and polyfluoroalkyl substances (PFAS) at fluorochemical production (FCP) sites may present contamination profiles that are too complex for targeted analyses (TA) to adequately characterize. Precursors transform, emerging compounds accumulate, and conventional target lists capture only a fraction of what is actually present.1,2 To address this, direct total oxidizable precursor (dTOP) assay, integrated with high-resolution mass spectrometry (HRMS)-based suspect and non-target screening (SS/NTS), along with TA, were applied to soils collected around a FCP site in Zwijndrecht, Flanders, Belgium. Total PFAS concentrations through target and SS/NTS reached 118 µg/g, placing this among the most heavily impacted sites reported in the literature.3 The dTOP assay required optimization before it could reliably handle such contamination level.

Materials and Methods
A Box-Behnken design identified sodium hydroxide and potassium persulfate concentrations as the dominant factors governing oxidation performance ($p < 0.01$).
Comparison of concentrations on pre- and post- dTOP extracts were used to assess the oxidative behaviors of each individual and compound classes.

Results
Spiking experiments confirmed method reliability. Perfluorooctyl sulfonamide (FOSA)-spiked soils yielded 79 ± 5% perfluorooctanoic acid (PFOA) molar conversion, while 6:2 fluorotelomer sulfonate (FTS) formed three perfluoroalkyl carboxylic acis (PFCAs) with total molar yield = 46 ± 8%. Perfluorooctane sulfonic acid (PFOS) recovery reached 96 ± 7%, consistent with its known resistance to further degradation. Under optimized conditions, near-complete oxidation was achieved for target sulfonamide-based precursors, with perfluoroalkyl sulfonamides (FASAs) and perfluoroalkyl sulfonamidoacetic acids (FASAAs) degrading at 99% and 100%, respectively, across both moderately and heavily contaminated soils. Furthermore, SS/NTS on both pre- and post-dTOP extracts collectively identified, at high level of confidence, over 100 homologues and isomers spanning 16 compound classes, including pentafluorosulfide sulfonic acids (SF5-PFSAs) and perfluorophosphoric diesters (PFPDEs).

Discussion and Conclusion
Short-chain PFSAs (C4–C6) resisted degradation, while longer homologues (C9–C15) underwent partial chain shortening, with degradation ranging from 28 to 97%. Long-chain PFCAs (≥C11) degraded through sequential CF2 elimination, consistent with stepwise oxidative shortening. FASAs and FASAAs, degraded completely (>99%). SF5-PFSAs, not generally considered oxidation-susceptible, converted up to 95%, while ether-based PFAS, such as ether-carboxylates (PFECAs) and ether-sulfonates (PFESAs), showed variable and inconsistent oxidation efficiencies. Post-dTOP SS/NTS further detected nitrogen- and sulfur-containing transformation intermediates identifiable only through diagnostic fragmentation patterns. Despite this, combined PFAS (semi)-quantified through TA and SS/NTS accounted for only 44% of the total PFAS measured from dTOP assay, leaving 56% unresolved, most likely due to the unidentified precursors and possible underestimation in SS/NTS semi-quantification, including features at confidence level 4.
Despite the use of various techniques, many PFAS precursors remain uncharacterized and the annotated compounds represent only a fraction of the actual precursor PFAS burden. Even so, the integrated TA-dTOP-SS/NTS framework applied here improves precursor estimation, reveals transformation pathways of emerging PFAS under oxidative conditions, and exposes the complexity of the PFAS contamination that single-method approaches underreport.

Acknowledgment
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P-00347 Sampling volatile PFASs in air: Activated carbon filters as a potential alternative to XAD resin

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Introduction

Per- and polyfluoroalkyl substances (PFASs) are a large and diverse group of ubiquitous pollutants found in the environment. While research focuses mainly on their presence in water and soil, atmospheric PFASs can travel over long distances and atmospheric transport might be a relevant pathway for environmental input. In air, PFASs can be found either bound to particulate matter (often ionic PFASs) or in the gas phase (usually volatile and semi-volatile neutral PFASs). Sampling neutral PFASs in air is challenging due to their high volatility and low ambient concentrations (in the pg m-3 range), which increases risks of sampling losses and contamination. Typically, polyurethane foam (PUF) and Amberlite XAD-2 resin are used as sorbent materials in active air samplers, often assembled in a cartridge as a PUF/XAD/PUF configuration. However, XAD is difficult to handle due to its fine grain size and electrostatic properties. Extensive cleaning steps may also be necessary to prevent matrix effects during measurements (Müller et al. 2012). Therefore, in this study, an alternative sorbent material is tested to sample volatile PFASs: GAIAC (Futamura Chemical Co., LTD), an artificial activated carbon filter. This technology has previously been used with low-volume active air samplers (cascade impactors) by Wu et al. (2021) and Lin et al. (2022). Their results show successful capture of volatile PFASs, including highly volatile and short-chain substances such as 4:2 fluorotelomer alcohol. In addition, no extensive cleaning steps or significant matrix effects have been reported, making GAIAC an interesting alternative to XAD-2. Hence, in the present study, the sampling performance of GAIAC is tested under high-volume air sampling conditions and compared to XAD-2. The used high-volume active air sampler (HV-AAS, Digitel DHA-80) is equipped with particle filters and cartridges, enabling the collection of particle-bound PFASs on filters and gaseous PFASs on sorbent material. In this method development study, the focus is on volatile PFASs in the gas phase, which mainly include fluorotelomer alcohols (FTOHs), perfluoroalkane sulfonamides (FASAs) and perfluoroalkane sulfonamidoethanols (FASEs). Two cartridge configurations are tested and compared: (A) PUF/GAIAC/PUF and (B) PUF/XAD/PUF (see attached Figure). In setup A, two GAIAC sheets are used, while in setup B, 6 g of XAD-2 in a cellulose bag is used to facilitate handling during sampling and sample extraction. Two PUFs with a density of 20 kg m-3 were installed above and below GAIAC and XAD (upper PUF 60x50 mm, lower PUF 15x50 mm). The lower PUF is used to test for potential breakthroughs during sampling. High-volume active air sampling is conducted for 6 hours at a constant flowrate of 500 L min-1. Sample materials are then extracted and analyzed with GC-MS, and results from the two setups are compared.

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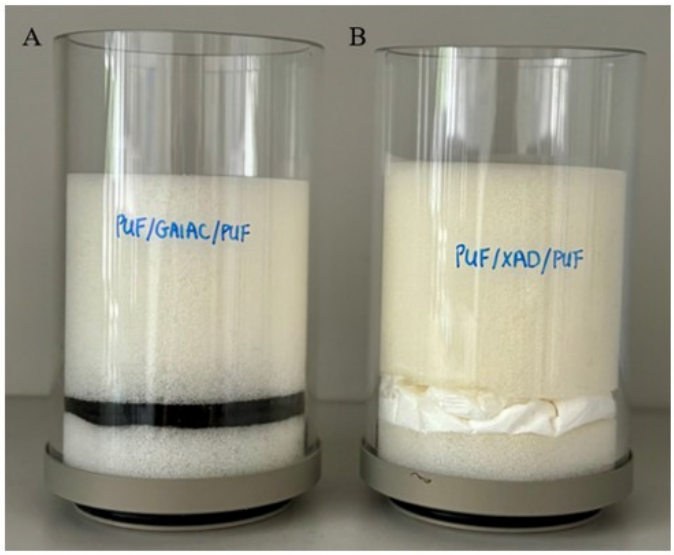


Figure: Tested cartridge setups for high volume active air sampling, (A) PUF/GAIAC/PUF and (B) PUF/XAD/PUF

P-00355 Optimized PTV method for analysis of brominated dioxins and furans using GC-HRMS

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Introduction
The knowledge of brominated dioxins in terms of occurrence, quantity and health risk is limited compared to chlorinated dioxins. One reason for this limitation are analytic challenges associated with the analysis of brominated dioxins. These compounds are known to be less stable compared to chlorinated dioxins, especially in terms of temperature, with octabromo-dibenzodioxin and the octabromo-dibenzofuran being extremely thermolabile. This challenge can be addressed by using Programmed Temperature Vaporizing (PTV) Injector instead of a standard Split/Spitless (SSL) Injector since PTV ensures a smooth transfer from the extract onto the analytical GC column, especially for the higher brominated dioxins/furans, and it reduces the thermal stress. Here we present an optimized workflow for the analysis of brominated dioxins and furans.

Materials and Methods
All experiments were carried out on a Thermo Scientific™ DFS Magnetic Sector GC-HRMS with two TRACE™ 1600 GCs and one extra wide Thermo Scientific™ RSH Autosampler. The GCs are equipped with a programable temperature Injector (PTV). The instrument method was tested on Bromodioxin/Furan Calibration Standard Solution in nonane from Cambridge Isotope Laboratories Inc. (CS1 PN: EDF5407-1; CS3 PN: EDF5407-3 and CS5 PN: EDF5407-5).

Results
We demonstrate successful application of the PTV methodology for analysis of polybrominated dibenzo-furans and -dioxins. Especially the challenging octabromo-dibenzodioxin and the octabromo-dibenzofuran could be measured down to the CS1 Standard.

Discussion and Conclusion
The PTV method reduces the thermal stress on the analytes and is applicable for application in routine analysis of challenging compounds such as brominated dioxins and furans.

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Fate and Transport

P-00363 Biomonitoring Reveals the Transition from Legacy to Emerging PFAS in Subtropical Estuaries: Dual Roles of Usage Shift and Environmental Parameters

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Introduction

Following global restrictions on legacy per- and polyfluoroalkyl substances (PFAS), emerging alternatives have been widely introduced, yet their environmental trajectories remain poorly understood. Using oysters as biomonitors, this study revealed the spatiotemporal dynamics of both legacy and emerging PFAS in the Pearl River Estuary from 2015 to 2020. Among frequently detected PFAS, total median concentrations decreased significantly from 48.4 to 5.56 ng/g dry weight, largely due to declines in legacy compounds. Conversely, emerging PFAS, such as hexafluoropropylene oxide dimer acid (HFPO-DA) and 6:2 fluorotelomer sulfonic acid (6:2 FTS), persisted at elevated levels, reflecting ongoing industrial use and their potential environmental accumulation. PFAS composition shifted from legacy-dominated in 2015–2016 to emerging-compound-dominated by 2020. Seasonal trends were pronounced for legacy PFAS, with higher concentrations in wet seasons, whereas emerging compounds exhibited substance-specific seasonal patterns. Spatial distribution of HFPO-DA correlated strongly with industrialized and urbanized zones, highlighting the role of regional socioeconomic activity. Environmental factors (pH, salinity, temperature) modulated PFAS partitioning and bioaccumulation. Overall, regulatory actions and industrial substitution drive compositional shifts in estuarine PFAS contamination, while hydroclimatic conditions influenced their bioavailability. Our study underscores the need for monitoring emerging PFAS in estuaries to assess ecological risks under evolving regulatory pressures.

P-00365 Extracellular secretion mechanism of proteins that transport persistent organic pollutants in cucurbit plants

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Introduction
It is known that plants in the Cucurbitaceae family are more prone to accumulate highly hydrophobic persistent organic pollutants (POPs) in their aboveground parts (leaves and stems) compared to plants in other families. Major latex-like protein (MLP) is a protein detected in the xylem sap of zucchini plants (Inui et al., 2013). It binds intracellularly with POPs taken up by roots to form complexes, which are then secreted extracellularly and transported through the xylem vessels to the aboveground parts, where the POPs accumulate (Fujita & Inui, 2021). Therefore, the extracellular secretion of MLPs is the most critical step determining the extent of POPs contamination in the aboveground parts. Zucchini cultivars with high POPs accumulation possess two types of MLPs: MLP-GR1 and MLP-GR3. Since MLPs lack a signal peptide at its N-terminus, it is expected to be secreted via a transport pathway different from the classical secretory pathway from the endoplasmic reticulum to the Golgi apparatus; however, the details remain unclear (Inui et al., 2023; Yoshida et al., 2025). The objective of this study is to elucidate the mechanism of MLP extracellular secretion. Identifying the extracellular secretion pathway of MLPs is expected to contribute to the development of crops that are not contaminated by POPs through the regulation of MLP secretion, as well as to the remediation of POP-contaminated soil using plants.

Materials and Methods
Endosidin2 (ES2), an inhibitor of extracellular protein secretion, inhibits the function of the exocyst complex and suppresses exocytosis. The plant materials used were the zucchini RA cultivar (Cucurbita pepo ssp. pepo cv. Raven), which has a high capacity for accumulating POPs in its aboveground parts. After cultivating RA for 10 days in MS medium containing 0.1% DMSO or 20 μM ES2, xylem sap and apoplast wash fluid (AWF) were collected. Furthermore, root extracts were fractionated into cytosolic and membrane fractions, and MLPs in the xylem sap, AWF, and root extracts were detected by western blot analysis. In addition, fluorescent observation via immunostaining of root cross-sections toward MLPs using a specific antibody and MLP gene expression analysis by qRT-PCR were performed.

Results
Treatment of zucchini plants with ES2 significantly shortened root length. Western blot analysis of xylem sap and AWF detected MLP-GR3, and the amount of MLPs contained in these samples showed a tendency to increase following ES2 treatment. Furthermore, analysis of the localization of proteins in root cells revealed that MLP-GR1 was mainly distributed in the membrane fraction, while MLP-GR3 was distributed in the cytosolic fraction. ES2 treatment reduced the amount of MLP-GR1 present in these fractions and increased the amount of MLP-GR3. In addition, the expression of both the MLP-GR1 and MLP-GR3 genes was significantly increased by ES2 treatment.
Immunostaining of zucchini lateral roots revealed that MLPs were predominantly localized in the pericycle, and its presence was also confirmed in the extracellular spaces of the outer endodermis and cortex. ES2 treatment resulted in the accumulation of MLPs within the cells of the cortex, endodermis, and pericycle, while the amount of MLPs in the cortex showed a decreasing trend.

Discussion and Conclusion
Treatment of ES2 caused MLPs to accumulate within root cells and inhibited its extracellular secretion. These results suggest that exocytosis mediated by the exocyst complex may be involved in MLP secretion. In other words, it is believed that MLPs are secreted out of the cell in an exocyst-dependent manner as part of an unconventional secretion pathway.

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P-00368 Impaired Osmotic Reserve by Chemical Exposure Amplifies Vulnerability of Estuarine Organisms to Climate-Driven Salinity Shift

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Introduction
Estuarine and transitional aquatic ecosystems are naturally characterized by dynamic salinity fluctuations. Under global climate change, the increasing frequency of extreme weather events, such as severe floods and droughts, is pushing these natural variations toward more extreme and unpredictable conditions. As a result, aquatic organisms are more often confronted with unpredictable osmotic conditions and are forced to operate near the limits of their osmoadaptive capacity. At the same time, estuaries are among the most heavily impacted aquatic ecosystems with respect to anthropogenic chemical pollution. These physiological disruptions may be negligible during environmental stability but can manifest as severe impairments when organisms are forced to rapidly adjust to salinity fluctuations, which ultimately reduces their capacity to maintain osmotic balance.

Results
We use the notion of an "osmotic reserve" as a unifying framework to describe the physiological safety margin that allows organisms to repeatedly counteract stochastic and extreme environmental salinity shifts. Based on known evidence, exposure to environmental pollutants have been shown to disrupt the physiological capacity required for effective osmoregulation in aquatic organisms. Specifically, pollutants interfere with endocrine signaling, impairing the systemic coordination of osmotic responses. They also directly disrupt core ion transport systems (e.g., Na+/K+-ATPase) and organic osmolyte metabolism, limiting the functional scope of osmotic adjustment. Furthermore, chemical exposure during sensitive stages can suppress ionocyte development, imposing permanent structural constraints on osmoregulation. Ultimately, the energy reallocated toward detoxification and stress repair under multi-stressor conditions further depletes the energetic resources available for mobilizing the osmotic reserve.

Discussion and Conclusion
The depletion of the osmotic reserve implies that salinity fluctuations that were previously tolerable may now exceed an organism's physiological capacity, thereby amplifying vulnerability to climate-driven extremes. To operationalize this concept for future assessment, we propose a multi-tiered quantitative framework. This includes establishing an Osmotic Reserve Index (OR) based on energetic partitioning, evaluating dynamic recovery kinetics, and defining the Critical Salinity Delta (ΔScritical). Future research should integrate these osmotic reserve metrics into Dynamic Energy Budget (DEB) and toxicokinetic-toxicodynamic (TKTD) models to predict physiological tipping points. Embedding this concept into ecological forecasting and environmental management offers a practical way to better capture organismal resilience in a rapidly changing world.

P-00369 Toxicokinetics of Ionizable Organic Chemicals in the Early Life Stage Zebrafish (Danio rerio)

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Introduction
Highly bioaccumulative chemicals can pose potential risks to public health and the environment. Previous investigations on chemical bioaccumulation have mainly focused on hydrophobic nonionizable organic chemicals, while ionizable organic compounds (IOCs), which constitute a substantial portion of commercial chemicals, have received insufficient attention. Moreover, it remains unclear how the bioaccumulation of IOCs in fish is affected by developmental stages. Herein, we selected eight pharmaceuticals with diverse physicochemical properties (molecular weight <500, log Kow: 0.51–4.92) as representatives of IOCs and investigated their toxicokinetic processes and bioconcentration potentials across two early life stages of zebrafish (embryo and larva). First, the influence of individual or mixture exposure on toxicokinetic parameters and the bioconcentration factor (BCF) in zebrafish embryos was compared. The deviation of toxicokinetic parameters and BCFs of studied IOCs under individual and mixed exposures was within one order of magnitude, suggesting acceptable variance in experiments using the mixed exposure method, which is more environmentally relevant and includes animal welfare benefits. The selected IOCs showed varied toxicokinetic parameters and BCFs in the two early life stages of zebrafish, including influences of dissociation form and hydrophobicity. Notably, the BCFs of highly hydrophobic IOCs, which ionize as cations in zebrafish larvae, were higher than zebrafish embryos, indicating greater bioaccumulation potential of cationic pharmaceuticals in zebrafish larvae compared to embryos.

P-00372 Application of Dispersive Solid-Phase Extraction for PFAS Analysis in Aqueous Samples

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are a class of anthropogenic chemicals characterized by persistence, bioaccumulation, and potential toxicity to humans and the environment. Reliable quantification of PFAS in environmental waters requires appropriate sample pretreatment. Solid-phase extraction (SPE) is widely used; however, it often suffers from reduced flow performance and variability in recovery, particularly for wastewater samples containing high levels of suspended matter.1)
Dispersive solid-phase extraction (d-SPE), in which sorbents are directly dispersed into the sample, has been proposed as a simple and rapid alternative.2) Despite its advantages, limited studies have investigated its applicability to PFAS analysis in aqueous matrices. In this study, the applicability of d-SPE for PFAS analysis in water samples was evaluated.

Materials and Methods
Water samples, including tap water and treated wastewater from a disposal facility, were used in this study. Recovery experiments were conducted using isotopically labeled PFAS standards (EIS, MPFAC-HIF-ES, Wellington Laboratories) corresponding to EPA Method 1633 target compounds.
Each water sample (100–500 mL) was spiked with EIS (50–100 µL). A dispersive solid-phase sorbent was directly added to the sample, followed by mixing and standing. The mixture was then centrifuged (3500 rpm, 5 min), and the supernatant was removed by decantation to collect the sorbent.
For the elution step, 10 mL of an organic solvent was added to the sorbent, followed by mixing, standing, and centrifugation (3500 rpm, 5 min). A portion of the supernatant was collected, and a mixture of internal standards (NIS, MPFAC-HIF-IS, Wellington Laboratories) was added to prepare the final solution for analysis.
Quantitative analysis was performed using LC-MS/MS (UltiMate 3000 LC coupled with TSQ Quantiva, Thermo Fisher Scientific). Chromatographic separation was achieved using an Accucore RP-MS column (100 mm × 2.1 mm, 2.6 µm).

Results
The extraction performance of d-SPE was evaluated by investigating the effects of sorbent type, sorbent amount, and elution conditions. Significant differences in recovery behavior were observed depending on the elution solvent used. For tap water samples, recoveries ranged from 77 to 102% with relative standard deviations (RSDs) of 1.2 to 10.1%. For wastewater samples, recoveries ranged from 57 to 86% with RSDs of 2.0 to 17.3%. Matrix-matched recoveries were between 61 and 94%.

Discussion and Conclusion
The results indicate that both sorbent-related parameters and elution conditions play important roles in determining extraction efficiency, with elution conditions having a particularly strong influence. Although matrix effects were more pronounced in wastewater samples compared to tap water, the overall recovery performance was acceptable. The d-SPE approach was effective even for samples containing suspended matter, which are known to cause operational issues in conventional SPE, such as clogging and reduced flow performance.
This study demonstrates that dispersive solid-phase extraction is applicable to PFAS analysis in a variety of aqueous samples, including complex wastewater matrices. The method offers a simplified and rapid pretreatment approach and has the potential to overcome limitations associated with conventional SPE methods. Therefore, d-SPE represents a promising alternative for PFAS sample preparation in environmental analysis.

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P-00373 PFAS in Marine Fish from the Italian Coast: Occurrence Patterns and Trophic Transfer

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants widely detected in aquatic environments. Unlike traditional hydrophobic pollutants, PFAS are amphiphilic compounds whose distribution and bioaccumulation are driven not only by partitioning, but also by interactions with proteins and other biomolecules. In marine food webs, biomagnification is compound-specific, with long-chain perfluoroalkyl carboxylic acids (PFCAs) and PFOS generally showing the strongest trophic enrichment. Since seafood represents a major pathway for human exposure, it is essential to better understand the extent to which trophic position drives PFAS accumulation in edible marine species.

Materials and Methods
Within the ongoing PNRR-PNC Project "CAP-fish", 425 muscle samples from ten widely consumed marine species collected along the Italian coast were analysed for 24 PFAS, including 19 legacy compounds (1) and 5 emerging substances listed in Commission Recommendation (EU) 2022/1431 (2). The investigated species were anchovy, bluefin tuna, clam, cuttlefish, hake, mantis shrimp, octopus, pink shrimp, red mullet, and sardine. Method LOQs were 0.010 µg/kg for most analytes, except for PFBA (0.200 µg/kg), PFOSA (0.025 µg/kg), and GenX (0.200 µg/kg). Values below LOQ were set to zero according to a lower-bound approach. Trophic magnification factors (TMFs) were estimated from linear regressions between ln-transformed concentrations and trophic levels (TLs). TMF values >1 were interpreted as evidence of trophic magnification (3).

Results
The analysis of PFAS concentrations revealed clear species-dependent patterns. Long-chain PFCAs exhibited the strongest trophic relationships, with PFTrDA (C13) and PFUnA (C11) showing significant biomagnification (TMFs of 4.0 and 2.7, respectively). Other long-chain PFCAs, including PFDoA (C12) and PFTeDA (C14), displayed TMFs above 2, with p-values close to significance (≈0.05), suggesting a consistent positive association with trophic level. By contrast, the remaining PFAS showed no specific trend. When anchovy and hake species were excluded from the analysis, trophic relationships became markedly stronger: PFCAs with chain lengths ≥ C11 showed TMF values exceeding 4, with PFTrDA reaching a TMF of 7.2 ($p < 0.001$; $R^2 > 0.88$). PFOS also exhibited significant biomagnification, with a TMF of 2.3 ($p = 0.038$).

Discussion and Conclusion
These results indicate that PFAS biomagnification in marine species cannot be interpreted as a simple function of the only trophic position, but it appears to be strongly compound-specific and shaped by ecological variability. The consistent behaviour of long-chain PFCAs, particularly PFTrDA and PFUnA, supports their greater biomagnification potential, in line with literature evidence (4); the marked improvement of the regression results obtained after excluding anchovy and hake from regression, suggests that species-specific ecological traits may decouple PFAS burdens from trophic expectations. Habitat use, feeding strategy and exposure pathways likely contribute to these deviations, indicating that TL alone is an insufficient predictor of PFAS contamination. In addition, in this work TLs were assigned using on literature values, which may not fully capture site-specific dietary variability. This limitation should be considered when interpreting trophic magnification patterns, as the use of fixed TL values can introduce uncertainty in TMF estimates. The CAP-fish project is still ongoing and the final data collection, comprising 1360 observations (136 per species), is expected to represent one of the most comprehensive database on PFAS occurrence in marine organisms. Hopefully it will help in better understanding the bioaccumulation mechanisms of the most relevant PFAS in such ecosystems.

Acknowledgment
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Flame Retardants: Biotransformation and Toxicity

P-00374 Matrix-dependent modulation of cholinesterase inhibition by organophosphate esters: A mixed-effects modeling approach

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Introduction
Organophosphate esters (OPEs), widely used as flame retardants and plasticizers, are widespread contaminants associated with continuous human exposure. Their biological effects remain insufficiently understood, particularly under physiologically relevant conditions. In this study, we evaluated the two-way influence between blood matrix composition and OPE bioavailability as well as their inhibitory effects on acetylcholinesterase (AChE) and butyrylcholinesterase (BChE), alongside non-cholinergic toxicity.

Materials and Methods
Experiments were performed using purified enzyme systems, both in the presence and absence of albumin, as well as in human blood matrices (serum, erythrocytes, whole blood), across a range of substrate (ATCh) concentrations. Hemolysis was additionally performed. Statistical analyses were performed in R (v4.5.1) using linear mixed-effects models (lme4), with log(IC_{50}) as the response variable and experimental replicate as a random effect.

Discussion and Conclusion
Type III ANOVA revealed highly significant main effects of matrix ($F = 177.59$, $p < 10^{-81}$), OPEs ($F = 796.08$, $p < 10^{-118}$), and ATCh ($F = 23.73$, $p < 10^{-10}$). The OPEs effect was dominant, confirming that chemical structure is the primary determinant of inhibitory potency. A highly significant Matrix × OPE interaction ($F(18,221) = 77.32$, $p < 0.001$) demonstrated strong compound-specific matrix effects. In contrast, interactions involving ATCh were not significant, indicating a consistent inhibition mechanism across all blood components and OPEs. Further analysis favored a reduced model (Matrix × OPE + ATCh), avoiding overparameterization. Compound-specific patterns were evident from post hoc analysis: triphenyl phosphate (TPHP) consistently exhibited the lowest IC_{50} values with minimal matrix-dependent variation, whereas tricresyl phosphate (TCP) and tris(2-chloroethyl) phosphate (TCEP) showed pronounced increases in BChE and serum, indicating strong matrix sensitivity. Tris(2-chloroisopropyl) phosphate (TCPP) displayed intermediate behavior, with elevated IC_{50} values particularly in erythrocytes. Pairwise contrasts confirmed significant differences among matrices and OPEs; however, these effects were reduced in whole blood, suggesting buffering by complex biological interactions. Also, we analyzed albumin impact that indicated moderate binding effects, most pronounced for TCP, while weaker effects were observed for TPHP and TCEP and none for TCPP. Regarding non-cholinergic activity, hemolysis assays indicated low to moderate effects of OPEs on erythrocyte integrity, generally remaining below 30% even at higher concentrations, suggesting limited membrane-disruptive potential in tested concentration range.
Overall, the results demonstrate that both chemical structure and biological matrix critically determine OPEs toxicity. These findings provide new insights into the potential biotransformation and toxicity of tested compounds supporting the need for further biologically relevant models in human health risk assessment.

Acknowledgment
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P-00375 Occurrence of polybrominated diphenyl ethers in fish from Croatia

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Introduction
Polybrominated diphenyl ethers (PBDEs) are a class of persistent organic pollutants widely used as additive flame retardants in variety of commercial and industrial products. Due to their persistence, lipophilicity, and resistance to degradation, PBDEs are released in the environment during production, use, and disposal of PBDE-containing products. As result, they accumulate in terrestrial and aquatic environments, and undergo biomagnification through food webs[1]. Fish are therefore particularly suitable indicators of environmental contamination and represent a relevant pathway for human exposure via diet. The analysis of PBDEs in fish samples enables the assessment of contamination levels, and potential risks to both ecosystem health and food safety.

Materials and Methods
The mass fractions of selected PBDEs were determined in fish sampled between 2020 and 2023 from 12 locations along the middle course of the Kupa River, Croatia. The sampling targeted fish species intended for human consumption, and was conducted in collaboration with recreational anglers. A total of 33 individual samples were analysed for the congeners BDE-28, -47, -99, -100, -153, -154 and -183. The dataset comprised species representing different trophic levels, including predatory fish (Northern pike, Wels catfish, and Pike-perch), omnivorous species (Common carp, and Bream), and a predominantly herbivorous species (Grass carp). Targeted PBDEs were extracted from lyophilised fish samples using microwave-assisted extraction, followed by clean-up procedures, and their mass fractions were determined using gas chromatography coupled with tandem mass spectrometry (GC–MS/MS) operated in multiple reaction monitoring (MRM) mode.

Results
Total PBDE mass fractions (∑PBDE) in positive fish samples ranged from 0.047 to 4.951 ng g-1 wet weight (ww), with a median of 0.662 ng g-1 ww. The only congener not detected in any sample was BDE-183, while BDE-47 and -100 were the most frequently detected (in 97% of the samples), followed by BDE-154 (in 88% of the samples). The observed congener profile, characterised by the dominance of BDE-47, contributing the largest fraction to ∑PBDEs (median 64%, up to 78%), is consistent with previously reported PBDE patterns in European and global fish[2,3], reflecting the environmental prevalence and bioaccumulation behaviour of penta-BDE formulations.

Discussion and Conclusion
The results of this study indicate widespread but generally low to moderate contamination of fish with PBDEs, with congener profiles consistent with global observations, reflecting historical use and environmental persistence of these compounds. Such findings highlight the importance of continued monitoring of PBDEs in aquatic ecosystems and their potential implications for food safety and human exposure.

Acknowledgment
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Screening and identification of novel contaminants

P-00376 Comprehensive characterization of indoor dust contaminants via integrated suspect and non-targeted approaches

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Introduction
Wide scope screening techniques are essential tools for the comprehensive characterization of environmental samples and the identification of emerging contaminants. Analytical workflows using gas chromatography coupled with high-resolution mass spectrometry (GC-HRMS) are particularly effective for complex matrices like indoor dust, which acts as a sink for a vast array of non-polar and semi-volatile organic compounds. As modern population spend approximately 90% of their time indoor (Dubocq et al., 2021), many of these substances may pose adverse health effects involving a potential risk to indoor inhabitants through various exposure pathways, such as ingestion, inhalation, or dermal contact.

Materials and Methods
In this study, a data processing workflow combining suspect screening (SS) and non-target screening (NTS) using GC quadrupole time-of-flight mass spectrometry (GC-QTOF) was developed and applied to indoor dust samples. Sample preparation followed a modified QuEChERS-based extraction protocol (Navarro et al., 2023) to ensure the efficient extraction of a broad range of contaminants while minimizing matrix effect. Data processing involved screening the samples against an extensive suspect list containing over 1,000 contaminants, which includes mass spectral and retention data. The methodology and workflow were optimized by analyzing the NIST SRM 2585 house dust reference material in triplicate (n=3), where 150 compounds were identified. This approach was applied to dust collected from diverse occupational (offices, kindergartens and schools) and residential settings to capture a broader chemical diversity. Complementary, NTS was performed to identify additional pollutants not present in the initial suspect database.
To facilitate comparison across different indoor settings, qualitative indicators such as the number of identified compounds and the contaminant burden were utilized. This burden was defined as the sum of normalized areas of the detected features relative to internal standards, providing a proxy for relative chemical loading.

Results
In total, over 200 pollutants were identified across all samples, reaching confidence levels 1-3 on the Schymanski's scale. The most prevalent classes included plasticizers, polymer additives, flame retardants, personal care products (PCPs) and other anthropogenic or industrial compounds.The studied micro-environments exhibited high variability, with 20 to 150 compounds detected per sample. This study identified distinct chemical signatures associated with specific environments. For instance, PCPs and plastic-related additives were widely distributed in educational settings, while industrial compounds linked to old electronic equipment predominanted in offices and homes. Notably, the workflow revealed the presence of several contaminants of emerging concern, such as rubber additives (e.g., p-phenylenediamine-type antioxidants) and volatile PFAS (e.g., alkylated N-(2-hydroxyethyl)-perfluorooctanesulfonamides), confirming that dust also serves as a significant reservoir for these compounds. Homes emerged as the most chemically complex and showed the highest pollutant burden. Characterizing these contamination profiles is fundamental to evaluating human exposure in indoor micro-environments, where modern populations spend the majority of their time.

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P-00380 Modeling of accelerated solvent extraction of lipids and lipophilic contaminants in Italian sheep ricotta

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Introduction
Dioxins, furans and polychlorobiphenyls (PCBs) are by-products of anthropic activities, as industrial manufacturing, combustion processes and metal production. These classes of contaminants are persistent pollutants that can accumulate along the food chain both directly and indirectly through animal products such as meat, eggs, milk and fish. They pose a risk to human health as they are endocrine disruptors and carcinogens. Moreover, they cause lipid metabolism disorders [1] altering the lipid profile and nutritional characteristics of contaminated foods [1]. For dioxins and PCBs confirmatory analysis, Regulation (EU) 2017/644 [2] indicates the Gas Chromatography-High-Resolution Mass Spectrometry (GC-HRMS) technique. Given their lipophilic nature, the analysis process requires an effective extraction of the lipid fraction which, conventionally, occurs using accelerated solvent extraction (ASE) with hexane and acetone, followed by a purification step. Scientific research in this field is focused both on the development of sensitive and accurate environmentally friendly analytical methods and, also, on the study of the effects of contamination by these molecules in food, which require highly performing approaches, as lipidomics. In this study, an ASE method was optimized for the extraction of PCBs, together with total lipid content and it was applied to Italian sheep ricotta, obtaining the lipid fingerprint of this matrix.

Materials and Methods
A Mixture Design (MD) in combination with a Desirability Optimization Methodology (DOM) was used to identify the optimal ASE conditions. The evaluated variables included extraction temperature, tested within the range of 80–120 °C, and different-environmentally friendly solvent mixtures, consisting of cyclohexane, ethanol (EtOH), and ethyl acetate (EtAc). As the responses in MD matrix, the area of PCB 209, as surrogate standard, together with Equisplash™ Lipidomix® deuterated lipid internal standards and the entire lipid profile were considered. Thermo Scientific™ Dionex™ASE™ 350 Accelerated Solvent Extractor was used for the total fat extractions. The extracts were analysed by an Ultimate 3000 UHPLC coupled with a Q-Exactive Orbitrap Mass Spectrometer. Lipid fingerprint from raw data was performed using LipidSearchTM 5.0.63.8 [3]. PCB 209 was carried out by means of the QuEChERS procedure coupled to GC-MS/MS analysis according to our experience [4]. All instruments and software were supplied by Thermo Fisher Scientific, Waltham, MA, USA.

Results
The results showed that the PCB 209 extraction was not affected by variations in ASE parameters in the ranges investigated. Differently, for the lipid fraction these were decisive, especially for polar lipids that required at least 15% EtOH. The DOM obtained from MD processing suggested that the triphasic mixture, composed of 70% cyclohexane, 15% EtOH, and 15% EtAc, together with a temperature value of 120°C, was the best compromise for the simultaneous extraction of lipids and PCB 209. The fingerprint obtained from the best extraction parameters was characterized by 746 lipids categorized into 20 different lipid subclasses. i.e glycerolipids, phospholipids and glycolipids.

Discussion and Conclusion
In this study, an optimized ASE procedure was implemented using a dedicated "Mixture Design" to enable efficient extraction of lipophilic contaminants, such as PCB 209, and lipids from Italian sheep ricotta. The knowledge of the lipid-specific adequacy of extraction procedures, allows to choose the appropriate method based on the lipid subclass of interest for studying contaminant-induced modification on the entire lipid profile of the matrix. These outcomes could be applied in food safety control plans.

Acknowledgment
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P-00381 Occurrence of PAHs, Fragrances, UV-Filters and Bisphenols in unhatched seabird eggs from Terra Nova Bay (Ross Sea, Antarctica)

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Introduction
Despite the detection of anthropogenic organic pollutants in Antarctica decades ago, a comprehensive understanding of their impact on wildlife is still lacking. Long-range atmospheric transport (LRAT), local emissions from scientific facilities, fishing, and increasing tourism are considered potential source of both Contaminants of Emerging Concern (CECs) and legacy pollutants in Antarctica [1]. In this context, abandoned unhatched eggs of Antarctic seabirds represent a valuable tool for non-destructive monitoring of pollutants [2].
In this preliminary study we analyzed polycyclic aromatic hydrocarbons (PAHs), personal care products (PCPs; including musks, non-musk fragrances, UV filters) and bisphenols (BPs) in unhatched eggs of Adelie penguins (Pygoscelis adeliae) and south polar skua (Stercorarius maccormicki) from three colonies in the Ross Sea.

Materials and Methods
Five abandoned unhatched eggs were collected during the austral summer 2021-2022 in/close to Adelie penguin rookeries along the Ross Sea coasts in Antarctica. Adelie penguin eggs were collected at Adelie Cove (AC; n=2) and Inexpressible Island (II; n=2); one skua egg was retrieved close to the Italian Mario Zucchelli Station (MZS; n=1). Samples were stored at -20°C until analyses, that were performed adopting a unified QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) method. Samples were homogenized and spiked with 13C-labelled internal standards. After extraction and purification, acetonitrile samples were concentrated, split and solvent-exchanged for GC-MS/MS (Trace 1310-TSQ 9000 Thermo Scientific) determinations of PAHs and PCPs; an aliquot was dedicated to LC-MS/MS (Agilent 1100-API 4000) instrumental analyses of BPs. Crude results were corrected using instrumental response factors and considering procedural mean blanks (n=4).

Results
The five egg samples showed a widespread presence of the analyzed contaminants and different spatial distributions. ΣPAH19 ranged 7.0-31 ng/g w.w. mostly represented by Naphthalene (4.1-15 ng/g w.w.). Among PCPs, non-musk fragrances, mainly represented by salicylates, were significantly higher (Σ7: 7.4-14 ng/g w.w.) than musk fragrances (Σ10: 0.1-2.9 ng/g w.w.). UV filters (Σ5: 8.0-15 ng/g w.w.) were dominated by benzophenone-3, ranging 7.8-10 ng/g w.w., while BPs were detected in only two samples (ΣBP6: 9.3-12 ng/g w.w.).

Discussion and Conclusion
Focusing on rookeries (supplementary figure), levels in the two samples from AC resulted higher than the penguins from II; the number of analytes detected in at least one of the two samples followed similar trends (AC: 40/47 contaminants; II: 17/47 contaminants). The skua egg collected at MZS resulted in intermediate concentrations of contaminants. Apart from belonging to different species, individual biological/ecological characteristics may be responsible for the results based on such a small sample size. Interestingly, the pattern of the PCPs found in egg samples was dissimilar to that detected in snow samples collected during the same campaign and attributed to LRAT. This shift could suggest specific adsorption mechanisms, matrix-transfer processes, and/or biotransformation of pollutants in the Antarctic ecosystem. Moreover, levels of benzophenone-3 similar to this study were previously detected in marine biota collected close to McMurdo Station and Scott Base [3]. Despite the low number of samples, these preliminary results are important in this low-studied region and highlight the potential exposure of Antarctic seabirds to both old and next generation of contaminants, needing further investigation to understand the role of local and distant sources.

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Analyses: Project PNRA19_00035 (Input Pathways of persistent organic pollutants to AntarCTica, ImPACT Group SCAR: an international project to unravel human impact in a changing world)

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P-00388 Dissolution dynamics of lithium-Ion battery cathode materials in aquatic environments: key drivers and molecular mechanisms

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Introduction
Lithium-ion batteries (LIBs) are emerging as a growing source of environmental contamination driven by the rapid expansion of battery production and disposal. Among commercial cathode materials, lithium nickel cobalt manganese oxides (NCM, LiNixCoyMn1-x-yO2) are widely used because of their high energy density and excellent electrochemical performance. Previous studies have shown that NCM materials can release lithium and transition metals (TMs) into aquatic environments, particularly from structurally unstable Ni-rich materials. Environmental factors, including pH, salinity, and organic ligands, may further influence metal mobility and dissolution behavior, yet the underlying dissolution pathways and thermodynamic mechanisms remain poorly understood. Here, we systematically investigated the dissolution behavior of representative NCM cathode materials under environmentally relevant aquatic conditions and employed density functional theory (DFT) calculations to elucidate the mechanisms governing metal release. We hypothesized that acidic and organic-rich environments would thermodynamically favor TM dissolution, particularly in structurally unstable Ni-rich NCM materials.

Materials and Methods
Four representative NCM cathode materials (NCM111, NCM523, NCM622, and NCM811) were investigated under environmentally relevant aquatic conditions. Dissolved lithium and TMs were quantified using inductively coupled plasma mass spectrometry (ICP-MS/MS). DFT combined with the computational hydrogen electrode (CHE) model was employed to investigate the thermodynamic mechanisms governing metal dissolution. Metal dissolution was further evaluated in six representative environmental water matrices, including landfill leachate, groundwater, river water, lake water, seawater, and rainwater.

Results
Lithium ions (Li+) exhibited consistently high dissolution ratios (>80%) under nearly all tested conditions, indicating strong environmental mobility and release potential. In contrast, TM dissolution (Ni2+, Co2+, and Mn2+) remained relatively low (<2%) but was highly sensitive to environmental conditions. Acidic conditions markedly enhanced Ni and Co dissolution, particularly in Ni-rich NCM811, where Ni release approached completion at pH 2. CA further promoted TM dissolution under acidic conditions through metal complexation and lattice disruption. Elevated salinity suppressed TM dissolution via ionic strength screening and competitive adsorption. HA exhibited composition-dependent effects, either suppressing dissolution through surface coating formation or enhancing Ni mobility via complexation. Experiments conducted in representative environmental waters further revealed that landfill leachate and seawater most strongly promoted TM release, particularly for Ni, whereas river water, lake water, and rainwater showed limited metal dissolution. Material composition also strongly influenced dissolution behavior, with structurally stable NCM111 exhibiting the lowest dissolution and Ni-rich NCM811 showing the highest metal release.

Discussion and Conclusion
The results are consistent with previous studies showing enhanced metal dissolution under acidic conditions and increased instability in Ni-rich cathode materials. DFT calculations further revealed that acidic conditions reduced the dissolution free energy (ΔG), thereby favoring metal release, whereas salinity and humic substances suppressed dissolution. Compared with previous studies conducted primarily in simplified aqueous systems, this work further evaluated dissolution behavior in environmentally relevant water matrices and identified pH and organic ligands as key drivers governing TM dissolution. Collectively, these findings provide mechanistic insights into the environmental behavior of NCM cathode materials and support environmental risk assessment and sustainable management of spent LIBs.

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P-00390 Monitoring of PCDDs, PCDFs and PCBs in feed materials in Greece during years 2002-2025

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Introduction
In animal production systems, contaminated feed is recognized as a primary route through which dioxins enter livestock, leading to human exposure via animal-derived food. As a result, dioxin contamination in feed represents not only an animal health concern but also a critical public health and regulatory issue.
Past incidents in feed as in the 2000 Belgium dioxin crisis, have demonstrated the need for stringent monitoring, regulatory limits, and preventive strategies to control dioxin levels in feed. The European Union set maximum levels (MLs) and action thresholds (ALs) for PCDD/Fs and PCBs in animal feed products, in Commission Directive 2002/32/EC, amended in Commission Regulation (EU) 277/2012. Many countries have reported monitoring results on dioxin levels in feed materials1-3, however such levels in Greece have not yet been reported. The aim of this study is reporting results of monitoring dioxin levels in feed samples from various Greek regions over the past 24 years.

Materials and Methods
A total of 1014 samples were collected for the National Dioxin Control Program for feed and custom controls during years 2002-2025. Samples were analysed according to procedures previously described for lipid extraction, clean-up and instrumental analysis4. The following feed categories were studied: binders/anticaking agents (60), animal fat (18), other land animal products (11), compound feed (143), compound feed for fish (191), fish/products derived thereof (80), fish oil (69), mineral origin feed (13), plant origin feed (289), premixtures (51), compounds of trace elements (67), vegetable oils (22).

Results
Concentrations of PCDD/Fs, dioxin-like PCBs (DL-PCBs), sum of PCDD/Fs and DL-PCBs, and non-dioxin-like PCBs (NDL-PCBs) in the studied feed samples were determined, expressed in ng WHO-TEQ/kg for dioxin-like compounds and in µg/kg for NDL-PCBs, at 12% moisture. The highest sum PCDD/Fs-DL-PCBs average and median concentrations were measured in fish oil (2.67 and 1.83 ng WHO-TEQ/kg respectively), while the highest maximum concentration was measured in "trace elements" category in a ZnO sample (22.8 ng WHO-TEQ/kg). Concentrations exceeding maximum levels for PCDD/Fs and sum of PCDD/Fs and DL-PCBs were found in two bentonite samples, two perlite samples and one ZnO sample. Exceedance of the sum of PCDD/Fs and DL-PCBs, was also observed in one compound feed for fish sample. Concentrations exceeding action level for PCDD/Fs were found in three fishmeal samples and one premixture. Concentrations exceeding action level for DL-PCBs were found in two compound feed for fish samples and one animal fat sample.

Discussion and Conclusion
The feed group with maximum percentage of samples exceeding ML (30% of analysed samples) was the mineral origin group. Average concentrations were comparable to those reported in relevant studies1-3 and in the EFSA Scientific opinion for dioxins in food and feed, 2018. Predominance of PCDFs in the TEQ congener profile of ZnO was observed, consistent with findings from the incident in South Korea, where the use of recycled ZnO resulted in elevated PCDF levels in pork meat. In the case of perlite and bentonite, materials of mineral origin, the predominance of PCDDs in the congener profile aligns with relevant findings in clays. The possible origin of PCDDs in minerals is their formation under the high-pressure and high-temperature conditions present in specific layers of the Earth5.

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P-00395 Evaluation of PFAS migration from soil to groundwater using a diagnostic method for residual PFAS in soil (NARO Method 202202)

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Introduction
PFAS are persistent and highly mobile environmental contaminants that have raised global concerns due to their potential for groundwater contamination and human exposure. In many regions, groundwater used for drinking purposes is largely derived from infiltration through soils, underscoring the importance of accurately evaluating PFAS migration from soil to groundwater. However, conventional leaching tests face significant limitations in this context, including insufficient process traceability1, restricted analytical coverage of target compounds, and an inability to adequately capture dynamic interactions between soil and aqueous phases. These limitations are particularly critical in soils with high organic matter content, such as volcanic ash soils, where strong sorption and retention of PFAS substantially influence their mobility. Accordingly, there is a clear need for a reliable and comprehensive analytical approach capable of quantifying PFAS partitioning and migration potential in soil systems. To address this challenge, a diagnostic method for residual PFAS in soil (NARO Method 202202) 2.was developed.

Materials and Methods
The proposed method employs a small soil sample (5 g) and incorporates surrogate standards3,4 at the beginning of the analytical procedure to ensure full-process traceability. A sequential extraction scheme is applied, consisting of an initial water extraction to quantify PFAS that partition into the aqueous phase, followed by solvent extraction of the same soil sample to determine PFAS retained within the solid matrix. This approach enables simultaneous quantification of both mobile (water-extractable) and residual (soil-bound) PFAS fractions, providing a comprehensive assessment of PFAS distribution within soil systems. Furthermore, the method is designed to accommodate multi-analyte PFAS determination, extending beyond the limited set of compounds typically addressed in conventional leaching tests.

Results
The diagnostic method successfully characterized PFAS partitioning across different soil types and demonstrated high reproducibility and analytical robustness. In soils with elevated organic carbon content, such as Andosols, hydrophobic PFAS (e.g., PFOS) exhibited strong retention within the soil matrix, whereas more water-soluble compounds (e.g., PFOA and HFPO-DA) were preferentially partitioned into the aqueous phase. The sequential extraction protocol enabled clear differentiation between mobile and residual PFAS fractions, allowing quantitative estimation of their migration potential to groundwater. Surrogate recoveries were within acceptable ranges, confirming consistent analytical performance across diverse soil matrices. In addition, the method required substantially smaller sample amounts and shorter processing times compared to conventional leaching methods, representing a significant improvement in operational efficiency.

Discussion and Conclusion
The NARO Method 202202 2 provides a robust and practical framework for evaluating PFAS migration from soil to groundwater. By simultaneously quantifying water-extractable and soil-retained PFAS, the method offers a comprehensive understanding of PFAS behavior and partitioning within soil systems. This represents a marked advancement over conventional approaches, which often underestimate migration potential due to incomplete assessment of soil-bound fractions. The ability to quantitatively assess PFAS mobility through sequential extraction enhances the accuracy of risk evaluation and supports more reliable prediction of groundwater contamination. Moreover, the integration of improved traceability and analytical efficiency makes the method well suited for large-scale environmental monitoring applications. Overall, this approach contributes to the development of a scientific framework for PFAS risk assessment and provides valuable information for regulatory decision-making and environmental management. Its application is expected to facilitate more effective strategies for addressing PFAS contamination in soil and groundwater systems.

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P-00397 Maize tassel-nanotube composite for atrazine and metabolite removal from water and soil: application and leaching assessment

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Introduction

Atrazine (ATZ) is one of the most widely applied triazine herbicides in agricultural production and is frequently detected in surface water, groundwater, and agricultural soils due to its persistence, mobility, and resistance to degradation. Its major metabolites, deethylatrazine (DEA) and deisopropylatrazine (DIA), are often equally persistent and toxic, posing significant environmental and public health concerns, particularly in rural communities dependent on untreated water sources. Sustainable and low-cost remediation technologies are therefore urgently required to address pesticide contamination in developing regions.

This study reports the synthesis, characterization, environmental application, and ongoing leaching assessment of a novel agricultural waste-derived adsorbent developed from physically activated maize tassel (MT) and non functionalized multiwalled carbon nanotubes (nfMWCNTs) for the removal of atrazine and its metabolites from water and soil systems. Different MT/nfMWCNT composite ratios (1:1, 2:1, and 3:1) were synthesized, with the 2:1 ratio demonstrating superior homogeneity and adsorption performance. Characterization using Brunauer-Emmett Teller (BET), Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDX), and Thermogravimetric Analysis (TGA) confirmed successful functionalization of nfMWCNTs through the transfer of maize tassel functional groups, resulting in enhanced porosity and improved thermal stability of the composite. BET surface areas ranged from 74.3 to 281 m^2 g^{-1}, while pore sizes ranged from 14.9 to 22.7 nm.

Batch adsorption and solid-phase extraction studies demonstrated efficient removal of ATZ, DEA, and DIA under optimized conditions of pH 7-8, 0.4 g adsorbent dosage, 180 min contact time, and methanol as eluent. Removal efficiencies ranging from 70-90% were achieved for the targeted compounds. LC-MS/MS analysis showed excellent analytical performance with linearity ranging from 0.001-100 ng mL-1 (R2 = 0.998). Environmental water samples collected from rivers, dams, and boreholes in Brits, South Africa, revealed detectable concentrations of ATZ (0.052 0.063 ng mL-1), DEA (0.012-0.027 ng mL-1), and DIA (0.010-0.012 ng mL-1). Building on these findings, ongoing postdoctoral work investigates the reusability, regeneration potential, composite stability, and leaching behaviour of the MT/nfMWCNT composite under environmentally realistic conditions. Leaching tests and soil column 100 nm experiments are being conducted to evaluate possible release of carbonaceous materials, contaminant mobility, and atrazine persistence in soil-water systems. Human and environmental risk assessment approaches are further being incorporated to contextualize measured contaminant concentrations in terms of ecosystem and public health risks. The findings demonstrate the potential of maize tassel-nanotube composites as sustainable, cost-effective, and scalable remediation materials for atrazine contaminated water and soil systems, while contributing toward sustainable environmental management, water security, and reduction of herbicide exposure risks in agricultural communities.

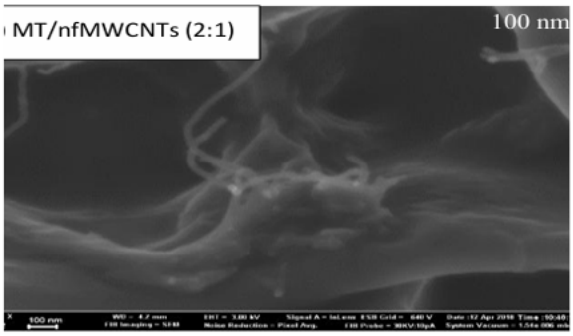


Figure 1: SEM micrograph of MT/nfMWCNTs (2:1) composite showing uniform morphology and successful integration of components

P-00401 Scoping report of research of Microplastic and Human Health in PARC

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Introduction
This report reviews the relevance of micro- and nanoplastics (MNPs) to human health within the Partnership for the Assessment of Risks from Chemicals (PARC) and considers how current PARC activities can support this emerging field. Plastic pollution is increasing globally, and evidence for human exposure to MNPs and plastic-associated chemicals is growing. Studies have detected MNPs in human blood, placenta, lungs, brain, and other tissues, but major uncertainties remain regarding exposure pathways, internal distribution, toxicological significance, and long-term health effects. Smaller particles are of particular concern because they may cross biological barriers and circulate within the body. Plastics may also contribute to harm not only as particles, but as sources and carriers of associated chemicals.

Materials and Methods
The report is based on published scientific literature, recent international and European initiatives, information from the PARC project database, and PARC activities, including the Mapping of Needs survey and the November 2024 workshop on microplastic research. These sources were used to identify the state of knowledge, methodological gaps, existing capacities within PARC, and opportunities for collaboration.

Results
A central finding is that progress is limited less by lack of interest than by the absence of harmonised and validated methods, especially for human samples. Standardised procedures for sampling, storage, preparation, detection, and reporting remain insufficient, which makes comparison across studies difficult and weakens the basis for biomonitoring and risk assessment. Techniques such as pyrolysis-GC/MS show promise for polymer quantification, but major challenges remain, including contamination control, particle-size characterisation, and agreement on whether exposure should be reported by mass, particle number, or both.

Discussion and Conclusion
PARC is well positioned to contribute because of its expertise in exposure science, hazard assessment, human biomonitoring, method harmonisation, and cross-European collaboration. Although microplastics are not yet a dedicated PARC topic, several ongoing and planned activities are relevant, including work on plastics-related chemicals, polymers, leachables, environmental monitoring, and biomonitoring harmonisation. The review also shows strong interest among PARC partners and clear synergies between environmental and human health activities. International initiatives such as the CUSP cluster confirm that MNPs are a rapidly developing research area while also highlighting persistent gaps in exposure assessment, health effects, and regulatory interpretation. Overall, the report concludes that PARC could play a leading role by prioritising harmonised analytical methods, interlaboratory collaboration, and integration of MNP objectives into monitoring, biomonitoring, and hazard assessment. Broader participation across Europe and closer links between particle research and expertise on plastic-associated chemicals would further strengthen the basis for future risk assessment and policy support.

Acknowledgment
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P-00405 Sewage sludge archive reveals temporal trends in PFAS use between 1993 and 2020

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Introduction

The mass production of per- and polyfluoroalkyl substances (PFASs) began in the 1950s and continues to this day. There are thousands of different PFASs which are used in a variety of applications. Historically, environmental monitoring programs focused especially on perfluoroalkyl carboxylic acids (PFCAs) and perfluorosulfonic acids (PFSAs), given their widespread use. Nowadays, monitoring programs often include more PFASs in their analytical target lists or use suspect and non-targeted approaches in order to improve our understanding of PFAS use and pollution patterns.

Sewage sludge acts as an integrated sink of municipal and industrial PFAS emissions into wastewater. Hence, sewage sludge can reveal which PFASs were in use around the time of the sampling. Therefore, in this study, we investigate temporal trends of PFASs in archived sewage sludges from a Swiss wastewater treatment plant. Sludge samples from 1993, 2002, 2007, 2012 and 2020 are extracted and prepared for measurement. We then conduct state-of-the-art analysis (LC-MS/MS and LC-Orbitrap-MS) to shed light on PFASs that may have been overlooked in past environmental monitoring studies.

Preliminary results show that, in 1993, the levels of PFCAs and PFSAs in sludge were dominated by C8 homologues, namely perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) (see Figure). This matches the PFCA/PFSA patterns that are observed in soil from Swiss farmland that had been fertilized with sewage sludge before this practice was banned in 2006 (Glüge et al. 2026). In a next step, sewage sludges that were sampled between 1993 and 2020 are analyzed and evaluated. The data reveals the impact of regulatory measures and shows how PFAS usage patterns shifted over time.

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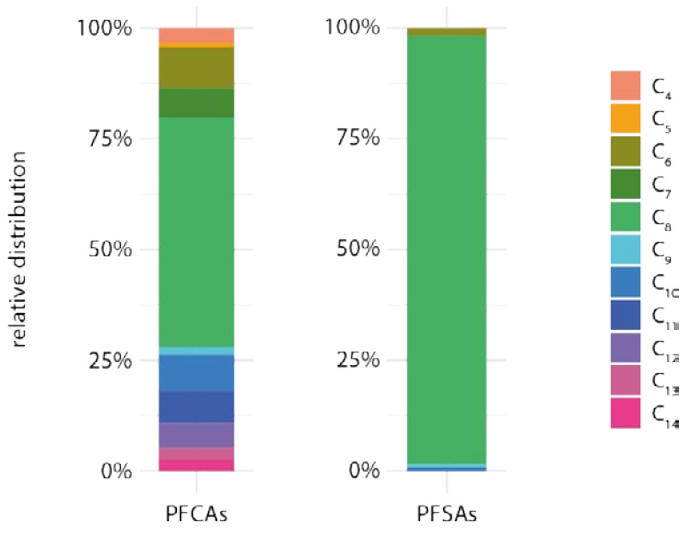


Figure: Distribution of PFCAs and PFSAs in Swiss sewage sludge in 1993.

P-00420 Polychlorinated dioxins and furans and dioxin-like PCBs in recycled plastics: occurrence and variability across polymer types

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Introduction
Recycled plastics may contain persistent organic pollutants (POPs) that compromise their safe reuse and circularity. Among these contaminants, polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and dioxin-like polychlorinated biphenyls (dl-PCBs) are of particular concern due to their persistence, bioaccumulation potential, and toxicity.
Previous studies have reported the presence of POPs in recycled polymers, especially in polyolefins derived from post-consumer waste streams [1, 2]. However, comparative information on contamination levels across different recycled polymer types remains limited. Therefore, this study evaluated the occurrence and variability of PCDD/Fs and dl-PCBs in recycled low-density polyethylene (LDPE), high-density polyethylene (HDPE), polyethylene terephthalate (PET), and polypropylene (PP).

Materials and Methods
A toluene extraction procedure previously developed for recycled LDPE was validated and successfully applied to the other polymer types. A total of 25 plastic samples, including virgin and recycled LDPE, HDPE, PET, and PP, were analyzed. Recycled materials originated from different recycling facilities and included post-consumer and post-industrial streams.
Ground samples (2 g) were extracted with toluene for 24 h under agitation at room temperature. Extracts were purified using an automated clean-up system and analyzed by GC-MS/MS following adapted EPA Methods 1613 and 1668. Toxic equivalency values were calculated using 2022 WHO-TEFs. Quality assurance included isotope-labelled standards, duplicate analyses, and procedural blanks.

Results
Clear differences were observed among polymer types and waste origins. PET samples showed the lowest contamination levels, with r-PET ranging from 3 8 pg/g for total PCDD/Fs and 5 30 pg/g for total dl-PCBs. In contrast, polyolefins exhibited substantially higher concentrations. The highest dl-PCB concentration was detected in a post-consumer PP sample (4400 pg/g), while elevated levels were also found in LDPE (2490 pg/g) and HDPE (2620 pg/g) samples. Maximum PCDD/F concentrations reached approximately 230 pg/g in recycled LDPE, whereas maximum concentrations in HDPE and PP samples were around 105 pg/g.
Toxicity values followed similar trends. The lowest toxicity levels were found in the virgin and recycled PET samples, ranging 0.1 0.6 pg WHO TEQ/g. In contrast, the highest total toxicity was observed in a post consumer LDPE sample, reaching approximately 6 pg WHO TEQ/g.

Discussion and Conclusion
Post-consumer samples showed higher contamination than post-industrial and virgin materials, indicating the importance of previous use cycles and environmental exposure, consistent with previous findings for phthalates in recycled plastic waste streams [3]. Congener profiles were dominated by OCDD and PCB-118, showing consistent patterns across polymer types. These profiles suggest common contamination pathways associated with legacy additives, environmental exposure, and recycling of mixed plastic waste streams. The variability among samples also indicates that contamination levels are strongly influenced by waste origin and recycling history.
The results demonstrate that conventional recycling and washing processes are insufficient to remove hydrophobic POPs from recycled polyolefins. The lower contamination observed in PET compared with LDPE, HDPE, and PP suggests that polymer polarity and structure influence contaminant retention. In addition, the higher contamination levels found in post consumer plastics highlight the relevance of waste origin in determining recycled material quality. These findings are particularly relevant considering the increasing regulatory pressure to incorporate recycled content into plastic products.
Improved monitoring and decontamination strategies are therefore required to ensure safer circular use of recycled plastics, especially in sensitive applications such as food-contact materials. The study also highlights the need to incorporate contaminant control criteria into plastic recycling regulations and quality certification schemes.

Acknowledgment
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P-00423 Solvent-based decontamination of recycled LDPE: temperature effects on removal of PAHs, PCDD/Fs and dl-PCBs

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Introduction
Recycled polyolefins, particularly low-density polyethylene (LDPE), may contain contaminants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), and dioxin-like polychlorinated biphenyls (dl-PCBs), limiting their safe reuse. Conventional recycling processes are based on water washing, generally ineffective for removing hydrophobic organic contaminants [1]. Therefore, this study evaluated solvent based decontamination treatments using different solvents and temperatures for the removal of these contaminants from recycled LDPE.

Materials and Methods
A highly contaminated post-consumer recycled LDPE sample was subjected to nine washing treatments using hexane, toluene, and ethanol at 50, 100, and 150 °C for 2 h in sealed autoclave reactors. After treatment, the plastic material was separated by vacuum filtration, dried, and analyzed. PAHs were extracted and analyzed by GC-MS according to EPA Method 8270E. PCDD/Fs and dl-PCBs were extracted, purified and analyzed by GC-MS/MS following adapted EPA Methods 1613 and 1668. TEQ values were calculated using TEFs proposed for PAHs and 2022 WHO TEFs for PCDD/Fs and dl-PCBs. Quality assurance included duplicate analyses and internal standards.

Results
All solvent treatments reduced contaminant concentrations compared to the water-washed control sample. Removal efficiency strongly depended on solvent type and temperature. The highest decontamination efficiency for PAHs was achieved using toluene at 50 °C, achieving a 96 % reduction in total concentration (from 1990 to 76 ng/g), and a 98 % reduction in toxicity (from 82 to 2 ng TEQ/g). Hexane at 50 °C also showed high efficiency (91 % reduction in concentration), while ethanol exhibited its best performance at 100 °C.
For PCDD/Fs and dl-PCBs, the most effective treatment was toluene at 50 °C. Total PCDD/F concentration decreased from 41 to 2 pg/g, while dl-PCBs decreased from 1370 to 40 pg/g (95 % and 97 % reduction, respectively). Toxicity reductions reached 88 %, with final values approaching those reported for low-contaminated recycled plastics. Unexpectedly, increasing treatment temperature to 100 and 150 °C reduced extraction efficiency for hexane and toluene. In some cases, contaminant concentrations and toxicities increased after treatment. The sample treated with hexane at 150 °C showed higher total PCDD/F toxicity than the control, mainly associated with increased levels of 2378-TCDD. Microscopic examination revealed that LDPE samples treated with toluene and hexane at high temperatures developed gel-like phases caused by polymer swelling. FTIR and thermogravimetric analyses confirmed that both gel and solid phases corresponded to the same material.

Discussion and Conclusion
The results demonstrate that solvent-based washing is more effective than conventional water washing for removing hydrophobic contaminants from recycled LDPE, confirming previous concerns about the persistence of POPs in recycled polyolefins [2]. Low-temperature treatments using non-polar solvents, particularly toluene at 50 °C, achieved higher efficiencies than previously reported PEG-based extraction methods [3]. Contrary to expectations, higher temperatures did not improve decontamination efficiency for non-polar solvents. Elevated temperatures promoted swelling and gelation of the LDPE matrix, entrapping contaminants and hindering their diffusion into the solvent, consistent with thermoreversible gel formation in polyethylene–solvent systems [4]. The increase in PCDD/F toxicity under some high-temperature conditions also suggests thermal transformation of precursor compounds during treatment.
These findings demonstrate that low-temperature solvent washing is a promising strategy for improving the safety of recycled polyolefins, supporting safer circular use of recycled plastics in sensitive applications.

Acknowledgment
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P-00428 Evaluation of a PCB Concentration Prediction Model for Insulating Oil Using Primary Equipment Information and Accumulated Analytical

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Introduction
The Stockholm Convention on Persistent Organic Pollutants (POPs) requires the elimination and proper disposal of polychlorinated biphenyls (PCBs). In accordance with this convention, conformity tests are conducted to ensure the appropriate treatment of PCB containing insulating oil. In particular, when performing PCB analysis using highly sensitive GC/ECD, it is necessary to determine in advance whether dilution is required to prevent contamination of the instrument by high-concentration samples. Currently, our company uses screening indicators such as manufacturing date, specific gravity, and aroma as criteria for evaluation [1]. However, these alone do not provide sufficient accuracy. Therefore, we are considering machine learning models as a more reliable screening method. In this study, we verified the applicability of a machine learning model to estimate PCB concentration using actual measurement data of PCB concentration in insulating oil and primary information such as nameplate information.

Materials and Methods
This study used analytical values of PCB concentrations in insulating oil and key equipment information collected by our company over the past ten years, including manufacturer, manufacturing year, model type, serial number, rated capacity, equipment name, oil volume, and total weight. Preprocessing included removing environment dependent characters and standardizing year formats. The machine learning model used was a random forest model, and its performance was evaluated using standard classification metrics implemented in Python.

Results
In Model 1 (initial model), five years of data were used to classify samples into two categories based on concentration ranges. As a result, the recall for the category requiring screening was 72%. Therefore, by extending the data period to 10 years and improving the preprocessing procedure, the recall rate of the classifications improved. In Model 2, based on insights obtained from the initial model, the number of features was reduced from eight to six, and the number of classification categories was increased from two to three. The resulting model achieved an overall accuracy of 93%. Recall values for each concentration category were 97% for ≤0.5 mg/kg, 70% for 0.5–50 mg/kg, and 49% for ≥50 mg/kg.

Discussion and Conclusion
The low recall in the ≥50 mg/kg category is likely attributable to class imbalance resulting from the limited number of samples belonging to this category in our accumulated analytical data. The findings of this study indicate that PCB concentrations can be estimated using accumulated analytical data and primary equipment information, and that this approach may also support more reliable and well informed dilution decisions in PCB analysis. Future work will focus on enhancing feature engineering and incorporating dictionary based lookup methods to improve model robustness and predictive reliability.

Acknowledgment
The authors express their sincere gratitude to Professor Kaoru Hiramatsu, Graduate School of Science and Engineering, Saitama University, and to the Saitama City Foundation for Business Creation for their valuable support in the development of the machine learning model.

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P-00430 Enhanced Toxicity Prediction in Aquatic Species via AI-Based Molecular Docking as a High-Efficiency Pre-Screening Filter

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Introduction

Traditional in vivo and in vitro toxicity testing demands substantial time and resources, driving an urgent need for advanced New Approach Methodologies (NAMs). While computational approaches have emerged as vital alternatives, efficiently predicting complex toxicity profiles and identifying key biological targets across extensive protein libraries remains a bottleneck. To address this challenge, this study introduces a high-throughput in silico framework that utilizes the AI-based molecular docking tool, GNINA, as a rapid pre-screening filter to prioritize target proteins prior to intensive wet-lab validation.

The developed pipeline consists of target library construction—integrating toxicological targets from the AOP Wiki with a filtered zebrafish whole proteome—followed by reverse docking comparison and systematic toxicity prediction. The predictive performance was rigorously evaluated using four reference chemicals (bisphenol A, triclosan, rotenone, and valproic acid), where GNINA demonstrated superior target enrichment over conventional AutoDock Vina. Notably, based on Enrichment Factor (EF5%) and BEDROC metrics, the AI-driven framework successfully concentrated actual target proteins within the top 5%, achieving high enrichment values (EF5% of 4–8) across the compounds.

Applying this validated 5% filtering strategy to emerging per- and polyfluoroalkyl substances (PFAS: PFBA, PFOS, PFNA), subsequent pathway enrichment and Protein-Protein Interaction (PPI) network analyses successfully captured complex, known toxicity mechanisms. The primary novelty of this work lies in redefining AI-based molecular docking as an ultra-efficient pre-screening tool that drastically narrows thousands of candidates down to a manageable top 5%, thereby eliminating statistical dilution during downstream pathway analysis. Consequently, this methodology offers high predictive utility and a practical prioritization guideline for emerging environmental contaminants. By serving as an agile front-end filter, this framework significantly reduces the temporal and financial burdens of exhaustive laboratory testing, accelerating environmental risk assessment.

P-00434 A TiO_2 Nanocomposite Strategy for Scalable, Regenerable PFAS Removal from Groundwater with adsorption and kinetic modelling

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Introduction
Per- and polyfluoroalkyl substances (PFAS), known as "forever chemicals," pose a major environmental and health threat due to their persistence and bioaccumulation in aquatic ecosystems. This study introduces a novel polymer-based nanocomposite adsorbent for the efficient removal of multiclass PFAS from portable groundwater. Engineered to target both long- and short-chain PFAS, the nanocomposite integrates functionalized nanomaterials into a polymer matrix, enhancing surface chemistry and adsorption performance where traditional adsorbents like activated carbon fall short.

Materials and Methods
High-purity (>99%) reference standards of 30 multiclass PFAS (PFAC30PAR) were purchased from Wellington Laboratories Inc. (Ontario, Canada). Methanol (LC-MS grade) and acetonitrile (LC-MS grade) were purchased from Thermo Fisher Chemicals (MA, USA). Ultrapure deionised water (resistivity of 18.2 megaohm-centimetres (MΩ·cm)) was produced in the laboratory using a Milli-Q water purification system (Millipore, Temecula, CA, USA). The nanocomposite was synthesized by integrating functionalized TiO_2 nanomaterial into a polymer matrix, optimising surface chemistry parameters to enhance adsorption performance across diverse PFAS chain lengths. Synthesis optimisation focused on achieving high surface area, a tunable pore structure, and excellent reusability, essential for sustainable water treatment applications.

Results
The optimized nanocomposite demonstrated exceptional performance, achieving >98% removal efficiency across all tested PFAS analytes. Laboratory and field-testing protocols evaluated removal efficiency for six key PFAS analytes: PFOA, PFOS, PFNA, PFHxS, PFBS, and HFPO-DA. Kinetic studies examined adsorption mechanisms using pseudo-second-order modelling, while equilibrium data were analysed using the Freundlich isotherm. The thermodynamic analysis assessed the spontaneity and feasibility of the process. Regeneration studies evaluated material durability through six consecutive cycles. A custom cartridge system was developed for integration with commercial Aqua water filters to enable scalable deployment.

Discussion and Conclusion
This research successfully bridges the gap between advanced material science and practical environmental remediation by developing a high-performance nanocomposite adsorbent with demonstrated efficacy against multiclass PFAS. The integration into commercially compatible filter cartridges provides a scalable, cost-effective solution for household and community-level water treatment. The combination of superior removal efficiency, sustained performance through multiple regeneration cycles, and practical deployment compatibility positions this technology as a promising strategy for addressing one of today's most persistent environmental contaminants.

Acknowledgment
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P-00436 Temporal trend of polychlorobiphenyls in animal by-products (ABPs): potential implications for safety from a One Health perspective

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Introduction
Animal by-products (ABPs) are materials of animal origin not intended for human consumption. They represent a key resource within the circular economy, with applications in feed, bio-based industries and alternative energy production [1]. Despite these benefits, co- or by-products for animal feeding, and feed ingredients must be carefully monitored, as their composition directly affects animal health and the quality and safety of products intended for human consumption. In addition to microbiological hazards, persistent organic pollutants such as polychlorinated biphenyls (PCBs) are of concern due to their persistence and lipophilicity, leading to bioaccumulation in animal tissues and transfer to food products [2].
This study assesses the occurrence and levels of six indicator non-dioxin-like PCBs (NDL-PCBs: 28, 52, 101, 138, 153 and 180) in rendered fats derived from low-risk Category 3 ABPs collected in Campania (Southern Italy) over a seven-year monitoring period (2018 and 2020–2025).

Materials and Methods
A total of 70 samples were collected from authorized processing plants handling slaughterhouse waste not intended for human consumption. Following collection, samples were stored at –20 °C until analysis. Briefly, samples (2 g) were spiked with ^{13}C-labelled internal standards, extracted by accelerated solvent extraction using an n-hexane/acetone mixture, and subjected to a two-step clean-up procedure involving acidified EXtrelut NT3 column and silica-based cartridges. Instrumental analysis was performed by HRGC-HRMS (DFS Magnetic Sector, Thermo Fisher Scientific). Results were expressed on a lipid basis and adjusted to a standardized moisture content of 12% to assess regulatory compliance (Regulation (EU) No. 277/2012).

Results
The sum of NDL-PCBs ranged from 0.040 to 62.5 ng g^{-1} fat, with mean and median values of 7.1 and 4.5 ng g^{-1}, respectively. In agreement with Pajurek (2024) [3], the congener profile was dominated by PCB 153 (mean: 2.7 ng g^{-1} fat), PCB 138 (mean: 1.8 ng g^{-1} fat) and PCB 180 (mean: 1.3 ng g^{-1} fat), reflecting the greater persistence of more highly chlorinated compounds. When compared with EU maximum limits (Regulation (EU) No. 277/2012) set for the sum of NDL-PCBs in feed materials, 20% of samples exceeded the threshold (10 µg kg^{-1}, 12% moisture basis), decreasing to 3% after accounting for measurement uncertainty.

Discussion and Conclusion
A decreasing temporal trend was observed for individual PCB congeners and total concentrations over the study period, with levels progressively approaching background values (3.2 ng g^{-1} fat), calculated as the mean concentration after excluding non-compliant samples exceeding EU maximum limits [3]. Moreover, the mean concentration of the sum of NDL-PCBs detected in rendered fats was comparable to those reported for feed, particularly animal fats, in Denmark based on official control data collected between 1998 and 2009 [4] (7.6 µg/kg feed at 12% moisture), and slightly higher than the average levels (5.9 µg/kg feed at 12% moisture) reported for animal fats available on the Polish market [3].
In conclusion, rendered fats from ABPs generally comply with current safety standards, supporting their sustainable reuse within the circular economy. Nevertheless, continuous chemical monitoring is essential to mitigate potential risks and ensure the safe integration of ABPs into feed and industrial applications from a One Health perspective.

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P-00439 Distribution of persistent organic pollutants (PCDD/Fs and PCBs) in the organs of thresher sharks Alopias vulpinus (Bonnaterre, 1788) and their offspring

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Introduction
The common thresher shark (Alopias vulpinus) is a large coastal pelagic species currently listed as vulnerable in the IUCN Red List of Threatened Species [1]. Due to its slow growth, large size, long lifespan, and high trophic level, this species accumulates persistent organic pollutants (POPs), such as polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polychlorinated biphenyls (PCBs), in its tissues. Given their toxicity and persistence, these contaminants may threaten this vulnerable species making the assessment of their bioaccumulation and tissue distribution of particular interest. In addition, its migratory behaviour makes this shark a valuable sentinel for marine environmental contamination [2].

Materials and Methods
In 2024, two common thresher sharks, a male and a pregnant female carrying one male and one female foetus, stranded off the coast of the Campania region (southern Italy). Muscle, liver, kidney, spleen, and brain were collected from the four specimens and analysed for PCDD/Fs and PCBs at the Istituto Zooprofilattico Sperimentale del Mezzogiorno.
For the analysis, 20 g of sample for PCDD/Fs and DL-PCBs and 10 g for NDL-PCBs were frozen, freeze-dried and extracted using an accelerated extractor system. The extracts were then purified using a column packed with EXtrelut NT acidified with 96% sulfuric acid followed by a PowerPrep system for PCDD/Fs and DL-PCBs. For NDL-PCBs, the extracts were cleaned up through an EXtrelut NT3 column acidified with 96% sulfuric acid and an Isolute FL cartridge. Instrumental analysis was carried out using high-resolution gas-cromatograph coupled to high-resolution mass spectrometer (DFS Magnetic Sector HRGC-HRMS system, Thermo Fisher Scientific). The identification and quantification of analytes were performed using the isotopic dilution technique.

Results
Concentrations ranged from 0.06 pg TEQ g-1 wet weight (ww) to 128.5 pg TEQ g-1 ww for PCDD/Fs, from 0.33 pg TEQ g-1 ww to 5923.4 pg TEQ g-1 ww for DL-PCBs, and from 6.42 ng g-1 ww to 32158.0 ng g-1 ww for NDL-PCBs. The liver was the main target organ for PCDD/Fs and PCBs accumulation in all individuals, except for higher PCDD/F levels observed in foetal kidney and heart. Surprisingly, in the adult male specimen, after the liver, the brain showed the highest levels of PCDD/Fs and DL-PCBs, while NDL-PCBs reached maximum levels in the heart. Overall, the female thresher shark showed lower PCDD/F and PCB levels than the male, except for the spleen, which was highly contaminated. In foetal kidney samples, PCDD/F, DL-PCB, and NDL-PCB concentrations exceeded those in the mother, indicating substantial contaminant transfer to the offspring. A similar pattern was observed in muscle tissue, where NDL-PCBs were higher in foetuses than in the mother.

Discussion and Conclusion
The results confirm the significant bioaccumulation of PCDD/Fs and PCBs in thresher sharks [3]. In particular, the presence of all DL-PCB congeners was observed in every organ analysed, both in adult specimens and in the two foetuses. The most relevant finding was the bioaccumulation of these contaminants in foetuses, indicating the transfer of POPs from mother to offspring.
To our knowledge, this is the first study to determine the concentration of PCDD/Fs and PCBs in organs of male and female thresher sharks and their offspring. These results provide important information on the distribution of POPs in this species and contribute to a better understanding of contaminant transfer pathway in elasmobranch fishes.

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P-00440 Honeybee pollen as a bioindicator for dioxins and other pollutant agents: a case study in Dimaro Folgarida (Trentino, Italy)

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Introduction
Pollen constitutes an important nutrient for bees, providing vital proteins and lipids1. When bees forage, they search for pollen and nectar, contributing to pollination and the reproduction of many plant species. During these foraging trips, which reach an average distance of 1–1.5 km, each bee collects up to 5 million microsamples from flowers and other environmental matrices during her daily activity. During their flights, bees are exposed to various chemical substances that are the result of anthropogenic activity, including pollution and/or agrochemical agents. Therefore, pollen could be employed as a matrix to investigate which contaminants are emitted in the territory and their level of pollution. More specifically, in this work, we performed a multiresidue analysis (e.g., identification and quantification of pesticides), an analysis of aromatics and polycyclic aromatic hydrocarbons (PAHs), an investigation on dioxins, and a palynological analysis using pollen. The rationale of this study is based on the lipophilic properties of pollutants, which can accumulate on the surface of pollen, enriched with sporopollenin. Sporopollenin, the main constituent of exine, is a complex biopolymer characterized by the presence of functional groups that contribute to adsorbing pollutant agents on the pollen.

Materials and Methods
The study was carried out as follows: seven apiaries were selected in the territory of Dimaro Folgarida (Trento, Italy), surrounding the landfill of "Ex Cave di Monclassico", within the municipality. The pollen was collected with pollen traps placed on two beehives per apiary over two consecutive days in both May and July 2022. Then, the 14 bee-collected pollen samples were analyzed according to internationally recognized protocols. Regarding pollutant agents, for aromatic compounds, the methods followed the EPA 5021A 2014 + EPA 8260 D 2018 protocols. The MP/C/39 rev 2 2019 method was used to analyze polycyclic aromatic hydrocarbons (PAH), while for multiresidue analysis, the presence of 617 molecules was investigated using the QuEChERS method, following the UNI EN 15662:2018. Conversely, dioxins were analyzed only in one site according to the EPA 1668C 2010 + WHO 2005 TEF protocols.

Results
Considering dioxins, the hive located near the landfill of Monclassico showed low levels of dioxins and PCBs. Specifically, five PCBs were detected: PCB 77, PCB 105, PCB 118, PCB 156, and PCB 167. Furthermore, a single octachlorodibenzodioxin congener, 1,2,3,4,6,7,8,9-OCDD, was above the limit of detection. All dioxins detected in this study were lower than the limit imposed by the law. Although the quantification of these contaminants was expressed in parts per trillion (ppt), a trend previously observed by Hao et al. emerged2. During spring, the abovementioned PCBs showed lower levels than in summer. PCB 118 increased from 7.3 to 11.7 ppt, while PCB 167 was detected only in summer. Regarding the multiresidue analysis, the presence of the fungicide fluazinam was noted in the majority of the samples, although its concentration has decreased since a previous study in 2019.

Discussion and Conclusion
In conclusion, pollen proved to be a promising matrix having the potential to be employed as a bioenvironmental indicator, due to its composition and the significant contribution of bees exploring a large area to feed themselves. In particular, the Dimaro area showed lower levels of dioxins than limits imposed by the law when pollen is considered as nutrient. Thus, results confirm the area's safety, as the other pollutants quantified in this project were also below toxic concentrations.

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P-00447 PM10-associated plastic additives in agricultural greenhouses: seasonal and indoor–outdoor variability

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Introduction
Agricultural greenhouses represent semi-enclosed environments where the extensive use of plastic materials for coverings and mulching films can lead to the release of organic contaminants, potentially affecting indoor air quality and increasing exposure risks for workers and cultivated plants. This study presents two field monitoring campaigns conducted in two different agricultural facilities aimed at characterising organic contaminants bound to PM10, focusing on phthalates and a broader suite of plastic-related additives.

Materials and Methods
Campaigns were carried out during both cold and warm periods to assess seasonal variability influenced by temperature and solar radiation. Air samples were collected simultaneously inside and outside the greenhouses in order to distinguish the contribution of greenhouse-related emission sources from background environmental contamination. Analytical determination was carried out as follows: PM10 samples were spiked with deuterated internal standards, followed by solvent extraction using a dichloromethane/acetonitrile mixture (50:50 v/v). Purification was performed on a Florisil column using a dichloromethane/ethyl acetate mixture (3:2 v/v) as eluent. Chemical analysis and quantification were carried out via gas chromatography-mass spectrometry.

Results
In the first facility, measurements focused on particle bound phthalates, and more than 20 compounds belonging to this class were investigated. Nine compounds were detected in the ng/m3 range, with di-n-octyl phthalate and didecyl phthalate among the most abundant species (Table 1). Indoor concentrations were generally comparable to or slightly higher than outdoor levels, suggesting the presence of indoor emission sources linked to greenhouse plastic materials. The detected profile included both low- and high-molecular-weight phthalates, consistent with emissions from flexible and technical plastic components, indicating combined contributions from volatilisation and direct release from material surfaces. In the second facility (Figure 1), a comprehensive targeted screening of about 70 polymer-related additives, including phenolic antioxidants, organophosphate flame retardants, UV filters, and alternative plasticisers (adipates and terephthalates), was performed. Additives were identified in both airborne particulate matter and plastic films, confirming a direct transfer from materials to the indoor air.

Discussion and Conclusion
Results indicate that agricultural greenhouses may act as microenvironments for chronic exposure to complex mixtures of semi-volatile organic contaminants associated with plastic materials. In addition to occupational inhalation exposure, particle deposition onto crops may contribute to indirect contaminant transfer along the food production chain, raising concerns for food safety and human health. These findings and the current lack of comprehensive literature on the topic highlight the need for further investigation into plastic-derived emissions in intensive greenhouse agriculture.

References
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ng/m³	indoor		outdoor	
	summer	*winter*	*summer*	*winter*
Dimethyl phthalate	0.002	0.003	0.003	0.001
Diethyl phthalate	0.09	0.83	0.23	0.75
Dibutyl phthalate	nd	0.029	0.018	0.022
Butyl benzyl phthalate	nd	0.006	0.002	0.003
Bis(2-ethylhexyl) phthalate	0.45	3.4	1.7	0.27
Di-n-octyl phthalate	6.1	1.2	7.7	0.64
Diisononyl phthalate	1.1	nd	2.3	nd
Didecyl phthalate	2.9	3.6	0.58	0.51
Bis(2-ethylhexyl) adipate	0.027	0.12	0.08	0.13

Table 1. Concentrations of phthalates and adipates measured in PM_{10} samples collected inside and outside the agricultural greenhouse during cold and warm seasons (nd: not detected).



Figure 1. PM_{10} air sampler installed inside the greenhouse.

P-00448 Missing Out Ultrashort Chain PFAS: Impact on Site Assessment, Remediation and Regulations

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Introduction
While there are regulations on PFAS in drinking water, importing and exporting goods, manufacturing consumer products and chemicals, most regulations are limited on the long chain PFAS and some of the known replacement PFAS. Ultrashort-chain PFAS, especially trifluoroacetic acid (TFA), are included in the revised European Drinking Water Directive and the measurements on those ultrashort-chain PFAS can be challenging. Understanding how accurately those are measured can have a significant impact on the assessment and remediation. In this presentation, technical review on accurate measurements on ultrashort-chain PFAS will be demonstrated with varying levels of ionic strength considering different sources of drinking water.

Materials and Methods
Native and labeled reference standards were purchased from various vendors. Agilent 6495D liquid chromatography with triple quadrupole system was used for quantitative analysis. PFC-Free kit was used to minimize the background contamination. Ground water samples from landfill monitoring wells were tested. To understand the impact on varying degrees of ionic strength in water samples, synthetic water samples with sodium salts, nitrate, bicarbonate, chloride, and sulfate to mimic high levels of ion concentration.

Results
Low level detection limits were achieved ranging from 0.004 – 0.054 ng/mL including TFA. Synthetic water sample data with high ionic strength test confirmed retention time stability for all ultrashort-chain PFAS analytes. All recovery and standard deviations were excellent with <15% and 100 ± 30%.

Discussion and Conclusion
A robust analytical method for ultrashort-chain PFAS measurements is demonstrated. Site assessment and remediation can now include ultrashort-chain PFAS information in their pre, during, and after remediation projects to have a better understanding of how overall PFAS concentrations change during the remediation process. From a regulatory perspective, this can be a great tool to correctly address recently revised European Drinking Water Directive as a quantitative tool for trifluoroacetic acid and other ultrashort-chain PFAS compounds, which might be included in the future revisions of the Directive.

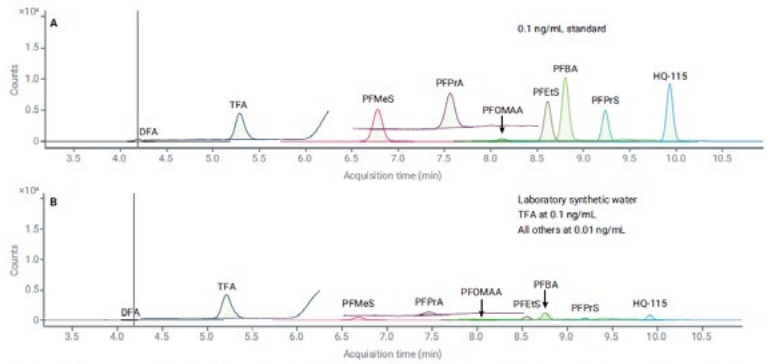


Figure 3. (A) Chromatogram of ultrashort PFAS in a 0.1 ng/mL calibration standard. (B) Chromatogram in laboratory synthetic water at 0.01 ng/mL for all compounds except TFA (0.1 ng/mL).

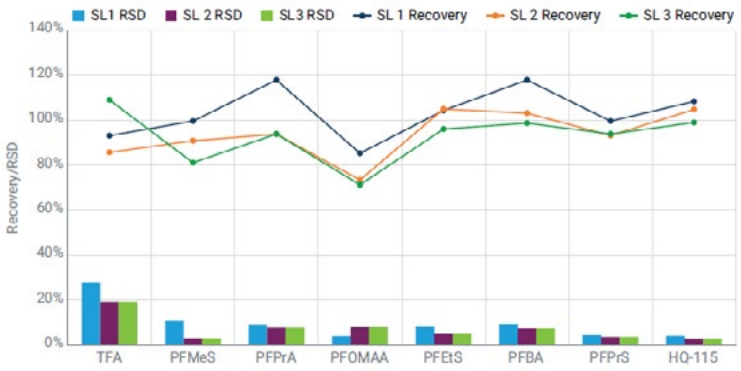


Figure 4. Recovery and RSD of replicates (n = 4) in laboratory synthetic water.

Determination of PFAS in Emissions and Ambient Air

P-00451 Forever Chemicals Found in the Stack Emission and Ambient Air: A Review of Regulatory Movements and Analytical Method Development

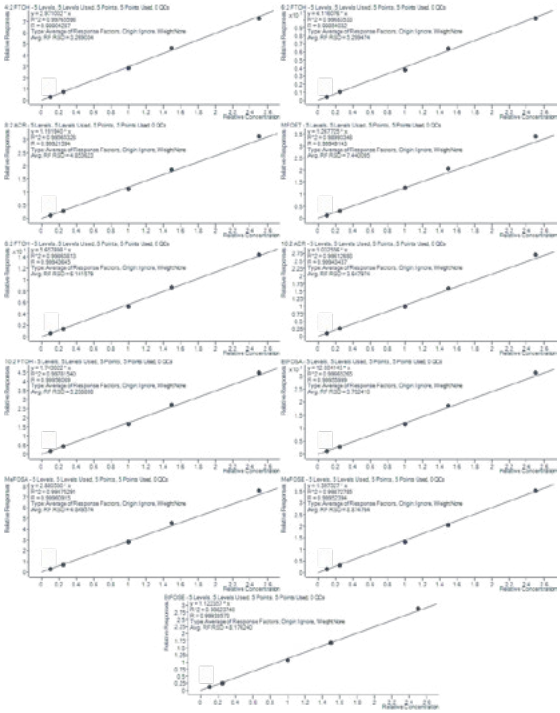
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Introduction
PFAS as environmental hazard is often looked up in the water and solid samples e.g. drinking water, soil, biosolids and so on. Concentrations can be relatively easily determined and exposure to drinking water and/or source water for drinking water is most frequently discussed topics in regulations. Providing clean water to drink as well as clean air to breathe to the citizens is a mission for all environmental protection agencies around the world. European Drinking Water Directive and a few other directives can address drinking water quality, however, air quality regarding volatile PFAS is often neglected either due to lack of understanding in the toxicity or the availability of analytical tools to measure them accurately. In this presentation, an overview of analytical tools for emissions and ambient air testing as well as recent developments in regulations will be reviewed thoroughly.

Materials and Methods
Thermal desorption tubes and canisters were used as sampling devices. Reference standards were purchased from multiple suppliers including a wide range of fluorotelomer alcohols (FTOHs) as well as fluorinated volatile analytes. Agilent 7010D gas chromatography tandem mass spectrometer (GC-MS/MS) was used for quantitative measurements on all compounds.

Results
For OTM-50 approach for stack emission testing, a calibration curve of five points (10cc, 20cc, 50cc, 100cc and 200cc) was achieved for a 10 ppb mixture of the 30 analytes. Hexafluorobenzene was added as the internal standard. Twenty-six of the 30 compounds were fit to a linear curve with the remaining 4 compounds fitting a quadradic curve. The calibration curves for all 30 compounds had R^2 values > 0.99 . The calculated concentrations for each analyte at each concentration level are within 20% of the theoretical concentration.
For thermal desorption approach for ambient air monitoring, all analytes including FTOH s and FOSAs were less than 8% RSD and instrument detection limits of 13 – 39 pg on column.

Discussion and Conclusion
Both stack emission testing and ambient air monitoring for various volatile PFAS compounds as well as fluorinated volatile compounds were successfully demonstrated using targeted approach with GC-MS/MS. This will be a helpful tool for regulatory decisions in emissions and ambient air quality and how these tools can be applied should be discussed with environmental agencies and laboratories.



Calibration curve for volatile PFAS using thermal desorption tubes

P-00457 High-Resolution Dioxin analysis using GC/Q-TOF Mass Spectrometry

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Introduction

Dioxins and dioxin-like compounds, including polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and dioxin-like polychlorinated biphenyls (dl-PCBs), are persistent organic pollutants (POPs) of significant environmental and toxicological concern. Due to their bioaccumulation potential and ultra-trace regulatory limits, their determination requires highly sensitive and selective analytical techniques.

Traditionally, high-resolution magnetic sector mass spectrometry (HRMS) has been the gold standard for dioxin analysis. However, recent advancements in gas chromatography coupled with quadrupole time-of-flight mass spectrometry (GC/Q-TOF) provide a powerful alternative, combining high resolving power, full-spectrum acquisition, and accurate mass measurement.

In this study, an Agilent GC/Q-TOF system was employed for the analysis of dioxins in environmental and food matrices. The system delivers high mass accuracy and sensitivity, enabling confident identification and quantitation of target analytes at trace levels. Accurate mass detection allows for improved selectivity by effectively discriminating against isobaric interferences and complex matrix backgrounds.

The use of full-scan acquisition offers significant advantages over traditional targeted approaches, enabling retrospective data analysis and confirmation of non-target or emerging contaminants. Additionally, the robustness and workflow efficiency of the GC/Q-TOF platform streamline routine analysis while maintaining compliance with regulatory requirements.

The results demonstrate that GC/Q-TOF provides reliable quantitation, excellent linearity, and consistent reproducibility for dioxin analysis. This approach represents a modern, flexible alternative to conventional HRMS methods, supporting both targeted and non-targeted screening in complex matrices.

References

1. EPA 1613B method

P-00459 Endocrine disrupting chemicals in edible insects and insect-based foods

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Introduction
The growing world population is driving the need for new, sustainable food sources. To reduce the environmental impact of traditional livestock production, the search for alternative protein sources has intensified. Edible insects represent a promising candidate for this alternative. Their nutritional value is comparable to that of traditional animal based products, and they require less space and water while producing lower greenhouse gas emissions. Insect based foods were formally recognised as novel foods by the European Union (EU) in 2018. Acheta domesticus, Tenebrio molitor, Alphitobius diaperinus and Locusta migratoria are currently approved for human consumption. While the Western population is not accustomed to insect based foods, edible insects are part of the traditional diet in almost 3,000 ethnic groups across 113 countries. Although edible insects have historically been harvested from the wild, the more recent method of insect farming allows insects to be reared in a controlled environment with a regulated diet, which helps mitigate possible contamination. While evidence for the nutritional benefits of insects is ample, their chemical safety remains an active area of research.
As with other foods, insects can accumulate potentially harmful contaminants throughout the production chain. Exposure may be direct or indirect, through feedstock or the environment in which they are reared (such as containers or soil). Endocrine-disrupting chemicals (EDCs) is a group of contaminants, that has recently attracted increasing attention. EDCs are substances that interfere with the endocrine system by inhibiting hormone biosynthesis and metabolism and disrupting the organism's homeostasis. Numerous studies have demonstrated that humans are exposed to EDCs through air, water and food, reflecting their widespread environmental presence. While EDCs in food have been widely studied, their occurrence in edible insects remains underinvestigated. With reports suggesting that the demand for edible insects will triple by 2030, their chemical safety is of great importance.

Materials and Methods
The analytical method used, was developed as part of a previous study focusing on the simultaneous determination of EDCs in edible insects. For this method, we achieved LOQs of 0.2-10 ng/g for phthalates, 0.1 ng/g for bisphenols and 1 ng/g for chlorinated paraffins. Analysis was conducted using gas chromatography coupled with high resolution mass spectrometry in negative chemical ionisation mode (GC NCI HRMS) and ultra high performance liquid chromatography coupled with tandem mass spectrometry (UHPLC MS/MS).

Discussion and Conclusion
This study, to the best of our knowledge, presents the first insight into the occurrence of EDCs in insect-based foods. Samples collected for this study were analysed for the occurrence of the aforementioned EDCs. The sample set included farmed insects from the Czech University of Agriculture and a variety of insect-based foods purchased on the Czech market (chips, protein powder, chocolate, protein bars). Furthermore, this study aims to evaluate human exposure to selected EDCs from the consumption of edible insects and assess their implications for human health.

Acknowledgment
The financial support from the Czech Science Foundation (21-19437S) is gratefully acknowledged. The work was supported by a grant from the Ministry of Education, Youth and Sports of the Czech Republic NTER-COST-LUC25 grant number LUC25019. The work used [data/tools/services/facilities] provided by the METROFOOD-CZ Research Infrastructure (https://metrofood.cz), supported by the Ministry of Education, Youth and Sports of the Czech Republic (Project No. LM2023064).

Progress in PFAS Analysis

P-00460 High-Throughput automated workflow for trace PFAS determination in challenging matrices

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are extensively found in marine life, posing health risks through seafood consumption.
Seafood is one of the regulated matrices by the U.S. FDA, EU, EURL, POPs, and AOAC.
Regulatory and standard-making bodies like the U.S. FDA, EFSA, EURL POPs, and AOAC have set stringent guidelines for PFAS levels in seafood.
Detecting trace PFAS level is challenging due to complex sample preparation like QuEChERS extraction followed by SPE cleanup, and evaporation/ reconstitution.
The manual steps can be labor-intensive and error-prone, affecting accuracy and reliability.
This study developed a fully automated workflow for PFAS quantitation in seafood – shrimp.

Progress in PFAS Analysis

P-00464 60+ PFAS: From Ultra-Short Chain to Ultra-Long Chain - A Complete Automated SPE Solution Combined with High-Performance SPE Cartridges

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Introduction
Enriching broad spectrum of PFAS including ultra-short to ultra-long PFAS in a single SPE run is quite challenging. USC PFAS are highly soluble in water. The high polarity of these compounds makes it difficult to trap them using current standard protocol established for short and other long chain PFAS. Currently there need to be two different methods for analyzing ultra-short chain and rest PFAS.
The objective of this work is to have a single SPE solution which enriches a broad spectrum of PFAS.
As existing European standard method1 requires solid phase extraction (SPE) prior to liquid chromatography-tandem mass spectrometry (LC-MS/MS) analysis for 20 PFAS in drinking water, it was taken as basis / reference for starting point to develop current solution.

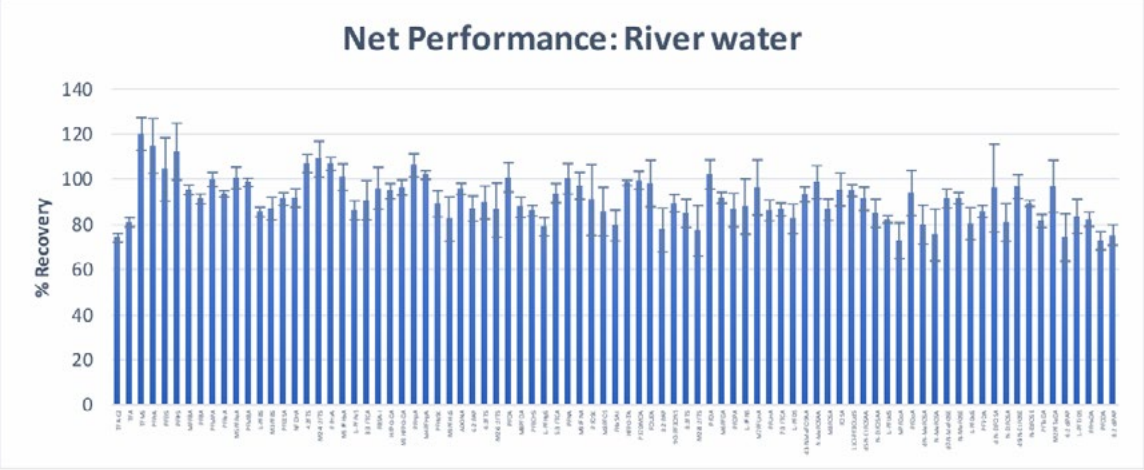
The developed method focused on enriching 60+ PFAS and parallelly cleaning up matrix using automated SPE process. This approach is beneficial to cover all PFAS analytes of importance for target screening.

Materials and Methods
A 250 mL river water sample was spiked with over 60 PFAS analytes. The compounds were subsequently enriched and purified using high performance solid-phase extraction (SPE) cartridges in an automated SPE system. The processed samples were then analyzed by LC-MS/MS.

Results
The absolute recovery of 60+ PFAS analytes after SPE cleanup in automated SPE-03 for river water is shown below. More results will be presented during the posters.

Discussion and Conclusion
The results demonstrate that automated SPE cleanup and enrichment of more than 60 PFAS compounds—including ultra-short- and ultra-long-chain species—can be successfully performed in a single run across various aqueous matrices.

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P-00467 Increasing concentrations of hexachlorobenzene and other organochlorine byproducts in fish in the Canadian Arctic

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Introduction

There is emerging evidence for increasing concentrations of hexachlorobenzene (HCB), pentachlorobenzene (PeCB), and hexachlorobutadiene (HCBD) in air at Alert in the Canadian High Arctic[1]. Global air monitoring using passive sampling has also shown increasing HCB, PeCBz, and HCBD at multiple northern locations, including in sites in Svalbard, Iceland, and the Yukon[2]. In the case of HCB, these increases come after decades of declining air concentrations related to bans on use as a fungicide and reduction in its presence as an impurity in some pesticides[3]. Less is known about trends and sources of another byproduct, octachlorostyrene (OCS); atmospheric concentrations in the Great Lakes were unchanged over the period 1991 to 2020[4]. An assessment of time trends in Arctic biota from the 1990s to 2014 found that HCB and PeCB were declining slowly (mean change 2.6 and 3.8%, respectively)[5].

This study compares the long term trends of HCB, PeCBz, HCBD and OCS fish from 7 lakes in the Canadian Arctic. We hypothesized that increasing air concentrations of these persistent and bioaccumulative compounds will be reflected in trends in fish as a result of long range transport and deposition.

Materials and Methods

Concentrations (ng/g lipid weight), based on samples from the 1990s to 2024, were available from four monitoring projects for lake trout (Salvelinus namaycush), burbot (Lota lota) and Arctic char (Salvelinus alpinus), under the Canadian Northern Contaminants Program. Temporal trends were analysed were analysed using HARSAT, an open-source, R-based statistical package.

Results

Increasing concentrations of HCB, HCBD and OCS were found for the majority of the 10 available datasets as illustrated in Table 1 (PDF attached). Trends for PeCB differed, with significant declines in 3 datasets and no change in 6 others. The increasing trends for HCB and OCS were most evident for the time period from 2005 to 2023, while concentrations from the 1990s to mid-2000s generally showed a decline. The most rapid increase was for HCBD in Arctic char and in burbot and lake trout from Great Slave Lake which began in the early 2000s and reached a maximum in 2023.

Table 1. General trends of HCB, PeCBz, HCBD and OCS in fish from 10 sampling locations in the Canadian Arctic[1]

Location	Hazen	Amituk	Char	Resolute	GSL West	GSL East	Kusawa	Laberge	GSL West	Ft Good Hope
Species	A. Char	A. Char	A. Char	A. Char	L. trout	L. trout	L. trout	L. trout	Burbot	Burbot
HCB	↑	↑	↑	↑	↑	→	→	↑	↑	↑
PeCB	↓	→	→	→	→	→	↓	↓	→	-
HCBD	↑	↑	-	↑	↑	↑	-	-	↑	-
OCS	→	↑	→	→	↑	↑	↑	↑	→	-

[1]All locations are individual lakes except Fort Good Hope, which is on the Mackenzie River. GSL West and East refers to sites in the West Basin and East Arm of Great Slave Lake. Arrows: → = no increasing trend, ↓ = declining concentrations, ↑=increasing concentrations, over the period ~2005 to 2024

P-00467 Increasing concentrations of hexachlorobenzene and other organochlorine byproducts in fish in the Canadian Arctic

Discussion and Conclusion

HCB and OCS showed similar trends at all sampling locations despite vast differences in lake size and population densities. This may reflect common global sources 2, 4. The increase in HCBD in char, burbot and lake trout mirrored atmospheric measurements at Alert from 2010 to 2021. While the trends of all 4 byproducts are probably best explained by primary sources, the rapidly warming Arctic climate could be driving secondary emissions of these semi-volatile compounds. For example, revolatilization of HCB arising from increasing ice-free seasons and areas of the Arctic Ocean and from glacier snow and ice caps.

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Progress in PFAS Analysis

P-00474 Overcoming the analytical challenges when testing for ultra-short chain PFAS in potable and non-potable waters

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Introduction
Ultra-short chain PFAS (USC-PFAS) are a subset of per- and polyfluoroalkyl substances (PFAS) characterized by having carbon chain lengths of 4 or less. They are less studied than their long-chain counterparts but are also found in environmental aquatic systems. Ultra Short PFAS like trifluoroacetic acid (TFA) are ubiquitous in the environment, and their widespread exposure raises concerns about potential environmental impacts.
Ultra-short PFAS are highly polar, which makes them difficult to retain on standard reversed-phase liquid chromatography columns. This can lead to poor separation and identification. Ultra-short PFAS often exist at very low concentrations in environmental samples. Achieving the necessary sensitivity to detect these low levels requires the most sensitive LC-TQ, where the 6495D in combination with the new Altura Poroshell PFAS column can reach these low limits without sample preconcentration. This poster describes excellent results for the signal to noise for all peaks at 10ng/L for all compounds, and a true blank for all compounds including TFA. This is partly due to the PFAS optimized instrument configuration that eliminates common background interferences.

P-00491 PFAS extraction from water and wastewater using innovative automated SPE equipment for high-throughput and high-sensitivity LC-MS analysis

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are a large and heterogeneous group of synthetic chemicals that pose significant analytical challenges due to their chemical stability and widespread environmental occurence [1,2].
The strength of the carbon–fluorine (C–F) bond confers exceptional resistance to thermal, chemical, and biological degradation, as well as hydrophobic and oleophobic properties [2]. These characteristics contribute to their persistence, bioaccumulation, and toxicity, leading to increase regulatory concern at the European level [1,3].
Recent European regulations, including Directive (EU) 2020/2184 and subsequent national implementations (Legislative Decree 18/2023 and 102/2025), have established strict limits for PFAS, with a "PFAS sum" of 0.1 µg/L as the parameter value for drinking water quality, measured using a method that ensures a limit of quantification (LOQ) equal to 30% of the limit value and more restrictive thresholds (0.02 µg/L) for the sum of "four PFAS" corresponding to perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS).
Liquid chromatography coupled with mass spectrometry (LC-MS/MS) is the reference technique for PFAS determination in environmental matrices [4]. However, direct injection methods are often insufficient to meet the required limits of quantification, making solid phase extraction (SPE) a necessary pre-concentration step. Traditional off-line SPE methods are characterized by high sample volume requirements, longer processing times, and higher solvent consumption, while on-line SPE offers improved throughput but may suffer from increased matrix effects and reduced flexibility [4].

Materials and Methods
Innovative equipment produced by Fluid Management System (FMS) and optimized by Lab Service Analytica was used in this study. This extraction equipment combines the best features of both SPE approaches, offering outstanding versatility in the aqueous sample volumes that can be loaded onto the cartridge, while maintaining low organic solvent consumption, high flexibility, reduced matrix effects, and automated sample processing with a high throughput.
The system features an optimized fluidics pathway made entirely with perfluorocarbon-free (PFC-free) materials to significantly improve process blanks. Furthermore, it combines two distinct fluid delivery systems: a positive pressure system for solvent dispensing and a vacuum system dedicated to aqueous sample loading. This configuration offers the flexibility to process drinking and waste water samples in volumes ranging from 100 mL up to 1 Liter directly onto the cartridge.

Results
Preliminary recovery studies on fortified samples showed acceptable performance, with recoveries between 70–130% for native compounds and 50–200% for isotope-labeled standards. A method LOQ of 0.001 µg/L for individual PFAS compounds was achieved, demonstrating suitability for compliance with current regulatory requirements.

Discussion and Conclusion
Further optimization of the extraction protocol and validation across a wider range of PFAS compounds are ongoing to further enhance robustness and method applicability.

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P-00492 Application of Surfactant-Free Foam Fractionation for PFAS Removal from Landfill Leachate

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Introduction
Per- and polyfluoroalkyl substances (PFAS), including representative compounds such as perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) were widely used in industrial and consumer products. Waste containing PFAS is ultimately disposed in landfills, resulting in the frequent detection of high PFAS concentrations in landfill leachate. Therefore, the development of effective, economical, and environmentally sustainable technologies for PFAS removal is urgently needed. Foam fractionation processes can potentially be applied to PFAS removal, concentration, or separation given that PFAS accumulate on the air–water interface of the generated foam. The objective of this study is to evaluate the application of foam fractionation for PFAS removal from landfill leachate through field investigations and laboratory experiments.

Materials and Methods
Field research at six leachate treatment facilities in industrial waste landfills (IWLs) in Japan were performed to compare with PFAS concentration in naturally generated foam and leachate under the foam. For two leachate samples (IWL leachate A and B), laboratory-scale batch treatments were conducted for 30 minutes using a protein skimmer to evaluate PFAS removal from landfill leachate by foam fractionation without the addition of surfactants. Foam fractionation experiments were conducted in triplicate, and 5.2 L of landfill leachate was used for each experiment. Total PFAS concentration in leachate A was approximately one-fifth to one-tenth that of leachate B, and the TOC concentration in leachate A was approximately 5–10 times higher than that in leachate B. Thirty-four PFAS compounds were selected for quantitative analysis, including 30 compounds listed in ISO 21675-NSS (13 linear perfluorocarboxylic acids (PFCAs), 5 linear perfluoroalkyl sulfonic acids (PFSAs), and 12 other PFAS), and four additional compounds.

Results
The foam-to-leachate concentration ratio of PFAS increased with increasing carbon chain length. The ratio of PFPeS, PFHxS, PFHpS PFOS, 6:2 FTSA, PFHpA, PFOA, PFNA, PFDA, and 5:3 FTCA were over 100, especially the ratio of PFOS and PFOA were over 3000, suggesting that long chain PFAS were concentrated to naturally generated foam at leachate treatment facilities. Most PFAS congeners exhibited pseudo-first-order removal kinetics during foam fractionation. For PFSAs, PFPeS, PFHxS, PFHpS, and PFOS achieved over 80% removal after 30 minutes. Similarly, for PFCAs, PFHxA, PFHpA, PFOA, PFNA, and PFDA each exhibited over 80% removal. Thus, the results suggested that longer carbon chain PFSA (C5<) and PFCA (C6<) were more easily removed by foam fractionation treatment than PFBS, PFBA, and PFPeA (short-chain PFAS). In foam fractionation experiments using leachate A and leachate B, the volume of generated foam after 30 min was approximately 500 mL for leachate A and approximately 200 mL for leachate B, representing a 2.5-fold difference. Nevertheless, no significant differences in PFAS removal characteristics were observed between the two experiments.

Discussion and Conclusion
The results of the field investigation and laboratory experiments demonstrated that surfactant-free foam fractionation has practical potential for the removal of PFAS from landfill leachate. In this study, foam was naturally generated even in Japanese landfill leachate derived from relatively inorganic waste, suggesting that the method may also be applicable to municipal solid waste (MSW) landfills, where greater foam generation is expected. In addition, our previous study indicated that the effect of pH on PFAS removal efficiency was limited, implying that foam fractionation can be applied over a wide pH range, including high-pH leachate from landfills containing large amounts of incineration ash. On the other hand, relatively low removal efficiencies were observed for short-chain PFAS. Furthermore, the removal efficiency did not vary significantly with the amount of foam generated. Overall, these findings highlight the potential of surfactant-free foam fractionation as a simple and cost-effective treatment option for PFAS-contaminated landfill leachate.

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P-00496 Microplastics in the bloodstream of dogs and cats: evidence of systemic exposure and implications for One Health

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Introduction
Microplastics (MPs) are increasingly recognized as pervasive contaminants occurring across aquatic, terrestrial, and atmospheric environments. Their small size, persistence, and physicochemical properties promote extensive environmental dispersion and bioavailability, raising growing concerns regarding their potential impacts on both animal and human health. Although MPs have been extensively documented in aquatic organisms and wildlife [1, 2], information concerning their occurrence in companion animals remains limited [3]. In the present study, we provide the first evidence of MPs in the blood of living dogs and cats through both quantitative and qualitative characterization.

Materials and Methods
A total of 20 whole blood samples from companion animals (14 dogs and 6 cats) were analyzed, and MPs were extracted according to [4].

Results
MPs were detected in 100% of samples, demonstrating systemic exposure in both species. No statistically significant differences were observed between dogs and cats in terms of MP abundance, morphology, size, or colour distribution, suggesting comparable exposure patterns and environmental sources. Whole blood analysis revealed a particle abundance ranging from 2 to 13 MPs per individual, with a median value of 6 MPs. Morphological characterization showed a clear predominance of filaments over fragments in all samples analyzed. Size distribution analysis indicated that most particles were smaller than 100 µm, supporting the hypothesis that smaller MPs may more easily translocate into the bloodstream. Colour distribution analysis demonstrated a prevalence of black particles (65.4%), followed by blue (16.5%), red (14.2%) and white/transparent particles (3.9%). Overall, a total of 127 MPs were identified. To further evaluate the suitability of blood-based matrices for biomonitoring studies, serum samples were also analyzed. MPs were consistently detected in serum, although at lower concentrations than in whole blood, showing a more homogeneous size distribution (<120 µm) while preserving similar qualitative features, including predominantly filamentous and dark-coloured particles.

Discussion and Conclusion
Our findings suggest that MPs circulate not only within cellular blood components and coagulation-associated elements but also in the freely circulating fraction, supporting their systemic bioavailability and potential transport to peripheral tissues. Taken together, these results confirm chronic exposure of companion animals to MPs and support the use of blood as a reliable matrix for MP detection and characterization. Given their close coexistence with humans and shared environmental exposure, companion animals may serve as valuable sentinels of environmental contamination within a One Health perspective. Future studies involving larger cohorts are needed to investigate possible associations between MP burden and health status, as well as the influence of factors such as age, sex, breed, lifestyle, and environmental exposure.

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P-00507 Temporal trends of halogenated contaminants in Tuscan stranded dolphins: legacy and emerging pollutants in Mediterranean odontocetes

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Introduction
Il bacino del Mar Mediterraneo, a causa della sua peculiare geomorfologia e dell'elevata antropizzazione costiera, si colloca tra gli ambienti marini più colpiti a livello globale dalla contaminazione ambientale. Nonostante il progressivo divieto di numerosi inquinanti organici persistenti (POP), queste molecole persistono in diversi compartimenti ambientali. I cetacei odontoceti, in quanto predatori apicali dotati di un esteso strato adiposo, sono particolarmente suscettibili all'accumulo di POP, fungendo da bioindicatori della salute dell'ecosistema marino (1). Di conseguenza, è stata condotta un'analisi mirata dei principali POP su esemplari di Tursiops truncatus e Stenella coeruleoalba spiaggiati lungo le coste toscane tra il 2009 e il 2025, con l'obiettivo di valutare le variazioni temporali nei modelli di contaminazione e identificare eventuali generazioni emergenti di composti nei tessuti attraverso approcci non mirati.

Materials and Methods
OCP e HBCDD sono stati rilevati in tutti i campioni. Le concentrazioni di OCP variavano da 7 pg/g di peso lipidico (lw) per δ-HCH a 66,8 µg/g lw per p,p"-DDE, con valori medi di 33,1 ± 22,2 µg/g lw nei delfini striati e 20,0 ± 12,9 µg/g lw nei delfini tursiopi. I DDT erano il gruppo OCP dominante, con p,p'-DDE come composto principale, in accordo con studi precedenti (2). La contaminazione da HBCDD era quasi interamente rappresentata dall'isomero α (>98,5% del totale di HBCDD), con concentrazioni comprese tra 0,0407 e 4,41 µg/g di peso lipidico e valori medi di 0,321 ± 0,175 µg/g di peso lipidico nei delfini striati e 0,618 ± 0,937 µg/g di peso lipidico nei delfini tursiopi.

Results
Tutti gli OCP e gli HBCDD sono stati trovati in tutti i campioni esaminati. I livelli di OCP variavano da 7 pg/g di peso lipidico (lw) (δ HCH) a 66,8 µg/g lw (p,p' DDE), con valori medi di 33,1 ± 22,2 µg/g lw nei delfini striati e 20,0 ± 12,9 µg/g lw nei delfini tursiopi. I DDT erano gli OCP predominanti, con p,p' DDE come composto principale, in linea con studi precedenti (2). Per quanto riguarda gli HBCDD, l'isomero α rappresentava la maggior parte (> 98,5%) della contaminazione totale in ciascun campione, con concentrazioni comprese tra 0,0407 e 4,41 µg/g lw e valori medi di 0,618 ± 0,937 µg/g lw nei delfini tursiopi e 0,321 ± 0,175 µg/g lw nei delfini striati.

Discussion and Conclusion
Il confronto tra gruppi temporali suggerisce una possibile riduzione dei livelli di contaminazione in entrambe le specie, in particolare per alcuni OCP preesistenti come i DDT. Tuttavia, questo modello dovrebbe essere interpretato con cautela, poiché le tendenze temporali nei cetacei del Mediterraneo non sono sempre chiare, possono essere limitate in entità e possono variare a seconda della specie, dell'area e della classe di contaminanti (1). Gli HBCDD hanno mostrato un modello meno coerente, in particolare nei delfini striati, dove i livelli sono rimasti pressoché invariati tra i gruppi temporali. Attualmente non sono disponibili soglie tossicologiche ampiamente accettate per gli OCP totali o gli HBCDD nei mammiferi marini; tuttavia, la persistenza di questi composti conferma la necessità di un monitoraggio continuo dei contaminanti alogenati preesistenti ed emergenti nei predatori apicali del Mediterraneo.

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P-00525 Understanding thermal decomposition behavior of per- and polyfluorinated alkyl carboxylic acids (PFCAs) and their salts using TG-DTA and Py-GC/MS

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are widely used in manufacturing due to their desirable properties. However, four types of ionic PFAS, including perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), as well as their salts and related compounds, have been banned or their use restricted under the Stockholm Convention. In Japan, waste containing PFOS and PFOA must be treated according to the Japanese technical note.1) Unfortunately, there is a significant difference in the temperature required for the removal and decomposition of PFCAs2) compared to their destruction1). This study investigated the fundamental thermal decomposition behavior of PFCAs and their salts, as well as the effects of carbon chain length and the types of salts on thermal decomposition.

Materials and Methods
This study used PFCAs with carbon numbers ranging from 4 to 9 (C4 to C9) and the PFCA salts PFCA-ammonium (PFCA-NH4), PFCA-potassium (PFCA-K), and PFCA-calcium (PFCA-Ca). All of the chemicals, except for PFCA-K and -Ca, were purchased. The K and Ca salts were prepared by neutralization in methanol. Thermogravimetry-differential thermal analysis (TG-DTA) for each sample was conducted under a nitrogen atmosphere at a heating rate of 10 °C/min to understand the weight loss profile at elevated temperatures.
We used pyrolysis gas chromatography mass-spectrometry (Py-GC/MS) to identify the decomposition products of each sample during heating at the initiation and termination temperatures of the weight loss profile.

Results
For all PFACs, namely the carboxylic acid form, the initiation of weight loss was observed below 100 ºC in the TG-DTA measurements. The initiation temperature increased with an increase in the carbon chain. The temperature required for weight loss termination of perfluorononanoic acid (PFNA, C9) with the longest carbon chain was found to be below 160 ºC. For PFCA salts, the initiation temperatures were considerably higher than those of PFCAs, depending on the types of counterions such as K+ and Ca2+ binding to the negative carboxylic group. For instance, the initiation temperatures for PFOA-K and -Ca were approximately 220 and 280 ºC, respectively. In the identification of gas emitted during the thermal decomposition of those PFOA salts using a Py-GC/MS, PFOA-K decomposed into perfluoro-1-heptene. In contrast, PFOA-Ca exhibited different decomposition pattern including the other fluorocarbons.

Discussion and Conclusion
According to the findings of an earlier study3), the thermogravimetric changes for PFCAs are attributed to volatilization. The volatility of PFCAs decreased with an increase in the carbon chain. Consequently, PFCAs with C4 to C9 can readily volatilize at temperatures below 160 ºC. However, a previous study found no significant weight change for PFOA and PFNA when heating contaminated soil at 200°C.2) Therefore, we consider that all of the PFCAs in the contaminated soil or waste does not exist as carboxylic acid form. On the other hand, the weight loss observed for PFCA salts is expected to be due to thermal decomposition based on an earlier study4). It is noteworthy that the thermal decomposition behaviors for PFOA salts were roughly similar to those of the other PFCAs. The Py-GC/MS results suggest that decomposition components differed between PFOA-K and PFOA-Ca. This indicates that the thermal decomposition behaviors of PFCA salts as well as PFCAs are important regarding the appropriate destruction and removal of PFCAs in soil and waste.

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P-00527 Coordination Compounds of Ge(IV) and Zn(II) with Framework-Forming Aromatic Ligands as Sorbent for SPE in Determining of PCDD/Fs and PCBs in Water Samples

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Introduction
Among the newly proposed alternative materials for SPE methods, porous materials, especially metal-organic frameworks (MOFs) and coordination compounds of various metals with aromatic ligands, stand out for their exceptional characteristics, including selectivity and high adsorption capacity. Their prospects are based on simultaneous mechanisms of interaction: hydrophobicity, dipole–dipole interactions, π-π stacking, and chelation between metal ions and Cl-substituents [1]. In this work, we investigated the different types of coordination compounds: coordination polymer of Zn with H3BTB – 1,3,5-tris(4-carboxyphenyl)benzene – {[Zn4O(BTB)2]·H2O}n (1) [3], homonuclear different-ligand complex Ge(IV) with gallic acid (H4Gal) and 1,10-phenathronine – [Ge(H2Gal)2(phen)] (2) [4], and a new hethero-metalic complex Ge(IV)-Zn with 1-hydroxyethane-1,1-diphosphonic acid (H4hedp) and 1,10-phenathronine [Zn(phen)2(H2O)2]2[Zn(phen)(H2O)4]2[Ge6(μ-OH)4(μ-O)2(μ-hedp)6]·18H2O (3) [5] as SPE sorbents for the extraction of polychlorinated dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) from the environmental water samples.

Materials and Methods
The coordination compounds 1-3 were synthesized according to [2-4]. The structural characteristics and thermal stability were investigated by elemental analysis, IR spectroscopy, powder X-ray diffraction, energy-dispersive X-ray spectroscopy, scanning electron microscopy, thermogravimetric analysis. Spiked samples of deionized water and natural water samples with a mass fraction of suspended solids less than 1% from the Dniester River in the Odesa region were used. The gas chromatography, coupled with high-resolution mass spectrometry (GC-HRMS), was used for measurements of PCDD/DFs (17 contaminants), dioxin-like PCBs (12 analytes) and non-dioxin-like PCBs (6 compounds).

Results
The powder XRD pattern and the scanning electron microscopy (SEM) images demonstrate the highly porous morphology of the obtained coordination polymer 1 that are agglomerates of nanosheets with a complex system of branched internal cavities and randomly formed surface defects [5]. The coordination compounds 2 and 3 also formed in the solid state highly ordered three-dimensional networks of layers parallel crystallographic plane. The cavities with a volume of 1084.76 Å3 are formed in the crystal 2, which is 33% of the dimensions of the unit cell. According to TGA data, the decomposition of the spatial lattice with further decomposition of organic ligands was observed at ~400°C for Zn-MOF 1, 260°C and 250°C for coordination compounds 2 and 3, respectively. The limits of detection are in the range 1.5-26.1 pg/L. The recoveries of congeners varies from 48.5% to 94.6% depending on the sorbent 1,2 or 3. Based on the recovery, LOQs, and precision data, it was observed that material 3 is more efficient than materials 1 and 2. For sorbent 2, the lowest recovery was obtained for all analytes. The total concentrations of PCDD/DF and dioxin-like PCBs in the samples of natural water were 0.001-0.105 pg-TEQ WHO/L with insignificant degree of contamination with OCDD, 1234678-HpCDF and dioxin-like PCB77, PCB105, PCB118 at low levels 4.7-32.4pg/L.

Discussion and Conclusion
Thus, the application of coordination compounds of Ge(IV) as a SPE sorbent in the analysis of persistent organic pollutants in water samples was demonstrated for the first time. The complex 2 demonstrated the highest efficiency as an SPE sorbent among the compounds studied, likely due to its porous structure and the presence of sterically available π-π stacking and hydrogen-bonding centers. The results of the analysis of water samples obtained by the proposed SPE method and the liquid-liquid extraction (LLE) method are in good agreement. Thus, the SPE method can be an environmentally friendly alternative to the LLE method.

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P-00531 Dioxin and PCB concentrations in bivalve molluscs species in Türkiye in 2016-2026

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Introduction
In this study, it was aimed to analyse dioxin and PCB concentrations of bivalve molluscs species from five different cities of Turkey in 2016-2026 in terms of export to EU. Moreover, this study is the first comprehensive, presenting dioxin and PCB concentrations in five different bivalve species in Turkey.

Materials and Methods
134 bivalve samples which of 8 are Chamelea gallina, 1 are Tapes decussatus, 36 are Tapes philippinarium, 12 are Donax turunculus, and 77 are Mytilus galloprovincialis were analysed for dioxins (PCDD/Fs), dioxin-like PCBs (dl-PCBs), and indicator (ICES6) PCBs' levels. Results were determined by either GC-HRMS or APGC-MS/MS equipped with 60 m DB5MS capillary column by using isotope dilution technique following fat extraction with ASE (as of 2025 with EXTREVA ASE) and EZ Prep clean-up (EPA 1613B, 1668C; EN 16215).

Results
The dioxin concentrations, total dioxin and dioxin-like PCBs concentrations and indicator PCBs concentrations determined in bivalve molluscs were 0.02-0.46 pg WHO-TEQ(2005)/g fresh weight, and 0.03-0.75 pg WHO-TEQ(2005)/g fresh weight, and 0.02-2.04 ng/g fresh weight respectively. While lowest concentrations determined in Tapes philippinarium, highest concentrations in Mytilus galloprovincialis; all the concentrations determined were considerably below the MLs indicated in EU and the Turkish Legislations.

Discussion and Conclusion
All the results found were below Turkish and EU regulations, and comparable with the results presented by Carro et al. (2026).

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P-00533 Leachability of Per- and Polyfluoroalkyl Substances in Wastes: Method Optimization and Application

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Introduction
Landfilling of waste containing per- and polyfluoroalkyl substances (PFAS) may contribute to environmental emissions of PFAS via landfill leachate [1]. Controlling such emissions requires identifying major source waste types and quantifying their PFAS emission potential. Estimating both past-to-present and future PFAS loading is essential: PFAS present in landfill layers drive current emissions, while ongoing disposal can influence future emissions. Understanding the leachability of PFAS in landfill inputs is critical for estimating emission potential and managing PFAS emissions over time. We examined a leaching test method for waste containing PFAS and applied the method to available waste samples.

Materials and Methods
Five waste categories of non-hazardous industrial waste, consisting of sludge (n = 9), mixed waste (n = 6), bottom ash (n = 5), waste glass and ceramics (n = 2), and slag (n = 2) were used for the method optimization and application. The sample was mixed with ultrapure water at a weight-to-volume ratio of 10%. A polypropylene (PP) container was used because they have shown low adsorption of measured PFAS and have not leached measured PFAS in procedure blank tests. The mixture was subjected to continuous horizontal shaking for 6 hours at room temperature, using a shaker adjusted in advance to a shaking frequency of approximately 200 cycles per minute and a shaking amplitude of 4–5 cm. The resulting sample solution was then centrifuged at 3,000 rpm for 20 minutes, followed by filtration using a PP vacuum filtration filter holder and a membrane filter made of mixed cellulose ester.

Results
A spike-recovery test of the leaching test method was conducted for 57 PFAS (45 anionic and 12 neutral compounds) in triplicate using ultrapure water without any waste matrix. Of the PFAS spiked, 30 showed recoveries within 70–130% in the resulting leachate solutions. Good recoveries were confirmed for many anionic PFAS, including PFOS, PFOA, PFHxS, and C9–C12 PFCAs. Application of the method to six waste categories revealed that PFAS leaching levels varied substantially among waste types. In sludge, PFHxA (median: 40 ng/L) showed the largest contribution, followed by 6:2 FTS (140 ng/L) and 5:3 FTCA (79 ng/L). In mixed waste, regulated PFAS dominated, with contributions ranked as PFOS (110 ng/L) > PFNA (77 ng/L) > PFOA (69 ng/L) > PFHxA (62 ng/L). Bottom ash was dominated by short-chain PFAS, including PFMOPA (87 ng/L), PFBS (11 ng/L), and PFBA (22 ng/L). In ceramic and glass waste, PFOA (11 ng/L) and short-chain PFCAs (PFPeA: 14 ng/L > PFHxA: 12 ng/L > PFHpA: 9.8 ng/L > PFBA: 7.8 ng/L) were dominant, while in slag, PFHxA (61 ng/L) was the main contributor.

Discussion and Conclusion
The proposed workflow enabled the assessment of the leachability of many anionic PFAS. Although further optimization of container and filter materials and filtration conditions is needed for compounds with low recoveries, the workflow successfully characterized PFAS leaching from PFAS-containing waste samples. Leached PFAS profiles and concentrations varied markedly among waste categories. In addition to regulated PFAS leaching from mixed waste, sludge and bottom ash were identified as potential sources of short-chain PFCAs, 6:2 FTS, 5:3 FTCA, and PFMOPA.

Acknowledgment
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P-00539 Experimental combustion tests of pfas-contaminated sewage sludge from municipal wastewater treatment plants

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Introduction

Per- and polyfluoroalkyl substances (PFAS) represent a large and diverse class of more than 10,000 synthetic organic chemicals that are chemically stable due to the presence of strong carbon–fluorine bonds. These structural characteristics confer exceptional resistance to thermal, chemical, and biological degradation, resulting in extreme environmental persistence. Due to their extensive use and persistence, PFAS are now ubiquitously detected in multiple environmental compartments such as surface waters, groundwater and soils. Among the various anthropogenic pathways contributing to PFAS releases into the environment, municipal wastewater treatment plants (WWTPs) have been identified as a critical vector since they are generally not designed to efficiently remove such highly persistent compounds. As a result, PFAS are commonly detected both in the influent and effluent of WWTPs, as well as in the sewage sludge generated during the treatment processes. The behavior of PFAS during wastewater treatment depends strongly on their molecular structure. Short-chain PFAS are relatively hydrophilic and remain mainly in the aqueous phase, whereas long-chain and high molecular weight PFAS are more hydrophobic and less volatile. These compounds tend to adsorb onto solid particles, resulting in their accumulation in sewage sludge, where concentrations may reach several thousand nanograms per gram of dry matter. This scenario highlights the urgent need to identify and validate sludge management strategies capable of effectively addressing PFAS contamination while ensuring environmental protection and operational sustainability.

Materials and Methods

To date, several technologies have been investigated for the treatment or removal of PFAS (physical adsorption, chemical oxidation or reduction, thermochemical processes, and emerging biochemical approaches). Among these, thermal treatment methods have attracted considerable attention due to their potential to irreversibly destroy PFAS molecules rather than merely transferring them from one environmental compartment to another. Incineration of civil sludges at high temperatures (800-900°C) is one of the possible strategies studied to degrade PFAS molecules (Garg et al., 2023), but more research is needed on the fate of PFAS compounds, on the degradation efficiency and on the fluorinate molecules distribution within the flue gases, ashes, and other byproducts. Within this context, the present study investigates the thermal degradation of PFAS during the incineration of municipal sewage sludge using a laboratory-scale bubbling fluidized bed combustor operated at 850 °C under atmospheric pressure. Both untreated municipal sludge and sludge spiked with five representative PFAS compounds (PFOA, PFOS, PFBA, PFBS and PFTeDA) were tested. The spiking approach was adopted to enhance analytical sensitivity, overcome limitations related to low natural PFAS concentrations, and enable a more accurate quantification of destruction and removal efficiency. The selected PFAS compounds were chosen to represent different chain lengths and functional groups commonly detected in wastewater sludges.

Results

Results showed that combustion efficiency was strongly influenced by excess air conditions, higher oxygen availability improved burnout and reduced CO and NOx emissions. PFAS abatement consistently exceeded 99.9%, with only PFBS, PFOS, and PFTeDA detected in flue gases at trace levels (4–37 ng/Nm^3). Residual PFAS in ashes ranged from 200 to 24,000 ng/kg, mainly concentrated in fly ash.

Discussion and Conclusion

The experimental campaigns aimed to assess the efficacy of the combustion process for the abatement of persistent PFAS compounds. Overall, results confirm that high temperature fluidized bed incineration is effective for PFAS destruction. It is important to note that the study was limited to evaluating the combustion section of the incineration process and did not include the downstream flue-gas treatment stages typical of full scale plants.

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P-00541 Evaluation of PAH removal from recycled LDPE using natural deep eutectic solvents, ionic liquids, and vegetable oils

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Introduction
Current decontamination methods applied during mechanical recycling of polyolefins are often insufficient to effectively reduce some of the organic contaminants that may pose a risk to the safe use of recycled plastics. Polycyclic aromatic hydrocarbons (PAHs) are non-intentionally added substances (NIAS) that may be present in recycled plastics. Certain PAHs exhibit carcinogenic properties in humans, pose ecotoxicological risks to aquatic organisms, and may persist in ecosystems through trophic accumulation [1].
The present study evaluated different treatments for reducing PAH concentrations in recycled low-density polyethylene (LDPE) using natural deep eutectic solvents (NADES), ionic liquids (ILs), and vegetable oils as extraction media.

Materials and Methods
Post-consumer recycled black LDPE supplied by a local recycling facility was used in this study. The material had previously undergone an industrial hot-water washing process performed by the company. The sample was specifically selected due to the high total PAH concentration, previously analysed [2].
Based on a literature review, thymol-camphor (1:1 v/v) and choline chloride–oxalic acid (1:1 v/v) were selected as NADES, 1-butyl-3-methylimidazolium trifluoromethanesulfonate [BMIM][Otf] as the ionic liquid, and sunflower oil as the vegetable oil.
Experiments were conducted in autoclave reactors using 10 mL of each extraction medium and 1 g of plastic material, limited by reactor capacity. Treatments were performed for 2 h at different temperatures (50, 100, and 150 °C). After treatment, the plastic material was recovered by vacuum filtration.
For PAH extraction, 2 g of shredded plastic sample was stirred with 30 mL of acetone:dichloromethane (1:1 v/v) for 24 h at 25 °C, followed by purification using C18 solid phase extraction cartridges. PAHs were analysed by gas chromatography coupled to mass spectrometry (GC-MS) using deuterated internal standards.

Results
All treated samples showed lower total PAH concentrations than the untreated LDPE sample. (1990 ng/g). In most cases, increasing temperature enhanced PAH removal, except for the choline chloride oxalic acid treatment, suggesting the presence of an optimal decontamination temperature.
PAH decontamination using oil at 100 °C was the most effective treatment, reducing the total concentration from 1990 to 65 ng/g and toxicity from 80 to 2 ng TEQ/g, corresponding to reductions of 97 % in both cases.
In contrast, choline chloride–oxalic acid showed the lowest performance, with removal efficiencies ranging from 3 to 31 %. Total PAH concentrations in these samples remained above 1000 ng/g, indicating that this treatment was ineffective for PAH decontamination.
The thymol–camphor treatment at 50 °C reduced the total PAH concentration from 1990 to 290 ng/g (85 % reduction), while toxicity decreased from 80 to 12 ng-TEQ/g (85 % reduction).
Treatments using [BMIM][Otf] resulted in residual total PAH concentrations between 265 470 ng/g at the studied temperatures, corresponding to removal efficiencies between 76 86 %.

Discussion and Conclusion
Overall, the results demonstrate the high potential of several of the evaluated extraction media for reducing PAH concentrations in recycled LDPE. Among them, sunflower oil at 100 °C showed the best performance, achieving a 97 % reduction in total PAH concentration. The use of vegetable oils is particularly attractive due to their low toxicity, low cost, and wide availability.
Although challenges related to industrial scale-up remain, these findings represent a promising step toward improving the safety and quality of recycled LDPE for applications with stricter regulatory requirements

Acknowledgment
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P-00549 Bisphenol A and its substitutes show pro-atherosclerotic potential through the dysregulation of CD36-driven cholesterol homeostasis

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Introduction

Bisphenol A (BPA) and its structural analogs are commonly found in consumer products, and concerns about their potential cardiovascular risks are growing. This study combined population data, cell and animal experiments, and molecular docking to explore the connection between bisphenol compounds (BPs) and atherosclerotic cardiovascular disease. In a cultured RAW264.7 macrophage model, environmentally relevant concentrations of BPs promoted lipid absorption and foam cell formation through the cluster differentiation 36 (CD36). In a male ApoE-/- mice model, BPs exposure increased aortic plaque burden. These effects were significantly reduced or eliminated in CD36-silenced cells and mice. Interestingly, BPA substitutes exhibited more potent effects than BPA itself. Molecular docking further supported the direct interaction between BPs and CD36, as well as the structure-toxicity relationship trend of these BPs. Overall, the findings suggest that BPs promote CD36-mediated lipid accumulation and the development of atherosclerosis. The study highlights the need to reevaluate the safety of BPs and provides a foundation for risk assessment and prevention strategies related to BPs exposure and cardiovascular disease.

P-00555 Surge of Ultrashort-Chain PFAS in Human Milk and Neonatal Hepatotoxicity: TFMS Induces Hepatomegaly via Energy Disruption

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Introduction
Long- and short-chain per- and polyfluoroalkyl substances (PFAS, C ≥ 4) have received extensive attention, yet ultrashort-chain PFAS (USC-PFAS, C ≤ 3) remain critically understudied. To date, seven USC-PFAS have been detected in biological matrices, including trifluoroacetic acid (TFA), pentafluoropropionic acid (PFPrA), trifluoromethanesulfonic acid (TFMS), perfluoroethanesulfonic acid (PFEtS), perfluoropropanesulfonic acid (PFPrS), perfluoro-2-methoxyacetic acid (PFMOAA), and bis(trifluoromethyl)amine (Ntf2). Previous studies reported median serum TFA at 8.46 ng/mL (Tianjin, China), peak urinary TFA at 290 ng/mL (US), and median cord blood levels of PFPrA (31.9 ng/L) and TFMS (0.3 ng/L) in Jinan, China. However, comprehensive assessments of USC-PFAS in breast milk and their health risks are limited. Toxicological evidence is largely confined to TFA, showing hematological, biochemical, and hepatomegalic effects. The biological impacts of other USC-PFAS, such as TFMS, especially following early-life lactational exposure, remain unknown. Hence, we analyzed human milk and infant urine in China alongside an in vivo lactational mouse model to characterize USC-PFAS exposure profiles, evaluate maternal-infant transfer, and investigate neonatal toxicity mechanisms.

Materials and Methods
Human milk samples (n=637) from two phases (Phase I: 2020–2021, 15 Chinese cities; Phase II: 2024–2025, Hangzhou) and 62 paired infant urine samples were analyzed for 35 PFAS (including 7 USC-PFAS). Lactational TFMS exposure (0, 4, 20, 100 mg/kg/day) was administered to ICR mice from parturition to postnatal day 19. Offspring were assessed for TFMS tissue distribution, hepatic histopathology, lipid/energy profiles, and non-targeted metabolomics.

Results
All seven USC-PFAS were detected in Phase I milk samples, with detection frequencies >90% for TFA, PFPrA, and TFMS, and >60% for PFMOAA. TFA predominated (city-specific medians: 652.4–1525.8 ng/L), followed by PFPrA (19.6–233.8 ng/L) and TFMS (4.6–218.5 ng/L). Temporal comparison revealed a dramatic surge of USC-PFAS: TFA, PFPrA, and TFMS levels increased 1.4- to 6.8-fold, whereas long-chain PFOA and perfluorononanoic acid (PFNA) significantly declined. In paired infant urine, TFA and PFPrA were excluded due to background contamination; TFMS emerged as the dominant USC-PFAS (median 1,287.0 ng/g creatinine). Mass balance analysis showed an absolute excretion-to-intake mass ratio (AEM/AIM) of 0.37 for TFMS, orders of magnitude higher than for long-chain PFOS (0.01). In offspring lactationally exposed to TFMS, urinary excretion exceeded total body burden by >22-fold, yet the retained fraction accumulated preferentially in the liver. At 20 mg/kg/day, significant hepatomegaly and elevated serum triglycerides were observed, with marked hepatic lipid accumulation by Oil Red O staining. Hepatic metabolomics revealed consistent enrichment of nucleotide/purine metabolism and ABC transporter pathways across all dose groups, characterized by fluctuations in key metabolites such as uridine 5'-monophosphate (UMP). Energy phenotyping showed elevated AMP/ATP ratios and reduced energy charge (EC) at ≥20 mg/kg/day, directly indicating compromised hepatic energy homeostasis.

Discussion and Conclusion
USC-PFAS have become dominant contaminants in human breast milk, with a significant temporal surge. Notably, TFMS exhibits high excretion propensity, contrasting with the bioaccumulation of long- and short-chain PFAS. Despite this high excretion, retained TFMS preferentially accumulates in the neonatal liver, inducing hepatomegaly similar to PFOS. However, whereas PFOS primarily disrupts membrane remodeling and phospholipid synthesis, TFMS specifically targets the energy-transport axis via energy homeostasis failure, underscoring the urgent need for risk assessments of USC-PFAS.

P-00570 Targeted and Non-Targeted Screening of POP's (Persistant Organic Pollutants) in groundwater and trade effluent wastewater using a benchtop mass spectrometer.

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Introduction
Persistent Organic Pollutants (POPs) are causing global concern due to their sustained presence in the environment, ability to travel long distances, and capacity to bioaccumulate in the fatty tissues of humans and wildlife.1 Attempts to mitigate the negative impact of traditional POP's, e.g. polychlorinated biphenyls (PCB's), (used in sealants and paint) and DDT (dichlorodiphenyltrichloroethane - synthetic insecticide),2 resulted in the widespread introduction of PFAS (per/perfluoroalkyl substances) as 'safer' alternatives. These compounds are now known to be toxic, persistent and mobile. Concerns have accelerated the need to screen 'raw' water sources that may be used for drinking water to ensure POPs levels are safe. QToF mass spectrometry offers the necessary sensitivity and resolution for both targeted and non-targeted screening of raw water samples. A major challenge to the targeted monitoring of PFAS is that out of the ~10,000 known and commercially relevant species, high-purity , quantitative reference standards are available for only about 6%3.
Here we describe the screening of two trade wastewater samples and a groundwater sample using an initial targeted workflow based on a PFAS screening library of 149 compounds. Further to this initial screening stage screening, further untargeted screening exploiting innate properties of PFAS compounds using Pattern Analysis application on waters_connect™ software.

Materials and Methods
A calibration curve (0.001-50ng/mL) was constructed using the 30 PFAS standard PFAC30PAR, and transferred into polypropylene vials .
Two samples of wastewater (WW1, WW2) and one sample of groundwater (GW) sourced in the UK were prepared for analysis .
A 300µL aliquot of the supernatant of each sample was transferred in triplicate to a polypropylene vial containing 50:50 MeOH:water with 0.1%v/v formic acid. LC-HRMS data were acquired on an ACQUITY ™UPLC ™I-Class System coupled to a Xevo™ G3 QTof Mass Spectrometer.
Data were collected in full scan using a QToF in MSE negative mode, which enables the simultaneous acquisition of both precursor and fragment ions in a single analysis.
Initial targeted screening against a PFAS library containing retention time, expected intact masses and known fragments was carried out. Identified compounds were then assayed against the standard curve.

Results
Targeted screening of the data using waters_connect Software against a panel of 149 analytes, From this panel, 9 targets were found in WW1, 12 in WW2 and 10 found in GW . Identified targets were quantified (n=3) against the standard curve.
The Pattern Analysis application has the EPA PFASSTRUCT 2024-3-14 library5 embedded, and combined with mass defect filtering, Pattern Analysis detected a homologous series C6H3F9O5 C7H3F11O5, C8H3F13O5 enabling the putative assignment of Methyl 2-[[difluoro(trifluoromethoxy) methoxy]-difluoromethoxy]-2,2-difluoroacetate, Methyl 2-[difluoro-[1,1,2,2-tetrafluoro-2-(trifluoromethoxy)ethoxy]methoxy]-2,2-difluoroacetate and Methyl difluoro{1,1,2,2-tetrafluoro-2-[1,1,2,2-tetrafluoro-2-(trifluoromethoxy)ethoxy]ethoxy}acetate respectively . These compounds are labelled respectively 1,2 and 3 in the data visualisation plots

Discussion and Conclusion
Successful targeted screening and quantitation of PFAS species within each sample was demonstrated.
The ability to perform qualitative and quantitative workflow in one analysis presents the opportunity to provide an initial screening platform to provide information for routine targeted screening.
The novel mass spectral properties of PFAS chemicals allow them to be discriminated from matrix background
The provision of a set of comprehensive flags and filters to the user allows flexible triage of complex samples, allowing the user to focus their attention on the components with the highest likelihood of being PFAS-related
The value of a pattern-based approach is not limited to PFAS analysis, but extends to any homologous compound class.

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P-00573 Occurrence of vapour-phase PCBs in interiors of Algerian farms

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Introduction
Owing to their physical/chemical properties, PCBs enjoyed numerous and important applications, e.g. as in heat exchangers, electric power transformers, pesticide additives and solvents, paper inks; the world production of PCBs reached millions of tons during their golden time. Nevertheless, as organic chemicals containing chlorine, the toxicity of PCBs began to be subject of study and has been definitively ascertained, so that increasing restrictions limited their production, usage and storage; all tools using PCBs were abandoned, and their removal and transformation in safer chemicals became necessary. Indeed, all environmental compartments resulted PCB contaminated, and the shadow of a longtime pollution loomed over the world. To dispose of PCBs, a faster and cheaper way presumably adopted in developed countries was that of transferring abroad dirty technologies and wastes. Therefore, the loads of PCBs tended to decrease in Europe, Japan and North America, but they did not elsewhere; today, traces continue to be detected over the rest of the world.

Materials and Methods
Two distinct in-field campaigns aimed at chemically characterizing the interiors of Algerian factories were performed in Lakhdaria (Bouira Province) and in Tougguort city and its surrounding (Saharan Region). In the first case, the subject of study was a paint production company; there, five indoor locations were examined; meanwhile, measurements were made in duplicate outdoors. In the Tougguort area, the study focused on five date palm farms, a waste treatment plant, a fuel station and an asphalt production company; there, measurements were carried out both in summer and fall seasons.
PCBs were enriched from air using passive sampling devices, wrapped with aluminium foils, sealed in plastic bags and stored at -16°C until analyzed. Sampling devices were extracted with solvent spiked with a mixture of reference compounds for quantitative assessments. After separation of the extract residues into four fractions of different polarity, instrumental analysis was performed in GC-MSD (scan mode). Despite this approach could limit the overall potential of the analytical system, on the other hand, it allowed exploring the occurrence of many other contaminants. To have a reference of ambient toxicity at the sites investigated, PAHs were determined in parallel, and the relative importance of PCBs could be estimated.

Results
The whole of results observed during the two campaign points out that:
- Indoor PCBs could exceed up to ≈100 times the respective outdoor values;
- Nevertheless, sometimes PCBs were less indoors, suggesting the presence of an external source;
- Indoors, PCB loads ranged from <0.02 ng/m3 to >60 ng/m3;
- Inside the same premise, the PCB loads could change by a factor >40;
- The PCB percent distribution according to the number of chlorine atoms changed with site and year time.

P-00579 Occurrence of Chlorinated Perfluoropolyether Carboxylates (ClPFPECAs) and their dechlorinated products in wild boar liver

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Introduction
Chloroperfluoropolyether carboxylates (ClPFPECAs) are emerging ether-based PFAS introduced by Solvay Company as alternatives to legacy long-chain PFAS in fluoropolymer production. However, they retain key PFAS-like properties, including persistence, mobility, bioaccumulation potential and poorly characterized toxicity (1). Their chlorinated terminal moiety may undergo reductive dehalogenation, forming hydroperfluoropolyether carboxylates (HPFPECAs), which have been reported together with their precursors in both environmental matrices and biota (2,3). This study investigates ClPFPECA/HPFPECA relationships in 73 wild boar livers to explore a possible influence of substituent patterns on apparent dechlorination.

Materials and Methods
During the 2022–2023 hunting season, 73 wild boars were sampled in Umbria region (8456 km2, Central Italy) collecting livers for the analysis of a series of legacy and emerging PFASs. Samples were extracted and purified as described in Moretti et al. (2). Ten ClPFPECA congeners and their corresponding dechlorination products, the HPFPECAs, were approximately quantified using the six ClPFPECAs that constitute the main components of the Solvay mixture as reference materials (Ultra Scientific Italia Srl, Bologna, Italy). Bond Dissociation Energies (BDEs) were calculated by means of the Schrödinger Suite (Schrödinger LLC, New York)

Results
In ClPFPECA notation, the first and second numbers indicate the number of ethoxy (e) and propoxy (p) units, respectively. Seven congeners were detected. ClPFPECA-0,2 was present in all the samples (Detection frequency, DF = 100%) and showed the highest concentrations (median = 0.078 µg/kg; mean = 0.141 µg/kg), followed by ClPFPECA-0,1 (DF = 97%; median = 0.058 µg/kg; mean = 0.136 µg/kg) and ClPFPECA-0,3 (DF = 75%; median = 0.073 µg/kg; mean = 0.087 µg/kg). ClPFPECA-2,0, ClPFPECA-1,1, ClPFPECA-1,2 were also frequently detected, but ClPFPECA-2,1 occurred only sporadically (DF = 18%; mean = 0.005 µg/kg). Regarding the dechlorination products, the highest detection frequencies were observed for HPFPECA-1,1 and HPFPECA-2,0 (DF = 93% and 89%; median = 0.040 and 0.035 µg/kg; mean = 0.060 and 0.067 µg/kg, respectively). The remaining HPFPECAs showed DF < 50 % with means from 0.007 to 0.014 µg/kg; notably HPFPECA-0,3 was never detected. The apparent dechlorination rates were: 2,1 ≈ 2,0 > 1,1 » 1,2 > 0,2 ≈ 0,1 > 0,3. In silico calculations of C-Cl BDEs for the different congeners, ranging from 71.7 to 74.8 kcal/mol, showed no correlation with the apparent dechlorination rates (4). Conversely, steric factors seem to have a role (Spearman correlation test). By constructing an empirical shielding score, a strong correlation was observed between this score and the apparent dechlorination ratios calculated as follows: HPFPECA/ (ClPFPECA + HPFPECA).

Discussion and Conclusion
The observed dechlorination pattern suggests a strong structural control on the ClPFPECA/HPFPECA balance. Congeners with two perfluoroethoxy units (e) close to the terminal chlorinated moiety showed the highest conversion, whereas congeners dominated by perfluoropropoxy units (p), particularly ClPFPECA-0,3, did not show any apparent conversion. This trend may reflect differences in conformational flexibility and steric accessibility of the chlorinated moiety. It should be emphasized that HPFPECA/(ClPFPECA + HPFPECA) ratios were apparent dechlorination percentages, not reaction yields. In fact, HPFPECAs may derive from environmental transformation, dietary uptake, in vivo metabolism, or a combination of these processes. In addition, low or undetected HPFPECA levels, such as for HPFPECA-0,3, may reflect unsuitable detection limits or further degradation rather than the absence of dechlorination. Further studies are needed to clarify the actual transformation pathways.

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P-00584 Polychlorinated Biphenyls (PCBs) in diapers

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Introduction
Polychlorinated Biphenyls (PCBs) are a class of chlorinated chemicals first produced commercially in the 1920s and were widely used for their chemical stability in applications such as transformers, hydraulic fluids and sealants. Their persistence and lipophilicity led to global environmental distribution and bioaccumulation in food webs with toxicological effects including endocrine disruption and carcinogenicity. Due to these risks, PCB production was banned in many countries in the late 1970s with global Elimination targeted under the Stockholm Convention in 2001. Despite these bans, PCBs remain prevalent in society through both legacy and non-legacy pathways. In Washington State, RCW 70A.350 (Safter Products for Washington law) identifies PCBs as priority chemicals and established a regulatory framework to reduce human exposure by restricting their presence in consumer products, emphasizing eliminating inadvertently generated PCBs from manufacturing processes. To address potential exposure pathways from consumer products, our laboratory was approached to develop a method for the analysis of PCBs in disposable diapers.

Materials and Methods
Sampling: 36 diapers were analysed as part of the project. The samples included diaper products marketed towards children (> 4 years) and adults.
Standards and Chemicals: All 13C-labelled internal and recovery standards as well as a 6-point calibration curve ranging from 0.2 - 2000 ng/mL was purchased from Wellington Laboratories Inc., Canada. An addition PCB congener mix covering all 209 PCBs was purchased from Accustandard, USA. Extraction solvents including acetone, hexanes and dichloromethane were purchased from Caledon Laboratories, Canada. Premade acid silica and carbon columns were supplied by CAPE Technologies, USA. Gel permeation columns were produced by CanSci, Canada.
Instrumentation: A Thermo Scientific TSQ 9610 DFS high resolution mass spectrometer (Thermo Fisher Scientific, Germany) coupled to a Trace 1310 Ggas chromatograph (Thermo Fisher Scientific, Germany) C [HF1] was used for analysis. Injections of 1 uL were run using the split/splitlessSSL i[HF2] nlet at a temperature of 220°C. Carrier gas used was helium at a constant flow of 1.3 mL/min. Separation was performed using an SGE Zebron ZB-Dioxin 60 m x 0.25 mm ID column (Trajan, Australia). All data was quantified using TargetQuan 4 and Xcalibur.

Results
(see table 1)

Results for diapers

Homologs	# of Congeners	Average conc. (ng/kg)	Median	Min	Max
Monochlorobiphenyls	3	2.50	0.60	0.11	19.5
Dichlorobiphenyls	12	309	90.5	20.4	3040
Trichlorobiphenyls	24	62.4	21.8	2.94	360
Tetrachlorobiphenyls	42	93.7	28.0	0.03	996
Pentachlorobiphenyls	46	16.9	1.83	0.13	391
Hexachlorobiphenyls	42	22.7	14.0	0.01	150
Heptachlorobiphenyls	24	15.8	5.09	0.01	103
Octachlorobiphenyls	12	3.80	0.11	0.02	33.1
Nonachlorobiphenyls	3	1.32	1.19	0.49	3.71
Decachlorobiphenyl	1	0.25	0.120	0.03	3.97
Total PCB		526	185		

Estimated Quantitation Limit 7-9 ng/kg

P-00584 Polychlorinated Biphenyls (PCBs) in diapers

Discussion and Conclusion

In the initial phase of method development, it was clear that there were coextracting residues that interfered with the analysis of PCBs, specifically the mono-tri substituted. There was a coextracting oily residue that was very difficult to separate from the PCB fractions during the cleanup stage. Various fractionations were attempted on acid silica and Florisil columns but the interferent remained with the lighter PCBs which impacted the clarity of the chromatograms. Diaper and absorbent products primarily contain sodium polyacrylate as the absorber, polypropylene, ethylene and urethane for the linings and cuffs, bleached wood pulp for the filling, along with lotions, dyes and perfumes. These synthetic components are suspected of making diaper analysis so challenging. An average soil matrix can easily be cleaned with just acid washes and a silica column while a sample that contains multiple synthetic additives that may not react with acid or base will likely require more selective clean-up methods. Using a combination of cleanup techniques including acid wash, tandem acid silica/carbon column and gel permeation chromatography, acceptable chromatography and detection limits (< 5ng/kg) were achieved. All samples analysed contained varying levels of PCBs.

Acknowledgment

Ryan Pratley for extracting the samples through the lab and Matt Wright for quantifying the data.

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P-00586 Key factors that threaten bee and wasp nesting in human-dominated landscapes: a case study in central Argentina

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Introduction

Anthropogenic stressors drive changes in insect communities, yet their relative impacts on beneficial taxa with divergent ecologies, such as solitary cavity-nesting bees and wasps, remain unclear. While habitat loss and fragmentation are widely recognized threats , the role of environmental pollutants—specifically persistent organic pollutants (POPs)—within urban landscapes is rarely isolated from other confounding spatial factors. This study evaluates the direct and indirect impacts of urbanization, environmental pollutant loads, and floral resource dynamics on wild bee and wasp nest abundance across land-use gradients in central Argentina.

Materials and Methods

Sampling was conducted across 55 sites capturing urban, peri-urban, agricultural, and semi-natural habitats in nine locations in central Argentina (Fig. 1). Standardized artificial trap nests containing cardboard straws (6 mm), wood traps (6–11 mm), and reeds (>12 mm) were deployed from October 2021 to March 2022. Landscape urbanization was quantified as the percentage cover of impervious surfaces within a 500 m radius of each site using Google Earth Pro. Floral abundance, species richness, and temporal stability were monitored monthly using standardized transects and timed random walks. For chemical analysis, one brood cell per bee nest (containing primarily pollen) was sampled, and cell contents were pooled by site, frozen, lyophilized, and ground. A total of 12 organochlorine pesticides (OCPs), 21 polychlorinated biphenyls (PCBs), and 8 polybrominated diphenyl ethers (PBDEs) were analyzed by gas chromatography-mass spectrometry (GC-MS) following clean-up procedures. Piecewise structural equation modeling (SEM) was performed to untangle the pathways of direct and indirect effects on nesting success.

Fig.1. (a) Sampling locations across central Argentina. In each location, sampling sites were selected in urban, peri-urban, agricultural, and semi-natural environments.

Results

We recovered 954 wasp and 746 bee nests, dominated by Megachile spp. (67% of bees) and Trypoxylon spp. (78% of wasps). Target POPs were detected in 80% of the pooled samples, with higher total loads concentrated in highly urbanized areas. The median contribution to the total POP load followed the order: DDTs (54%) > HCH (23%) > CHLs (16%) > HCBs (5%) > PCBs (2%) > PBDEs (1%). Calculated p,p'-DDE/p,p'-DDT and p,p'-DDD/p,p'-DDT ratios (>0.6) indicated legacy accumulation as well as potential fresh inputs of DDT at several urbanized sites. Wasp richness decreased strongly with urbanization (X^2 = 12.97, p = 0.0003), whereas bee richness showed no significant relationship. The piecewise SEM revealed that wasp nesting decreased directly and sharply with increasing urbanization (β = -0.806). Conversely, urbanization exerted a weak direct positive effect on bee nesting (β = 0.151) but an overarching indirect negative effect strictly mediated by environmental pollution (β = -0.523).

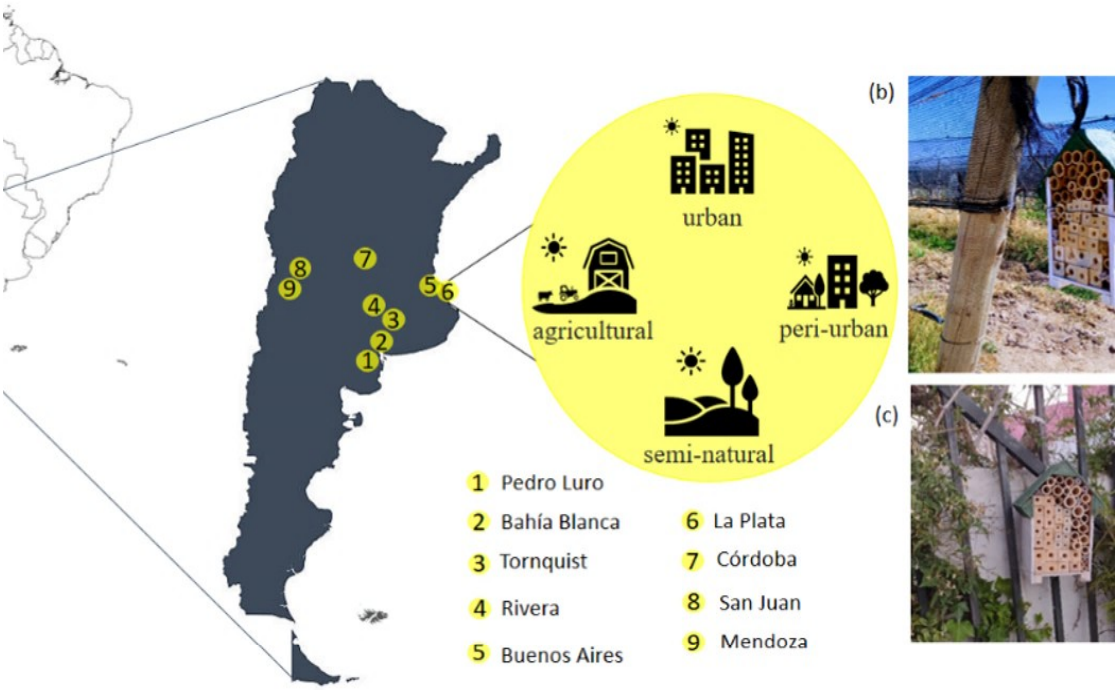
P-00586 Key factors that threaten bee and wasp nesting in human-dominated landscapes: a case study in central Argentina

Discussion and Conclusion

Our findings reveal distinct, taxon-specific responses to anthropogenic stressors in human-modified environments. Wasps exhibit high sensitivity to habitat conversion and the resulting loss of preferred prey or nesting resources. Conversely, urbanization impacts bee nesting primarily through chemical pollution. Pollen represents a key environmental exposure pathway for obligate pollen-collecting bees, whereas predatory wasps avoided this specific route due to their diet of spiders. Floral stability enhanced nesting for both taxa (β = 0.22 for bees, β = 0.271 for wasps) but failed to mitigate the negative impacts of urbanization or chemical exposure. Thus, dominant stressors differ fundamentally between these ecologically divergent taxa (habitat loss for wasps versus pollutant exposure for bees), emphasizing that effective conservation requires taxon-specific strategies rather than a one-size-fits-all approach in Neotropical landscapes.

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P-00588 Concentrations, exposure predictors and risk assessment of Dioxins, Furans and dl-PCBs in Spanish Serum Samples

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Introduction
The persistence and accumulation of dioxins (PCDDs), furans (PCDFs) and dioxin-like polychlorinated biphenyl (dl-PCBs) continue to raise public health concerns. 480 serum samples from adults (18-65 years old) living in a Mediterranean Region of Spain were collected. All 29 congeners analysed were detected, with detection frequencies ranging from 3% (123789-HxCDF) to 100 % (PCB-118, PCB-105, PCB-167, PCB-157, PCB-156, and PCB-189). The congeners that contributed most, in terms of toxic equivalents (TEQ), were 12378-PCDD among PCDD/Fs and PCB-126 among dl-PCBs. The median total concentration of PCDD/Fs and dl-PCBs, expressed in TEQ, was 8.9 pg TEQ g-1. In the worst-case scenario, expressed as percentile 95 (p95), concentration obtained was 19.7 pg TEQ g-1. As expected, strong associations were observed between the overall results obtained and participants' age. Two main age groups were identified in the present study: 18-40 years and 41-65 years. Additionally, significant associations with smoking status, home location, gender, body mass index (BMI) and dietary consumption were revealed. A health risk assessment for PCDD, PCDF and dl-PCBs was carried out. Hazard index (HI) values for both the median and p95 were below the concerned level (HI<1). However, 3 % of the analysed samples exhibited HI exceeding 1, suggesting potential risk in a small subset of the population.

P-00590 Dietary Exposure to Dioxins, Furans and dl-PCBs in the Valencian Population with updated values: Food Analysis and Risk Assessment

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Introduction

Dietary exposure to polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and dioxin-like PCBs (dl-PCBs) was assessed in the Valencian population between 2020 and 2022. A total of 150 marketed samples of animal origin were collected and analysed over this period, covering the main food groups contributing most to dioxin exposure such as meat, fish and dairy products Analysis was performed by Gas Chromatography coupled with High-Resolution Mass Spectrometry (GC-HRMS), in accordance with Commission Regulation (EU) 2017/6441. Occurrence concentrations were combined with dietary intake data obtained from food frequency questionnaires administered to 548 participants to estimate exposure in adults. Risk characterisation was performed applying the updated Tolerable Weekly Intake (TWI) of 2 pg WHO-TEQ kg^{-1} body weight $week^{-1}$ established by EFSA in 20182. Results were compared with those from a previous regional study (2010–2011)3, enabling temporal trend analysis and evaluation of the effectiveness of European risk-management measures.

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P-00593 A novel strategy for the clean-up and the fractionation of PCDD/F and PCB congeners in environmental samples

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Introduction

In this research work a novel strategy for the clean-up and the fractionation of PCDD/Fs (polychlorinated dibenzo-p-dioxins/furans) and PCBs (polychlorinated biphenyls) in environmental sample extracts was developed. Several studies were conducted since the beginning of the century for developing clean-up methods for the analysis of PCDD/Fs and PCBs in environmental and food samples [1, 2, 3]. The innovative clean-up and fractionation method was implemented on a PowerPrep™ system using only two packed columns: a multi-layer silica column (acid, basic, and neutral) and a self-designed composite column with a defined graphene loading. Unlike the globally established procedure [3], which requires three packed columns (silica, alumina, and carbon), our streamlined approach successfully removes matrix interferences while completely separating the PCDD/Fs fraction from both the non-ortho PCBs and mono-ortho PCBs fraction. An important objective of the present study was also the removal of dichloromethane (probably carcinogenic to humans Group 2A of IARC, International Agency for Research on Cancer) as the solvent used for the affinity separation in the consolidated procedure as well as the reducing of solvent consumption, purification time and costs in order to minimize the environmental impact of the entire procedure even safer for human health. Specifically, for the elution of the seventeen target PCDD/F congeners, the innovative method of clean-up requires 30 mL of toluene. The optimized method allows the quantitative elution of PCB congeners and, in particular the recovery of four non-ortho congeners (PCB 77, 81, 126, 169) together with twelve dioxin-like PCBs and six marker PCBs (28, 52, 101, 138, 153, 180), using only 30 mL of hexane and 15 mL of a mixture composed of hexane and toluene, 95:5 respectively (% v:v). Moreover, several tests were performed using stable isotope labelling solution for PCDD/Fs and PCBs, demonstrating that this self-assembled composite column shows excellent recovery yields, also in compliance with the official EPA method, i.e., 1613 Rev. B and 1668 Rev. C. Recovery values of labelled PCDD/Fs resulted in the range between 53% (2,3,7,8-TCDF 13C12) and 78% (1,2,3,6,7,8-HxCDD 13C12) and, for PCBs in the range between 66% (PCB 52 13C12) and 103% (PCB 105 13C12).

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P-00609 Method for the Analysis of Mixed Halogenated Dioxins and Furans (PBCDD/F) in Flue Gases and Residues

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Introduction
Combustion processes, particularly when brominated waste is used (e.g. flame retardants from plastics, textiles and electronic equipment), can result in the formation of not only chlorinated (PCDD/F) and brominated (PBDD/F) dioxins and furans, but also of mixed-halogenated dioxins and furans (PBCDD/F). In this context, the probability of formation is as PCDD/F > PBCDD/F > PBDD/F generally considered to be significantly higher for the mixed-halogenated species than for their brominated homologues, due to their thermodynamic stability.

Table 1: Quantity of 2,3,7,8-substituted Dioxin/Furan-Congeners with 1-2 Bromine atoms

Compound Class	Mono-Brominated	Di-Brominated	Total Mono- and Di-Brominated Compounds
Dioxins (PXDD)	38	42	80
Furans (PXDF)	72	81	153
Totals	110	123	233

From the 4,600 congeners, around 900 appear in the toxicologically relevant 2,3,7,8-substitution pattern, and only 233 of these are subject to closer toxicological assessment (see table 1), given a maximum contribution of 1–2 bromine substituents based on the usual ratio of chlorine to bromine in the input.

Materials and Methods
As part of our method development for the analysis of selected PBCDD/F compounds (using GC/HRMS) in flue gas and waste samples, the following validation data (see table 2) were obtained regarding measurement uncertainty (acc. to DIN ISO 11352) and recovery rates in the full procedure (extraction, clean-up and analysis):

Table 2: Recovery Rates (Full Procedure) and Expanded Measurement Uncertainity

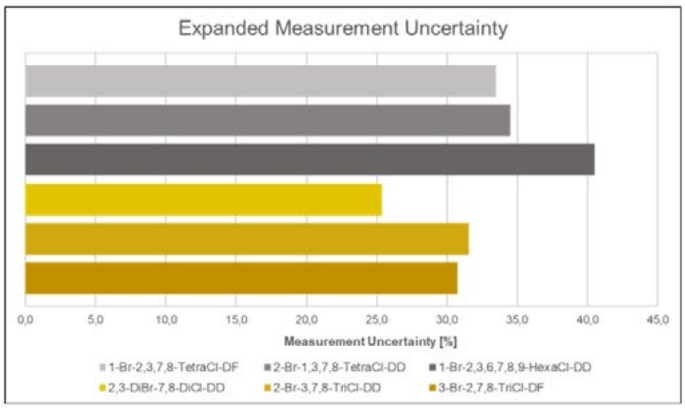
Compound	Recovery throughout the entire analytical process [%]	Expanded Measurement Uncertainity [%]
3-MonoBr-278- TriCl-DF	89.0	30.8
2-MonoBr-378-TriCl-DD	93.8	31.5
23-DiBr-78-DiCl-DD	98.6	25.4
23-DiBr-78-DiCl-DD	98.6	25.4
2-MonoBr-1378-TetraCl-DD	104	34.5
1-MonoBr-2378-TetraCl-DF	102	33.5
1-MonoBr-236789-HexaCl-DD	83.4	40.5

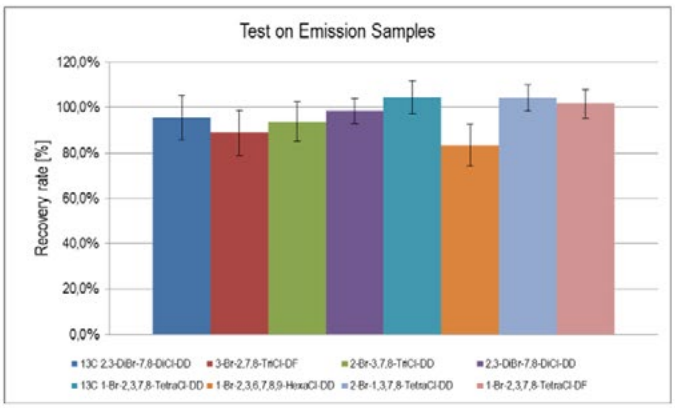
Results
The method was tested on real samples (filter dust and exhaust gas samples in accordance with the European Standard EN 1948) and has proven to be robust and reproducible. Within this validation 1-MonoBr-236789-HexaCl-DD could be detected in filter dust samples from a waste incineration plant. Further investigations on additional real samples are currently in progress.

Discussion and Conclusion
Mixed-halogenated dioxins and furans (PBCDD/F) are currently under discussion for inclusion in the Stockholm Convention's list of POPs. In toxicity studies to date, they are sometimes classified as significantly more toxic than their purely brominated and, in some cases, chlorinated homologues. With a careful selection of a few components, an assessment of toxic relevance can be made, similar to other cases (e.g. 8 PBDD/F according to the German Ordinance on the Prohibition of Chemicals). Our investigations provide indications of this. Nevertheless, there is still a lack of sufficient standards to expand the group of such 'indicator PBCDD/F' to a growing representative selection.

Progress in non-polar POPs Analysis

P-00609 Method for the Analysis of Mixed Halogenated Dioxins and Furans (PBCDD/F) in Flue Gases and Residues





P-00612 Optimized chemometric workflows for Py-GC×GC-MS analysis of tire wear particles

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Introduction
Tire wear particles, or TWPs, are a growing source of micro- and nanoplastic contamination. TWPs undergo physicochemical deterioration after being deposited in metropolitan environments, including mechanical wear and UV exposure. to characterize these intricate transitions sophisticated and reliable analytical methods are needed.. In this way, pyrolysis coupled with comprehensive two-dimensional gas chromatography-mass spectrometry (Py-GC×GC-MS) offers superior separation capacity over traditional 1D methods. As one challenge of the technique, the generated data can exceed 1,000 peak signals per sample, increasing the complexity of the analysis.

Materials and Methods
In this way, this study aims to implement and evaluate advanced chemometric tools within an applicable optimized workflow into aged TWPs. At first, pixel-based strategies and feature-based alignment methods to streamline data processing were compared. For pixel-based alignment, Two-Dimensional Correlation Optimized Warping (2D-COW), Recursive Automated Peak Alignment (RAFFT), and interval correlation-shifting (icoshift) were applied to correct retention time shifts. Simultaneously, feature-based alignment approaches, including Simple-to-use Interactive Self-modeling Mixture Analysis (SIMPLISMA), Point Pattern Matching, and Mass Spectral Metadata Alignment, were utilized to resolve and match co-eluting pyrolyzates and degradation markers by the MS signals.

Discussion and Conclusion
This work establishes a more reliable routine for feature selection, transforming raw, high-density multidimensional profiles into an improved analytical workflow. Also, the alignment, data analysis workflow, and data dimensionality reduction were enhanced in this study. This chemometric structure facilitates untargeted screening of TWPs in Py-GC×GC-MS platforms. Finally, this routine improves data interpretability, providing a more robust foundation for tracking degradation and supporting environmental mitigation approaches.

Acknowledgment
The authors acknowledge the COST Action ICPLASTIC CA23131 ISO compatible, efficient and reproducible protocols/equipment for mICro-nanoPLASTIC detection through machine-learning - ICPLASTIC, supported by COST (European Cooperation in Science and Technology), and the Fonds de la Recherche Scientifique (FNRS) for financial support of the current study.

P-00618 A preliminary comparison between GC-EI-HRMS and LC-APCI-HRMS methods for the determination of legacy Polybrominated Diphenyl Ethers (PBDEs) in marine biota

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Introduction
Polybrominated diphenyl ethers (PBDEs) are anthropogenic brominated flame retardants (BFRs) historically utilized in a vast array of industrial and consumer products. Due to their high persistence and lipophilic nature, PBDEs are ubiquitous environmental contaminants that bioaccumulate through the food chain. In 2024, the European Food Safety Authority (EFSA) updated its risk assessment, focusing on ten priority congeners (BDE-28, -47, -49, -99, -100, -138, -153, -154, -183, and -209) [1]. Conventional analytical determination typically relies on gas chromatography-electron ionization-mass spectrometry (GC-EI-MS). However, these traditional workflows often suffer from limited efficiency for highly brominated congeners such as BDE-209. This study evaluates an alternative liquid chromatography-atmospheric pressure chemical ionization-high-resolution mass spectrometry (LC-APCI-HRMS) approach, comparing its performance with the reference GC-EI-MS method—configured for 9 of the 10 EFSA-priority congeners—to assess the applicability of this platform for routine PBDE monitoring in biota samples.

Materials and Methods
Fifty-six marine samples, including anchovies, mantis shrimps, and sardines, were processed for the determination of 9 PBDEs (BDE-28, -47, -49, -99, -100, -153, -154, -183, and -209), using a consolidated multi-residue method based on isotope dilution and automated extraction and purification techniques [2]. Instrumental analysis was performed by gas chromatography (GC) and liquid chromatography (LC) coupled with high-resolution mass spectrometry (HRMS). GC-EI-HRMS analysis was performed on a magnetic sector DFS mass spectrometer (resolution 10,000 FWHM) using a 30 m capillary column and PTV injection. LC-APCI-HRMS analysis utilized a UHPLC system equipped with a C18 polar-functionalized reversed-phase column coupled to a Q-Orbitrap mass spectrometer. The APCI source operated in negative ion mode. Instrumental performance was statistically evaluated using a paired t-test method.

Results
The two instrumental methods exhibited distinct ionization mechanisms and sensitivity trends. The GC-EI-HRMS method targeted different ions based on the degree of bromination: tri- and tetra-BDEs were monitored via the molecular radical cation ([M]+·), while penta- through deca-BDEs were quantified using the more abundant fragment ion resulting from the loss of two bromine atoms ([M-2Br]+). Conversely, the APCI source in negative mode provided efficient ionization via specific adduct and fragment formation: low-to-medium brominated PBDEs were monitored as displacement products ([M-Br+O]-), while BDE-209 was quantified through the pentabromophenate elimination ion ([C6Br5O]-). Notably, in contrast to the decreasing sensitivity observed with GC-EI-HRMS as bromination increased, LC-APCI-HRMS demonstrated a complementary sensitivity profile, where response intensity increased with the degree of bromination.
The LC-APCI-HRMS method successfully detected PBDEs at pg/g levels for all investigated congeners, with the sole exception of BDE-28, which showed limited sensitivity compared to GC. The reliability of the comparison was confirmed by the analysis of the 56 marine samples: the results obtained from both instrumental platforms were statistically aligned, as evidenced by a paired t-test ($p > 0.05$) and high correlation in the congener profiles.
In conclusion, LC-APCI-HRMS represents a valid, robust, and reliable instrumental alternative to traditional GC-EI-MS. By providing superior performance for highly brominated congeners and reduced susceptibility to thermal degradation, this approach offers a versatile strategy for routine monitoring and research applications, including PBDEs traditionally overlooked because of GC-MS limitations. Furthermore, the LC-based system allows for the potential integration of other BFR classes, such as hexabromocyclododecanes and tetrabromobisphenol A.

Acknowledgment
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P-00634 Old and novel AhR agonists: evaluation of their AhR-inducing potencies and novel toxic modes of action in human cell models

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Introduction
Toxicity and carcinogenicity of persistent dioxin-like compounds (DLCs), such as PCDD/Fs and PCBs, and less persistent polycyclic aromatic hydrocarbons (PAHs), are largely mediated via aryl hydrocarbon receptor (AhR) activation. Therefore, the AhR-dependent induction of gene expression serves as an important measure of toxic potency AhR ligands. Our studies over the last decade that are overviewed in this presentation provide information about both cell-type specific and overall dioxin-like potencies of a number of groups of environmental pollutants.

Discussion and Conclusion
Extensive in vitro screening revealed important species- and even cell-specific differences and sensitivity to pollutants in human and rodent models (Chem Res Toxicol 2015, 28:641; Toxicology 2018, 404-405:33). Deviations from the established toxic equivalency factors were found particularly for PCB 126 and mono-ortho-chlorinated PCBs. Several AhR target genes (including CYP1B1, AHRR, TIPARP and ALDH3A1) could be more sensitive than commonly used CYP1A1 induction as a model AhR-dependent endpoint, with possible consequences for risk assessment of AhR agonists.
Additionally, there are many less persistent polyaromatic compounds showing significant AhR-mediated potencies. Assessment of the AhR-mediated activities of PAHs in a human cell-based reporter gene assay allowed us to identify potentially important groups of toxic AhR-active polyaromatics, including for instance benzofluoranthenes, environmental six-ring PAHs and benzo[b]naphtho[d]thiophenes (contributing significantly to overall AhR-mediated activity of complex mixtures) or polar aromatics isolated from diesel exhaust particles, river sediments or airborne particulate mater (Environ. Poll. 2017, 220:307; Environ. Poll. 2020, 266:115125; Sci. Total Environ. 2023, 879:162924). In the case of environmental PAHs, their in vitro toxicity profiling (Sci. Total Environ. 2022, 815:151967) further revealed a wide spectrum of toxic effects, mostly linked with AhR activation, including activation of estrogen receptor alpha (via PAH metabolites), suppression of androgen receptor activity, enhancement of dexamethasone-induced glucocorticoid receptor and triiodothyronine-induced thyroid receptor activities, as well as repression of target genes of pregnane X receptor and peroxisome proliferator-activated receptor alpha in HepaRG cells. The AhR agonists among PAHs also reduced the expression of glucose metabolism genes and induced early cell stress and genotoxicity markers such as ATF3, GDF15, CDKN1A/p21 and GADD45A. AhR inhibition has been found to be linked with disruption of fatty acid synthesis, e.g. in colon cancer cells (Cancers 2022, 14:4245), where AhR may contribute to the metabolic switch associated with carcinogenesis.
In further in vitro studies, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and benzo[a]pyrene (BaP) were used as representatives of persistent non-genotoxic AhR agonists and AhR agonists with significant genotoxic potential, respectively, to study their toxicity in human lung cell models. This approach helped us identify novel candidate genes (such as GREM1, HIPK2, SOX9, and ID1) that may improve the monitoring of AhR-regulated transcriptional activity in lung cell models (Toxicol. Lett. 2018, 292:162). Prolonged exposure to the genotoxic AhR ligand BaP induced an epithelial-to-mesenchymal transition (EMT)-like phenotype in lung carcinoma A549 cells, which was associated with a p21-dependent cell-cycle delay (Chemosphere 2021, 263:128126). In normal human bronchial epithelial HBEC-12KT cells, further evaluation of genes primarily regulated by AhR and genes deregulated exclusively by BaP (mainly through its toxic metabolites) (Environ. Toxicol. Pharmacol. 2024, 107:104424) revealed a set of genes linked to cancer development and progression, as well as significant deregulation of sphingolipid metabolism (Environ. Res. 2025, 285:122699). Taken together, these studies improved our understanding of the gradual cell transformation elicited by both AhR activation and the additional toxic and genotoxic effects of carcinogenic PAHs such as BaP.

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P-00636 Chloride-Enhanced UHPLC-ESI-HRMS Method for the Determination of Short- and Medium-Chain Chlorinated Paraffins

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Introduction
Chlorinated paraffins (CPs) are complex mixtures of polychlorinated n-alkanes (PCAs) widely used as industrial additives, plasticizers, and flame retardants[1]. Due to their potential impact on human health and the environment, Short-Chain CPs (SCCPs, C10–13) and Medium-Chain homologues (MCCPs, C14–17) were added to Annex A of the Stockholm Convention in 2017 and in 2025, respectively, with specific exemptions for limited use and production[2]. Currently, occurrence data are insufficient to comprehensively assess human dietary exposure, largely because the inherent complexity of CPs hinders the development of standardized analytical protocols for food matrices[3]. To address this issue, an Ultra High-Performance Liquid Chromatography-High-Resolution Mass Spectrometry (UHPLC-HRMS) method was optimized to fully characterize both SCCPs and MCCPs.

Materials and Methods
Three SCCP (51.5%, 55.5%, and 63% Cl) and two MCCP (52% and 57% Cl) technical mixtures were investigated. The ionization behavior of PCAs was first evaluated via direct infusion analysis (DIA), comparing electrospray ionization (ESI) and atmospheric pressure chemical ionization (APCI). Subsequently, the UHPLC-ESI-HRMS method was optimized using a 5 ng µL-1 pooled standard mixture. Chromatographic performance was tested across three analytical columns (Acquity BEH C18, Accucore aQ, and Kinetex Phenyl-Hexyl). Reversed-phase separation employed water and various organic solvent mixtures as mobile phases, both modified with 0.1 mM ammonium chloride to enhance ionization. Several source and mass spectrometry parameters (temperatures, gas flow, spray voltage, mild trapping, and RF lens) were fine-tuned. Mass spectrometric data were acquired in full scan MS mode, and the MS resolving power was set at 120000. Finally, method linearity and sensitivity were assessed using five calibration levels (0.1-25 ng µL-1) analyzed in triplicate.

Results
ESI exhibited a higher overall ionization efficiency compared to APCI, predominantly forming the [M+Cl]- adduct. The Kinetex Phenyl-Hexyl column was selected for its superior peak shape, yielding lower base peak width (~0.5 min) and full-width-half-maximum (FWHM, ~0.2 min) than the alternatives. Optimal chromatographic response was achieved using methanol:water (9:1, v/v) as the organic mobile phase. Optimized MS parameters included an ion transfer tube temperature of 300 °C, vaporizer temperature of 375 °C, auxiliary gas at 21 a.u., spray voltage of 2000 V, active mild trapping, and an RF lens set to 70%. Excellent linearity was achieved for all CP mixtures, with determination coefficients (R2) ranging from 0.965 (SCCP 51.5% Cl) to 0.999.

Discussion and Conclusion
This study demonstrates that PCA homologue groups can be effectively ionized using a chloride-enhanced UHPLC-ESI-HRMS approach, utilizing the [M+Cl]– adduct for quantification due to its high abundance and minimal spectral interferences. Thermally-assisted ESI proved crucial: while higher temperatures favored highly chlorinated, longer-chain PCAs, lower temperatures suited shorter-chain, less chlorinated congeners. Consequently, an intermediate temperature was established as a robust compromise, ensuring high sensitivity across diverse carbon chains and chlorination degrees. Ultimately, this optimized, high-throughput analytical method is designed for real-sample application. The proposed methodology may contribute to routine food monitoring and to reducing current gaps in exposure data.

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P-00638 Per- and Polyfluoroalkyl Substances (PFAS) in Italian Food: Contamination Levels and Dietary Exposure

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are a class of synthetic compounds recognized as significant hazards to both the environment and human health. They are often referred to as "forever chemicals" due to their extreme persistence. PFASs can bioaccumulate along the food chain and have been detected in a wide range of food matrices.
Following the 2020 opinion of European Food Safety Authority (EFSA) on the risks to human health associated with PFASs in food [1], the European Commission established maximum levels in foodstuffs for four legacy PFAS (Commission regulation (EU) 2023/915): perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), and perfluorohexane sulfonic acid (PFHxS). Because regulatory enforcement requires ultra-trace detection ($pg \cdot g^{-1}$ range), developing highly sensitive and selective analytical methods for complex matrices is essential.
In this study, a sensitive method was applied to determine levels of ten perfluoroalkyl carboxylic acids (PFCAs) and eight perfluoroalkyl sulfonates (PFSAs) in 707 food samples commonly consumed in Italy, including eggs, meat, milk, vegetables, baby food, fish and fish products. Samples were extracted using the QuEChERS approach, with subsequent clean-up via dispersive solid-phase extraction (d-SPE). Analysis was performed using ultra-high-performance liquid chromatography coupled with high-resolution mass spectrometry (UHPLC-HRMS) [2].
Overall, both contamination levels and detection frequencies were higher in aquatic organisms than in terrestrial products (meat, eggs, and milk), with the exception of liver. While levels in meat, eggs, and milk were generally close to or below the LOQ, liver samples showed higher levels; in these samples, PFOS was the most prominent compound together with long-chain PFCAs. Similarly, in fish, molluscs, and crustaceans, long-chain PFCAs were frequently quantified, while PFOS represented the primary PFSA. In vegetables, no significant PFAS concentrations above the limit of quantification (LOQ) were detected.
Excluding vegetables, the sum of four regulated PFAS follows the trend: cephalopods > crustaceans > liver > fish > molluscs > eggs > meat > milk. Across these categories, the average lower-bound sum of the four regulated PFAS ranged from 0.004 µg/kg in milk to 0.417 µg/kg in cephalopods. PFOS was the most ubiquitous compound and the primary contributor to this sum, except in bivalve molluscs, where PFOA predominated. In aquatic species, PFOS detection frequency ranged from 49% to 75%, with the highest values observed in crustaceans. PFOA and PFNA were detected with similar frequencies (approximately 15–50%), exceeding 50% only in crustaceans. PFHxS was the least frequently detected compound, with occurrence ranging from 4% to 10%. Non-regulated long-chain PFCAs (from PFDA to PFTeDA) showed relatively high detection frequencies in crustaceans and molluscs (18–60%). A similar pattern was observed in fish, although with slightly lower frequencies and different proportions. Among the regulated PFASs, the highest concentration was found in a clam sample, with PFOA at 3.8 µg/kg. However, the maximum concentration overall was 4.0 µg/kg for the non-regulated analyte PFUnDA in a squid sample.
Dietary exposure was assessed for different population groups based on age, using national food consumption data from the EFSA database. Exposure was estimated using two-dimensional Monte Carlo simulations to account for both variability and uncertainty. Risk characterization was performed by comparing exposure distributions with the EFSA tolerable weekly intake (TWI), set at 4.4 ng/kg body weight for the sum of the four legacy PFASs. This approach enables the identification of population groups and consumption patterns associated with higher exposure, providing valuable scientific support for food safety risk management.

Acknowledgment
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P-00643 Persistent organic pollutants in novel foods: preliminary findings in edible insects and dietary supplements (plant- and non-plant-based)

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Introduction
Global population growth, climate change, and increasing anthropogenic pressures pose significant challenges to sustainable food production. In parallel, innovation and globalization are accelerating the introduction of novel foods into the European Union market. These products are increasingly recognized for their high nutritional value and low environmental impact. Among them, algae and edible insects have emerged as primary alternatives, as exemplified by the recent authorization of cricket powder (Commission Implementing Regulation (EU) 2023/5). However, these emerging matrices are particularly vulnerable to chemical pollution [1], and therefore it becomes necessary to assess their contamination. (as suggested by EFSA in 2018 and 2022) [2,3].
This study aims to characterize the presence of selected persistent organic pollutants (POPs), including dioxins, polychlorinated biphenyls (PCBs), and polybrominated diphenyl ethers (PBDEs), evaluating their occurrence in these novel matrices in light of their environmental persistence and potential bioaccumulation.

Materials and Methods
A total of 13 novel food samples (food products and dietary supplements) were collected at retail level, including six insect-based products formulated with varying proportions of cricket and mealworm flours, six plant-based matrices, and one krill oil-based sample. A multi-class method was applied to determine levels of chlorinated (PCDD/Fs, DL-PCBs and NDL-PCBs) and brominated (PBDEs) pollutants. The analytical method based on isotope dilution technique and detection via gas-chromatography high-resolution mass spectrometry (GC-HRMS) to combine high selectivity with optimal sensitivity.

Results
Contamination levels varied significantly across food categories and product compositions, with a clear distinction between dietary supplements and insect-based products. Overall, chlorinated contamination in dietary supplements remained low; PCDD/Fs averaged 0.058 pg WHO-TEQ/g (median: 0.041), DL-PCBs averaged 0.016 pg WHO-TEQ/g (median: 0.003), and NDL-PCBs averaged 0.10 ng/g (median: 0.090). While most dioxin congeners remained near or below the LOQ, Chlorella pyrenoidosa and krill oil supplements emerged as notable exceptions, reaching contamination levels of 0.18 and 0.10 pg WHO-TEQ/g, respectively. Regarding PBDEs, the sum of 10 congeners (∑10 BDEs) ranged from 0.44 to 1.3 ng/g, with a profile dominated by BDE-209 (contributing approximately 50%), followed by BDE-47 and BDE-99. Exceptions to this profile were observed in noni juice and chia seeds, where BDE-209 levels were near the LOQ.
Among insect-based products, a positive correlation was observed between the proportion of insect content and contaminant levels. Specifically, the highest levels of PCDD/Fs were found in products composed primarily of insects, either as whole organisms or in powdered form, ranging from 0.16 to 0.27 pg WHO-TEQ/g. In foods or snacks, where insects account for no more than 10% of the total composition, the toxicological sum is approximately one order of magnitude lower (0.008–0.033 pg WHO-TEQ/g). The contamination profile was characterized by highly chlorinated PCDD/Fs congeners, with hepta- and octa-dioxins contributing 15% and 80% to the analytical sum, respectively—findings that align with those reported by Poma et al. (2019). Similarly, PBDE contamination was notable in insect-based samples (0.30–10 ng/g for ∑10 BDEs), with BDE-209 predominating at approximately 80% of the total, followed by BDE-47 (13%), and BDE-99 (8%). In conclusion, while this study provides essential preliminary data on the occurrence of POPs in novel foods, the limited sample size necessitates further, more comprehensive investigations. A broader range of food categories must be evaluated to ensure safety and compliance within the rapidly expanding novel food regulatory framework

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Legacy and Emerging Flame Retardants: Occurrence and Exposure

P-00645 Chlorinated and Brominated POPs in Mediterranean Seafood: Preliminary Results from the CAP-fish Project

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Introduction
Seafood consumption is a primary pathway for human exposure to persistent organic pollutants (POPs), such as polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs), polychlorinated biphenyls (PCBs), and polybrominated diphenyl ethers (PBDEs). In the Mediterranean Sea, the bioaccumulation of these hazardous substances is exacerbated by limited water exchange, posing significant public health concerns despite the nutritional benefits of fish. The CAP-fish project aimed to address data gaps in the Italian official monitoring system, which primarily targets farmed species, by assessing contaminant levels in wild-caught seafood and evaluating associated human health risks.

Materials and Methods
Within the framework of the CAP-fish project, a total of 290 samples from eight fish and shellfish species of major relevance to the Italian population, in terms of catch volume and consumption, were analysed. The investigated species included anchovies, sardines, pink shrimp, mantis shrimp, hake, mud mullet, cuttlefish, and octopus, collected from 12 Italian coastal regions. A multi-residue method was applied to determine trace levels of chlorinated (17 PCDD/Fs, 12 DL-PCBs, and 6 NDL-PCBs) and brominated (10 PBDEs) persistent organic pollutants. The analytical approach was based on isotope dilution, followed by gas chromatography coupled with high-resolution mass spectrometry detection.

Results
Preliminary results indicated that concentrations in the analyzed species were below European Union maximum levels[1]. PCDD/Fs ranged from 0.003 to 0.6 pg WHO-TEQ/g upper bound (ub), while DL-PCBs and NDL-PCBs ranged from 0.004 to 2.9 pg WHO-TEQ/g and 0.1 to 48 ng/g (ub), respectively. Sardines and mud mullet exhibited the highest contamination, with average values for the sum of PCDD/Fs and DL-PCBs reaching 1.8 and 0.9 pg WHO-TEQ/g, respectively. PBDE levels (Σ10PBDE) remained low ranging between 0.1 and 0.5 ng/g (ub). Moreover, in all the examined species, no correlation emerged between PCDD/F WHO-TEQ and Σ10PBDE, whereas Σ10PBDE showed a moderate association with DL-PCBs WHO-TEQ and a more marked relationship with NDL-PCBs. Contamination profiles showed similar trends across most species, in agreement with previous literature data[2]. In terms of total analytical concentrations, the PCDD/F pattern was dominated by 2,3,7,8-TCDF and 2,3,4,7,8-PeCDF, whereas mono-ortho PCBs 118, 105, and 156 accounted for over 99% of the DL-PCB fraction. Among NDL-PCBs, congeners PCB 153, 138, and 180 were the most abundant, reflecting the distribution patterns commonly observed in marine fish species. Cuttlefish represented the main exception, showing distinct contamination profiles for all three contaminant classes. PBDE profiles exhibited slight species-specific variations, however PBDE 47 and 209 were generally the most abundant congeners, followed by PBDE 99, 100, and 154. These preliminary findings had shown background levels for the considered Mediterranean species. Nevertheless, further investigations will also include large predatory species, such as tuna, which are known to bioaccumulate higher levels of POPs.

Acknowledgment
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P-00650 Comprehensive Evaluation of Total PFAS in Wastewater Treatment Plants Using Integrated Target, Suspect, and Non-Target Screening with Semi-Quantitative Analysis

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Introduction
Per- and polyfluoroalkyl substances (PFAS) comprise a broad range of compounds that may not be fully represented by conventional target analysis due to limited authentic standards and the occurrence of emerging compounds, precursors, and transformation products. As a result, PFAS contamination in wastewater treatment plants (WWTPs) may be underestimated when only target compounds are considered. Therefore, integrated assessment approaches are required to improve understanding of actual PFAS burdens and associated environmental risks.

Materials and Methods
In this study, integrated target, suspect, and non-target screening using liquid chromatography–high resolution mass spectrometry (LC–HRMS) was applied to comprehensively evaluate PFAS occurrence and Total PFAS in WWTPs in Korea.
A total of 37 target PFAS were analyzed across treatment stages. Additionally, suspect and non-target screening was performed to identify precursor- and transformation-related compounds.
To address limitations associated with unavailable authentic standards, concentrations of suspect and non-target compounds were estimated using a response factor prediction-based semi-quantification approach and incorporated into Total PFAS assessment. Concentration prediction models were developed according to PFAS structural classes using quantitative datasets, and prediction performance was evaluated by comparing predicted and measured response factors.

Results
Among the 37 target PFAS analyzed, 17 compounds were detected at least once. Additionally, 12 precursor- and transformation-related compounds were identified through suspect and non-target screening. PFAS composition and occurrence patterns differed depending on industrial sources and treatment conditions.
The proposed semi-quantification approach demonstrated acceptable prediction accuracy and supported the applicability of concentration estimation for compounds lacking authentic standards.
PFBS (1.7–63,000 ng/L), GenX (0–440 ng/L), and 6:2 FTS (8.1–350 ng/L) were identified as dominant PFAS in WWTP samples. Overall removal efficiencies ranged from –100% to 45%, indicating concentration changes throughout treatment processes.
Inclusion of semi-quantified compounds enabled broader interpretation of PFAS occurrence and compositional changes across treatment stages.

Discussion and Conclusion
These findings demonstrate the limitations of standard-based PFAS assessment and suggest that integrated screening combined with machine learning-assisted semi-quantitative approaches can support comprehensive Total PFAS evaluation and risk-informed environmental monitoring strategies.
The proposed framework enables concentration prediction according to PFAS structural classes and extends interpretation beyond conventional target-based quantification. This approach may contribute to more comprehensive environmental risk assessment and improved environmental monitoring strategies.

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P-00661 Non-Target Screening of Environmental Contaminants in Glaucous Gulls (Larus hyperboreus) from Svalbard Using High-Resolution GC×GC-TOFMS in EI and ECNI Mode

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Introduction
Glaucous gulls (Larus hyperboreus) are top predators of the Arctic and sub-Arctic, making them valuable sentinels for environmental contamination in polar ecosystems1,2 (Figure 1). This study investigated the occurrence and distribution of organic contaminants in liver samples from adult gulls collected at multiple locations across Svalbard using a non-target screening approach.

Materials and Methods
Glaucous gull liver samples (10 g) and two laboratory blanks (Na_2SO_4 only) were homogenized with Na_2SO_4, spiked with ^{13}C-PCB 159 and extracted twice with acetone/cyclohexane by orbital shaking and ultrasonication. Lipid removal proceeded in three stages: (1) freezing–lipid filtration; (2) HR-GPC and (3) Florisil column fractionation and concentrated to 100 µL in isooctane for instrumental analysis. Samples were analyzed by comprehensive two-dimensional gas chromatography coupled to high-resolution time-of-flight mass spectrometry (GC×GC-HRTOFMS) instrument, operated in both electron ionization (EI) and electron capture negative ionization (ECNI) modes.

Results
The orthogonal separation power of GC×GC improved resolution of co-eluting compounds compared to conventional one-dimensional GC, while high-resolution accurate mass data enabled confident identification and semi-quantification of a broad range of contaminants3.
A wide array of compounds was detected, including legacy persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs), organochlorine pesticides, and brominated flame retardants, as well as emerging contaminants and biogenically produced semi-volatile organic compounds (SVOCs). The dual ionization strategy proved particularly valuable: EI provided broad-spectrum coverage with library-matchable spectra, while ECNI enhanced sensitivity and selectivity for halogenated compounds.
Results were compared with data previously acquired on a single-dimension GC-HRMS platform, allowing direct evaluation of the analytical improvements offered by the GC×GC approach.

Discussion and Conclusion
These findings highlight the value of high-resolution GC×GC-TOFMS for non-target contaminant profiling in Arctic wildlife and contribute to a better understanding of POP exposure in a key sentinel species. Continued monitoring using next-generation analytical platforms is essential for tracking emerging contaminant threats in the Arctic.

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P-00661 Non-Target Screening of Environmental Contaminants in Glaucous Gulls (Larus hyperboreus) from Svalbard Using High-Resolution GC×GC-TOFMS in EI and ECNI Mode



Figure 1. Glaucous gull standing on an ice covered shelf in Svalbard.

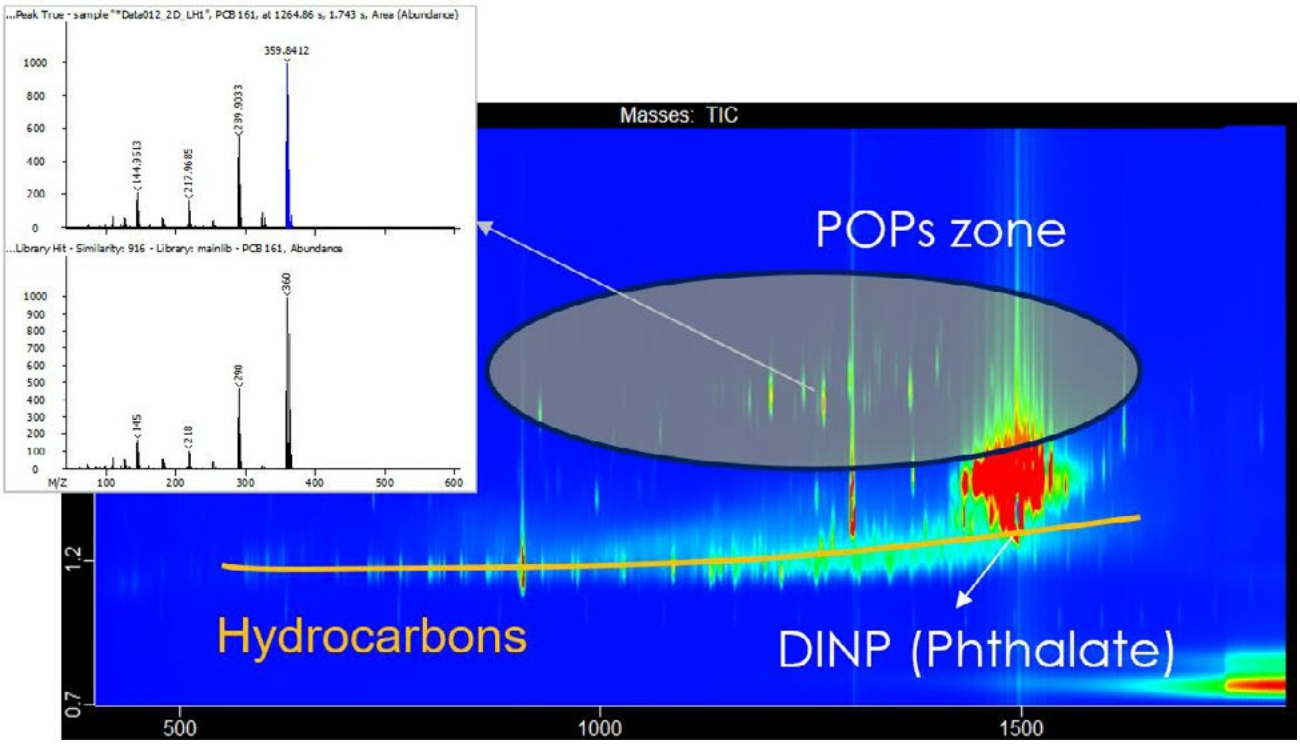


Figure 2. GC×GC-HRTOFMS analysis in EI mode of a glaucous gull liver sample. Inset shows the mass spectrum match for a HexaCB against the NIST library.

P-00663 Evaluation of Candidate Reference Materials for Routine Monitoring of Microplastics in Water Networks via µ-Raman Spectroscopy

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Introduction
The European Commission adopted in 2024 a harmonized methodology for measuring microplastics (MPs) in drinking water [1, 2]. This regulatory framework aims to establish standardized protocols to measure and map the extent of microplastic pollution across water networks. In particular, specific tests are required to evaluate MP recovery rates [3]. To validate the full analytical protocol, water samples must be fortified with a known quantity of clearly identifiable microplastics [4].
The added particulate material used as reference material (RM) must meet stringent criteria. It must possess adequate size, density, and numbers to evaluate recovery rates on both 100 µm and 20 µm filters employed during sampling. Furthermore, the document prescribes the achievement of specific analytical performances, primarily concerning the following conditions: at least two of the drinking water priority polymers must be tested, including one with a higher density and another with a lower density than water. For both tests, the number of spiked particles must strictly range between 50 and 150. The analytical procedure is deemed acceptable only if the recovery rate falls in 100% ±40%. These strict requirements make the selection of the most appropriate reference materials an essential topic for quality assessment in routine monitoring.

Materials and Methods
The investigation evaluated three distinct candidate formulations: (RM I) white polyethylene microspheres of different sizes and densities; (RM II) reference solutions containing fragments of mixed polymer composition, featuring both white and colored particles; and (RM III) a novel formulation in which particles are pre-counted and encapsulated within a water-soluble casing. For RM I, standard solutions were prepared by weighing and dispersing particles in a water-ethanol solvent, aiming to spike approximately 150 particles into the sampler module.

Results
The experimental data highlighted some performance differences among the formulations. The first candidate materials tested were white polyethylene microspheres (RM I) in three size fractions: 27–45 µm, 106–125 µm and 125-150 µm. Data showed that microspheres in the 27–45 µm fraction yielded acceptable recovery rates between 80% and 98%, the 106–125 µm fraction allowed recovery rates of only 82–94%, while 125–150 µm fraction allowed lower recovery rates: 79-82 %.
The investigation revealed that the larger, spherically shaped reference material suffered from structural handling issues. Due to their size and smooth geometry, these 125–150 µm polyethylene microspheres easily slid across the surface of the substrate. Consequently, they were partially lost during silica filter handling operations and transfer procedures required for µRaman measurements. Furthermore, perfect microsphere-shaped MPs do not accurately represent realistic environmental conditions.
To address these limitations, subsequent tests were conducted using candidate RM II (fragments between 10–100 µm containing ten different polymers) and RM III.

Discussion and Conclusion
The results contribute to identifying the most suitable RM for routine protocols. Notably, the study highlights the advantages of using pre-counted particles in a water-soluble casing (RM III). This formulation simplifies routine analysis, minimizes handling losses on silica filters, and significantly enhances the accuracy of MP measurement and mapping in drinking water networks.

Acknowledgment
ACQUEDOTTO PUGLIESE SpA, BARI - ITALY

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P-00690 Machine Learning and Artificial Intelligence in Environmental Forensic Contaminant Source Identification

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Introduction
Environmental forensic source identification in complex, multi-party United States Superfund site investigations present substantial data challenges. Sites contaminated with polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), per- and polyfluoroalkyl substances (PFAS), polycyclic aromatic hydrocarbons (PAHs), and other persistent organic contaminants typically generate large multivariate chemical datasets alongside voluminous historical documentary records spanning decades of industrial operation, regulatory correspondence, and remedial environmental investigation. Developing defensible source attribution conclusions requires both rigorous statistical analysis and systematic engagement with a vast evidentiary record. We present two complementary frameworks—an AI-driven document intelligence system and an interactive multivariate visualization platform—that together substantially advance the efficiency and defensibility of environmental forensic source identification.

Results
The first framework addresses the challenge of synthesizing large collections of site-specific historical documents, including deposition transcripts, manufacturing records, analytical reports, environmental investigation reports and regulatory submissions. We have developed an artificial intelligence system built on large language model (LLM)-based retrieval-augmented generation (RAG) that enables structured natural language querying across indexed document corpora. A critical innovation in this approach is the concept of knowledge nodes—curated, domain-specific reference sets that function as guardrails within the AI system. Knowledge nodes may take the form of keystone peer-reviewed literature relevant to a specific contaminant class, or comprehensive PRISM (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) research summaries that encode the current state of scientific consensus. By anchoring AI-generated responses to vetted, citation-traceable knowledge nodes, the system constrains outputs within a scientifically defensible boundary, reducing the risk of unsupported inferences that would be inadmissible in litigation contexts. This architecture has been applied across PCDD/Fs, PCB, PFAS, and PAH investigations to rapidly locate relevant site history, identify responsible parties, and retrieve supporting scientific literature. Examples of how this AI works will be provided from publicly available documents from Centredale Manor, Rhode Island (a superfund site in the USA).
The second framework addresses pattern recognition and source grouping within high-dimensional chemical datasets. We have developed an interactive visual data portal that integrates Uniform Manifold Approximation and Projection (UMAP), hierarchical cluster analysis (HCA), chemical fingerprint visualization, and geospatial mapping within a unified exploratory environment. UMAP projects the multivariate chemical space of contaminant profiles (congener distributions) into low-dimensional embeddings that preserve local and global data structure, enabling visual identification of sample clusters sharing common chemical signatures. HCA provides complementary hierarchical grouping, while geospatial mapping contextualizes identified chemical clusters within the physical geography of a site. Critically, the portal is fully interactive allowing subject matter experts to select a cluster of samples in UMAP space and instantly view the corresponding chemical fingerprints, dendrogram membership, and geographic distribution, or conversely, select samples by location and examine their multivariate chemical relationships. This interactivity enables rapid, data-driven hypothesis generation and source attribution that is not achievable through conventional statistical analysis. Case studies using this interactive tool will be demonstrated to show its efficacy in identifying various sources and patterns of contaminants.

Discussion and Conclusion
Applied across contaminant source identification cases in Superfund litigation, these frameworks have demonstrated substantial improvements in analytical throughput and evidentiary transparency. The knowledge node architecture ensures AI-generated insights remain anchored to scientifically credible reference material, while the visual data portal enables source identification that is both analytically rigorous and readily communicable to non-technical stakeholders. Together, they represent a meaningful advance in the application of machine learning and artificial intelligence to environmental forensic practice.

P-00697 Automated Modular 8-Sample PFAS Extraction, Cleanup, and Concentration in 90 min for Food, Soil, and Solid Samples

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Introduction
Per- and polyfluoroalkyl substances (PFAS) have been used in a wide variety of products, ranging from Teflon to firefighting foams and food packaging materials. As a result, PFAS compounds can be found in food, soil, biosolids, and other environmental samples. The publication of new analytical methods such as U.S. EPA Method 1633 has significantly increased the demand for reliable, rapid, and low-background PFAS sample preparation methods.
This paper describes a rapid automated 90 min sample preparation method for extraction, cleanup, and concentration of PFAS samples in food, soil, and other solid matrices prior to LC-MS analysis.

Materials and Methods
The method combines: One Step (PLE) Extraction & Concentration and EzVac Prep cleanup
into a streamlined workflow designed to reduce manual labor and sample preparation time.
Certified fish reference material from the European Commission Institute for Reference Materials and Measurements (IRMM) was used for method evaluation. Two grams of sample were spiked with isotopically labeled PFAS standards and extracted in stainless steel extraction cells packed with Ottawa sand.
Extraction conditions included: 20% acetonitrile / 80% basic methanol, ~ 1500 psi, 60 °C, and 10 min extraction time. Approximately 30 mL of extract from PLE was directly transferred to the concentration system and concentrated to about 5 m, followed by final cleanup using the EzVac Prep manifold with GCB/WAX/LipiZirTM cleanup cartridges to remove matrix interferences before LC-MS analysis.
The same workflow was also evaluated for beef, soil, and other solid samples.

Results
Results showed all certified PFAS values within accepted uncertainty ranges, with excellent reproducibility and RSD values comparable to the manual EPA Method 1633 workflow. The automated workflow reduced total sample preparation time from ~ 24 h for the manual method to ~ 90 min while maintaining excellent recoveries, low native background contamination, and reliable performance. Beef and solid samples spiked at different concentration levels also demonstrated excellent reproducibility with RSDs < 10%.

Discussion and Conclusion
Results of the work presented here demonstrate excellent sensitivity and reproducibility while using an automated modular workflow that is approximately 15 x faster than traditional manual methods. Native PFAS background of the PLE system with Ottawa sand used as diluent was < 0.02 ng/g. Labeled PFAS recoveries were within the performance windows required by EPA Method 1633. The combination of automated PLE extraction, concentration, and EzVac Prep cleanup using GCB/WAX/LipiZir cartridges provides a simplified and reliable approach for PFAS analysis in complex food and environmental matrices.
Automated modular 8-sample extraction, cleanup, and concentration using PLE and EzVac Prep provides a fast, reliable, and low-background alternative to traditional manual PFAS sample preparation methods for food, soil, and solid samples.

P-00699 Automated Dual Vacuum and Positive Pressure SPE Cleanup of PFAS Extracts from Water, Wastewater, and Biosolids

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Introduction
PFAS compounds are widely distributed environmental contaminants commonly found in water, wastewater, biosolids, and other environmental matrices. EPA Method 1633 provides a framework for PFAS analysis using extraction, cleanup, concentration, and LC-MS/MS analysis. Existing vacuum-based extraction systems often suffer from pressure variation and inconsistent solvent delivery, while fully pressurized systems can experience clogging and failures caused by particulates passing through sensitive pumps, valves, and filtration components. The work presented here describes a patent-pending automated dual vacuum and positive pressure SPE cleanup approach designed to overcome these limitations.

Materials and Methods
Wastewater samples (500 mL) and biosolid samples (5 g) were analyzed following EPA Method 1633. Water and wastewater samples were processed directly using WAX SPE cartridges. Biosolid samples were extracted with 30 mL methanol either manually or using Pressurized Liquid Extraction (PLE) at ~1500 psi and 60 °C for 10 min. Biosolid extracts were concentrated to ~5 mL at 60–70 °C and diluted to 50 mL de-ionized water prior to cleanup. Automated cleanup was performed using a dual vacuum and positive pressure SPE system equipped with WAX and GCB/WAX cleanup cartridges prior to LC-MS/MS analysis.

Results
The vacuum-assisted sample loading enabled direct transfer of water, wastewater, and biosolid extracts onto the SPE cartridges while minimizing cartridge clogging caused by suspended particulates. Positive pressure solvent delivery provided accurate solvent volumes and optimized flow control, resulting in excellent reproducibility and improved cleanup consistency. Recoveries of isotopically labeled PFAS surrogate compounds were generally between 70–120% for all matrices analyzed with low PFAS background contamination and minimal matrix interferences during LC-MS/MS analysis.

Discussion and Conclusion
The automated dual vacuum and positive pressure workflow demonstrated excellent sensitivity, reproducibility, and low native PFAS background contamination across water, wastewater, and biosolid matrices. The vacuum mode allows direct sample loading to the cartridges, reducing clogging problems commonly observed in pressurized systems. Positive pressure solvent delivery enables precise solvent handling and optimized flow rates for greater reproducibility during conditioning, washing, and elution steps.
The dual vacuum and positive pressure SPE cleanup approach provides a reliable, low-background, and reproducible solution for PFAS analysis in water, wastewater, and biosolid samples following EPA Method 1633. Combining vacuum-assisted sample loading with precise positive pressure solvent delivery improves reproducibility, reduces clogging, and enhances overall system reliability for complex environmental sample preparation.

P-00705 Performance evaluation of a new tailor-made solid-phase extraction column optimized for Multicomponent PFAS Analysis

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are organic fluorine compounds that are increasingly recognized as environmental pollutants globally. In recent years, many countries have developed testing methods for water, and investigations into the actual presence of PFAS are ongoing. However, PFAS exposure is not limited to water; it also occurs through various environmental media such as air, soil, rain, and notably through food products. Since PFAS can be detected in different environments and foods, there is a strong need to establish accurate analytical methods not only for water but also for all environmental media and food samples.

Currently, the analytical methods proposed by the U.S. EPA and FDA do not fully meet these needs, resulting in a cycle of trial and error at analytical laboratories globally. The most challenge is that the types and amounts of foreign substances vary between samples, making it difficult to perform uniform extraction and purification methods. This is especially for complex matrices such as bottom sediments, foods, and agricultural products. the U.S. FDA has recommended a method based on QuEChERS, which is simple and effective for screening, however, it has limitations regarding the precise quantification of total PFAS. In this study, we addressed these challenges by combining a custom-made solid-phase extraction (SPE) column tailored to each sample's specific matrix, based on a method developed by the National Institute of Agro-biological Sciences (NIAS). Using this method, we simultaneously purified 30 PFAS components and 24 labeled PFAS components, which are of major concerns globally. We demonstrated the effectiveness of this method using a variety of sample types.

Materials and Methods

PFAS extraction and subsequent sample preparation were performed according to a custom-designed method developed by the National Institute for Environmental Studies (NIES). The extracted solution was purified using an anion exchange solid-phase extraction column and a carbon solid-phase extraction column. During this process, both the solvent used and the amount of packing material in the purification columns were optimized. The resulting post-treatment solution was analyzed by LC-MS/MS.

Confirmation of Purification Effectiveness of Each Sample: For each sample, optimal extraction and preparation procedures were performed. The resulting eluents were processed using one of two tailor-made SPE columns (Types A, and B). The appropriate column was selected based on the condition that the color of the extractant became nearly transparent, indicating effective purification.

Evaluation of the recovery of 24 Labeled PFAS components in the solid-phase extraction of each sample : Internal standard solutions were added to each sample beforehand. The samples were then concentrated, adjusted to pH 4 or below, and purified using the corresponding tailor-made SPE column. The purified extract was analyzed by LC-MS/MS to determine the recovery rates of the 24 labeled PFAS components.

Results

C**onfirmation of Purification Effect:** The results demonstrated effective purification, as evidenced by the nearly transparent extract solutions obtained using the two different tailor-made SPE columns under optimized conditions.

Recovery of the PFAS Components: The results of addition and recovery of 24 labeled PFAS components in each sample Showed good recoveries for all samples.

Discussion and Conclusion

Using the newly developed tailor-made solid-phase extraction column, we confirmed that high purification efficiency is maintained while achieving good recovery rates for multiple PFAS components. By optimizing the steps from extraction to purification for each sample, we improved the removal of matrix components, which has been a conventional challenge, and established a method that allows preparation of sample solutions applicable to LC-MS/MS analysis in a single purification step. In future studies, we will examine the applicability of this method to a wider variety of soil samples.

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P-00716 Bisphenol A causes melatonin biosynthesis epigenetic reprogramming of melatonin biosynthesis genes in arabidopsis thaliana

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Introduction
Bisphenol A (BPA) is a widely used chemical that is commonly found in soils and surface waters worldwide and acts as an oxidative stressor on plants. Our understanding of how BPA exposure affects cellular redox homeostasis remains limited. We discovered that the epigenetic reprogramming of melatonin biosynthesis helps defend against oxidative stress induced by BPA in Arabidopsis. Five key BPA-responsive genes were identified, with AT1G26220 (encoding SNAT2) showing exceptional specificity to BPA and its analogs in various tissues. BPA binding to consecutive M1-M2 elements in the AT1G26220 promoter led to decreased H3K9ac and H3K14ac levels, subsequently significantly reducing AT1G26220's expression. It alters the melatonin biosynthesis pathway in order to maintain the redox homeostasis in plants by increasing the cellular antioxidative capacity and alleviating specific BPA-induced cellular damage. This epigenetic reprogramming changes the melatonin biosynthesis pathway, enhancing the dynamic redox homeostasis in plants. Additionally, this specific oxidative response in plants reduces the harmful effects of BPA to some extent. Our study finds a sophisticated and structure-specific epigenetic response to BPA in plants, providing a solid molecular mechanism that enhances our understanding of plant resistance to BPA at the cellular level and contributes to assessing BPA risks globally.

P-00725 Feasibility Evaluation of GC-MS/MS for Efficient Determination of Persistent Organic Pollutants (POPs) as an Alternative to GC-HRMS

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Introduction
Gas chromatography–high resolution mass spectrometry (GC-HRMS) has long been established as the gold standard for the trace-level determination of persistent organic pollutants (POPs) such as dioxins. However, the global discontinuation of GC-HRMS instrumentation, compounded by its high operational complexity, excessive power consumption, and substantial maintenance costs, has created an urgent need for reliable alternative analytical platforms. In this study, gas chromatography–tandem mass spectrometry (GC-MS/MS) was selected as a candidate replacement owing to its high sensitivity in quantitative analysis and operational accessibility, and its feasibility as a practical and sustainable alternative to GC-HRMS for routine environmental monitoring was systematically evaluated.

Materials and Methods
Comprehensive comparative analyses were conducted on authentic environmental samples from three matrices — stationary source emission gas, ambient air, and soil — targeting PCDD/Fs, dl-PCBs, hexachlorobenzene (HCB), and pentachlorobenzene (PeCB). All sample preparation was performed in accordance with the Korean Environment Standard Test Methods for Persistent Organic Pollutants: emission gas samples following ES 10902.1b, ambient air following ES 10901.1b, and soil following ES 10907.1c. Solid-phase fractions were extracted by Soxhlet extraction and liquid-phase fractions by liquid–liquid extraction (LLE), followed by sequential purification using multi-layer silica gel and alumina column chromatography. Instrumental analyses were performed using a GC-HRMS (JMS-800D UF, JEOL Ltd., Japan) and a GC-MS/MS (JMS-TQ4000GC, JEOL Ltd., Japan). For GC-HRMS analysis, chromatographic separations were carried out on the following capillary columns according to target analyte: PCDD/Fs were analyzed on both an SP-2331 (60 m × 0.32 mm × 0.20 μm) and a DB-5MS UI (30 m × 0.25 mm × 0.25 μm) for confirmatory dual-column analysis; dl-PCBs were separated on a DB-5MS UI (60 m × 0.25 mm × 0.25 μm); and HCB and PeCB were analyzed on a DB-5MS UI (30 m × 0.25 mm × 0.25 μm). For GC-MS/MS analysis, PCDD/Fs and dl-PCBs were separated on a DB-5MS UI (60 m × 0.25 mm × 0.25 μm), while HCB and PeCB were analyzed on a DB-5MS UI (30 m × 0.25 mm × 0.25 μm).

Results
GC-HRMS analysis has been completed for all three matrices, while GC-MS/MS analysis is currently ongoing. Analytical equivalence between the two platforms will be assessed based on quantitative data and toxic equivalency (TEQ) values using correlation analysis and paired t-test.

Discussion and Conclusion
This study is expected to provide critical empirical evidence supporting the global regulatory transition towards GC-MS/MS for the continuous monitoring of dioxins and related POPs, and to serve as a scientific basis for future revisions of the domestic Korean Environment Standard Test Methods for POPs analysis.

Advances in the (bio)remediation of POPs

P-00726 POPs-like hazardous compounds in textile effluent from developing nations: their remediation using an integrated native macrophyte-microalgae approach

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Introduction
Textile industry effluents (TIE) are mixtures of dyes, carcinogens, heavy metals, fibres, and recalcitrant pollutants, posing risks to human life and aquatic health. Synthetic dyes, like azo dyes, share characteristics similar to POPs, including persistence due to aromatic ring stability, bioaccumulation potential, and carcinogenic by-products [1]. While classical POPs are regulated under the Stockholm Convention, specific azo dyes are banned under EU REACH and the national legislation of many countries, such as China, Japan, India, Vietnam, yet these dyes are widely used and unmonitored. This study characterizes POPs-analogous compounds from real TIE and examines their degradation using an integrated treatment system (ITS) with native macrophytes (Ludwigia adscendens) and a microalgae consortium (Chlorella sp., Scenedesmus sp., and Oocystis sp).

Materials and Methods
TIE was collected from drain outfall of textile industries at Gaya, Bihar, India. The colour, organic, nutrient, and heavy metals (Pb, Cr, Cd, Cu) load were quantified using standard protocols. The screening of macrophytes and microalgae from TIE-affected area was done using quadrate sampling and standard plating methods, respectively. Removal of quantified pollutants from TIE, and degradation of POPs analogous compounds in the ITS were monitored using UV-visible spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), and Gas Chromatography Mass Spectrometry (GC-MS). The toxicity of treated TIE was assessed on Ceriodaphnia sp. using acute bioassay.

Results
GC-MS identified 4-nitroanisole (by-product of banned Disperse Orange 3), butylated hydroxytoluene (BHT), and phthalate esters, with other textile industry auxiliaries. The untreated TIE exceeded the permissible limits of Central Pollution Control Board, India, for BOD, COD, Pb, and Cd. The ITS significantly reduced >85% organic load, and ~ 80% heavy metals outperforming mono-treatment systems. Further 4-nitroanisole, BHT, and carcinogenic aromatic amines were degraded and not detected in ITS. The acute bioassay result indicated 96.6 % survival rate of Ceriodaphnia sp compared to 20% in untreated TIE.

Discussion and Conclusion
The performance of the ITS was due to synergistic interaction between L. adscendens and microalgae consortium. Macrophyte reduced the toxicity of TIE, facilitating algal growth, which further reduce nutrients and heavy metals [2]. The complete degradation of 4-nitroanisole and BHT, with no carcinogenic aromatic amines in the ITS, indicates biomineralization of POPs analogous intermediates [3], which enhance Ceriodaphnia sp. survivability. However, phthalate esters were persistent across all treatment systems, which highlights the limitations of the current bioremediation approach for specific recalcitrant plasticizer class pollutants and the need for complementary treatment methods. This ecologically adapted, cost-effective integrated bioremediation approach demonstrates strong potential for sustainable treatment of hazardous recalcitrant pollutants in TIE affected areas.

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P-00729 An AHP-Based Multi Criteria Decision Analysis to Evaluate Governance Strategies for Novel Entities

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Introduction
Novel entities, newly synthesized or unintentionally emerged compounds, including their metabolites, constitute one of the complex dimensions of the Triple Planetary Crisis, which describes climate change, biodiversity loss and pollution that collectively threaten stability of Earth. Unlike other planetary boundaries, defining a control variable for novel entities is challenging due to their heterogeneity, spatiotemporal variability, and equity dimensions (Smit et al., 2026). These substances follow a recurring paradigm. They enter the environment, accumulate, then are scrutinized through toxicological/risk assessment studies, while alternative substances for which proactive studies are not carried out, end up becoming part of the same cycle. As harms are well-documented, as in the cases of PFAS, the problem shifts into the domain of management and harm mitigation. The efforts built upon the global scale novel entity problem were documented in literature and horizon scanning studies underscore severity of the issue (Green et al., 2023; Scheringer et al., 2026). Existing actions have their own limitations that lag far behind the rate of entry of novel entities. Current governance responses remain fragmented across regulatory bodies, industry, science, and engineering each operating under different objectives, timelines, and value systems, producing conflicting priorities and gaps. Multicriteria decision analysis (MCDA) has been widely applied in environmental studies, yet, its potential is not utilized in the aforementioned complex problem. The aim of this study is to comparatively evaluate strategies for the management of novel entities across multiple stakeholders, by using a structured Analytical Hierarchy Process (AHP) based MCDA.

Materials and Methods
A preliminary assessment was attempted in this study to identify an effective governance strategy for novel entity management by the use of a structured AHP-based MCDA. A set of evaluation criteria (i.e., banning, restriction, essential use exemptions, substitution alternatives, green chemistry, benign-by-design principles, prospective hazard assessment, persistence-mobility-toxicity screening, advanced treatment) was derived from the literature. An expert survey is prepared to extract pairwise comparisons at both the criteria and strategy levels. Consistency ratio check and sensitivity analysis also constitutes part of the study.

Results
The AHP hierarchy was structured into four governance strategy alternatives, namely, regulatory control, industrial response, scientific assessment, and engineering intervention, with a set of evaluation criteria including effectiveness, feasibility, economic cost, precautionary value, and cross-sector applicability (Malloy et al., 2013). Expert responses are currently being collected and analyzed.

Discussion and Conclusion
By integrating environmental, technical, economic, and regulatory criteria within an AHP-based hierarchy, this preliminary assessment study has the potential to put forth wide stakeholder perspectives to assess strategies and trade-offs across multiple sectors for effective management of novel entities.

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P-00731 Decoupling of bioaccumulation and trophic magnification in methylsiloxanes: Evidence from the Tokyo Bay marine food web

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Introduction
Methylsiloxanes (MSs), including cyclic MSs and linear MSs, are widely used in silicone manufacturing and consumer products. Several cyclic MSs have attracted increasing attention because of their persistence, widespread occurrence, long-range transport potential, and bioaccumulative properties, leading to their consideration as POPs-like contaminants 1. While elevated bioaccumulation factors (BAFs) have been reported for some MSs, evidence for trophic magnification remains inconsistent. The objective of this study was to evaluate trophic transfer and biomagnification of MSs in the Tokyo Bay marine food web.

Materials and Methods
Pelagic and benthic organisms representing eight species and seawater samples were collected from Tokyo Bay, Japan. Target analytes included cyclic, linear, and modified MSs. Concentrations were determined by GC-MS. Trophic positions were estimated using stable nitrogen isotope ratios (δ15N), and trophic magnification factors (TMFs) were calculated by weighted least-squares regression of lipid-normalized concentrations against trophic position. In addition, BAFs were evaluated using bivalves and seawater samples collected from Japanese coastal waters.

Results
MSs were widely detected in seawater, bivalves, and food-web samples throughout Tokyo Bay. D5 was the predominant compound and exhibited broad spatial distribution in seawater. TMFs were estimated for eight compounds with detection frequencies greater than 50%. TMF values ranged from 0.18 for L4 to 2.4 for D4. Most MSs showed TMFs below unity or confidence intervals overlapping unity, whereas D4 exhibited significant trophic magnification. In the complementary coastal monitoring study, D4, D5, and D6 exhibited BAF values exceeding 5,000.

Discussion and Conclusion
Despite elevated BAFs, most MSs exhibited limited trophic magnification in the Tokyo Bay food web. D4 was the only compound showing both high bioaccumulation potential and significant trophic magnification. The findings support the concept that bioaccumulation and trophic magnification represent distinct ecological processes 2. While elevated BAFs reflect efficient uptake from environmental media, they do not necessarily indicate efficient trophic transfer through food webs. The relatively low octanol–air partition coefficients (KOA) of MSs compared with classical POPs such as PCBs may partly explain the limited trophic magnification observed for D5 and D6 despite their substantial bioaccumulation from seawater 3.
Overall, the findings highlight that BAF alone may overestimate trophic transfer potential and that both BAF and TMF should be considered when assessing the POPs-like bioaccumulation characteristics of MSs in aquatic ecosystems.

Acknowledgment
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P-00735 Per- and polyfluoroalkyl substances (PFAS) in process wastewater from different industries

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are a large and structurally diverse class of synthetic compounds that have been widely used in different industrial applications due to their unique physiochemical properties, including chemical and thermal stability, low surface energy, and surfactant properties [1,2] Industrial process wastewater can be an important pathway for their emission to the environment, yet the chemical diversity of these emissions remains insufficiently characterized. In this study, target analysis and suspect screening were combined to investigate the occurrence of PFAS and inorganic fluorinated anions in source-specific industrial process wastewater samples and in pooled wastewater separated by conductivity before treatment at a waste management facility.

Materials and Methods
Pooled wastewater samples were collected from two different tanks at the waste management facility, a high conductivity tank (HCW) and a low conductivity tank (LCW), the samples were collected from both tanks once a week for five weeks (February-April 2024). Additionally, 26 individual source specific samples were collected between February 2024 and May 2025. Aliquots of the samples (50 mL) were extracted according to ISO 21675 method with some modifications [3]. The extracts were analyzed using LC-MS/MS, SFC-MS/MS, and LC-qTOF.

Results
Target analysis of the pooled process wastewater showed that the PFAS profile varied between weeks but no significant difference between the conductivity separated tanks was seen. The sum concentration of 49 detected PFAS in pooled samples ranged between 222 ng/L and 26513 ng/L. The PFAS profile and concentrations of the source specific samples varied and were not explained by industrial category alone, indicating the importance of site-specific processes and temporal variation. Fluorotelomer sulfonates were among the most frequently detected PFAS, with 6:2 FTSA detected in 92% of the samples and reaching 1283 ng/L. PFOS was also detected in several samples despite regulatory restrictions, with maximum linear and branched PFOS concentration reaching 3382 and 3244 ng/L, respectively. Short-chain and ultra-short-chain PFAS were also observed, including PFBS, PFBA, TFA, and PFPrA. Notably, PFBA reached 10476 ng/L in process wastewater from a metal distribution and processing facility, representing the highest concentration observed for any target PFAS in the study.
The inorganic anions BF4-, PF6-, and FSI- were detected in both source specific samples and pooled samples at higher concentrations compared to PFAS.
Suspect screening further revealed structurally diverse fluorinated compounds beyond the routinely monitored PFAS, including bisphenol AF, fluorotelomer-based precursors, sulfonamidoacetic acids, hydrogen-substituted PFCA, fluorotelomer silanes, and electrolyte-related transformation products. Overall, the results demonstrate that industrial process wastewater contains a complex mixture of conventional PFAS, precursor-related compounds, inorganic fluorinated anions, and other fluorinated substances not captured by routine target analysis. The study highlights the need for broader fluorochemical monitoring strategies that combine target analysis, suspect screening, repeated sampling, and source-specific sampling to better characterize industrial wastewater emissions and identify emerging fluorochemical source signatures.

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P-00741 Toxicity evaluation of soil from open burning areas of textile and plastic waste in the Atacama Desert, Chile

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Introduction
Burning of textiles and plastic waste in illegal dumping sites is a frequent practice in the Atacama Desert. This activity releases chemicals with potential toxicity towards biota. The use of model organisms, such as animals and plants allow the evaluation of the toxic effect of chemicals1. The aim of this study was to determine the toxicity of the soil from sites where illegal burning occurs in Alto Hospicio (Iquique, Chile) using Daphnia magna and Ostracoda sp. as animal model organisms, and Chenopodium quinoa and Lactuca sativa as plant models.

Materials and Methods
Two different elutriates were prepared containing a mixture of soil from the study area and organism culture water in a ratio of 1:4 mixture (100%) agitated for 1, 24, or 72h, and a 1:2 mixture (300%) agitated for 24h. To evaluate acute toxicity (mortality), juveniles of D. magna2 and Ostracoda sp.1 (n=10) were exposed to 0, 1.56, 3.13, 6.25, 12.5, 25, 50, and 100% to the 48h elutriate. For chronic toxicity (number of offspring), neonates of D. magna3 (n=1) were exposed to 0, 0.39, 0.78, 1.56, 3.13, 6.25, and 12.5% to the 24h elutriate for 21d. Toxicity in C. quinoa and L. sativa was evaluated using seed germination bioassays exposing seeds (n=25) to concentrations ranging from 0 to 300% of the elutriate for 120h. All bioassays were performed in triplicate.

Results
Mortality in D. magna was 67% at the 100% of 1h elutriate, 100% at 25% of 72h elutriate, and 40% at 3.13% of 24h elutriate ($p<0.05$). This 24h elutriate also caused mortality in Ostracoda sp. at concentrations from 1.56 to 12.5%. The number of offspring of D. magna increased at higher concentrations of the 24h elutriate compared to control. Germination (%) of C. quinoa rose between 2h (0-5.3%) and 8h (13.3-29.3%) compared to the 48h (100%) at 3.13-100%. The 300% concentration showed significant lower germination between 8h (11%) and 12h (23%) compared to the control (47-88%) and the 100% concentration (13-43%) at the same time ($p<0.05$). At 24h, L. sativa showed higher germination at concentrations of 0-12.5% (13-20% germination) than at 25-300% (0-3% germination). By 72h, germination exceeded 90% in all treatments, except at 300%, where inhibition was complete (0% germination).

Discussion and Conclusion
Soil elutriates from sites of illegal burning of textile and plastic waste in Alto Hospicio have a toxic effect on the organisms tested. The 24h elutriate was most toxic during acute exposure. D. magna was more sensitive to this exposure than Ostracoda sp. The increase of D. magna offspring after 21d could indicate an adaptive stress response4. C. quinoa and L. sativa showed delayed germination after elutriate exposure, particularly at 100 and 300%, with L. sativa being more sensitive than C. quinoa. These results suggest that other species inhabiting the Atacama Desert could also be affected by the toxics released during textile and plastic waste burning activities.

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P-00743 Do my arteries contain microplastics? Characterization of carotid plaques using comprehensive two-dimensional gas chromatography and high-performance time-of-flight mass spectrometry

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Introduction
Microplastics, defined as plastic particles smaller than 5 mm, have been detected in human tissues and fluids, including vascular structures, which raises concerns about their potential role in disease. These particles can act as carriers for hazardous additives and environmental contaminants and have been linked to biological effects such as inflammation and oxidative stress. Their presence in carotid plaques highlights the need for sensitive analytical techniques that can characterize low-abundance, heterogeneous polymeric materials in complex biological matrices.

Materials and Methods
Carotid plaque samples were collected, pulverized, chemically digested, density-separated, and deposited onto glass fiber filters. Two 8 mm filter sections were transferred to quartz liners for analysis. Samples were analyzed using thermal desorption and pyrolysis coupled with comprehensive two-dimensional gas chromatography and time-of-flight mass spectrometry (GC×GC–TOFMS). Thermal desorption enabled characterization of volatile and semi-volatile additives and adsorbed compounds, while pyrolysis generated polymer-specific fragment markers for material identification. GC×GC–TOFMS provided enhanced chromatographic resolution, rapid spectral acquisition, and high sensitivity for resolving complex mixtures. Data processing included untargeted peak detection with spectral deconvolution, database matching, and mass

Results
Microplastic-associated markers corresponding to polystyrene, nylon, polyvinyl chloride, polyethylene, and polyethylene terephthalate were detected in carotid plaque samples. Retrospective interrogation of GC×GC–TOFMS datasets using targeted analyte finding resulted in the characterization of pyrolytic markers using retention windows and mass delta thresholds for pinpoint accuracy detection.

Discussion and Conclusion
The results highlight the effectiveness of GC×GC–TOFMS for detecting and characterizing microplastic-associated markers in complex matrices. Polymer-specific pyrolytic markers for polystyrene, nylon, polyvinyl chloride, polyethylene, and polyethylene terephthalate were confidently identified. The combined thermal desorption and pyrolysis workflow provided complementary information, enabling both additive profiling and definitive polymer fingerprinting. Enhanced chromatographic resolution and spectral deconvolution improved detection of trace-level components, while retrospective targeted screening using retention windows and mass delta thresholds increased selectivity and confidence. Overall, this approach represents a robust, sensitive, and versatile platform for comprehensive microplastic characterization in challenging samples, supporting both untargeted discovery and targeted analysis workflows.

Screening and identification of novel contaminants

P-00750 Comprehensive characterization of chemicals in mainstream smoke from heated tobacco products using GC×GC-TOFMS

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Introduction
Heated tobacco products (HTPs) have become popular in recent years. The formation of many harmful combustion-derived compounds is expected to be reduced because HTPs operate at lower temperatures than conventional cigarettes. However, the presence of various flavors and additives in HTPs may lead to the formation of previously unidentified compounds. Comprehensive characterization of mainstream smoke is challenging using conventional gas chromatography–mass spectrometer (GC-MS) in scan mode due to the severe peak overlap caused by its complex chemical composition. In contrast, two-dimensional gas chromatography–time-of-flight mass spectrometry (GC×GC-TOFMS) provides enhanced chromatographic resolution and enables comprehensive chemical characterization. In this study, mainstream smoke from HTPs was analyzed using GC-MS and GC×GC-TOFMS to characterize known and previously unidentified compounds.

Materials and Methods
Three HTP devices and six product variants were selected for analysis. Mainstream smoke was collected using an automatic smoking machine operated in accordance with the Health Canada Intense regime. Particulate matter in the mainstream smoke was collected on a glass fiber filter pad. After the sampling, the filters were ultrasonically extracted three times with 30 mL of dichloromethane for 15 min each. The combined extracts were evaporated and transferred to vials. The samples were further concentrated and analyzed using GC-MS in scan mode and GC×GC-TOFMS. The GC×GC-TOFMS data were subjected to untargeted analysis with ChromaTOF software coupled with the built-in National Institute of Standards and Technology Mass Spectral Database.

Results
GC×GC-TOFMS separates compounds based on their polarity by combining a non-polar primary column with a polar secondary column, thereby providing enhanced chromatographic resolution. Band-like peak groups corresponding to acyclic alkanes (n- and iso-alkanes) and hydrocarbons substituted with carboxylic acid structure, aldehyde, and polyoxyethylene functional groups, were observed.
Menthol and nicotine were identified in the GC-MS chromatograms and were also identified by the GC×GC-TOFMS analysis. In addition, compounds that could not be resolved in the GC-MS chromatograms due to peak overlap with menthol and nicotine were successfully separated and identified by the GC×GC-TOFMS analysis.
Furfural, 5-methylfurfural, and 3,5-dihydroxy-6-methyl-2,3-dihydropyran-4-one were detected in the GC-MS chromatograms. These furan derivatives and other oxygen-containing heterocyclic compounds are known to be generated during heating processes. A previous study reported the presence of these compounds in mainstream smoke from HTPs sold in Japan [1]. In addition to these compounds, 5-acetoxymethyl-2-furaldehyde, dihydrobenzofuran, and loliolide were newly detected in HTP mainstream smoke by GC×GC-TOFMS analysis.

Discussion and Conclusion
The results showed that a wide range of compounds were present in mainstream smoke from HTPs. In particular, 5-acetoxymethyl-2-furaldehyde was detected only in products associated with one HTP device. This compound contains both a furan ring and an acetoxy functional group. Previous studies have reported that this compound is formed at approximately 250°C as an intermediate during reactions associated with the heating of sugars [2]. These findings suggest that certain compounds were specifically formed from precursors such as amino sugars and polysaccharides in tobacco leaves, depending on the heating temperature (approximately 300°C) and the device-specific heating system of HTPs. In addition to these identified compounds, device-specific peaks were also observed in certain tobacco products. In future studies, we plan to identify the unknown compounds by acquiring accurate mass data using GC-Orbitrap-MS and applying in silico structure prediction tools that do not rely solely on mass spectral libraries.

Acknowledgment
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P-00754 Effects of perinatal dioxin exposure on regional brain activation monitored by near-infrared spectroscopy (NIRS) during performing function-related tasks in 16-17 years children from Da Nang birth cohort in Vietnam: A preliminary analysis

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Introduction
In 2008-9, we recruited birth cohorts residing near former Da Nang airbase in Vietnam (Da Nang birth cohort) and measured dioxin levels in breast milk. From 4 months of age, we followed up birth cohort children and increased autistic traits (poor social and communication abilities) at 3-years of age in children of both sexes associated with increased 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) exposure [1]. We also found children having increased risks with ADHD symptoms and learning difficulty in high exposed groups to TCDD/TEQ-PCDFs at 8 years of age [2]. However, these findings were based on their behavior observed by caretakers, not on biological alteration during their performance. Recently, mobile functional Near-infrared spectroscopy (fNIRS) of prefrontal cortex (frontal part of the frontal lobes of brain) is often used to measure regional brain activity induced by task performance for individuals with cognitive deficits in the daily living environment. Therefore, in the present study, we monitored brain activation in prefrontal area using mobile near-infrared spectroscopy (NIRS) during performing function-related tasks in the local area to clarify the effects of perinatal dioxin exposure on brain function.

Materials and Methods
A total of 127 children from a Da Nang birth cohort participated and completed all necessary tasks in the present study when they reached 16-17 years of age. Brain activity indicated by NIRS signals (changes of light absorption by cortex) of HOT-2000 (Neu) associated with hemoglobin levels of brain blood flow during 2 kinds of performance, the Fist-Edge-Palm (FEP) task (a sequential hand movement) and palm tapping (a reference task). Each task was repeated 3 times in the same protocol. Also, mean levels of left and right NIRS signals were compared between FEP task and reference task in each trial by the paired t-test in high and low TEQ- PCDD/Fs exposure groups with 17.5 (pg-TEQ/g lipid) of the cut-off levels, respectively. In addition, general linear model was used to compare the means of NIRS signals at the first trial between high and low TEQ- PCDD/Fs exposure levels after adjusting confounding factors.

Results
During the first trial of FEP, NIRS signals in the right prefrontal area were significantly increased compared with those during the first trial of reference task in the low TEQ-PCDD/Fs group in boys. Whereas, no significant difference of signals between FEP and reference tasks were found in the high TEQ-PCDD/Fs group, suggesting that brain activity induced by FEP task may be suppressed by dioxin exposure. NIRS signals were decreased as trials continued and no significant differences between FEP and reference tasks were found during the 2nd and 3rd trials. Right NIRS signals during reference task were significantly lower in high TEQ-PCDD/Fs group compared with low exposure group, as well as signals during FEP task, suggesting dioxin influence not only sequential hand movements but also simple hand movements, although reduction of activity was larger for FEP task

Discussion and Conclusion
In the present study, perinatal dioxin exposure originating from Agent Orange was suggested to impair neuronal activity in the prefrontal cortex, particularly in the right brain, during the process of learning motor behavior. However, prefrontal cortex is also involved to learning process of cognitive skills. In future, we will investigate the relationships between NIRS signals and executive functions to clarify dioxin effects on brain functions.

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P-00758 Accelerated Solvent Extraction of Per- and Polyfluoroalkyl Substances in Thermally Reactivated Granular Activated Carbon

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Introduction
Granular activated carbon (GAC) adsorption is widely used to remove recently regulated per- and polyfluoroalkyl substances (PFAS). Thermal reactivation of PFAS-laden spent GAC has great potential to break the accumulation of PFAS within the environment and to reuse reactivated GAC [1]. However, information on solvent extraction methods for determining PFAS in thermally reactivated GAC remains limited. Accurate determination of PFAS in thermally reactivated GAC is essential for assessing the potential risk of PFAS contamination associated with the reuse of reactivated GAC. Here, we examined the applicability of a conventional shaking–ultrasonic extraction method [2] and an accelerated solvent extraction (ASE) system for quantifying PFAS in thermally reactivated GAC.

Materials and Methods
Four thermally reactivated GAC samples (A–D) collected in Japan between 2025 and 2026 were examined in this study. Sample A, B, and D were obtained from landfill leachate treatment plants and sample C was collected from a potable water treatment plant. Three samples A, C, and D were petroleum-based activated carbons, and sample B was coconut shell–based. After grinding each sample to <1 mm, the samples were spiked with 13 isotope-labeled compounds (Wellington Laboratories MPFAS-C-ES) and extracted using either a conventional shaking–ultrasonic method or an ASE system (Dionex ASE350), with methanol containing 0.3% ammonia used as the extraction solvent in both methods.

Results
The shaking–ultrasonic extraction method showed recoveries of ≥70% for 12 of the 13 isotope-labeled compounds in samples A–C, whereas M2PFTeDA exhibited lower recoveries of 56%, 65%, and 69%, respectively. In sample D, recoveries of ≥70% were obtained for 8 of the 13 isotope-labeled compounds, while lower recoveries were observed for M3PFHxS (67%), M7PFUnDA (66%), MPFDoDA (49%), M8PFOS (41%), and M2PFTeDA (16%), suggesting that extraction efficiency was influenced by perfluoroalkyl chain length. In contrast, the ASE method achieved recoveries of ≥70% for all isotope-labeled compounds in samples A and B. In sample C, 12 of the 13 isotope-labeled compounds showed recoveries of ≥70%, with only M2PFTeDA showing a slightly lower recovery (67%). In sample D, 10 of the 13 isotope-labeled compounds were recovered at ≥70%, whereas MPFDoDA, M2PFTeDA, and M8PFOS showed lower recoveries of 68%, 44%, and 60%, respectively.

Discussion and Conclusion
This study investigated the extraction of isotope-labeled compounds from thermally reactivated GAC and showed that the ASE method provided higher PFAS extraction efficiency than the conventional shaking–ultrasonic extraction method. ASE improved the recovery of M2PFTeDA by approximately 10–20% in samples A and B. In sample C, ASE increased the recovery of MPFDoDA by approximately 10%, whereas that of M2PFTeDA remained comparable between the two methods. In sample D, ASE improved the recoveries of M3PFHxS and M8PFOS by approximately 5% and 20%, respectively, and those of M7PFUnDA, MPFDoDA, and M2PFTeDA by approximately 10–30%. These improvements were more pronounced for PFAS with longer perfluoroalkyl chains. Nevertheless, the recovery of M2PFTeDA in sample D remained below 50% with both extraction methods. However, performing ASE in two sequential batches improved the recovery of M2PFTeDA from 44% to 68%, suggesting that increasing the number of ASE extraction batches may enhance the recovery of PFAS with longer perfluoroalkyl chains.

Acknowledgment
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P-00759 Temperature-dependent transformation and coupled formation mechanisms of PXDD/Fs during thermal treatment of MSWI fly ash

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Introduction

Polyhalogenated dibenzo-p-dioxins and dibenzofurans (PXDD/Fs), including PCDD/Fs, PBDD/Fs, and PBCDD/Fs, are highly toxic persistent pollutants generated during municipal solid waste incineration (MSWI). However, their temperature-dependent transformation and cross-halogen coupling mechanisms during the thermal treatment of fly ash (FA) remain poorly understood. In this study, FA from a grate furnace was thermally treated at 400-800 °C, with simultaneous quantification of PXDD/Fs in both gaseous and solid phases. Thermogravimetric analysis (TGA), Pearson correlation analysis, and principal component analysis (PCA) were combined to elucidate their evolutionary mechanisms. Results indicate that increasing temperature significantly promoted the decomposition of solid-phase PXDD/Fs and reduced toxicity equivalents (TEQ), while simultaneously inducing the secondary formation of PXDD/Fs in the gaseous phase. Driven by the lower thermal stability of C-Br bonds, gaseous PBDD/Fs and PBCDD/Fs both reached their formation peaks at 600 °C, whereas PCDD/Fs peaked at 700 °C. Homologue fingerprinting revealed significant compositional restructuring: highly chlorinated species were persistently enriched, brominated species underwent progressive debromination, and cross-halogenated furans were distinctly enriched in the intermediate temperature zone (600-700 °C). Mass concentration ratios (DFs/DDs) and PCA further confirmed that the decomposition and formation of PXDD/Fs are governed by a shared radical precursor pool and cross-halogen recombination reactions. This study elucidates the underlying principles of coupled transformation across polyhalogenated systems. It not only deepens the mechanistic understanding of the dioxin formation network but also provides scientific guidance for optimizing FA thermal remediation strategies and mitigating mixed-halogenated emissions.Polyhalogenated dibenzo-p-dioxins and dibenzofurans (PXDD/Fs), including PCDD/Fs, PBDD/Fs, and PBCDD/Fs, are highly toxic persistent pollutants generated during municipal solid waste incineration (MSWI). However, their temperature-dependent transformation and cross-halogen coupling mechanisms during the thermal treatment of fly ash (FA) remain poorly understood. In this study, FA from a grate furnace was thermally treated at 400-800 °C, with simultaneous quantification of PXDD/Fs in both gaseous and solid phases. Thermogravimetric analysis (TGA), Pearson correlation analysis, and principal component analysis (PCA) were combined to elucidate their evolutionary mechanisms. Results indicate that increasing temperature significantly promoted the decomposition of solid-phase PXDD/Fs and reduced toxicity equivalents (TEQ), while simultaneously inducing the secondary formation of PXDD/Fs in the gaseous phase. Driven by the lower thermal stability of C-Br bonds, gaseous PBDD/Fs and PBCDD/Fs both reached their formation peaks at 600 °C, whereas PCDD/Fs peaked at 700 °C. Homologue fingerprinting revealed significant compositional restructuring: highly chlorinated species were persistently enriched, brominated species underwent progressive debromination, and cross-halogenated furans were distinctly enriched in the intermediate temperature zone (600-700 °C). Mass concentration ratios (DFs/DDs) and PCA further confirmed that the decomposition and formation of PXDD/Fs are governed by a shared radical precursor pool and cross-halogen recombination reactions. This study elucidates the underlying principles of coupled transformation across polyhalogenated systems. It not only deepens the mechanistic understanding of the dioxin formation network but also provides scientific guidance for optimizing FA thermal remediation strategies and mitigating mixed-halogenated emissions.

P-00762 Multi-contaminant exposure in non-native American mink from Iberian freshwater ecosystems

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Introduction
Freshwater ecosystems are increasingly exposed to multiple, co-occurring stressors, including biological invasions, chemical pollution, land-use change, and hydrological alteration. Predators occupying high trophic positions are particularly useful for assessing these pressures because they integrate contaminant exposure across different habitats and prey pathways. Non-native predators may provide particularly valuable information on contaminant transfer in freshwater food webs, as their broad trophic interactions can reflect how pollutants move across altered ecosystems. In this context, the non-native American mink (Neogale vison) represents a valuable model species. Its semi-aquatic habits, broad diet, high mobility, and routine removal during control programs provide a unique opportunity to assess contaminant burdens using multiple tissues without additional pressure on native wildlife.

Materials and Methods
Here, we investigated the occurrence and distribution of multiple contaminant groups in American mink collected during population control campaigns conducted between 2023 and 2024 in two freshwater systems (Angueira and Maçãs Rivers) in northern Portugal. A total of 49 individuals were analysed to assess organic contaminants in liver, including polybrominated diphenyl ethers, PBDEs, and methoxylated PBDEs, MeO-BDEs, as well as essential, potentially toxic, and technology-critical elements in kidney, muscle, and fur. Stable isotope ratios, $\delta^{13}C$ and $\delta^{15}N$, were also measured to explore dietary sources, trophic position, and their relationship with contaminant exposure.

Results
In total, 13 PBDE and MeO-BDE congeners and 63 elements were quantified, allowing the evaluation of contaminant burdens across tissues and the potential influence of sex, body size, and trophic ecology. Concentrations of ∑PBDEs and ∑MeO-BDEs in the liver were relatively low, 0.0712 and 0.0645 ng g^{-1} wet weight, respectively, when compared with values reported for other regions and experimental exposure scenarios, suggesting limited contamination by these legacy compounds in the sampled freshwater ecosystems. Contaminant patterns did not differ between males and females. Among the analysed tissues, fur showed high accumulation of most essential elements and several potentially toxic elements, such as As and Sr, indicating its usefulness as a minimally invasive matrix for monitoring. Isotopic values suggested comparable trophic positions between sexes, with $\delta^{13}C$ around –25‰ and $\delta^{15}N$ around 12‰, and a moderate overlap in trophic niche space, 38%. Positive, although generally weak to moderate, relationships between $\delta^{15}N$ and selected PBDE congeners indicate that diet and trophic position may partly contribute to exposure.

Discussion and Conclusion
Nevertheless, the lack of strong contaminant-isotope relationships indicates that contaminant accumulation is likely shaped by multiple interacting factors, including prey type, habitat use, local contamination sources, and compound-specific behaviour. Future studies including prey species and sympatric native predators, such as the Eurasian otter, would be important to clarify trophic transfer, biomagnification, and niche-mediated differences in contaminant exposure. Overall, American mink from northern Portuguese freshwater systems showed detectable but generally low burdens of multiple contaminant classes. These results suggest that local environmental conditions and feeding ecology are important drivers of contaminant exposure. As American mink are frequently removed during control programs, this species serves as a useful sentinel for multi-contaminant monitoring, with liver and fur providing complementary information on organic and elemental contamination in freshwater ecosystems.

Acknowledgment
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P-00764 The cost of compliance in medical waste management: Comparing treatment solutions and environmental impacts across twelve Caribbean countries

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Introduction

Healthcare waste management in Small Island Developing States (SIDS) is constrained by narrow landmasses, high specialized infrastructure costs, an acute lack of economies of scale and limited human resources. Across twelve Caribbean nations evaluated under the Global Environment Facility (GEF) Implementing Sustainable Low and Non-Chemical Development in Small Island Developing States (ISLANDS) Programme, baseline data reveals an operational landscape split between obsolete public incinerators, non-functional autoclaves, private collection networks, and uncontrolled open burning. This paper evaluates the systemic and environmental impacts of competing healthcare waste treatment pathways within these distinct socio-economic and geographical contexts.

When evaluated against international guidelines, regional thermal treatment facilities frequently exhibit severe technical deficits. Small-scale dual-chamber batch incinerators routinely operate with secondary chamber temperatures peaking below 1000°C and lack any downstream air pollution control systems. Due to the extreme chlorine loading of medical waste—often containing 10% to 15% polyvinyl chloride (PVC) by weight—combined with metallic catalysts like copper and iron, these oxygen-starved, cold-start conditions transform the incinerator into an effective chemical reactor. Trapped unburnt carbon and chlorine gas in the slowly cooling metal stack creates optimal conditions for the de novo synthesis of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), yielding emission factors of up to 40,000 µg TEQ/t.

To bypass this emission pathway, international donor strategies have prioritized the procurement of non-burn steam sterilization (autoclaving) units. However, applying the lifecycle metrics of the UNEP UPOPs Toolkit reveals a critical operational paradox when non-burn technologies are deployed in isolation. Autoclaved waste is rendered non-infectious but remains structurally intact, resulting in the disposal of the entire PVC-dense volume into unlined municipal landfills. These landfills operate far beyond design capacities and are highly vulnerable to deep-seated, spontaneous fires. Shifting chlorinated medical waste to an unmanaged landfill prone to open burning merely relocates the UPOPs synthesis pathway.

This study compares these quantitative PCDD/F emission factors and empirical data of different existing studies across various treatment configurations to determine their true environmental cost. The study highlights a critical regional paradox: insisting upon strict adherence to Best Available Techniques (BAT) and Best Environmental Practices (BEP) in resource-scarce environments frequently leads to systemic failure. When complex, highly compliant infrastructure such as autoclaves breaks down due to maintenance deficits or prohibitive reagent costs, the default reality is a complete reversion to uncontrolled open burning or (deep) burial at non-engineered landfills. Ultimately, the study shows that effectively reducing U-POPs emissions demands matching technology directly to localized resource capacities.

P-00769 Evaluating Environmental Quality Standards Considering Mixture Effect and Application of Mixture Assessment Factor

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Introduction
Increasing number and variety of chemicals is the current problem of chemicals management not only for their individual but also for their cumulative effects. When chemicals are released to the environment during their production, use or end-of-life, they co-occur in the environment creating unintentional mixtures. Environmental quality standards (EQSs) are set considering the individual effects of chemicals and the effect of unintentional mixtures are considered neither in European Union (EU) nor in Turkish regulations. This may lead to underestimation of environmental and human health risks; thus, requiring evaluation of EQSs. To account for the mixture effect, use of a Mixture Assessment Factor (MAF) is suggested in the European Chemicals Strategy for Sustainability (CSS). Currently, Turkish Regulation on Surface Water Quality (TRSWQ) sets EQSs for 250 specific and 45 priority pollutants. This study reassesses the EQSs of 49 of these chemicals, those most frequently detected in Yeşilırmak Basin, by (i) grouping them according to their organ toxicity and toxicity endpoints; (ii) calculating cumulative human health risks associated with each toxicity target and (iii) suggest use of MAF for those exceeding acceptable risk.

Materials and Methods
A total of 49 chemicals of the TRSWQ, reported by Küçük et al. (2021) to have more than 5% frequency of occurrence, based on a two-year monitoring in Yeşilırmak Basin, was used in this study. ProTox 3.0 model was then applied for toxicity predictions upon grouping according to their toxicity targets (i.e., hepatotoxicity, neurotoxicity, nephrotoxicity, respiratory toxicity, cardiotoxicity, immunotoxicity, mutagenicity, cytotoxicity and BBB-barrier). RfD values from IRIS Database were used to calculate Hazard Quotients (HQs) for non-carcinogenic human health risks of water consumption. The exposure was determined considering the EQS concentrations. HQs of each chemical are summed up to quantify their total effect, Hazard Index (HI). If HIs exceed 1, a MAF was calculated for the group with highest HI and applied to all groups with HI>1.

Results
The results showed that when exposure to the mixture of chemicals is considered, substantially larger HI values than the corresponding individual HQ values are obtained. The most sensitive age group is children; therefore, MAF size was calculated based on HI for children. Neurotoxicity and BBB-barrier have HI>1 for 33 and 44 chemicals, respectively. The highest HQ of 7.9 was obtained for BBB-barrier. Following the algorithm by Backhaus (2023), the MAFexact was determined as 5 and applied to chemicals with HQ's exceeding 1/MAFexact. The results of MAFexact application indicated that more stringent EQS are required for 3 out of 49 chemicals assessed: As, Sb and 2,6 xylenol. For instance, 2,6 xylenol has an EQS of 54 µg/L in TRSWQ; however, protective EQS value becomes 4.6µg/L with MAF application.

Discussion and Conclusion
The results demonstrate the impact of the mixture effect while considering EQSs. In this study, the chemicals were grouped by their toxic effects to avoid unnecessary application of MAF to chemicals with low HQs and toxicity groups with low HI. The estimations of MAF in this study were based on chemicals detected in Yeşilırmak Basin; however, the chemicals with MAF application requirements are basin-specific. This study underlines the requirement of determining basin specific risk driver chemicals by long-term monitoring or identifying the possible chemicals considering nearby sources, i.e. industries, to set EQSs depending on the water use.

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P-00776 Dioxins, PCBs and PFAS in eggs from industrial production and backyard chickens in Denmark

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Introduction
Dioxins, polychlorinated biphenyls (PCBs), and per- and polyfluoroalkyl substances (PFAS) are listed as undesirable substances under the Stockholm Convention with the aim of reducing their occurrence in food and feed. Mitigation measures have been effective, resulting in a substantial decline in background contamination levels in food and feed.
The study was initiated to investigate the impact of small-scale, free-ranging hens with access to soil on the levels of dioxins and PCBs. However, it soon became evident that PFAS also constituted a concern and was therefore included in the study. Previous research has demonstrated that eggs from such production systems may contain elevated levels of dioxins and PCBs (https://dioxin20xx.org; Sørensen, 2014, Abstract 1160); this formed the basis for the present investigation.
Contamination in henhouses is generally linked to local sources (e.g. bonfire residues, old construction materials) as well as diffuse background contamination from combustion processes, including both local emissions and long-range atmospheric deposition from industrial activities across Europe. PFAS contamination may additionally originate from sources such as firefighting foams and contaminated drinking water.

Materials and Methods
This study evaluated national monitoring data from more than 400 egg samples collected by the Danish authorities between 2019 and 2026 across various production systems, including caged/barn, free-range, organic, small-scale poultry holdings (<100 chickens), and backyard chickens.
The analytical method for dioxins and PCBs uses ASE extraction, DSP system clean-up and DFS GC-HRMS detection. PFAS is analyzed by dispersive SPE and UPLC–MS/MS detection. Compliance was assessed against the action and maximum levels set in Regulation (EU) 2023/915.

Results
The content of dioxins and PCBs in eggs from large-scale industrial producers, as typically available in supermarkets, has decreased markedly over the past decades and has consistently remained below EU maximum levels throughout the period 2019–2026. For PFAS, only a small number of samples exceeded the maximum levels between 2023 and 2026.
In contrast, no corresponding decrease has been observed in eggs from small-scale poultry holdings and backyard chickens, where levels of dioxins, PCBs, and PFAS frequently exceed established EU maximum limits. Eggs from outdoor production systems with direct access to soil appear particularly susceptible to accumulate these persistent compounds. In this study regulatory maximum level for dioxins was exceeded in 17% of eggs from small-scale holdings and 27% of eggs from backyard chickens. Furthermore, the PCB action level was exceeded in 8% and 16% of samples from small-scale and backyard production, respectively. For PFAS, exceedances were observed in more than 30% of eggs from backyard chickens.

Discussion and Conclusion
The marked difference between small-scale and large-scale poultry holdings is primarily due to differences in feeding and exposure conditions. In large-scale operations, hens obtain nearly all of their diet from controlled feed. In contrast, hens in small-scale systems typically have access to extensive outdoor areas, where they forage in soil, continuously ingesting insects and other materials.
Time trends in dioxins and PCBs, together with patterns of PFAS occurrence, in eggs from different production systems are presented. The results suggest that egg production in certain locations may be associated with an increased risk of contamination and should therefore be carefully evaluated. A small number of backyard chickens may not always constitute a healthy, safe, and sustainable source of eggs for household consumption, as elevated levels of dioxins, PCBs, and PFAS have been observed in these eggs under certain environmental conditions.
In Denmark, official dietary guidelines recommend consuming eggs from a variety of sources rather than relying solely on home-produced eggs.

P-00795 From definition of PFASS in 2021 to restriction proposal in 2026: analysis by a chemist.

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Introduction
In 2021 Wang et al. in "Reconciling terminology of the universe..." [1] attempted to create a definition of PFASS implementable by non-experts. The authors warned against using their definition for non-experts for regulatory actions. Unbelievable, but the current recommendation of the ECHAs Risk Assessment Committee(RAC) and Socio-Economic Analysis Committee(SEAC)[2] is a rephrased formula for non-experts by Wang et al.[1]. Our study investigated gnoseological roots of the confusion.

Materials and Methods
This was a theoretical study: reading texts written by non-experts in chemistry with eyes of a professional chemist.

Results
Definition for non-experts by Wang et al. is not a scientific text: it contains a repetition of the same statement (could be good for explanation for non-experts, not acceptable for scientific definition) and it gives equal status to CF3 and CF2 groups, whilst the former is a sub-case of the latter. Such elementary logical error is unacceptable in scientific definition. Definition for non-experts by Wang et al. was proven to be too difficult for implementation even by its authors. They failed to correctly depict the structural elements within definition scope on the figure[1]. Definition by Wang et al. is not an "OECD definition". See disclaimer[1]. Thus, non-peer reviewed opinion of Wang et al.[3] to call it "A new OECD definition for per- and polyfluoroalkyl substances" was erroneous. Wang et al. failed again to depict the structural elements correctly[3]. The main formula in the restriction proposal [2] is a rephrased definition for non-experts by Wang et al.[1], despite the warning not to use it for regulation. Both define the same: substances with -CF2-fragment(with few noted exceptions), not fluoroALKYL substances. The purpose of rephrasing was not explained. Impressively, the rephrased definition for non-experts was complemented with a long and complex passage non-implementable at all. Aimed at exclusion of degradable substances, it was a full failure, too. Indeed, any CF3-X substance is, an F-CF2-X substance. In all cases CF3-X conforms to exclusion conditions, it does not do so as X'-CF2-X, X'=F. Thus, most of the restriction formula is theoretically absurd. The culmination so far (May,2026) was recommendation of RAC to remove that complex passage as "unjustified". We agree that passage of such poor quality can hardly be justified(albeit the mentioned substances are fully degradable). Neither can be justified the result of RAC decision: the scope of restriction equal to non-peer reviewed non-scientific definition for non-experts.

Discussion and Conclusion
The scope of the proposal in its current form looks catastrophic in the eyes of a chemist. "Reconciling terminology of the universe..." occurred in 2020-2021, in the dark times of pandemics, when fear and anxiety ruled human minds. Not unexpectedly, something apparently understandable seemed plausible to non-experts, and no surprise that the scared community seeked a salvation in it. Then the proposal was developed fully online, no face-to-face meetings. Another mistake, partly excusable under the circumstances. The third negative factor was non-scientific campaign by supporters of "OECD definition" (OECD is a political organization for economic matters): they even blamed opponents in being politically or economically motivated(sic!)[4]. What's not understandable – why organic chemists were not involved in the process. The absence of experts in chemistry needs careful investigation, as well as why the voice of science was not heard for over 5 years in nowadays Europe.

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P-00797 Establishing Scientific and Regulatory Foundations for Persistent Organic Pollutants (POPs) Standards in Korea

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Introduction
Persistent Organic Pollutants (POPs) are globally regulated under the Stockholm Convention due to their persistence, bioaccumulation potential, long-range transport, and adverse effects on human health and ecosystems. In Korea, POPs are managed under the POPs control Act, which recognizes the need to establish environmental quality standards and human exposure safety criteria. However, only a limited number of standards have been established to date, restricting the effective use of national monitoring data for risk management and policy development. This study aimed to identify regulatory and technical needs for POPs standard development in Korea and propose improvements to the legal and institutional framework for POPs management and standard setting.

Materials and Methods
Domestic and international regulatory frameworks, environmental standards, and six criteria-development methodologies for POPs were reviewed and compared. Among the approaches evaluated, the U.S. Environmental Protection Agency's Ambient Water Quality Criteria (AWQC) was selected for pilot application because it considers both drinking water and fish consumption pathways, which are important exposure routes for bioaccumulative contaminants. Three representative POPs—polychlorinated biphenyls (PCBs), perfluorooctane sulfonate (PFOS), and perfluorooctanoic acid (PFOA)—were selected as case-study substances. In addition, domestic and international legal and institutional frameworks for POPs management were analyzed to identify regulatory gaps and develop recommendations for improving the national standard-setting system.

Results
The review identified the need for more effective mechanisms to incorporate newly listed Stockholm Convention substances into national management systems and to strengthen coordination among media-specific environmental regulations. Application of the AWQC methodology demonstrated that it can provide a practical framework for deriving human health-protective water quality criteria for POPs in Korea. Comparison of the derived criteria with data from the national POPs monitoring program identified several locations where contaminant concentrations exceeded the calculated criteria. Although these locations were not used as drinking water sources, some concentrations substantially exceeded the derived values, indicating the need for further investigation to identify potential sources and better characterize local environmental contamination. In addition, the study identified several data needs for future criteria development, including nationally representative freshwater fish consumption rates and bioaccumulation factors relevant to Korean environmental conditions.

Discussion and Conclusion
This study provides an initial scientific and regulatory foundation for the development of environmental standards for POPs in Korea. The study identified key technical needs for future criteria development, including the generation of Korea-specific bioaccumulation factors and freshwater fish consumption data, as well as the establishment of guidance for media-specific management goals and standard-setting procedures. From a regulatory perspective, improved mechanisms are needed to facilitate the timely incorporation of newly listed Stockholm Convention substances into national management systems and to strengthen coordination among media-specific environmental regulations. As the Stockholm Convention continues to expand the list of regulated substances, the proposed framework may support more systematic POPs management, enhance the utilization of national monitoring data, and strengthen evidence-based protection of human health and the environment.

Acknowledgment
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Progress in non-polar POPs Analysis

P-00799 Distribution homogeneity of environmental contaminants throughout (sub)liver parts

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Introduction
There is a widespread belief that when investigating environmental contaminants in liver, the same sub-part (e.g., lobe, sub-lobe) should be considered within a sample set to ensure comparability of quantitative results. Retrieved literature reports uneven distributions for trace elements in cattle (Luna et al., 2019), pharmaceuticals in humans (Jacobsson et al., 2005) and anticoagulants rodenticides in fox (Taylor et al., 2020). These findings were hypothesised to be related to differences in blood flow, abundances in enzymes or other molecules involved in contaminant partition, and functional units between the right and left lobes of the liver. However, we were unable to find comprehensive and indisputable data in the literature supporting heterogeneity in the distribution of contaminants within the liver, in particular for persistent organic pollutants such as PCDD/Fs, PCBs, or PFAS. Therefore, to ensure comparability of results, the question arises as to whether partial liver sampling (e.g., liver biopsy in a living animal, or random sampling at the slaughterhouse for monitoring purpose) could lead to an over- or underestimation of the content of any specific contaminant, or whether sampling and homogenisation of the entire liver is fundamentally required.

Materials and Methods
The liver of a wild male boar hunted in December 2025 in the Grunewald forest (Berlin, Germany), near a former army training ground, was collected. This species was selected considering available mass of liver (2.46 kg) and the expected presence of moderate to high levels of a diverse range of contaminants. Following an initial visual examination, no apparent lesions or signs of hepatic disease were observed. The liver was subdivided into 15 anatomical sections: four within each lateral lobe (left and right), three within each medial lobe (left and right), and one corresponding to the caudate lobe. Subsamples were homogenised. An average subsample pool (QC) was prepared by mixing aliquotes from all primary subsamples.

Results
So far, results are available for trace elements and PFAS, indicating no significant differences among subsamples, taking into account the analytical variability estimated from the QC (n = 6), except for the caudate lobe. The latter exhibited lower values, possibility related to the higher connective tissue content and/or lower perfusion flow rate.

Discussion and Conclusion
Although statistically limited, this preliminary study based on the liver of a single wild boar suggests that samples collected from any region of the left or right lobes are representative of the whole liver with respect to trace element and PFAS contamination. Additional analyses are planned to determine whether this finding also applies to PCDD/Fs, dl/ndl-PCBs, BFRs, PCNs, OCPs, PCAs, anticoagulant rodenticides and pesticides.

Acknowledgment
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P-00811 Long, short, ultrashort and non-target PFAS screening of wastewater and sewage sludge from treatment plants in Bergen, Norway

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Introduction
Per- and polyfluoroalkyl substances (PFAS) enters wastewater treatment plants (WWTPs) from a variety of sources including consumer products, aqueous film forming foam (AFFF)– contaminated sites (e.g., airports) and are subsequently released to the marine environment. Sludge is additionally used for biogas production, with the resulting digestates applied as fertilizers. This practice is expected to expand significantly follow EU strategic initiatives to reduce agricultural import dependencies and improve resource circularity. However, data of PFAS occurrence in sludge and wastewater in sludge and wastewater is limited and primarily restricted to a handful of the most prominent PFAS, despite the vast number of PFAS compounds currently known.

Materials and Methods
This study presents a comprehensive assessment of PFAS in influent, effluent, and sewage sludge from three main WWTPs in Bergen, Norway. Target analysis of PFAS, including ultrashort-chain compounds, was performed using liquid chromatography coupled to triple quadrupole mass spectrometry (LC-MS/MS), while non-target screening (NTS) using high-resolution mass spectrometry (LC-HRMS) was utilized to identify unknown PFAS.

Results
In sludge, long chain compounds dominated at concentrations up to ug/kg wet weight , whereas short chain compounds distributed more to the water phase at concentrations up to hundreds of ng/L, representing substantial yearly inputs to the marine environment. High levels and negative removal rates were found especially in the treatment station in the vicinity of the airport utilizing biological process (activated sludge), evidencing the inefficiency of the wastewater treatment at removal PFAS.

Discussion and Conclusion
The results highlight a potential critical vulnerability this circular economy: the risk risks transferring legacy and emerging fluorinated contaminants into agricultural soils and the broader food web. This prompts further investigation into emissions of wastewater and the uptake of PFAS into plants and livestock from digestates and the need for updated regulatory frameworks to protect food safety and the environment.

Per and polyfluorinated substances (PFAS): Toxicity

P-00816 Regrettable substitution – The substitution of PFAS in consumer products, and its potential consequences for human health

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are a group of chemicals of concern due to their prevalence, persistence and mobility in the environment, as well as the associations with adverse health effects. The usage of these compounds has been very popular due to their water- and fat-repelling properties, making excellent additions in both rain protection gear and non-stick pans. During the last decades, the general public has become more aware of the issues regarding PFAS, and thus consumers have started to put higher demand on the retailers and producers to provide PFAS-free substitutions.
In this project, called "Regrettable Substitution", we are working to assess the toxicological impact of textiles treated with durable water repellents (DWRs) that are labelled as PFAS-free. The project aims to provide companies working on PFAS-free transition with more data to base their product design choices when developing a safe-by-design product.

Materials and Methods
The main goal of the project is to chemically and biologically characterize different textile samples treated with DWR, both with and without PFAS. The aim is to identify potential differences in biological activities and to identify the chemical drivers underlying the observed toxicity. To cover groups of chemicals with different polarity and potential toxicological effects, two extraction methods will be performed on the textile samples, one using methanol, and the other using a mixture of n-hexane:acetone 4:1 (v/v).
The initial chemical analysis of the methanol extract will consist of combustion ion chromatography (CIC) to measure if fluorine is present in the textiles. Secondary analysis might be performed, depending on the initial results on extractable organic fluorine (EOF), and a target PFAS liquid-chromatography tandem mass spectrometry (LC-MS/MS) method will be applied. This to ensure that the PFAS levels are negligible. The hexane/acetone extract will be analyzed using a suspect chemical screening method with high-resolution gas chromatography mass spectrometry (HRGC-HRMS) to identify semi- and nonpolar compounds in the textiles. The chemical results will be combined with the bioassay data to determine which compounds are bioactive in the bioassay analyses.

The bioanalysis will consist of a battery of Chemical-Activated Luciferase gene eXpression (CALUX) in vitro assays, covering several endpoints such as estrogenic, androgenic, and genotoxic effects, as well as oxidative stress. A transthyretin (TTR) protein binding assay will also be utilized.

Discussion and Conclusion
Depending on the results from bioassay and chemical characterization, effect-derived analysis (EDA), using GC- and/or LC-fractionation will be applied to identify and confirm chemical drivers of the observed bioassay effects. The overall aim of the project is an assessment of if the phase-out of PFAS in outdoor clothing has been successful in consideration of both human and environmental health.

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P-00826 Comparative Evaluation of Targeted and Total Fluorine Approaches for PFAS Monitoring in Harbour Sediments

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Introduction
Harbours are linchpins of global commerce, and their maintenance is essential to keeping harbours operational. This requires regular removal of sediments through dredging. Dredged material has beneficial uses, but most of this material is dumped at sea. This can lead to the formation of sediment plumes, potentially posing an environmental hazard to local organisms, as harbour sediments are often contaminated with a variety of legacy and emerging pollutants.
While different regions of the world have developed and use different risk assessment approaches for dredged materials, they share one key challenge: per- and polyfluoroalkyl substances (PFAS) are not systematically monitored. PFAS, also known as "forever chemicals", comprise a large group of persistent organic pollutants that have been linked to adverse health effects, including neurotoxicity, immunotoxicity, teratogenicity, and cancer. Although the use of some legacy PFAS, such as perfluorooctane sulfonic acid (PFOS), has been restricted since 2009, these compounds remain widespread in the environment. This challenge is further complicated by the large number of PFAS substances, with more than 4,700 compounds currently listed by the Organisation for Economic Co-operation and Development (OECD).

Materials and Methods
The aim of this study was to evaluate different methodologies for comprehensive PFAS monitoring in harbour sediments. Conventional targeted methods, applying liquid chromatography–tandem mass spectrometry (LC-MS/MS), are highly sensitive and selective but are unsuitable for the simultaneous monitoring of thousands of PFAS. Consequently, alternative total fluorine approaches have been developed. The total oxidizable precursor (TOP) assay converts perfluoroalkyl acid (PFAA) precursors into PFAAs, which are readily measurable by LC-MS/MS. Extractable organofluorine (EOF) analysis using combustion ion chromatography (CIC) converts all organofluorine compounds into inorganic fluoride, enabling a broader assessment of fluorinated contaminants.

Results
The above listed methods were applied to 20 sediment samples collected from harbours in south-eastern Sweden. The sum of target PFAS concentrations in these samples ranged from below the limit of quantification (LOQ) to 8.2 ng/g dry weight (d.w.). The presence of PFAA precursors was indicated by the TOP assay, which resulted in more than 300 % increase in the concentration level of PFAA in some samples. However, this contribution was dwarfed by the results of EOF analysis. Among the 16 samples with EOF concentrations above the LOQ, unidentified organofluorine (UOF) compounds accounted for 71–100% of the EOF.

Discussion and Conclusion
These results demonstrate that targeted PFAS analysis alone substantially underestimates the fluorinated contaminant burden in harbour sediments. The total fluorine methods evaluated here are therefore important for a more comprehensive characterization of PFAS contamination in dredged sediments. Given that the environmental impact of the unidentified organofluorine fraction remains unknown, incorporating such approaches into dredged material assessments could improve environmental risk evaluations and management decisions.

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P-00833 TCDD-Induced Lower Urinary Tract Dysfunction Is Regulated by Compartment-Specific Estrogen Receptor-α Signaling

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Introduction

Dioxins are a known endocrine disrupting chemical negatively affecting many different organs in the body. We have previously demonstrated that in a model of lower urinary tract symptoms (LUTS)/benign prostatic hyperplasia (BPH), fetal exposure to dioxin led to exacerbated LUTS/BPH in C57BL/6 male mice. Little is known for the role of estrogen receptor-alpha (ER-α) in this dioxin model system. The objective of this study was to determine whether stromal and epithelial ER-α are necessary for the development of lower urinary tract dysfunction (LUTD) in this dioxin-sensitized model. To delineate compartment-specific roles of ER-α, we employed stromal-specific smooth muscle Cre (B6.Cg-Tg(Tgln-cre)1Her/J) and epithelial-specific Cre (B6.Cg-Shh^tm1(EGFP/cre)Cit/J) drivers crossed with ER-α floxed mice to selectively delete ER-α in prostatic stroma or epithelium, respectively. Animals were subjected to a two-hit paradigm consisting of in utero exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) followed by testosterone (T) and 17β-estradiol (E2) treatment in adulthood. Voiding function was longitudinally assessed using weekly void spot assays (VSA) for four weeks. At study endpoint, bladder and prostate tissues were collected for morphometric analysis.

No significant differences in body mass were observed across treatment groups, indicating that systemic toxicity did not confound functional outcomes. Consistent with prior findings, deletion of ER-α in either stromal or epithelial compartments of T+E2 treated mice attenuated bladder metrics compared to control untreated mice, supporting a requirement for ER-α signaling in LUTD development. TCDD-treated stromal ER-α knockout mice exhibited significantly ($P<0.05$) decreased voiding frequency (20%) relative to corn oil/T+E2 treated controls. Moreover, loss of epithelial ER-a in TCDD exposed/T+E2 treated mice led to significant ($P<0.05$) decrease (52%, relative to controls) in urinary frequency. This phenotype is consistent with LUTS/BPH and bladder hypertrophy secondary to outlet obstruction. Our experiments bring to light the ability of TCDD to induce urinary dysfunction in a mouse DOHaD model. These findings suggest that while ER-α signaling in both epithelial and stromal compartments contribute to the development of voiding dysfunction, stromal and epithelial ER-α play a protective role in maintaining lower urinary tract patency under TCDD exposure conditions. Together, these results highlight a complex, compartment-specific role for ER-α in mediating the interaction between endocrine disruption and LUTD pathogenesis and provide new mechanistic insight into how environmental toxicants such as TCDD influence prostate–bladder axis function and may prove useful for the targeting of estrogen signaling pathways in the treatment of LUTS/BPH.

P-00838 Development of an Analytical Method for PFAS in Environmental Water Using Online SPE-LC/MS

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants of global concern because of their widespread occurrence, bioaccumulation potential, and potential adverse health effects. Online SPE-LC/MS has attracted increasing attention as a high-throughput technique for rapid, sensitive, and automated PFAS analysis. In our previous study (Takazawa et al., 2025), we developed an analytical method combining liquid–liquid partitioning with online SPE-LC/MS for 0.5 mL water samples. This approach effectively removed highly polar ionic matrix components prior to SPE and automated the analytical workflow. However, the small sample volume raised concerns regarding sampling variability. Therefore, this study developed a simple, rapid, and accurate method for PFAS analysis in environmental water using a 10 mL sample volume.

Materials and Methods
Thirty-five PFAS were selected as target analytes. Ultrapure water, hard water, river water, and brackish water were used as test matrices. A 10 mL water sample was mixed with 100 µL of 2 N hydrochloric acid and 5.7 mL of ethyl acetate, followed by manual shaking for 15 s to perform liquid–liquid partitioning. After standing for 1 min, approximately 1 mL of the organic phase was transferred to a vial and placed in the online SPE-LC/MS system. A 200 µL aliquot of the extract was loaded onto a weak anion-exchange SPE cartridge (Flash-SPE WAXs, 3 mg), washed with methanol, and eluted with 50 µL of 0.1% ammonia in methanol. The eluate was mixed with 100 µL of 0.1% aqueous acetic acid in the sample loop and introduced directly into the LC/MS system by valve switching. Surrogate correction was not applied in order to evaluate the intrinsic analytical performance of the proposed method.

Results
Partitioning 10 mL of water with 5 mL of ethyl acetate produced approximately 4.3 mL of organic phase. Therefore, the ethyl acetate volume was increased to 5.7 mL to obtain 5 mL of organic extract after partitioning, resulting in an approximately two-fold enrichment of PFAS. The proposed method eliminated concentration steps such as nitrogen evaporation and enabled closed-system sample preparation, reducing analysis time and minimizing the risk of PFAS contamination. Spike-recovery experiments at 25 ng/L showed satisfactory recoveries (75–120%) and good reproducibility (RSD <10%) for 31 PFAS in all test matrices, except for the highly polar compound 4:2 FTS and the neutral compounds FOSA, N-MeFOSA, and N-EtFOSA.

Discussion and Conclusion
Liquid–liquid partitioning efficiently recovered hydrophobic PFAS adsorbed onto sample containers and suspended particles into the ethyl acetate phase. In addition, satisfactory analytical performance was maintained for hard water and brackish water containing high concentrations of ionic matrix components, such as sulfate and nitrate ions, indicating that liquid–liquid partitioning effectively removed these interferences before SPE and preserved the retention capacity of the weak anion-exchange sorbent. By combining ethyl acetate-assisted liquid–liquid partitioning with online SPE-LC/MS, a simple, rapid, and reliable method was developed for the determination of 31 PFAS in 10 mL water samples. The method enables automated sample preparation, minimizes PFAS contamination, and provides reliable performance across diverse water matrices, making it suitable for routine monitoring of PFAS in environmental water.

Acknowledgment
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P-00856 The influence of the liner type on the GC injection: a specific look at PFAS and other POPs

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Introduction
Nowadays, liquid chromatography is the most widely used technique for analyzing per- and polyfluoroalkyl substances (PFAS) [1]. With the discovery of volatile and semi-volatile PFAS, also gas chromatography (GC) is gaining space for the analysis of these pollutants from different matrices [2-3].
Generally, gas chromatography is the main technique used for the analysis of (semi-)volatile compounds. Despite its widespread use, the choice of liner is often not given much consideration when optimizing the method. However, in hot vaporization injections (e.g., split and splitless), the mechanism of analyte introduction into the injector and transfer into the column is rather complex, and if not properly optimized, can generate severe discrimination in quantitative analysis [4]. The liner is designed to slow down the passage of the liquid sample between the syringe needle outlet and the column inlet in hot vaporization injections, allowing for more complete and uniform evaporation of the sample [5] and that is why it is important to choose the one best suited to the analysis that need to be performed. There are many types of liners with different characteristics (e.g., presence of packing, different geometries, presence of restrictions), which means that the vaporization of analytes is not always the same.

Materials and Methods
In this study, the influence of liners with different geometries on injector discrimination phenomena in vaporization injections was evaluated. Specifically, they differed each other by the presence or not of glass wool and its position, the presence or not of focus points that hold the glass wool in the right position, the use of a different packing material than glass wool (i.e., felt) or a different geometry (i.e., cycle), the presence or absence restrictions at the ends of the liner.

Results
These liners were compared in terms of recovery, discrimination among compounds with different volatilities, reproducibility of the vaporization and stability. The parameters were evaluated for different PFAS families (e.g., fluorotelomer alcohols, fluorotelomer acrylates, fluorotelomer iodine) and other POPS (PCBs, PAHs, Pesticides) using GC-FID and GC-MS.

Discussion and Conclusion
This study shows that the liner has an impact on the resulting GC method in terms of discrimination, preservation, and the column transfer of the analytes.

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P-00858 Assessment of PFAS in groundwater of National Parks from Canary Islands

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Introduction
During the last decades, per- and polyfluoroalkyl substances (PFAS) have been in the focus of research as contaminants of emerging and critical concern. These compounds are known for being persistent, bioaccumulative, and toxic for living organisms. PFAS are widely distributed contaminants that pose increasing challenges for water quality management and environmental risk assessment. Numerous studies have investigated PFAS in the aquatic environment covering both freshwater and marine ecosystems. However, while PFAS research in surface water has been extensive, less attention has been paid to groundwater. Groundwater is one of the main water resources, representing about 26 % of total waters used for human consumption. This underlines the need to assess and understand the subsurface fate and transport mechanisms of PFAS leading to groundwater contamination.
The main objective of the present study is to analyze the presence of PFAS in groundwater of four National Parks in the Canary Islands (Spain).

Materials and Methods
Groundwater samples were collected from different locations, including Tenerife (Teide), La Gomera (Garajonay), La Palma (Caldera de Taburiente), and Lanzarote (Timanfaya). Sampling was conducted between December 2025 and February 2026. Three samples were collected per island, and all samples were were stored at 4 °C until analysis.
Samples were thawed at room temperature, then subsequently filtered through glass microfiber filters to avoid possible solids, and spiked with a 13C-labelled mix. The extraction was performed using a solid-phase extraction (SPE) with the InertSep WAX FF/GCB cartridges. PFAS were then eluted with 4 mL of 0.3 % ammonia in MeOH. The extracts were filtered through a 0.2 µm nylon syringe filters, and evaporated under nitrogen until near dryness. All samples were reconstituted with 200 µL of a MeOH and water mixture (30:70) with the corresponding injection standards before UPLC-MS/MS analysis. For chromatographic separation, an Acquity UPLC BEH C18 column was used. The UPLC system was also equipped with a VanGuard™ BEH C18 pre-column, as well as an isolator column. The quantification was carried out with a Waters XEVO TQS, triple-quadrupole mass spectrometer. Ionization was performed in negative mode (ESI-) and acquisition in multiple reaction monitoring (MRM) mode.

Results
Analytical results showed a heterogeneous spatial distribution of the monitored compounds. Low levels of regulated PFAS (PFOA, PFHxS, and PFOS) were found, while longer chains (> 8 C) were rarely detected or not detected. In the case of short-chain PFAS, higher levels were detected. While long-chain species show a restricted mobility due to their greater hydrophobicity and tendency to be adsorbed onto organic matter and air-water interface in the subsoil near to emission sources, short-chain PFAS continue spreading rapidly due to a higher hydrophilicity and low affinity for solids in the aquifer.

Discussion and Conclusion
As PFAS content in groundwaters is not yet regulated, this work raises an emerging issue. Attending to the European Union´s Annual Average Environmental Quality Standard (AA-EQS) for PFOS (0.65 ng/L), all samples showed values below this threshold. Despite this compliance, current regulatory frameworks may underestimate real-world PFAS exposure in aquatic environments, so further research on the extend of PFAS in groundwater from the studied natural parks is warranted.

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P-00869 Fate and transformation of psychotropic drugs in urban wastewater systems and receiving rivers via the integration of targeted and suspect screening analysis

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Introduction

Psychotropic drugs are increasingly recognized as emerging contaminants because of their extensive clinical use, continuous discharge, and potential neuroactive effects on non-target aquatic organisms. However, their behavior in municipal wastewater systems, particularly the formation and fate of transformation products (TPs), remains insufficiently characterized. This study investigated the occurrence, removal, transformation, and ecological risks of 47 psychotropic drugs in two full-scale wastewater treatment plants (WWTPs) in Guangdong Province, South China, and in their receiving rivers. The target list covered antidepressants, benzodiazepines, anticonvulsants, an anesthetic, and a hormone. A combined analytical strategy was applied, integrating targeted quantification by UPLC-MS/MS with suspect screening of TPs by UPLC-QToF/MS.

Targeted analysis showed that psychotropic drugs were widely present throughout the wastewater, sludge, river water, and sediment matrices. Overall, 35 of the 47 target compounds were detected in the WWTP systems and their receiving environments, and 13 compounds were ubiquitously observed across wastewater and river samples. In the influents, 34 and 29 compounds were detected in plants LJ and GM, respectively, while 29 and 27 compounds remained in the corresponding effluents, confirming that conventional WWTPs act as important point sources of psychotropic drugs to aquatic environments. O-desmethylvenlafaxine, venlafaxine, oxcarbazepine, lamotrigine, carbamazepine, clozapine, and oxazepam were among the dominant compounds. Annual mass load calculations further indicated substantial emissions from WWTP effluents to receiving rivers.

Removal performance varied markedly among compounds, but most psychotropic drugs showed strong recalcitrance during conventional treatment. Venlafaxine, for example, was removed by only 10.8% and 2.64% in the two plants. Several compounds, including oxazepam, lamotrigine, carbamazepine, and estazolam, even increased after treatment, likely owing to deconjugation, metabolite back-transformation, desorption from returned sludge, or microbial conversion from related parent compounds. Mechanistic interpretation suggested that hydrophobic compounds such as sertraline were mainly removed by sludge sorption, whereas tandospirone removal was more closely associated with biodegradation. Chlorination contributed to the additional removal of several electron-rich compounds, such as clozapine and O-desmethylvenlafaxine, although this process may also generate disinfection-related by-products.

To characterize transformation processes, the study established a seven-step suspect screening workflow involving scientific library construction, HRMS acquisition, candidate filtering, Kendrick mass defect analysis, MS/MS library comparison, and confirmation with authentic standards when available. Of 118 potential TP candidates, 25 were assigned as tentative TPs, and 18 were further identified at high confidence levels. Eight TPs were confirmed at level 1 using standards, and nine TPs were newly identified in WWTP-related samples. The identified TPs were mainly associated with carbamazepine/oxcarbazepine, venlafaxine/O-desmethylvenlafaxine, escitalopram, sertraline, and tandospirone. Only a limited number of TPs appeared to be formed within WWTP processes, consistent with the overall persistence of the parent drugs. In contrast, human metabolites entering the plants via influent wastewater contributed to a broader TP diversity. Some metabolites, particularly TP-OCX-254, TP-OCX-270, and TP-TDS-165, occurred at concentrations higher than their parent compounds, highlighting the need to include metabolites and TPs in environmental monitoring.

Ecological risk assessment showed that venlafaxine, oxazepam, and sertraline posed high potential risks in receiving rivers, with risk quotients above one, while O-desmethylvenlafaxine and lamotrigine presented medium risks. For qualitative TP prioritization, the study integrated toxicity-weighted concentration with the ToxPi framework using instrumental response, detection rate, and predicted no-effect concentration. This approach identified TP-CIT-322 and TP-OCX-195 as high-priority contaminants. Overall, the results demonstrate that psychotropic drugs and their TPs persist through conventional wastewater treatment, enter receiving environments, and may contribute to ecological risks. Improved treatment technologies, emission control, and parent–TP integrated monitoring are therefore essential for managing psychotropic pharmaceutical pollution.

Screening and identification of novel contaminants

P-00871 Screening of nitrated synthetic phenolic chemicals in ambient fine particulate matter

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Introduction
Phenolic compounds, characterized by a hydroxyl group directly attached to an aromatic ring, are highly reactive due to the strong electron-donating nature of the hydroxyl group. This electron-rich characteristic makes them highly susceptible to electrophilic substitution or free-radical addition reactions with common atmospheric electrophiles. Consequently, the nitration of volatile phenols is recognized as a critical pathway for secondary organic aerosol formation and has garnered significant attention. However, while recent studies indicate that synthetic phenolic chemicals, such as bisphenols, readily enter the atmosphere and accumulate in particulate matter via volatilization, research on their susceptibility to nitration remains scarce. To address this knowledge gap, this study aims to develop a targeted screening strategy for identifying the nitration products of phenolic chemicals in atmospheric fine particulate matter (PM2.5).

Materials and Methods
PM2.5 samples were collected in Jinan, Shandong Province, from September 2023 to May 2024 using a medium-volume sampler at a flow rate of 100–140 L/min. A total of 210 samples were collected over 24-hour periods, alongside one field blank per sampling event. Target compounds were extracted via sequential ultrasonication: filter pieces were spiked with surrogate standards (10 ng each) and extracted twice with acetonitrile (3 mL) and twice with dichloromethane/hexane (1:1 v/v, 3 mL). The combined extracts were concentrated under nitrogen, reconstituted in 100 µL methanol with internal standards, and analyzed using an UHPLC system coupled to an Orbitrap Exploris 240 high-resolution mass spectrometer (HRMS).

Results
A suspect screening method for nitrated products of phenolic chemicals was established. Pooled PM2.5 samples were separately reacted with $NaNO_2$ containing either ^{14}N or ^{15}N to generate nitration products characterized by a fixed isotopic mass difference. After profiling using LC-HRMS, feature pairs were filtered based on a precursor mass difference of 0.997 ± 0.002 Da and a retention time deviation of < 0.1 min. This yielded a list of candidate of mono-nitration products. Subsequently, this list was cross-referenced with feature from PM2.5 samples without treatment using exact mass matching (tolerance: 5.0 ppm). Features meeting this criterion were retained as environmentally relevant nitration candidates. Finally, the theoretical precursor mass of each candidate's parent compound was back-calculated by subtracting 44.9851 Da (the net mass shift corresponding to $-NO_2$ replacing -H), thereby generating a list of potential parent compounds. These parent compounds were further identified and annotated through database matching and other analytical methods.

Discussion and Conclusion
Applying this established strategy, a total of 240 nitrated product features were obtained from the pooled PM2.5 samples in Jinan. These were further matched to yield 68 hits corresponding to 35 synthetic phenolic chemicals, including cresols, alkyl-substituted phenols, biphenols, parabens, and benzophenones. Furthermore, four specific nitration products were successfully synthesized via laboratory nitration reactions using authentic standards to validate the screening results.

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Environmental and human exposure to plasticizers and other consumer product chemicals

P-00873 Suspect screening of Rubber-Derived Chemicals in Workers Reveals Widespread Internal Exposure and Associations with Liver and Kidney Function

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Introduction
The rubber industry holds a significant position within global manufacturing. To enhance rubber performance, large quantities of functional chemicals, such as vulcanization accelerators, plasticizers, and antioxidants, must be added during production. Despite their widespread industrial use, the rubber-derived chemicals (RDCs) can be continuously released during rubber manufacturing, product usage, and waste disposal, resulting in complex environmental and human exposure scenarios. In rubber manufacturing environments, workers may experience chronic exposure to diverse mixtures of RDCs through inhalation, dermal contact, and dust ingestion, highlighting the need for comprehensive characterization of occupational chemical exposure profiles.

Materials and Methods
A total of 407 serum samples were collected from rubber-manufacturing workers between August and November 2023. A pooled serum sample was prepared and used as a quality control (QC) sample for RDC screening. Sample preparation was performed using liquid-liquid extraction. All the sample analysis was conducted on a Vanquish UHPLC instrument coupled to the Orbitrap ExplorisTM 240 mass spectrometer (Thermo Fisher Scientific, Waltham, MA, USA). A comprehensive suspect screening workflow was established to characterize RDCs in the pooled serum samples. Confidence of the compound identification was assigned according to the widely adopted Schymanski framework. Associations between specific RDCs and clinical indicators of liver and kidney function were further analyzed based on quantitative and semi-quantitative results of the RDC concentrations.

Results
Using a curated suspect list of 1,409 RDCs, 83 candidates were identified and labelled as level 3, among which 56 representative chemicals (level 2) were quantified or semi-quantified. Processing aids, including diethyl phthalate and dibutyl sebacate, and protective agents, such as 3,5-di-tert-butyl-4-hydroxybenzaldehyde, were ubiquitous, with detection rates exceeding 95%, indicating a complex multi-component exposure environment and widespread internal exposure to multiple RDCs among the workers. Multiple linear regression analyses revealed significant associations between specific RDCs and clinical indicators of liver and kidney function, suggesting potential occupational impacts on organ function.

Discussion and Conclusion
This study has important implications for occupational health management and environmental regulation. First, the widespread internal exposure to RDCs observed in rubber manufacturing workers highlights the need for improved exposure control strategies. Second, the observed associations between RDCs and liver and kidney function biomarkers suggest that current occupational exposure limits may not fully account for the health risks associated with long-term, low-dose, and mixed chemical exposure. These findings support the integration of biomonitoring data and mixture toxicity considerations into regulatory frameworks. Given the multi-component and persistent nature of chemical exposure in rubber manufacturing environments, future studies should incorporate longitudinal designs and toxicokinetic models to better elucidate the mechanisms underlying cumulative effects of long-term, low-dose mixture exposure, thereby providing a scientific basis for the formulation of more effective occupational health protection standards.

Acknowledgment
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P-00876 Microdroplet Interfaces Drive Aging and Toxicity Amplification of Secondhand Smoke

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Introduction
The details of the PTS formation mechanism on the molecular level are important for controlling PTS formations in industrial thermal processes. Identification of the intermediates, including organic free radicals, during the thermochemical reactions of precursors, such as chlorophenol, is required. Field studies has shown that concentrations and characteristics of organic pollutants generated from different thermal-related industrial processes were quite different. Uncovering the discrepancy of catalysis mechanisms by different metal compounds for organic pollutants formation is instructive for the effective target control of priority organic pollutants from different thermal-related industries.

Materials and Methods
The occurrence of free radicals produced during the thermochemical reactions of pentachlorophenol (PCP) as the precursor were monitored by electron paramagnetic resonance (EPR) spectroscopy, which could provide direct evidence for understanding the mechanisms involved in PTS formation. The catalysis pathways of different metal oxides were also proposed on the basis of the organic free radical intermediates identified by EPR and the organic pollutants screened by gas chromatography quadrupole time-of-flight mass spectrometry (GC/Q-TOF-MS).

Results
Different organic radical spectrums were acquired when PCP was used as the precursor during the thermal reaction at the temperature range from 298K to 600K under different catalysts, indicating different catalysis mechanisms of different metal compounds. Elucidation of the complex spectrum is the first step to clarify the organic free radical intermediate species. The thermal reaction products of pentachlorophenol under different metal compounds catalysis were identified by GC/Q-TOF-MS. The characteristics of the screened chemicals were quite different on the surface of different catalysts. Chemicals under the catalysis of CuO are of higher chlorination degree, octachlorodibenzo-p-dioxin were only detected in the CuO system with the same condition, indicating that CuO has the strongest catalytic ability to dioxins among the four metal oxides. Under the catalysis of ZnO, chemical of higher oxidation state was dominant, including the benzofenac methyl ester, and some polycyclic aromatic hydrocarbons like 1,4-diiso-propylnaphthalene. The products from the catalysis of Al2O3 has less chlorine substitution and longer carbon chain, demonstrating that PCP is more prone to dechlorination and alkylation under Al2O3 catalysis.

Discussion and Conclusion
CuO dominated dehydrogenation reactions of PCP to form pentachlorophenoxy radicals, and the poor stability of organic free radical intermediates on CuO surface made them readily be dimerized to high chlorinated organic pollutants. The specific high proportion of semiquinone radicals and oxygen-containing derivatives in ZnO system indicated that oxidation reactions were predominant. Differently, methyl substituted organic free radical intermediates and long-chain products including the polycyclic aromatic hydrocarbons of high rings were dominant in two polymorphs Al2O3 systems, which demonstrated that Al2O3 has significant advantages for catalyzing alkylation reactions. The consistent characteristics of organic free radical intermediates and final organic pollutants suggested an essential role of free radical intermediates on the organic pollutants formation.

Acknowledgment
This work was supported by the National Natural Science Foundation of China (grant numbers 21936007, 21906165, 22076201 and 92143201).

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P-00878 Formation mechanisms of persistent organic pollutants intermediated by organic free radicals

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Introduction
The details of the PTS formation mechanism on the molecular level are important for controlling PTS formations in industrial thermal processes. Identification of the intermediates, including organic free radicals, during the thermochemical reactions of precursors, such as chlorophenol, is required.Field studies has shown that concentrations and characteristics of organic pollutants generated from different thermal-related industrial processes were quite different. Uncovering the discrepancy of catalysis mechanisms by different metal compounds for organic pollutants formation is instructive for the effective target control of priority organic pollutants from different thermal-related industries.

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The occurrence of free radicals produced during the thermochemical reactions of pentachlorophenol (PCP) as the precursor were monitored by electron paramagnetic resonance (EPR) spectroscopy, which could provide direct evidence for understanding the mechanisms involved in PTS formation. The catalysis pathways of different metal oxides were also proposed on the basis of the organic free radical intermediates identified by EPR and the organic pollutants screened by gas chromatography quadrupole time-of-flight mass spectrometry (GC/Q-TOF-MS).

Results
Different organic radical spectrums were acquired when PCP was used as the precursor during the thermal reaction at the temperature range from 298K to 600K under different catalysts, indicating different catalysis mechanisms of different metal compounds. Elucidation of the complex spectrum is the first step to clarify the organic free radical intermediate species. The thermal reaction products of pentachlorophenol under different metal compounds catalysis were identified by GC/Q-TOF-MS. The characteristics of the screened chemicals were quite different on the surface of different catalysts. Chemicals under the catalysis of CuO are of higher chlorination degree, octachlorodibenzo-p-dioxin were only detected in the CuO system with the same condition, indicating that CuO has the strongest catalytic ability to dioxins among the four metal oxides. Under the catalysis of ZnO, chemical of higher oxidation state was dominant, including the benzofenac methyl ester, and some polycyclic aromatic hydrocarbons like 1,4-diiso-propylnaphthalene. The products from the catalysis of Al2O3 has less chlorine substitution and longer carbon chain, demonstrating that PCP is more prone to dechlorination and alkylation under Al2O3 catalysis.

Discussion and Conclusion
The differences of organic free radical intermediate species, concentrations and foramtion mechanisms under the catalysis of different metal compounds were uncovered, which were verified mutually with the characteristics of final organic pollutants screened by time-of-flight mass spectrometry. CuO dominated dehydrogenation reactions of PCP to form pentachlorophenoxy radicals, and the poor stability of organic free radical intermediates on CuO surface made them readily be dimerized to high chlorinated organic pollutants. The specific high proportion of semiquinone radicals and oxygen-containing derivatives in ZnO system indicated that oxidation reactions were predominant. Differently, methyl substituted organic free radical intermediates and long-chain products including the polycyclic aromatic hydrocarbons of high rings were dominant in two polymorphs Al2O3 systems, which demonstrated that Al2O3 has significant advantages for catalyzing alkylation reactions. The consistent characteristics of organic free radical intermediates and final organic pollutants suggested an essential role of free radical intermediates on the organic pollutants formation.

Acknowledgment
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Environmental and human exposure to plasticizers and other consumer product chemicals

P-00882 Environmental distribution and health risks of emerging plastic additives

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Introduction
A large variety of industrial chemicals has been used as additives in plastic goods to enhance the functions and length of service. They include plasticizers, flame retardants, antioxidants, UV stabilizers, and others. During the lifetime of plastic goods, some of these industrial additives may release from host products and enter into the environment. Understanding the environmental distributions and potential risks of this complexity of chemicals becomes necessary but challenging. In the present study, we collected indoor dust from 21 cities located across China and explored the compositions and abundances of various types of plastic additives in dust. The results revealed a high complexity of additives present in indoor dust. The levels varied across cities and were associated with city GDP. A number of emerging chemicals, including new plasticizers and antioxidants, exhibited higher abundances than their legacy compounds. The neurotoxicity of chemical components of indoor dust also exhibited significant geographical variations, which was driven by concentration differences of selected chemicals across cities. Our results demonstrate that plastic additives show a widespread distribution in indoor environment and some of them may exhibit toxic effect meriting further evaluations.

P-00889 Human Exposure to BPS derivatives in urine in Chinese population

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Introduction

The widespread use of bisphenol S (BPS) as a substitute for bisphenol A has raised concerns about exposure to its derivatives, a topic largely unexplored in human populations. This study presents an investigation of multiple BPS derivatives in human urine in three cities from eastern and western China. Among the 317 urine samples, we revealed a landscape of widespread co-exposure. The geometric mean concentrations of BPS derivatives were 0.422 ng/mL, 0.548 ng/mL, and 0.376 ng/mL for Wuxi, Chengdu, and Shehong cities, respectively. Significant geographic differences were observed, with higher concentrations in Chengdu than in Wuxi ($p < 0.05$). Demographic factors such as age were remarkably associated with elevated urinary levels, with concentrations generally decreasing as age increased. A nationwide analysis revealed spatial variation across Chinese provinces, with concentrations negatively correlated with compound hydrophobicity. Additionally, estimated daily intakes of BPS derivatives (median: 9.50 ng/kg bw/day) suggest relatively low human exposure. These findings underscore the pervasive and varied exposure to BPS derivatives among the Chinese urban population, shifting the focus beyond BPS itself and highlighting the urgent need for comprehensive risk assessments of bisphenol-based substitutes.

P-00891 Assessment of Green Techniques for Monitoring Per- and Polyfluoroalkyl Substances in Soil, Water, and Packaged Dairy Products

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Introduction

PFAS contamination is a global issue that has attracted significant scientific attention due to the widespread presence of PFAS in environmental matrices and consumer products. Due to their grease- and waterproofing properties, these chemicals are used in a wide range of consumer products. Unbridled use, mismanaged dumping, and incineration of waste, industrial effluents, and firefighting foam are major routes of exposure to these chemicals in the environment. PFAS contamination underscores the need for continuous monitoring of the environmental matrix, consumer products, and food materials. Of note, soil, water, and packaged food materials are routes of PFAS exposure. Even at low levels, these PFAS chemicals exhibit endocrine disruption, hepatotoxicity, neurotoxicity, and other health effects

Although many analytical techniques have been reported for PFAS estimation, environmentally sustainable green extraction methods are limited. The study has explored the potential of three green extraction techniques for investigating PFAS in environmental matrices and packaged food samples. Accelerated solvent extraction, in-glass closed-chamber rocket evaporation, and QuEChERS were used to investigate various PFAS in urban soil, river water, and packaged milk and yogurt samples.

81 soil samples were collected from marketplaces, gas stations, traffic intersections, gardens, and public parks to gain insight into the spread of PFAS in soil. The potential of in-glass, closed-chamber rocket evaporation as a framework for the plastic-free, simple, and quick preconcentration of samples was investigated. The ASE-LC-HRMS method demonstrated high sensitivity, with limits of detection (LOD) ranging from 0.32 to 2.54 ng/mL and limits of quantification (LOQ) ranging from 0.96 to 7.70 ng/mL for 24 analytes. In all sampling locations, PFAS contamination was observed. Perfluorohexane sulfonic acid (PFHxS; 568.42 µg/kg) was most abundant near petrol pumps, whereas perfluoroheptane sulfonic acid (PFHpS; 499.16 µg/kg) predominated at traffic intersections. Increased concentrations of perfluorononanoic acid (PFNA; 518.25 µg/kg) were detected in marketplace samples, while public parks and gardens exhibited comparatively lower contamination levels. Sodium perfluorooctane sulfonate was the predominant compound across all sites, with a cumulative concentration (ΣNaPFOS) of 188.51 µg/kg and recoveries ranging from 80% to 170%.

28 river water samples were collected from a densely populated metropolis in India. The efficacy of in-glass, closed-chamber rocket evaporation was investigated as a plastic-free, rapid, and simple preconcentration technique. The LODs and LOQs of 0.25–3.84 ng/mL and 0.83–12.81 ng/mL, as determined by LC-HRMS. Perfluoroheptanoic acid (PFHpA), perfluoroheptane sulfonic acid (PFHpS), and PFHxS were the most prevalent PFAS, with concentrations of 203.3 ng/L, 141.04 ng/L, and 126 ng/L, respectively. Pearson correlation analysis was employed to investigate the co-occurrence patterns of PFAS. The developed method achieved a green analytical index score of 0.65, indicating satisfactory environmental sustainability.

To evaluate PFAS contamination in dairy products, a modified QuEChERS method was optimized by varying extraction salts, dispersive solid-phase extraction (dSPE) cleanup salts, and sample volume. Eight milk and five yogurt samples packaged with different packaging types were analysed. Recovery studies at three spiking levels were used to validate the method. Tetra-packaged milk samples exhibited 15 PFAS, whereas plastic pouch-packaged milk samples contained seven different PFAS. A total of 5 PFAS were detected in yogurt samples, which showed lower contamination. In a highly contaminated milk sample, the highest cumulative PFAS concentrations were observed to be 240.9 ng/mL, and in a yogurt sample (54.4 ng/mL). The hazard assessment calculated the hazard index (HI) at 3, indicating potential carcinogenic health risks from PFAS exposure through dairy product consumption.

Overall, the work highlights the pervasiveness of PFAS contamination and its possible effects on human health while demonstrating the efficacy of green extraction techniques for PFAS identification in environmental and food matrices.

Environmental and human exposure to plasticizers and other consumer product chemicals

P-00901 Comparison of environmental impact mitigated for Fe3O4-based nano-detergents: A life cycle perspective & scenario analysis

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Introduction

The development of new detergents and the evaluation of their environmental impact are of great importance for the development of the laundry industry and environmental protection. Nanotechnology can modify the structure of materials on a tiny scale to achieve specific properties, which significantly improves the performance of materials[8][9][10]. With the rapid development of nanotechnology, nano-detergents, as an emerging technological product, provide new solutions to improve washing performance.

The environmental impact of detergents can be analyzed using Life Cycle Assessment (LCA), which is a method for evaluating the environmental impacts of a product, process system, etc., due to the input of energy, raw materials, etc., and the output of waste. The LCA methodology identifies and quantifies the environmental impacts at different stages, providing a scientific basis for the development of more environmentally friendly production and use strategies.

In summary, two new efficient nano-detergents based on iron tetroxide and 1,2-dodecanol have been developed in this work. The impacts of the nano-detergents are analyzed to identify environmental hotspots in their life cycle and propose targeted eco-design optimization strategies through hotspot analysis. This study aims to provide data support and design guidance for the development of the detergent industry and to provide a scientific basis for the development of more environmentally friendly and sustainable detergent products

Materials and Methods

The main objectives of this study are to combine LCA and scenario analysis methods for the development of sustainability strategies for nano-detergents, to identify the main environmental factors associated with the life cycle of new nano-detergent products, and to make recommendations on how to minimize the aspects of the product life cycle. The dosage of the two nano-detergents was chosen as the functional unit under the same load of washing 2.0 kg of household laundry (washing temperature: 25°C at room temperature and dosage of 13.2 g and 15.1 g, respectively) to facilitate the comparative analysis of their environmental impact.

P-00903 Rhizosphere microbiome transplantation as a resource-efficient approach to enhance growth, and microbial functional diversity in urban plants

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Introduction
Urban soils are increasingly affected by degradation, compaction, pollution, and water limitation, which can constrain plant performance and the functioning of urban green spaces. Rhizosphere microbiome transplantation (RMT), which transfers entire microbial communities from donor plants to target species, has emerged as a potential alternative to conventional single-strain inoculants.

Materials and Methods
Here, we evaluated the effects of RMT on Cota tinctoria, a species commonly used in urban lawns and gardens, using microbial communities sourced from Festuca ovina. Following seedling establishment, plants were exposed to controlled drought conditions and assessed for growth (biomass, height, leaf number), physiological (chlorophyll content), biochemical (phenolic compounds), and microbial (community-level physiological profiles of soil, rhizosphere, root endophytes, and leaf endophytes) responses.

Results
RMT was associated with higher plant biomass, height, and leaf production compared with the control treatment, whereas photosynthetic pigments and most phenolic compounds showed limited responses. Functional analyses revealed compartment-specific patterns, with relatively stable soil and rhizosphere communities and pronounced increases in substrate utilization, metabolic activity, and functional diversity in root and leaf endophytes. Stress-index analyses suggested a shift in endophytic carbon-use patterns toward greater carbohydrate utilization.

Discussion and Conclusion
Collectively, these results indicate that application of a rhizosphere microbiome transplant is associated with changes in plant performance and microbial functional profiles under drought conditions. The study provides preliminary insights into the potential use of microbiome-based approaches in urban vegetation management, while highlighting the need for additional mechanistic and field-based investigations.

Acknowledgment
This study was conducted as part of the Water4All project "Management of rainwater runoff in urban areas for tackling extreme hydroclimatic events" (reference No. Water4All-2022-FP-00121) and was financed by the National Centre for Research and Development (NCBiR), Poland, under agreement No. WATER4ALL/I/6/SPRINGINESS/2024.

P-00907 Ubiquitous and remarkable tire-derived chemicals (TDCs) contamination in road-related environmental receptors across the Tibetan Plateau

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Introduction
The Tibetan Plateau is sparsely populated with limited industrial scale; however, the growth in vehicle ownership and the development of tourism have led to increasingly busy regional traffic. Tire-derived contaminants (TDCs) released from road traffic lack targeted regulatory restrictions and exhibit toxic effects on organisms 1, which has rendered TDCs a fast-growing research hotspot 2,3. Characterized by a simple natural ecosystem structure and highly sensitive ecological receptors, the Tibetan Plateau provides an ideal place to explore the impact of TDCs on the surrounding environment.

Materials and Methods
The cities of Lhasa, Nyingchi, and Shigatse were selected as three representative areas for investigation. Road dust (collected from four functional areas: mountain (n = 6), urban center (n = 7), urban outskirts (n = 7), and suburban (n = 18)), roadside soil (n = 17), puddle water and river water adjacent to the sampling sites (n = 28) were collected. Solid samples were extracted via ultrasound-assisted extraction, using 3.0 mL acetonitrile (twice) and 3.0 mL hexane/dichloromethane mixture (1/1, v/v) (twice). For water samples, solid-phase extraction was performed using Oasis HLB cartridges (Waters, 6 cc/150 mg). The 46 TDCs, including antioxidants, accelerators, corrosion inhibitors, cross-linking agents and their transformation products, were analyzed using the high-performance liquid chromatography system coupled to a mass spectrometer (HPLC-MS/MS) with selective reaction monitoring mode.

Results
All 46 TDCs were detected in road dust samples, demonstrating their pervasive presence. Among them, 39, 37, 43, and 43 TDCs were identified with a detection frequency higher than 60% in road dust, roadside soil, puddle water, and river water, respectively. To investigate the influence of road conditions on the distribution of TDCs, road dust sampling sites were categorized into urban center, urban outskirts, suburban and mountain areas based on functional zone and geographical features. Road dust from mountain areas exhibited unexpectedly remarkable contamination of 6PPD and 6PPDQ compared to road dust from urban and suburban areas ($p < 0.05$). Roadside soil acts as a key sink where TDCs transport from roadways to the broader environment; its TDC concentrations (ΣTDCs range: 441.1–8914.5 ng/g) were significantly lower than those measured in road dust (ΣTDCs range: 500.1–5790.8 ng/g) ($p < 0.05$). To establish a preliminary benchmark, TDCs levels measured in puddle water on the Tibetan Plateau were compared with stormwater runoff concentrations from other studies (ΣTDCs range: 951.2–7969.0 ng/L). As a key receptor, river water directly governed the safety of aquatic ecosystems and the potential for long range TDCs transport. The TDCs concentrations in river water from Tibetan Plateau exhibited low levels (ΣTDCs range: 138.3–488.8 ng/L).
Based on the maximum concentrations, 6PPDQ, 6PPD, CPPDQ and DPPDQ exhibited high risk (RQ = 1.5–328.4), while 7PPD, DNPD, IPPDQ, DPG, TMTM and TBTD posed a medium risk (RQ = 0.1–0.5). Notably, even under the more conservative scenario of median concentrations, 6PPDQ still presented a high risk (RQ = 48.1).

Discussion and Conclusion
This study provides the first report of widespread contamination by TDCs on the Tibetan Plateau, with some TDCs concentrations in road dust, roadside soil and puddle water samples from Tibetan Plateau were comparable to those found in the same types of samples from urban cities with significantly higher traffic volumes. Given the fragile nature of the plateau ecosystem, long-term routine monitoring and targeted risk management strategies are urgently needed.

Acknowledgment
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P-00909 Nucleic Acid Biosensors for In Situ Imaging of Polycyclic Aromatic Hydrocarbon Exposure-Induced DNA Damage in Living Cells

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Introduction
Contaminant exposure induces a series of DNA damage in cells, leading to the onset and progression of diseases including cancer. Investigating DNA damage caused by contaminants in living cells is of great significance for assessing cytotoxicity, genotoxicity, and carcinogenicity. Apurinic/apyrimidinic endonuclease 1 (APE1) is the most prevalent base excision repair protein in the human body and an important biomarker for cellular carcinogenesis. Its intracellular expression level and distribution are closely associated with the physiological state of cells, enabling the assessment of cell viability and DNA damage levels.
In this study, we developed a computer simulation-assisted nucleic acid nano-fluorescent probe targeting APE1 to reveal DNA damage induced by environmental contaminants in individual living cells. Molecular simulations of APE1 and its various substrates were performed to elucidate the interaction mechanism between APE1 and its reaction substrates. Based on these findings, a novel structured DNA probe with a fast product dissociation rate was rationally designed. Experimental results demonstrated that the probe successfully eliminated the product inhibition effect and significantly enhanced sensitivity, validating the feasibility of molecular simulation in probe design.
Furthermore, high-affinity APE1 substrates were conjugated onto the surface of ZnO_2 nanoparticles to construct ZnO_2@DNA nanoprobes. The ZnO_2 nanoparticles serve dual roles as both the probe carrier and a cofactor provider, releasing Zn^{2+} to activate APE1 upregulated by contaminant exposure. The AP sites within the fluorescent DNA substrate are cleaved by the activated APE1, releasing fluorophores and generating fluorescence signals to indicate the location and extent of APE1-associated DNA base damage in living cells.
The ZnO_2@DNA fluorescent probe was subsequently applied to investigate DNA damage in living human hepatocytes induced by benzo[a]pyrene (BaP) exposure. Results demonstrated that BaP at concentrations of 5–150 μM induced significant AP site-type DNA damage within 2–24 hours, exhibiting both time-dependent and concentration-dependent effects.

Acknowledgment
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Environmental and human exposure to plasticizers and other consumer product chemicals

P-00911 A knowledge graph-bayesian network-driven suspect screening strategy for phthalate exposure assessment

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Introduction
The widespread substitution of phthalate esters (PAEs) in industrial production has resulted in an increasingly complex environmental exposure and metabolic transformation in humans.

Materials and Methods
To systematically elucidate their biotransformation relationships, a knowledge graph-Bayesian network-driven suspect screening (KGBS) strategy that integrated text mining, probabilistic reasoning, and high-resolution mass spectrometry (HRMS) was developed.

Results
A total of 54,838 associations between PAEs and their metabolites were extracted through text mining from 3167 publications to construct a Bayesian inference-embedded knowledge graph, which quantitatively prioritized biotransformation events. This framework was then coupled with an HRMS workflow and a mechanistically informed spectral library, forming a unified KGBS platform for compound discovery. Applied to paired indoor dust and human urine samples, the KGBS framework identified 68 PAEs and 49 metabolites, including 18 PAEs and 14 metabolites, that were newly annotated in this study. The prioritization scores and diagnostic MS2 fragmentation fingerprints provided mechanistically informed support for their metabolic linkages.

Discussion and Conclusion
By coupling Bayesian inference with suspect screening, KGBS enabled pathway-centric interpretation of contaminants and their transformation products, which established a scalable and self-evolving strategy for data-driven reconstruction of biotransformation networks, thus offering new perspectives for exposome characterization and human exposure risk assessment.

Acknowledgment
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PFAS Analysis

P-00913 PFAS Reference Standards storage and handling

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Introduction

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The testing of PFAS in environmental and commercial products has become an increasingly more ubiquitous globally. The high fluorophilicity of many commonly tested PFAS in conjunction with their ionic nature can result in prominent adsorption onto un-deactivated surfaces and micelle formation in solution. If unaccounted for, these effects can lead to erroneous results and shorten shelf-life of standards. This poster will discuss how specific characteristics of PFAS compounds can lead to complications in the storage and handling of certified reference material and provides recommendations to mitigate these difficulties.

P-00916 Associations between perinatal dioxin exposure and pubertal arrival in girls from a Da Nang birth cohort in Vietnam

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Introduction
The effects of dioxin exposure on puberty development have been investigated and later puberty has been reported in Russian boys with high dioxin exposure levels in sera (1). However, in girls, no significant difference of age at menarche was found in girls in Seveso, Italy (2), although inverse significant association between breast development and dioxin-like compounds levels was reported in girls in Flanders, Belgium (3).
In 2008-09, we recruited a total of 241 mother–child pairs living nearby former Danang airbase in Vietnam and have followed them up to investigate the adverse effects of perinatal dioxin exposure indicated by dioxin levels in maternal breast milk.
When they reached to 11 years old, we investigated associations between puberty development and perinatal dioxin exposure to clarify the impacts of perinatal dioxin exposure originating from Agent Orange on sexial development in girls.

Materials and Methods
A total of 62 girls from Da Nang birth cohort were participated to the survey. The secondary sex characteristics of the girls was measured by observation of female medical doctors using Tanner stages of breast and pubic hair for girls. The onset of puberty was defined when tanner stage of breast or pubic hair is greater or equal 2 (1st pubertal sign in females). Evidence of the menarche was interviewed and bust and hip sizes were measured at the surey. Puberty onsets were compared between girls exposed to high and low TEQ- PCDD/Fs (lower: < 17.5pg-TEQ/g lipid, higher: >=17.5 pg-TEQ/g lipid). In addition, associations between body sixe markers and dioxin levels were analyzed after adjusting for confounding factors.

Results
The rate of girls with >= Stage 2 of Tanner breast development scale was 68% and significantly lower in higher TEQ-PCDD/Fs group, compared with lower exposure group (90%). Their difference was significant, even after adjusting for confounding factors (OR = 0.061, $p<0.05$). For pubic hair scale, the rate of girls with >= Stage 2 was lower (50%) in the higher TEQ-PCDD/Fs group compared with low exposure group (73%), but their difference was not significant ($p =0.076$). Also, there was no significant difference of the rate of girls with menarche experience between 2 exposure groups (36% in higher group and 38% in lower group). In addition, dioxin exposure showed biphasic effects on body composition before and after menarche: Bust/abdominal ratio was significantly inversely associated with TEQ-PCDD/Fs levels in girls without menarche, whereas it was positively associated with TCDD levels in girls with menarche ($p< 0.05$).

Discussion and Conclusion
These findings suggest that perinatal dioxin exposure may delay the onset of breast development, which was suggested in the Flemish girls (3). Whereas, TCDD may increase feminine body composition (increasing fatty tissue) in girls exposed to dioxins from Agent Orange in Vietnam. For menarche arrival, there was no significant influence of perinatal dioxin exposure, which was suggested in the study for women in Seveso, Italy (2), suggesting no influence on development of the uterine lining. However, girls in the current study were 11 years of age and more than 60% of girls had no menarche experience. We will continuousely follow up them to conclude the effects of perinatal dioxin exposure on menarche arrival in future.

Acknowledgment
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P-00917 Toward a risk-oriented planetary boundary for novel entities: A life cycle perspective

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Introduction
To maintain the stable functioning of the earth system, the planetary boundaries framework defines nine critical boundaries that constrain anthropogenic pressures on the planet. Among them, the boundary for novel entities remains insufficiently operationalized, as its control variables, quantification methods, and safe operating space are still under active debate. Novel entities comprise synthetic chemicals, engineered materials, and other anthropogenic substances that are novel in a geologic sense and capable of disrupting earth system processes. These substances can be released throughout their life cycles and may generate ecological risks through environmental exposure and intrinsic toxicity. Such risks are also spatially heterogeneous because emission intensities, environmental conditions, and ecosystem sensitivities vary across regions. Existing candidate control variables remain insufficient for directly quantifying ecological risks associated with novel entities.

Materials and Methods
Here, we propose a risk-oriented life cycle assessment framework for operationalizing the planetary boundary of novel entities. The framework adopts the multi-substance potentially affected fraction of species (msPAF) as the control variable, integrates life cycle inventories with spatially resolved multimedia fate modeling to quantify emissions and predict environmental concentrations, and characterizes ecological risks through species-level effects.

Results
Regional risks are further aggregated using volume-weighted scaling to estimate global risks. Following the principle of protecting 95% of species, we define the safe operating space as msPAF < 5%. Using pyrethroid pesticides in the Pearl River Estuary, China, as a representative case of high-risk novel entities, we show that downstream environmental releases affect approximately 1% of species at the estuary scale and remain within the safe operating space. However, risks at several local sites exceed the proposed threshold, highlighting the importance of regional-scale assessment. In contrast, upstream production risks affect approximately 5% of species and substantially exceed downstream risks, demonstrating the necessity of incorporating life-cycle processes into novel entity assessments.

Discussion and Conclusion
Overall, the proposed framework integrates control variables, risk quantification pathways, and safe operating space into a unified boundary-setting scheme, providing a methodological basis for advancing a risk-oriented planetary boundary for novel entities.

Per and polyfluorinated substances (PFAS): Occurrence and exposure

P-00922 Long-term trends of PFAS and contaminants of emerging concern in European lobster from western Norway (2009–2025)

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Introduction

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants that are widely distributed in marine environments and can accumulate in aquatic food webs. Despite increasing regulatory restrictions, long-term datasets documenting PFAS trends in marine invertebrates remain limited. This study uses a 15-year time series of European lobster (Homarus gammarus) from western Norway to assess temporal changes in PFAS contamination and to explore the occurrence of contaminants of emerging concern using suspect and non-target screening approaches.

Long-term environmental records are essential for evaluating the effectiveness of chemical regulations and identifying emerging contaminants in marine ecosystems. In this study, European lobster (Homarus gammarus) collected annually from a coastal site in western Norway between 2009 and 2025 (n = 115) was used to investigate temporal patterns of per- and polyfluoroalkyl substances (PFAS) and other contaminants of emerging concern (CECs).

Target analysis of 26 PFAS was performed using LC-MS/MS, complemented by suspect and non target screening using high-resolution mass spectrometry. Twelve PFAS were consistently detected across the time series. The contamination profile was dominated by long-chain perfluoroalkyl carboxylates, particularly PFTrDA, PFUnDA and PFDoDA, indicating widespread background exposure rather than influence from a major local source.

Statistical modelling revealed a significant downward trend for all detected PFAS throughout the monitoring period, with annual decreases ranging from approximately 2 to 10%. These findings suggest a substantial reduction in environmental PFAS burdens over the past decade and are consistent with declining emissions following international restrictions on several PFAS-related substances. Associations between lobster size and contaminant concentrations were compound-specific, with long-chain perfluoroalkyl carboxylates tending to increase with body size, while PFOS compounds showed the opposite pattern.

To broaden the chemical coverage beyond targeted PFAS, high resolution mass spectrometric suspect and non-target workflows were applied. Twelve additional contaminants were tentatively identified, including pharmaceuticals, pesticide-related compounds and chemicals associated with plastic materials. While most exhibited stable or decreasing responses over time, several compounds displayed increasing or variable signals. Among these was trifluoroacetic acid (TFA), a highly persistent fluorinated degradation product that has recently gained attention because of its widespread occurrence in the environment.

The results demonstrate a clear decline in legacy PFAS contamination in European lobster, while simultaneously highlighting the presence of emerging contaminants that are not routinely included in monitoring programs. The study illustrates the benefits of integrating targeted and non-target analytical approaches for long-term assessment of chemical pressures in coastal marine food webs.

P-00924 Bisphenol Compounds Induce Genome-Wide Epigenetic Alterations

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Introduction
Bisphenol A (BPA) is a widely used industrial chemical that is environmentally prevalent. Due to substantial evidence of its adverse effects on reproduction, neurobehavior, metabolism, and inflammatory responses, BPA has been increasingly restricted, prompting the development of structurally similar bisphenol analogues (BPs), such as BPAF, BPF, BPS, and BPAP, as replacements.

Materials and Methods
To assess their potential health risks, we developed advanced approaches to map genome-wide alterations in the epigenetic landscapes, including DNA cytosine methylation and hydroxymethylation.

Results
Leveraging these advanced techniques, we identified a novel feedback circuit involving ERα activation, DNMT, TET2, and DNA hydroxymethylation in ER^+ breast cancer cells, and revealed that TET2 mediated DNA hydroxymethylation plays a pivotal role in modulating BPA/BPS stimulated proliferation. Furthermore, we established, for the first time, a direct linkage between chemical exposure, DNA hydroxymethylation, and tumor associated proliferation. These findings further elucidate the estrogenic activity of BPA and BPS and their significant implications for the regulation of epigenetic DNA hydroxymethylation and cell proliferation. We also investigated the developmental toxicity of BPAP in zebrafish embryos. Exposure to BPAP induced concentration and time dependent lethality, with median lethal concentrations (LC_{50}) of 36 µmol/L at 24 hpf, 22 µmol/L at 48 hpf, and 8.5 µmol/L at 72 hpf. In addition to mortality, BPAP exposure caused significant developmental abnormalities, including delayed hatching, morphological malformations, and reduced spontaneous movement, along with altered DNA demethylation patterns. Transcriptomic profiling revealed upregulation of inflammatory pathway genes (il1b, ptgs2b, fosab), suggesting that BPAP triggers inflammatory responses at the molecular level.

Discussion and Conclusion
Collectively, these findings provide critical evidence for the environmental health risks of bisphenol compounds, highlighting the need for comprehensive toxicological assessments of BPA alternatives in aquatic ecosystems. This methodological framework can also be applied to other environmental pollutants.

P-00926 Effects of co-occurring PFASs and CAHs on microbial communities in soil and groundwater: ecological niches and implications for bioremediation

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Introduction

Abstract
The combined effects of per- and polyfluoroalkyl substances (PFASs) and chlorinated aliphatic hydrocarbons (CAHs) on native microbial communities in the subsurface remain poorly understood. Here, high-throughput sequencing was used to investigate indigenous microbial communities in contaminated soil and groundwater and to assess the relative contributions of deterministic and stochastic processes to community assembly. Perfluorooctanoic acid was the dominant PFAS in the subsurface. Short-chain perfluorocarboxylic acids (C < 8) predominated in groundwater, whereas perfluorosulfonic acids were preferentially retained in soil. CAHs reached concentrations of 650.15 mg/L in groundwater, indicating the possible presence of dense non-aqueous-phase liquids. Microbial diversity in groundwater was more strongly associated with contaminant distribution than that in soil. β-nearest taxon index (βNTI) analysis showed that homogeneous selection primarily shaped soil communities, whereas stochastic processes dominated groundwater community assembly. Anaerobic fermentative taxa, including Bacillus and Sva0485, dominated soil, while pollutant-degrading taxa such as Oxalobacteraceae and Dehalogenimonas were enriched in groundwater. These findings demonstrate that compartment-specific microbial communities and assembly processes should be considered when designing effective in situ bioremediation strategies for sites co-contaminated with PFASs and CAHs.
Keywords: PFASs; CAHs; co-contamination; soil; groundwater; microbial community assembly; bioremediation

P-00929 EMN Pollution Monitoring (POLMO) - Improving reliability in pollution monitoring

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Introduction
The EU has highlighted the need for high quality data to support Europe's progress towards a zero-pollution ambition. This network provides measurement science expertise to society, the environmental community and industry to metrologically support monitoring of chemicals, radionuclides, biological/microbiological and particulates pollution in air, water and soil. The European Metrology Network (EMN) for Pollution Monitoring (POLMO) acts as a bridge between stakeholder and end-user communities and contributes to environmental sustainability by pollutant measurements.

Materials and Methods
EMN POLMO (2026) created task groups in order to draw a roadmap for the coming years. One task group is TG-6 PFAS (per- and polyfluoroalkyl substances). Through coordinated research and expert collaboration, TG 6 PFAS helps ensure that Europe can accurately monitor a possible PFAS pollution and better assess its risks to human health and the environment.

Results
EMN POLMO TG 6 PFAS is a technical group within the POLMO network that focuses on improving measurement capabilities for PFAS, a large family of persistent and environmentally harmful fluorinated chemicals. The group works to harmonize analytical methods, strengthen laboratory comparability and capabilities with matric reference materials and interlaboratory comparisons to support regulatory needs by developing reliable, traceable approaches for detecting PFAS in water, soil, air and industrial emissions.

Discussion and Conclusion
For PFAS industrial emissions to air, analytical methodologies are essential to provide regulatory agencies, the regulated community, and the public at large potentially helpful tools. Here, a standardized and harmonized European sampling and sample preparation approach is needed for gaseous industrial emissions. Therefore, several members are part of the Euramet project MetZeroPol (2026) and involved in the new CEN/TC 264 WG 48 - "Emissions and ambient air - Determination of PFAS" group in order to uniformly regulate the standardization of analytical methods for PFAS emissions from industrial plants.

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P-00931 Personal Care Products (PCPs) and Polycyclic Aromatic Hydrocarbons (PAHs) in the snowpack of the Lake Tahoe region (USA)

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Introduction
Mountain regions are highly sensitive and vulnerable to combined impacts of anthropogenic pressures and climate change [1]. Winter tourism may represent a relevant environmental stressor in mountain areas, through skiing activities and the presence of related services and infrastructures, constituting a local source of both legacy pollutants and contaminants of emerging concerns for the snow deposition. In addition, also the long-range atmospheric transport of contaminants may contribute to the accumulation of pollutants in the snowpack. This acts as a temporary reservoir until the seasonal melting in spring, when contaminants can be remobilized, potentially affecting the water resource.
In this study we analyzed polycyclic aromatic hydrocarbons (PAHs) [2] and personal care products (PCPs) [3], including musks, non musks fragrances and UV-filters in snowpack samples collected in the Lake Tahoe region (California and Nevada, USA).

Materials and Methods
Samples were collected in three sites in Lake Tahoe region (California and Nevada, USA): Diamond Peak (DP), Central Sierra Snow Lab (CSSL) and Sagehen Creek Field Station. The first site is located near a ski facility, whereas the other two are situated in more background areas, with limited influence from direct anthropogenic contamination sources. In particular CSSL is a station specialized in collecting snow, meteorology, climatology data. A total of 11 snowpack samples were collected in 2024 and 2025, before the seasonal melting (March and April). Snow was left to thaw at room temperature and extracted using HLB cartridges at the Desert Research Institute (NV, USA). Samples were stored at -20°C and later eluted in a stainless steel organic free clean-room with toluene, dichloromethane and n-hexane at Ca' Foscari University of Venice (IT). 13C-phenanthrene was used as internal standard and instrumental analyses were conducted by GC-MS/MS (Trace 1310 - TSQ 9000 Thermo Fisher) [4].

Results
The highest concentration of ΣPCPs (222 ng L-1) and ΣPAHs (744 ng L-1) was detected at DP, respectively in 2024 and 2025. The UV-filter Octocrylene (OCR) resulted the most abundant compound among PCPs, with the highest concentration occurring in DP 2024 (100 ng L-1), when also the UV-filter Ethylhexyl Salicylate (EHS) was detected at similar levels. Focusing on fragrances, Oranger Crystals (0.3-6.2 ng L-1), Benzyl Salicylate (0.4-1.3 ng L-1) and musk Tonalide (AHTN 0.1-0.4 ng L-1) were found in all sampling sites. PAHs, represented mainly by phenanthrene (26-478 ng L-1), were detected in all sites at higher concentrations in 2025 compared to 2024.

Discussion and Conclusion
The highest concentrations of both PCPs and PAHs were observed in DP, suggesting that the ski facilities and other recreational infrastructures may represent a local source of contamination, in particular during the winter season. OCR resulted the most abundant PCP in most samples, with the highest concentration at DP probably due to its use in sunscreen products applied by skiers. However, the lower concentrations of OCR detected also at Sagehen and CSSL, may suggest the contribution of atmospheric deposition. Focusing on PAHs, their ubiquitous presence is attributable to multiple sources of emissions due to combustion processes linked principally to pyrogenic origin, related to use of fossil fuels for infrastructure heating and vehicles.
In spite of the low number of samples collected, this study provides a first glimpse into the PCP and PAH contamination of the snow in the Lake Tahoe region, pointing at the possible most relevant local and distant sources.

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P-00938 Sustainability in Legal and Technical Standards for Microplastics: The Gap Between Aspiration and Reality

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Introduction
Microplastics have emerged as a major environmental concern due to their persistence, widespread distribution, and potential impacts on ecosystems and human health. Regulatory and standardization frameworks are essential tools for addressing such challenges; however, both legal and technical references often struggle to keep pace with rapidly evolving scientific knowledge. In the field of microplastics, significant uncertainties remain regarding their formation, degradation, and environmental fate. Consequently, existing regulations and standards may not adequately reflect the current state of scientific understanding, creating gaps that can hinder effective environmental protection and sustainable material development.

Materials and Methods
A qualitative gap analysis was conducted on current legal and technical normative references related to plastics, compostability, and biodegradability. The analysis focused on identifying inconsistencies between the objectives of sustainability claims and the actual scientific evidence supporting material performance. Particular attention was given to standards commonly used for the assessment of plastics under composting conditions, including ISO 20200 and EN 14995.

Results
The analysis revealed significant gaps within both regulatory and standardization frameworks. Legal references are designed to guide societal development and environmental protection; however, their implementation typically follows a lengthy legislative process. As a result, regulations often lag behind scientific advances and may require continuous revision to address emerging challenges associated with microplastics.
Similar limitations were identified in technical normative references. Standards are intended to harmonize testing procedures and provide reliable criteria for material evaluation. Nevertheless, the rapid evolution of environmental concerns requires frequent updates of such documents. Furthermore, access to standards in Europe generally requires purchase, potentially limiting their widespread application and creating barriers to harmonization.

Discussion and Conclusion
A critical issue concerns the distinction between compostability, disintegration, and biodegradability. The growing market demand for environmentally friendly products has increased the risk that materials are promoted as sustainable despite limited evidence of their actual environmental performance. In this context, standards may be misinterpreted and used to support questionable sustainability claims. ISO 20200 provides a relevant example. The standard evaluates the disintegration of plastics under composting conditions and, based on its title, may be perceived as a tool for assessing the environmental suitability of plastic materials. However, the standard explicitly states that it is not applicable for determining biodegradability and that additional testing is required before claiming compostability. Consequently, a material that successfully disintegrates may simply fragment into smaller particles, including microplastics, without undergoing complete biological degradation. Reliance on disintegration alone may therefore lead to misleading conclusions regarding sustainability. Comparable limitations are present in EN 14995, which establishes requirements and procedures for determining the compostability and anaerobic treatment of non-packaging plastics. Although the standard provides valuable guidance, compliance does not necessarily guarantee complete biodegradation under real environmental conditions. From a scientific perspective, biodegradability is defined by the ability of microorganisms, including bacteria, fungi, and algae, to metabolize a material and ultimately convert it into carbon dioxide, water, biomass, and other harmless products without leaving persistent residues. However, the degradation behaviour of many plastics marketed as biodegradable is strongly dependent on environmental conditions. Elevated temperatures can induce structural changes from an amorphous to a crystalline state, reducing water absorption and limiting microbial access to the polymer matrix. Under such conditions, biodegradation rates may decrease substantially or cease entirely, preventing complete mineralization and potentially contributing to the persistence of plastic residues in the environment.

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Per and polyfluorinated substances (PFAS): Toxicity

P-00940 Comparative effects of PFOS, fluorinated aqueous film-forming foams (AFFF), and fluorine-free foams on lipid metabolism in blue mussels (Mytilus edulis)

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are highly persistent environmental contaminants increasingly detected in marine ecosystems, drinking water and food. While legacy compounds such as perfluorooctane sulfonate (PFOS) are known to bioaccumulate and induce toxic effects, less is known about the environmental impacts of newer PFAS-containing firefighting foams and fluorine-free alternatives. Firefighting foams represent an important source of PFAS release to coastal marine environments, where filter-feeding organisms may be particularly vulnerable to exposure.

Materials and Methods
This study investigated PFAS bioaccumulation and potential disruption of lipid metabolism in blue mussels (Mytilus edulis), an ecologically important sentinel species in marine environments. Mussels were exposed over a 14-day period (6 h day^{-1}) to six treatments: seawater control, low PFOS (4 µg L^{-1}), high PFOS (40 µg L^{-1}), fluorine-free foam (16.7 mg L^{-1}), low fluorotelomer sulfonate (FTS) foam (16.7 mg L^{-1}), and high FTS foam (167 mg L^{-1}). FTS-based foams were included as representative of modern fluorinated alternatives, as they typically contain shorter-chain PFAS that are considered less bioaccumulative than long-chain PFAS, but remain highly persistent and mobile in aquatic systems.
The study aimed to quantify PFAS bioaccumulation in whole mussels and assess whether exposure altered gonadal lipid metabolism. Lipid metabolism was evaluated using comprehensive lipid profiling, including fatty acid analysis of neutral lipid classes and polar lipid classes. Fatty acid composition was analyzed for 11 lipid classes including the four main phospholipids (PC phosphatidylcholine, PE phosphatidylethanolamine, PS phosphatidylserine and PI phosphatidylinositol) and its ether linked phospholipids (Plasmalogens), across all the treatment groups.

Results
Preliminary results show a general decrease in storage lipids, triacylglycerols (TAG) in the exposed groups compared to the control group, suggesting increased physiological stress under contaminant exposure. Mussels also appear to adjust membrane fluidity by increasing saturated fatty acids (16:0) in some of the polar lipid classes (especially for PC, the dominant phospholipid in the outer leaflet of the cell membrane), indicating a potential homeostatic response to chemical stress. These responses differed between lipid classes and exposure groups. Preliminary results also show that intermediate lipid classes, such as diacylglycerols (DAG) and monoacylglycerols (MAG), were more responsive to PFAS exposure, suggesting a potential increased sensitivity of lipid metabolic intermediates to contaminant stress.

Discussion and Conclusion
Overall, the results suggest that PFAS exposure induces measurable disruptions in mussel lipid metabolism, characterized by reduced energy-storage TAGs and shifts in membrane lipid composition. The increase in saturated fatty acids in key phospholipids indicates a likely compensatory response to maintain membrane stability under chemical stress, while the heightened responsiveness of DAG and MAG points to sensitivity within lipid metabolic pathways. Together, these patterns support that PFAS, both legacy compounds and newer PFAS-containing firefighting foams, exposure triggers energetic and structural lipid remodeling in mussel gonads.

Acknowledgment
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P-00942 Preliminary development of an LC-HRMS screening method for fluorinated organic contaminants in eggs

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Introduction
Each year, millions of tons of fluorinated compounds are produced and used in industrial applications, including as flame retardants and water-repellent agents.[1] In addition, numerous fluorinated pesticides and pharmaceuticals, characterized by high resistance to metabolic degradation, have been extensively commercialized.[2] Consequently, human and environmental exposure to these substances has become a major focus of scientific research in recent years.[3] This study describes the preliminary development of a targeted LC-HRMS screening method for the determination of per- and polyfluoroalkyl substances (PFAS).

Materials and Methods
At this preliminary stage, the current method includes 25 perfluorinated compounds (e.g., PFOS and ADONA) and 35 polyfluorinated compounds (e.g., fluopyram and triflupromazine). Sample extraction and clean-up procedures were optimized using QuEChERS and dispersive solid-phase extraction (d-SPE), respectively, and analyte recoveries were evaluated in fortified samples at concentrations ranging from 0.1 to 4 ng/g. Chromatographic performance was assessed using two 150 mm C18 columns packed with superficially porous particles and fully porous particles, respectively, incorporating stationary phases with different selectivity. Method development was performed on a Q-Orbitrap mass spectrometer operating in Data-Dependent Acquisition (DDA) mode. Full-scan and MS/MS spectra were acquired at mass resolutions of 100,000 and 30,000 FWHM (at 200 Th), respectively. Polarity switching was not implemented because of the markedly different ionization behaviors of the target analytes. Perfluorinated carboxylates are typically analyzed in negative electrospray ionization (ESI) mode as environmental contaminants, whereas polyfluorinated compounds are generally analyzed in positive ESI mode as pesticide and veterinary drug residues.

Results
With respect to extraction and clean-up procedures, preliminary recovery results (average recoveries of 40–60%) indicate a trend toward improved performance when using a d-SPE mixture composed of 2 g $MgSO_4$, 0.5 g NaCl, 0.1 g C18, and 0.1 g Envi-Carb, without the addition of QuEChERS extraction salts during the extraction step. The two chromatographic columns exhibited comparable separation performance, allowing the selection of the superficially porous particle column because of its more favorable backpressure characteristics. Two aqueous mobile phases were also evaluated. A clear improvement in instrumental response was observed when ammonium formate was used instead of ammonium acetate. Furthermore, ammonium acetate generated additional interferences that appeared particularly problematic for PFBA analysis. Increasing the vaporizer temperature led to only marginal improvements in negative ionization mode, likely due to the well-known tendency of perfluorinated carboxylates to undergo in-source neutral loss of CO_2. A temperature of 250 °C for negative polarity and 340 °C for positive polarity provided the highest and most reproducible signal intensities. The ion transfer tube temperature was set at 280 °C for positive polarity and 265 °C for negative polarity.

Discussion and Conclusion
These preliminary results demonstrate significant potential not only for targeted screening (semi-quantitative) applications but also for the further development of quantitative methodologies and the implementation of non-targeted analytical workflows. The high structural variability of the compounds considered in this work enables the screening of a wide range of PFAS.

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P-00944 One dinner in a restaurant and health risk. Risk assessment based on eleven years of PBDEs monitoring in fish meat from Poland

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Introduction
Polybrominated diphenyl ethers (PBDEs) have been used as flame retardants for more than 30 years. They are classified as POPs and pollute the environment. Despite their ban, they are still present in the environment. In 2014, the European Commission released the Recommendation (2014/118) on the monitoring of traces of brominated flame retardants in food, which comprises PBDEs. According to the European Commission Scientific Opinion "Update of the risk assessment of polybrominated diphenyl ethers (PBDEs) in food" meat and meat products, and fish and seafood are the most important contributors to the chronic dietary exposure to PBDEs. The EFSA CONTAM Panel concluded that it is likely that current dietary exposure to PBDEs in the European population raises a health concern. The aim of the study was the evaluation of the results of 11 years (2014-2025) monitoring of PBDE levels in fish meat intended for sale in Poland.

Materials and Methods
The raw, non-processed fish was collected through the national control plan for the official surveillance of food of animal origin from 2014 until 2025 in accordance with Regulations 2014/589/EU and 2017/644/EU. The 267 samples were split into four groups: Baltic fish (132 samples), aquaculture (84 samples), river fish (18 samples), and imported fish (23 samples). The samples were analysed using an accredited procedure according to PN/EN 17021. The muscles were homogenised and freeze-dried. Before the 13C-labeled standards were added and analytes were extracted using an accelerated solvent extractor (ASE 300). Next, the extract was manually cleaned up and analysed using GC-HRMS. The risk assessment was based on the Combined Margin of Exposure (MOET) carried out according to EFSA Tier 1 (BMDL for BDE- 47 repro, -99 develop, -153 neuro, -209 repro and for the congeners for which no Reference Point BDE-47 was used). The typical body weights of 70 kg and 23.1 kg for adults and children, respectively, were used.

Results
A distinct gradient of ∑10PBDEs contamination based on the origin of the fish. The highest median was found in Baltic fish (0.080 – 2.07 ng/g wet weight), next in imported fish (0.031 – 0.480), aquaculture (0.030-0.160), and the lowest in river fish (0.035-0.144). BDE-47 was the dominant congener across all groups, confirming its high bioavailability for fish and persistence in aquatic environments. The MOET smaller than 25 raises a health concern. A 230 g portion of Baltic's Garfish, polluted on median, could be a health concern for adults. Already 80 g of the same fish could be a health concern for children. A slightly higher portion (120 g) of Baltic's Salmon and Trout polluted on the median level would be considered a risk to children's health. Other fish were also an important source of PBDE, but were not a potential health concern.

Discussion and Conclusion
Most of the freshwater (aquaculture and river) and imported fish available on the Polish market could be considered as being safe for consumers in relation to ∑PBDE content. A frequent consumption of Baltic fish may lead to health concerns. Children, who often eat Baltic fish, are a particularly at-risk group.
Dietary guidelines should emphasize the moderation of Baltic predatory fish consumption to mitigate chronic dietary exposure to PBDEs.

Environmental and human exposure to plasticizers and other consumer product chemicals

P-00946 INQUIRE Project; Polyglycol ethers in indoor house dust

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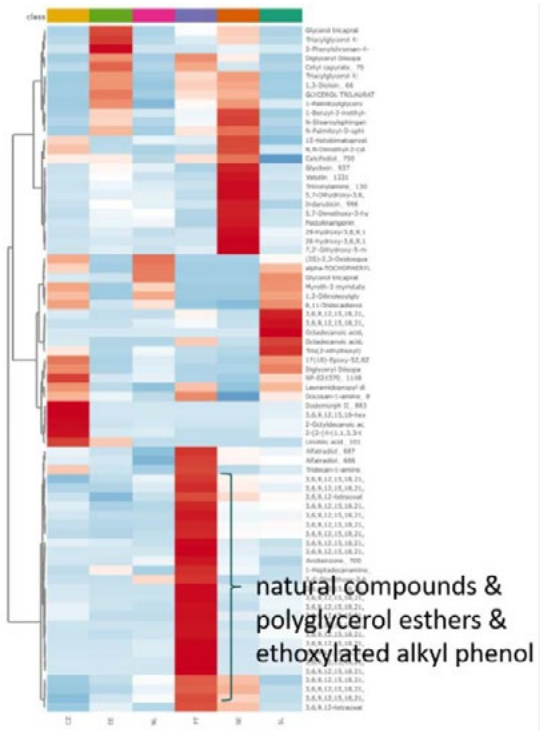
Introduction
Humans spend about 90% of their time indoors, which increases their potential exposure to hazardous substances that accumulate in household dust over time. This study aimed to identify potentially harmful chemicals present in house dust collected from various European countries.

Materials and Methods
As part of the EU-funded INQUIRE project, which focuses on improving indoor air quality, nearly 300 dust samples were gathered from homes across eight European nations.
Dust samples were extracted using a mixture of n-hexane and acetone and analyzed using liquid chromatography coupled with trapped ion mobility spectrometry time-of-flight mass spectrometry (LC-TIMS-TOF) in both positive and negative ionization modes. Chemical annotation was performed using suspect and non-target screening (SNTS) approaches.

Results
More than 20,000 chemicals were detected in total. Notable differences in chemical profiles were observed between countries; for example, samples from the UK showed a distinct composition compared to those from other countries. Several classes of compounds were identified, including lipids, steroids, insect repellents, fragrances, herbicides, and plasticizers, with concentrations varying across samples.
A wide range of polyglycol ethers (PGEs) was detected, including hexaethylene glycol monooctadecyl ether, octaethylene glycol monododecyl ether, and triethylene glycol monododecyl ether.

Discussion and Conclusion
PGEs contributed significantly to the observed differences in chemical profiles between countries and were found at elevated levels in certain regions (Figure 1). The consistent presence of some PGEs suggests common sources. These compounds are widely used in products such as cosmetics and personal care items, as well as in industrial applications including solvents in paints, coatings, printing inks, and cleaning agents.

Acknowledgment
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P-00948 TD/Py-GC×GC-HRTOFMS with Multimode Ionization for Comprehensive Characterization of Microplastics and Their Chemical Alterations

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Introduction
The increasing environmental and health concerns associated with micro- and nanoplastics (MNPs) have driven the development of advanced analytical approaches for their reliable characterization and quantification. Pyrolysis–gas chromatography–mass spectrometry (Py-GC-MS) has emerged as a powerful technique for polymer identification through the thermal degradation of plastic materials into characteristic marker compounds. However, the analysis of MNPs remains challenging due to their small particle size, low concentrations, and the presence of complex environmental and biological matrices that generate substantial analytical interferences [1]. The combination of thermal desorption and analytical pyrolysis enables the characterization of both volatile and semi-volatile additives as well as polymer-specific pyrolyzates within a single analytical workflow, providing a more comprehensive characterization of the MNP organic composition.
Furthermore, the integration of comprehensive two-dimensional gas chromatography (GC×GC) offers significant advantages by enhancing separation efficiency, sensitivity, and chemical characterization capabilities. GC×GC has the potential to resolve overlapping compounds, improve quantification accuracy, and facilitate the detection of minor plastic related constituents and degradation byproducts, making it a crucial approach for MNP analysis. Coupling GC×GC with high-resolution time-of-flight mass spectrometry (HRTOFMS) further strengthens its analytical performance by providing superior separation power, accurate mass measurements, and a more comprehensive chemical description of pyrolysis products.

Materials and Methods
In this work, we describe a generic analytical framework based on thermal desorption/analytical pyrolysis coupled with comprehensive two-dimensional gas chromatography and high-resolution time-of-flight mass spectrometry (TD/Py-GC×GC-HRTOFMS) for the broad-scope screening and characterization of microplastics originating from tire materials. The use of a multimode ion source enabled the successful acquisition of data in both electron ionization (EI) and positive chemical ionization (PCI) modes, providing complementary structural and molecular information.

Results
The analytical workflow was evaluated using cryo-milled tire tread, as well as poly(vinyl chloride) (PVC) and polystyrene (PS) standards.

Discussion and Conclusion
The developed approach demonstrates the potential of TD/Py-GC×GC-HRTOFMS for comprehensive characterization of MNPs and their transformation products, while highlighting remaining analytical challenges that must be addressed for robust analysis of complex environmental and biological samples.

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Screening and identification of novel contaminants

P-00949 Evaluation of possible formation pathways for fluorinated dioxins in industrial emissions

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Introduction
PFAS ("forever chemicals") in household and industrial waste are destroyed by more than 99 % in modern waste-to-energy plants at sufficiently high temperatures (from approx. 850°C). Incineration is therefore regarded as an important sink for permanently removing these substances from the cycle, rather than allowing them to accumulate in the environment. Recent studies show that modern European standards are sufficient to safely degrade the substances without significant quantities being released into the environment. Proper disposal is, however, a complex matter. The Federal Environment Agency is researching degradation and emissions of these substances in waste streams. Filtered pollutants or contaminated activated carbon originating from water treatment must be disposed of as industrial or hazardous waste in specialised high-temperature facilities. To have a deeper look at the possible formation of hazardous compounds, fluorinated dioxins (more precisely: polyfluorinated dibenzodioxins and dibenzofurans, or PFDD/PFDF for short) can be of interest. They are fluorinated analogues of the better-known chlorinated dioxins (PCDD/F) [1].

Materials and Methods
These chemical compounds have chlorine atoms of typical dioxins replaced by fluorine atoms. They are regarded as chemical by-products; according to current scientific knowledge, their formation during the combustion of fluorine-containing materials in the environment is considered highly unlikely. In animal experiments, they accumulate heavily in the thymus (a gland of the immune system). Compared with chlorinated dioxins, however, they are characterised by significantly faster degradation within the animal's organism. Considering the environmental occurrence, there are no significant or known environmental findings of this group of substances, which is why they do not currently pose an acute risk to the environment or the food chain. Some possible formation pathways should be elucidated to form this class of fluorinated chemicals using in silico methods.

Results
As a result of the applied in silico approaches, possible formation pathways and formed fluorinated dioxins or dioxin-like compounds can be predicted.

Discussion and Conclusion
Dibenzo-p-dioxins and dibenzofurans (PFDD/PFDF) can be formed both in laboratory experiments [1] and can be observed in samples after waste incineration. Here, incineration parameters like temperature may be adjusted to reduce or prevent the formation of these hazardous compounds.

Acknowledgment
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P-00951 XenOmics: An Innovative Risk Assessment Toolkit Based on Omics Methodologies and Artificial Intelligence for Occupational Safety

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Introduction
The aetiology of neurodegenerative diseases, such as Parkinson's and Alzheimer's disease (AD), is increasingly recognized as the result of a complex interaction between genetic susceptibility and cumulative lifetime exposure to occupational and environmental neurotoxic agents (1). Various classes of xenobiotics present in industrial and agricultural settings (i.e. pesticides, solvents, heavy metals and welding fumes) have been linked to pathological mechanisms such as oxidative stress, mitochondrial inhibition, and chronic neuroinflammation (2, 3). As occupational exposure typically involves low-dose chemical mixtures and long latency periods, traditional single biomarkers are insufficient to establish a clear causal link to environmental conditions. The XenOmics project aims to bridge this gap by developing and validating an integrated methodological protocol and an innovative toolkit for proactive toxicological risk assessment in occupational toxicology.

Materials and Methods
XenOmics, funded by Italian National Institute for Insurance against Accidents at Work (INAIL), is structured across six progressive Work Packages (WPs) executed by a multidisciplinary team from Sapienza University of Rome and the Italian CNR. Following protocol standardization and ethical approval (WP1),air quality will be assessed through the analysis of particulate matter and volatile organic compounds (WP2). Targeted chemical characterization will be performed by GC-MS and ICP-MS, while untargeted screening of complex chemical profiles will be achieved via high-resolution GC-HRMS (Orbitrap technology). Concurrently, a cohort study will recruit 150 participants divided into three age- and sex-matched groups: 50 exposed workers, 50 healthy controls, and 50 AD patients. Blood samples will be processed to isolate plasma, serum, and peripheral blood mononuclear cells (PBMCs). High-resolution multi-omics analyses (WP3) will involve metabolomics on plasma/serum using UHPLC/MS/MS, alongside transcriptomic and epigenomic analysis (RNA-Seq and Bisulfite Sequencing) on PBMCs to map DNA methylation and mRNA transcription patterns. Relational databases will centralize these multi-omics, environmental, and clinical data (WP4). Supervised Machine Learning (ML) algorithms will then be deployed for data integration, dimensionality reduction, latent pattern extraction, and predictive modeling. Finally, candidate biomarkers and xenobiotics will undergo biological validation (WP5) using advanced in vitro 2D and 3D models, including blood-brain barrier models and stem cell-derived "mini-brain" organoids.

Results
The primary expected product of XenOmics is a scalable and highly versatile integrated methodological protocol designed as a standard reference tool for occupational risk assessment. A central outcome will be the identification of a validated "molecular signature", i.e. a highly sensitive, combined snapshot of metabolic, transcriptional, and epigenetic alterations capable of detecting early-stage biological damage before clinical symptoms manifest. These biological data, integrated with environmental exposure inputs, will yield an AI-driven predictive model capable of calculating an individual risk index. Furthermore, the project will generate a comprehensive, structured relational database of environmental, clinical, and omics data to serve as a lasting reference for long-term longitudinal studies.

Discussion and Conclusion
XenOmics establishes a novel holistic paradigm in toxicological and neuroscientific research by shifting from conventional targeted investigations to complete untargeted molecular and environmental landscaping. This comprehensive approach allows the detection of emerging, unforeseen contaminants and unexpected biological alterations. The translation of these scientific outputs into technological tools and practical safety guidelines has the potential to significantly improve occupational medicine. It replaces broad, less effective generalist measures with timely, personalized preventive interventions (such as task rotation, optimized personal protective equipment, or workplace reallocation) substantially minimizing biological damage, reducing social healthcare costs, and enhancing worker well-being.

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3. Leng F and Edison P (2021). Neuroinflammation and microglial activation in Alzheimer disease: where do we go from here? Nat Rev Neurol, 17:157-172.

Risk Assessment and Risk Management

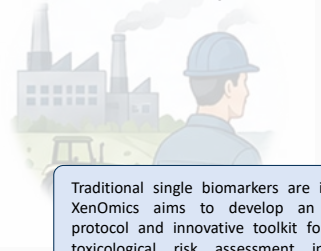
P-00951 XenOmics: An Innovative Risk Assessment Toolkit Based on Omics Methodologies and Artificial Intelligence for Occupational Safety

XenOmics

An integrated multi-omics and environmental approach for proactive toxicological risk assessment in workers exposed to neurotoxic agents

INTRODUCTION

Neurodegenerative disease arise from the interaction of genetic susceptibility and lifetime exposure to occupational and environmental neurotoxic agents



Traditional single biomarkers are insufficient. XenOmics aims to develop an integrated protocol and innovative toolkit for proactive toxicological risk assessment in exposed workers

MATERIAL AND METHODS

WP1 Protocol standardization & ethics

WP2 Environmental sampling & chemical characterization

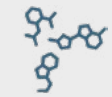
WP3 Multi-omics analyses

WP4 Data integration & database

WP5 Biological validation

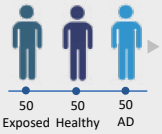
WP6 Dissemination & impact

SAMPLES

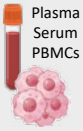


Volatile Organic Compounds

150 partecipants



50 Exposed 50 Healthy 50 AD



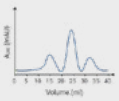
Plasma Serum PBMCs

DATA ACQUISITION

Multi-omics analyses (metabolomic, transcriptomic, epigenomics) by untargeted and targeted investigation



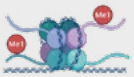
HIGH-RESOLUTION MULTI-OMICS ANALYSES



Metabolomics (Plasma/Serum) UHPLC/MS/MS



Transcriptomics (PBMCs) RNA-Seq



Epigenomics (PBMCs) Bisulfite Sequencing

DATA INTEGRATION, MACHINE LEARNING & PREDICTIVE MODELING



Relational database of multi-omics, environmental and clinical data



Data integration & dimensionality reduction



Latent pattern extraction

BIOLOGICAL VALIDATION



2D cell cultures



Blood Brain Barrier (BBB)



Mini brain organoids

RESULTS

INTEGRATED PROTOCOL & TOOLKIT



Scalable, versatile standard reference tool for occupational risk assessment

IDENTIFICATION OF A MOLECULAR SIGNATURE



Combined multi-omics alterations detecting early biological damage

AI-DRIVEN PREDICTIVE MODEL



Individual risk index integrating omics data and environmental exposure

COMPREHENSIVE RELATIONAL DATABASE



Structured environmental, clinical and omics data for long-term longitudinal studies

This research is developed in the framework of the INAIL BRIC 2025 call (ID 52), through which the Italian National Institute for Insurance against Accidents at Work (INAIL) supports collaborative research addressing emerging occupational risk scenarios and enhancing the prevention of work-related diseases

P-00953 Smart Electrochemical Biosensing: Harnessing AI for Real-Time Monitoring of Emerging Pollutants

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Introduction
Emerging pollutants pose increasing risks to aquatic ecosystems and human health due to their persistence, low concentrations, and complex environmental matrices. Although electrochemical biosensors enable rapid and portable detection, their practical applications are often limited by poor selectivity and signal interference. Here, we present an AI-enabled electrochemical biosensing strategy that integrates machine learning with electrochemical fingerprint analysis for accurate, real-time quantification of toxic pollutants. This intelligent framework significantly enhances analytical robustness and provides a promising platform for next-generation smart environmental monitoring.

Materials and Methods
A portable electrochemical biosensing platform was developed by integrating a bio-inspired electrochemical sensing interface with machine learning-assisted signal processing. Electrochemical fingerprints were collected using differential pulse voltammetry and cyclic voltammetry under various environmental conditions, including different pH values, ionic strengths, and mixed contaminant compositions. Instead of relying solely on characteristic peak currents, multidimensional electrochemical features—including peak intensity, peak potential, current derivatives, and waveform characteristics—were extracted to construct a comprehensive sensing dataset. Several supervised machine learning models, including Random Forest (RF), Support Vector Machine (SVM), Artificial Neural Networks (ANN), and Extreme Gradient Boosting (XGBoost), were trained and optimized for pollutant identification and concentration prediction. Model performance was evaluated through cross-validation and independent testing using environmental water samples.

Results
The AI-assisted electrochemical biosensing platform demonstrated substantially improved analytical performance compared with conventional electrochemical calibration methods. Machine learning effectively distinguished overlapping electrochemical responses originating from different pollutants and significantly enhanced quantitative prediction accuracy under complex environmental conditions. The optimized model achieved excellent concentration prediction with high coefficients of determination (R^2 > 0.99) and low prediction errors across multiple pollutant concentrations. Moreover, the intelligent algorithm effectively compensated for environmental interferences such as pH variation, salinity fluctuation, and matrix effects, resulting in improved robustness and reproducibility. Validation using real water samples demonstrated excellent agreement with standard analytical methods while maintaining rapid response and portable operation. The integration of AI further enabled automatic pollutant recognition and intelligent decision-making without manual interpretation of electrochemical signals.

Discussion and Conclusion
This study demonstrates that artificial intelligence fundamentally transforms electrochemical biosensing from conventional signal measurement into intelligent information interpretation. Machine learning not only enhances the selectivity and quantitative capability of electrochemical biosensors but also significantly improves sensing robustness under dynamically changing environmental conditions. The proposed framework establishes an intelligent sensing paradigm capable of extracting hidden electrochemical information beyond traditional peak analysis, enabling reliable real-time monitoring of emerging pollutants. More importantly, the combination of portable electrochemical sensing, artificial intelligence, and automated data analytics provides a scalable foundation for future Internet of Things (IoT)-enabled environmental monitoring networks and digital water quality management systems. This AI-driven electrochemical biosensing strategy therefore offers substantial potential for smart environmental surveillance, early warning, and sustainable water resource protection.

Acknowledgment
This work was supported by the National Natural Science Foundation of China Youth Fund (No. 32200085), the China Postdoctoral Science Foundation (No. 2022M713074), and the Talent Funding project of CAS (No. 29E2C201).

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P-00955 Performance comparison of three generation tandem mass-spectrometers for analysis of organochlorine pesticides by atmospheric pressure ionization gas chromatography

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Introduction
Organochlorine pesticides are synthetic organic chemicals that contain chlorine and were widely used as insecticides in agriculture and public health. Common examples of organochlorine pesticides include dichloro-diphenyl-trichloroethane and its metabolites, chlordanes, hexachlorocyclohexanes, and dieldrin among others. These compounds are chemically very stable and are highly hydrophobic, which makes them persistent in soils, sediments, and the environment. Because they are lipophilic, organochlorine pesticides tend to accumulate in fatty tissues and biomagnify as they move up the food chain. Exposure to these chemicals has been associated with endocrine disruption, reproductive and developmental problems, neurotoxicity, and in some cases an increased risk of cancer. For these reasons, most organochlorine pesticides have been banned or heavily restricted in many countries and are listed under the Stockholm Convention for elimination or control (1). In accordance with the Stockholm Convention, ongoing monitoring of these persistent organic pollutants is necessary to enable national authorities to decide if measures beyond surveillance are needed. At the Environmental Pollution Laboratory of the University Hospital of Northern Norway, organochlorine pesticides are measured in human research samples, frequently from population studies that examine links between environmental pollutants and adverse health outcomes.
Instrumental upgrades are inevitable. At the Environmental Pollutant Laboratory, the older-generation instrument is currently being phased out, but many datasets were generated using it. To ensure comparability between data from the old and new instrumentation, a performance-comparison study was conducted. The study's findings will be used to develop a strategy for handling existing datasets in subsequent statistical analyses to address any potential instrumental method bias.

Materials and Methods
The sample preparation and original instrumental analysis method were established and validated previously (2). Briefly, 150 µL of human serum or plasma are extracted by solid phase extraction using a 96 well Oasis HLB plate (60 mg, Waters, Milford, USA). Extracts are then cleaned on custom made Florisil columns (Sep Pak, 100 mg, 1 cc, Waters, Milford, USA) and analyzed using a Waters APGC source on a modified Agilent 7890a GC coupled to a Xevo TQ S tandem quadrupole mass spectrometer. The method has been transferred to newer generation systems consisting of Waters APGCs with a modified Agilent 7890b and 8890 GC coupled to a Xevo TQ XS and TQ-absolute tandem quadrupole mass spectrometer.
For the performance comparison, we prepared and analyzed a total of 50 samples according to our standard liquid handler protocol: eight standard reference materials (four non fortified NIST 1957 and four fortified NIST 1958 human serum samples), 12 external quality control assessment samples, and 30 population serum samples from Tromsø (ages 14–91 years; 15 males and 15 females). All samples were measured for 23 organochlorine pesticide compounds on each of the three instruments. Quantification was performed using the internal standard method. Calibration curves were generated from 11 standards with concentrations ranging from 0.005 pg/µL to 10 pg/µL.

Results
Linearity was evaluated and found to be slightly better on the newer-generation systems, while sensitivity was markedly improved. On the Xevo TQ S system several compounds were not detectable at the lowest calibration concentrations, whereas these compounds were detectable on the Xevo TQ XS and TQ-absolute system.

Discussion and Conclusion
Overall, the newer-generation instruments demonstrate clear advantages, providing greater sensitivity and higher detection frequency in real samples with an increased number of detectable analytes.

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P-00958 Dissolved Organic Carbon Enhances TCDD Mass Transfer from Soils to Activated Carbon

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Introduction

The effectiveness of activated carbon (AC) used in sequestration remediation of hydrophobic organic contaminants (HOCs) is often constrained by the slow transfer of contaminants from soil pools to strong sorbents. Dissolved organic carbon (DOC) could influence the mobility of HOC; however, its role in overcoming the transport limitation remains poorly elucidated. Here, we investigated the mass transfer of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) from to magnetic activated carbon (MAC) from TCDD-contaminated soils at varying DOC levels. Using ^{14}C-labelled TCDD, we directly quantified TCDD in soil, aqueous, and MAC compartments, and examined the mass transfer among these phases. DOC could enhance TCDD mass transfer to MAC in all tested soils with varying soil properties. For example, the mass transfer increased from 13.2% to 32.4% in Oshtemo sandy soil in the presence of 1000 mg L^{-1} DOC in solution. Independent experiments demonstrated strong DOC–TCDD association with sorption coefficient KDOC = 19,200 L kg^{-1}, indicating the enhanced DOC-mediated transport of TCDD in aqueous phase. A semi-mechanistic model using independently measured process parameters could successfully predict TCDD transfer kinetics. The results suggest that the mass transfer of DOC-associated TCDD to MAC is substantially faster than that of free-dissolved TCDD. Despite the enhanced mass transfer to MAC, the reduction of gastrointestinal bioaccessibility of TCDD in MAC remained negligible. Together, these findings reveal that DOC can remarkably enhance mass transfer of soil-bound TCDD to AC, but the bioaccessibility might not be reduced based on the experimental results.

P-00962 Comprehensive PFAS Screening in Textiles Using LC-MS/MS and GC-MS/MS

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are widely utilized in industrial applications for their unique stability and repellency. However, their persistence leads to environmental accumulation and human health risks. To mitigate them, the European Union Persistent Organic Pollutants (POPs) Regulation established strict concentration limits of 0.025 mg/kg (25 ppb) for compounds such as PFOA, PFOS, and PFHxS in textiles, a potentially significant source of exposure. The European standard EN 17681 provides the analytical framework, using LC-MS/MS for ionic PFAS (Part 1) and GC-MS for neutral volatile PFAS (Part 2).

This study developed analytical methods based on EN 17681-1/2 for 39 PFAS. For LC-MS/MS, 33 compounds were calibrated at 0.1–10 µg/L, with fluorotelomer alcohols (FTOHs) at 10–1000 µg/L. For GC-MS/MS, eight targets listed in the method plus four FTOHs were calibrated at 1–10 µg/L. The GC-MS/MS was equipped with a high-sensitivity ion source to ensure stable detection at trace levels; a preconcentration step can also be added to further enhance signals. Recovery tests were conducted by spiking textile samples below the current regulatory limit of 0.025 mg/kg. Furthermore, the study compared the previous EN 17681-1:2022 (methanol extraction) with the revised EN 17681-1:2025 (alkaline hydrolysis) using old ski-wear samples.

Results showed excellent linearity for all analytes ($R > 0.998$). Repeatability at the lowest calibration level was good, with %RSD (n=5) generally within 20%. Spike and recovery tests below the regulatory limit were successful, with recoveries between 70% and 130% and %RSD (n=3) within 11%. The high-sensitivity ion source on GC-MS/MS was critical for achieving stable responses at these trace levels without requiring additional preconcentration steps.

In the ski-wear analysis, the EN 17681 1:2025 alkaline hydrolysis pretreatment yielded significantly higher levels of NMeFOSE and 6:2, 8:2, and 10:2 FTOHs compared to the 2022 method. This confirms the effectiveness of the revised procedure in releasing bound or precursor PFAS.

The integrated use of LC-MS/MS and GC-MS/MS allows comprehensive PFAS screening below regulatory limits; targeting FTOHs in both LC-MS/MS and GC-MS/MS provides additional insights into the origin of FTOHs in the samples for better assessment of the exposure while using the products. By optimizing instrumental sensitivity, practical routine screening is possible without preconcentration.

P-00964 Enhanced performance for FOSA and FOSEs analysis with an ultra-sensitive PFAS-multiclass method in environmental samples

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Introduction
With the increasing regulatory drivers and public pressure for managing PFAS in the environment, foods, and consumer and industrial products, laboratories are in need of efficient multiclass-PFAS methods that enable routine ultra-sensitive quantitation. As the classes of PFAS to be monitored expand the instrument performance may be compromised for specific compounds as their ionization efficiency changes based on their physico-chemical properties.

Materials and Methods
In this work, we validated a LC-MS/MS method (LCMS-8065 XE, Shimadzu Corporation) for a multiclass-PFAS panel including PFCAs, PFSAs, FTSs, FOSAs, FOSAAs, FOSEs, FTCAS, PFESAs and PFECAs across matrices of environmental relevance (drinking water, wastewater, tissue…). Sample preparation varied depending on the matrix of interest: co-solvation and direct injection for drinking water, and pre-concentration (either Solid Phase Extraction or solvent extraction) for other sample types.

Results
Method Detection Limits (MDLs) were below 1 ng/L in drinking water for all targeted compounds. In solid samples, MDLs ranged from <0.05 to 0.2 ng/g for PFCAs, PFSAs, PFESAs and PFECAs, < 0.5 ng/g for FTSs and FTCAS, and < 0.6 ng/g for FOSAs, FOSAAs, and FOSEs. In this presentation we will share the detailed results of the method validation, with emphasis on classes of PFASs that are historically worse performers in multiclass-PFAS methods, such as FOSAs and FOSEs.

Discussion and Conclusion
A method for highly sensitive and accurate analysis of 29 PFAS down to less than 1 ng/L in drinking water was validated using the LCMS-8065XE, in one cycle of 18 minutes by direct injection without sample preconcentration.
A separate LCMS method for the analysis of 40 PFAS in extracted samples, following EPA 1633A as reference, was also validated. Concentrations up to 80 times lower than the LLOQ in EPA Method 1633A, using a neat standard solution were achieved with excellent linearity. Hight throughput and robust instrument performance was demonstrated by maintaining accurate quantification during extended operation (>900 injections) without maintenance or cleaning.
The performance of a novel ESI source was demonstrated across multiple classes of PFAS in a single method.

Acknowledgment
The authors would like to thank CEM Corporation for providing the extracted solid samples.

References
Application notes:
1. An Ultra-high Sensitivity Analysis of 29 PFAS Compounds in Drinking Water by Direct Injection.
2. Breakthrough Sensitivity and Robustness for PFAS Analysis for EPA Method 1633A.

Per and polyfluorinated substances (PFAS): Occurrence and exposure

P-00968 Linear and Branched PFAS Isomers Addressing Challenges in Environmental Quantitation

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Introduction
In contrast, to the currently used telomerization process, many legacy per- and polyfluoroalkyl substances (PFAS) were manufactured using electrochemical fluorination (ECF), a process that produced mixtures of linear and branched isomers. As a result, environmental contamination frequently reveals complex isomer distributions rather than the predominantly linear compounds commonly used as analytical calibrants. Despite this, routine environmental measurements are often based on quantitation using linear isomer standards alone.

Materials and Methods
Accurate determination of total PFAS concentrations is complicated by differences in chromatographic behaviour, ionization efficiency, and fragmentation patterns among linear and branched isomers during liquid chromatography-mass spectrometry (LC-MS) analysis. These differences can influence measured response factors and introduce uncertainty into quantitative results when environmental samples contain significant proportions of branched isomers. Furthermore, growing evidence suggests that PFAS isomers may exhibit differing environmental fate, bioaccumulation, and toxicological properties, increasing the importance of isomer-specific characterization.

Results
This study evaluates LC-MS performance characteristics for selected linear, monomethyl-branched, and dimethyl-branched PFAS isomers. Comparisons of chromatographic retention, instrument response, and fragmentation behaviour were conducted to assess the impact of isomer structure on analytical measurement. Results demonstrate significant differences between isomer classes, highlighting challenges associated with the quantitation of environmentally relevant PFAS mixtures using linear isomer calibrants alone.

Discussion and Conclusion
Addressing these challenges requires improved characterization of branched PFAS isomers and the development of analytical reference materials that better reflect environmental contamination profiles. The data presented provide insight into isomer-specific analytical behaviour and support efforts to improve quantitative accuracy, method harmonization, and future evaluation of the environmental and toxicological significance of PFAS isomer composition.

P-00970 Thirty Years of Changing Human Exposure to POPs and PFAS in Northern Norway (1979–2016): Integrating Biomonitoring and Emission-Based Modeling

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Introduction
Persistent organic pollutants (POPs) and per- and polyfluoroalkyl substances (PFAS) have been extensively regulated during recent decades, resulting in major changes in environmental emissions and human exposure. Understanding how regulatory actions translate into changes in human body burdens is essential for evaluating the effectiveness of chemical management strategies. Long-term biomonitoring studies combined with mechanistic exposure models provide a unique opportunity to assess temporal trends and identify the processes driving human exposure.
The objective is to characterize long-term trends in human concentrations of POPs and PFAS in Northern Norway from 1979 to 2016, evaluate the influence of biomonitoring study design on observed trends, and assess the extent to which temporal patterns of PCBs can be explained by historical emissions using mechanistic exposure modeling.

Materials and Methods
The study synthesizes findings from repeated serum measurements in participants of the Tromsø Study, including both longitudinal follow-up of the same individuals over three decades and repeated cross-sectional sampling of 30-year-olds across survey years. Concentrations of major organochlorine pesticides, polychlorinated biphenyls (PCBs), and PFAS were determined in samples collected between 1979 and 2016. Temporal trends in repeated measurements were evaluated using mixed-effects models to distinguish the influence of aging, birth cohort, and calendar year. Emission-based mechanistic models, including CoZMoMAN, were used to estimate exposure histories of PCBs in repeated measurements 1979-2007 and predict serum concentrations from historical emissions, environmental transport, bioaccumulation, and dietary intake.

Results
Concentrations of legacy POPs declined markedly throughout the study period. Compared with concentrations measured in the 1980s, reductions exceeding 70% were observed for several PCB congeners and organochlorine pesticides by the late 2000s. PFOS and PFOA increased from the 1980s, peaked at the 2001 measurement, and subsequently declined following industrial phase-outs and regulatory restrictions, whereas several longer-chain PFAS continued to increase for longer periods. Temporal trends in human concentrations mirrored known production and emission histories. Comparisons between study designs demonstrated that repeated cross-sectional sampling of 30-year-olds showed steeper declines than longitudinal follow-up of older individuals, despite similar overall patterns. These differences reflect the influence of age and birth cohort effects on measured concentrations and illustrate how study design influences interpretation of temporal trends. Calendar year was a stronger determinant of concentrations than age, highlighting the dominant role of changing environmental exposure. Mechanistic model predictions reproduced observed PCB trends and support that reductions in environmental emissions were the primary driver of declining human body burdens.

Discussion and Conclusion
Human blood burdens of legacy POPs and PFAS in Northern Norway changed profoundly between 1979 and 2016, reflecting the combined effects of regulation, emission histories, environmental persistence, and bioaccumulation. The comparison of longitudinal and repeated cross-sectional biomonitoring designs demonstrated that observed trends depend not only on changing exposure but also on population age structure and birth cohort characteristics. Integration of biomonitoring data with emission-based modeling improves interpretation of temporal trends, strengthens evaluation of regulatory effectiveness, and provides a framework for understanding current and future exposures to both legacy and emerging contaminants.

Acknowledgment
We are grateful to the study participants.

P-00972 Organic contaminants in Norwegian wild caught seafood – results from two years of an official control program

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Introduction
Norway has an extensive fishery (>2 mill tons per year). In order to document that the seafood caught in Norwegian waters is safe for consumption, comprehensive surveys and monitoring of contaminants in seafood has been carried out for more than 20 years. In 2024 and 2025, risk-based official controls of wild caught seafood were carried out to fulfil the requirements of the regulations (EU) 2022/631 and 2022/632. The selection of species to include in the control program was based on an evaluation of contaminants in Norwegian wild caught fish based on existing monitoring data (1), where capture volume, contaminant levels and knowledge gaps were considered as risk factors.

Materials and Methods
During 2024 and 2025, the Norwegian Food Safety Authority took out 195 and 95 seafood samples, respectively, at fish handling facilities along the entire Norwegian coast to be analysed for contaminants at the Institute of Marine Research. Mackerel, herring, cod, haddock and saithe were included due to their high sampling volumes. Atlantic halibut, Greenland halibut, tusk, anglerfish and ling were included because they have previously been shown to have higher levels of one or more contaminant. In 2025, several crustacean species (edible crab, king crab, snow crab and shrimp) were included due to data gaps. All samples were analysed for PFAS (LC-MS/MS), while species with an oily fillet or data deficiency were also analysed for dioxins, dioxinlike (dl-) PCBs, non-dl PCBs and brominated flame retardants (PBDEs, HBCDs and TBBP-A). Dioxins, furans and non-ortho-PCBs were determined using HRGC/MS, mono-ortho PCBs, PCB6 and PBDEs were determined using GC-MSMS and HBCD and TBBP-A were analysed at Eurofins using LC-MS/MS

Results
There were no exceedances of the maximum levels for PFOS, PFOA, PFNA, PFHxS, sum PFAS4, dioxins, sum dioxins and dl-PCBs or sum PCB6.
Shrimp had the highest mean and median concentration of sum PFAS4, followed by brown meat of brown crab, and haddock and Greenland halibut had the highest levels among the fish species. Mainly PFOS and PFNA contributed to the total PFAS4, as the results for PFOA and PFHxS were mostly below limits of quantification.
Greenland halibut had the highest concentrations of dioxins, PCBs and PBDEs in muscle, followed by mackerel and herring, while haddock, snow crab and king crab had the lowest concentrations. Brown meat from brown crab had higher concentrations of dioxins and dl-PCBs than all muscle samples from fish and crustaceans. The concentrations of non-dl PCBs and PBDEs, however, were higher in Greenland halibut muscle than in brown meat from brown crab.
Among the HBCD isomers and TBBP-A, only α-HBCD had measurable concentrations, and these were only measurable in Greenland halibut, mackerel and herring. The concentrations were highest in Greenland halibut.

Discussion and Conclusion
The PFAS results were consistent with results from 2023 (2). Also in 2023 we found that shrimp had higher PFAS concentrations than fish muscle. For dioxins, PCBs and PBDEs, concentrations were similar to or lower than concentrations measured previously through baseline studies and long term monitoring (1; https://sjomatdata.hi.no/#search/). Contaminants in Norwegian seafood is mainly a result of long-range pollution. However, elevated dioxins and dioxin-like PCBs in brown meat of crab were probably due to a local source of contamination in the area where some of the crab were caught.

Acknowledgment
We thank the Norwegian Food Safety Authority inspectors for sampling and our laboratory personnell for the sample preparation and analytical work.

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P-00974 Spatial and temporal variation of per- and polyfluoroalkyl substances in Atlantic cod from the North Sea and Barents Sea (2009–2024)

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Introduction
Per- and polyfluoroalkyl substances (PFAS) are manmade chemicals used in various industrial applications due to the unique properties of the perfluoroalkyl chain. PFAS are ubiquitous in the environment, even in biota from remote environments far from direct emission sources, due to their high environmental mobility, persistence and bioaccumulation potential, and the substances are of increasing concern due to their multiple toxic effects.

Materials and Methods
Archived liver samples from Atlantic cod (Gadus morhua) collected in the North Sea and Barents Sea were analysed to investigate spatial and temporal variations of PFAS-concentrations in this species over a 15-year period. Cod livers from the North Sea (2010–2024, n=39 pooled samples) and the Barents Sea (2009–2024, n=52 pooled samples) were analysed using a sensitive method for the quantification of 25 PFAS, including perfluoroalkyl carboxylic acids (C4–C14), perfluoroalkane sulfonic acids (C4–C12), sulfonamides, and novel fluorinated alternatives.

Results
Of the 25 targeted PFAS, ten PFAS were detected above the quantification limits. Across all samples Σ10PFAS ranged from 0.78–7.7 µg kg^{-1} wet weight (ww), with similar mean levels in the North Sea (2.7 µg kg^{-1} ww) and in the Barents Sea (2.8 µg kg^{-1} ww). PFOS occurred at the highest concentrations with an overall mean of 1.0 µg kg^{-1} ww across all samples, followed by PFTrDA and PFUnDA with overall mean values of 0.59 and 0.55 µg kg^{-1} ww, respectively. The remaining quantified PFAS had overall mean concentrations below 0.17 µg kg^{-1} ww.
Despite comparable overall burdens of the sum Σ10PFAS in the Barents Sea and North Sea, the PFAS-profiles differed between the two marine regions. In the Barents Sea, PFOS was the dominant compound accounting for about 41% of Σ10PFAS, followed by PFUnDA (20.7%) and PFTrDA (16.7%). On the other hand, in the North Sea, PFOS and PFTrDA were almost equally abundant, constituting 30% and 26.1% of Σ10PFAS, respectively, followed by PFUnDA which accounted for 18.1% of Σ10PFAS. The percentage of PFOSA, a precursor of PFOS, of the sum PFOS+PFOSA was much higher in the North Sea than in the Barents Sea, with PFOSA constituting 15% of this sum in the North Sea compared to only 5.0% in the Barents Sea.
Differences in PFAS-profiles may indicate differences in source influences and environmental transport mechanisms but could also be influenced by biological differences between cod collected in the North Sea and the Barents Sea. To further study the spatial variation independent of biological differences, a statistical model including biological covariates was developed for five PFAS that were detected in more than 90% of the pooled samples, i.e. PFOS, PFDA, PFUnDA, PFTrDA and PFOSA. After adjustment for biological differences using the statistical model, we still found significant differences between PFAS-profiles in the Barents Sea compared to the North Sea. The Barents Sea showed a PFOS-dominated, legacy profile consistent with long-range transport and limited local sources, whereas the North Sea exhibited enrichment in long-chain PFCAs and PFOSA, reflecting stronger continental and riverine influence.
Temporal variation of PFOS, PFDA, PFUnDA, PFTrDA and PFOSA in cod liver in the period 2009-2024 was investigated separately for the Barents Sea and the North Sea, using the statistical model adjusting for biological differences. Declining trends were observed for most of these PFAS in the investigated period, both in the Barents Sea and in the North Sea, and the results will be presented.

Discussion and Conclusion
This work provides new insights into the long-term dynamics of PFAS contamination in northern marine ecosystems and contributes to the evaluation of regulatory and environmental drivers influencing PFAS exposure in marine food webs.

Per and polyfluorinated substances (PFAS): Occurrence and exposure

P-00975 Method development and validation of a serum and urine method for the analysis of ultra-short chain PFAS in humans

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Introduction
Short chain (SC) and ultra-short chain (USC) per- and polyfluoroalkyl substances (PFAS) contaminants are globally distributed, highly persistent, and have high water solubility and bioavailability. Recently, trifluoroacetic acid (TFA), the most prevalent USC-PFAS in the environment, was recommended by the European Chemicals Agency to be classified as a reproductive toxin in humans1. Despite evidence of USC-PFAS concentrations increasing in both the environment and food products, data coverage on human matrices, especially urine is limited2. Further, the connection between paired serum and urine samples is not well understood, including what the appropriate choice for analysing long-term trends in humans would be. As such, this study aimed at developing and validating extraction methods for the analysis of short-chain and USC-PFAS in both human urine and serum. These methods will then be used to measure paired samples to provide insights into the relationship between these matrices in humans.

Materials and Methods
A dilute-and-shoot method was successfully validated following PARC guidelines in urine across four spiking levels for 9 of 10 USC- and SC-PFAS including 5 perfluorocarboxylic acids (PFCAs), 4 perfluorosulfonic acids (PFSAs) and one perfluoroethercarboxylic acid (PFECA). Limits of detection below 0.01 ng/mL were achieved for 8 compounds, while TFA was validated at 0.2 ng/mL, well below typical measurements in recent publications (10-100 ng/mL). Persistent issues with perfluoropropanoic acid (PFPrA) in background samples made validation difficult and will not be discussed here. Inter- and intra-day spike and recovery tests resulted in acceptable precision (%RSD < 25) and accuracy (recovery 75 - 125%) for the remaining 9 compounds at all four spiking levels (0.02, 0.1, 0.5, 5 ng/mL for most compounds; 0.5, 5, 20, 100 ng/mL for TFA) except for PFMOAA (recovery 160%) and TFMS (%RSD = 25 – 30%) at the lowest spiking level.

Results
The validated method was used to measure USC-PFAS in samples provided by volunteers within the laboratory. Results indicated a similar range of TFA measured (10 – 60 ng/mL) compared to a recent study from Australia (3.4 – 300 ng/mL)3. Trace amounts of trifluoromethanesulfonic acid (TFMS) was also detected in 90% of samples (median = 0.04 ng/mL).

Discussion and Conclusion
A similar extraction method for serum has been tested and is currently in the process of validation. It will similarly be evaluated across four spiking levels and multiple days to ensure inter- and intra-day precision (%RSD < 25) and accuracy (recovery 75 – 125%). Once both methods are complete, they will be used to evaluate paired urine and serum samples gathered from the Flanders, Belgium region to identify if any correlations between the matrices exist. The results will ideally inform governments and other regulatory instances about the ideal sampling scenarios for long-term exposure assessments of these emerging contaminants, including TFA.

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P-00979 Simple and fast method for PAHs quantification in oil & oil-rich food using Molecularly Imprinted Polymers extraction

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Introduction
Polycyclic Aromatic Hydrocarbons (PAHs) are a large group of organic compounds with two or more fused aromatic rings and are known to be carcinogenic. Human beings are exposed to PAHs mainly by intake of food. As these compounds are highly soluble in lipophilic matrices, oils and oils rich food can be an important source of contamination by PAHs. U.S. Environmental Protection Agency (EPA) has designated 16 PAHs as priority pollutants due to their potential toxicity in humans and other organisms and their prevalence and persistence in the environment. In addition, in 2023, EU Commission Regulation 2023/915, amending Regulation 835/2011 has set maximum levels in edible oils to 2µg/Kg of benzo[a]pyrene individually, and 10 µg/Kg of benzo[a]pyrene, benzo[b]fluoranthene, chrysene and benzo[a]anthracene combined.

Materials and Methods
Analysis of PAHs in certain matrices remains challenging, necessitating meticulous sample preparation to preserve the integrity of analytical devices and to reach lower limit of quantification (LOQ).
In this study, up to 25 PAHs compounds were analyzed by GC-MS/MS. Two extraction methods of PAHs in oil and oil rich food were compared: QuEChERs extraction, and Molecularly Imprinted Polymers (MIPs) applied to Solid Phase Extraction (SPE). Although, QuEChERs is a cost-effective solution, it does not always provide a thorough clean-up contrary to MIP extraction which allows a thorough sample cleaning. MIP sorbent also brings higher selectivity in comparison to some other extractions methods like classic polymeric or silica based SPE prior to analysis.

Results
The MIP extraction method was chosen.
The developed method with MIP extraction was validated in accordance with EU Commission Regulation 2023/915 of 25 April 2023 on established maximum levels for certain contaminants in food. 25 PAHs were validated in sunflower oil and 18 PAHs in avocado and walnut oil with limits of quantification (LOQ) at 0.5-1µg/Kg (except for naphthalene at 10µg/Kg). Excellent results were obtained with recovery yields ranging between 70% and 110%. Relative standard deviations were determined between 5% and 25%.

Discussion and Conclusion
Better results were obtained with MIP extraction than with QuEChERs extraction. MIP cartridges were more selective, resulting in lower background interferences, facilitating the detection of lower concentrations of PAHs. Except for Naphthalene, after extraction, LOQs were 4 to 20 times lower with MIP compared to QuEChERS.
MIP extraction enables the analysis of 25 PAHs in diverse oil and oil rich food.

P-00982 Efficient cleanup methods for the analysis of 30 PFAS using solid-phase extraction (SPE) for environmental and industrial matrices

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Introduction
Perfluorinated compounds (PFAS) are particularly resistant to degradation, which leads to their accumulation in living organisms and in the environment. Perfluorinated compounds have been the subject of increasing concern in recent years due to their potentially harmful effects on human health.
The analysis of PFAS in certain matrices remains complex and requires careful sample preparation to preserve the integrity of the analytical systems and achieve lower limits of quantification (LOQs).
This study presents turnkey solutions designed for the quantification of PFAS in environmental and industrial samples using solid-phase extraction (SPE) cartridges and disks prior to LC-MS/MS.

Materials and Methods
In this study, a list of 28 to 30 historical and emerging short-chain to long-chain PFAS was analysed in salmon trout, tap and river waters as well as synthetic industrial salted waste using SPE disks or cartridges to concentrate and purify the samples. Once loaded and after a washing step, the PFAS were eluted prior to analysis.
The analyses were carried out using LC-MS/MS, with a delay column designed to remove PFAS from the solvent and the LC tubing.
Sample preparation based on Polymeric SPE columns
Polymer-based SPE has proved effective for the analysis of PFAS, particularly due to its ability to concentrate, purify and quantify these compounds via a reproducible and robust protocol.
2 g of salmon trout were spiked with 29 PFAS at concentrations ranging from 0.2 to 1 µg/kg and then extracted using an organic solvent. The extraction solutions were subsequently purified using a dual-layer SPE consisting of a polymeric phase and Graphitised Carbon Black (GCB). A layer of GCB enables more effective cleaning of even the most complex matrices.
For tap water, polymeric SPE cartridges were used to treat 500 mL samples spiked with 30 PFAS at concentration ranging from 0.004 to 0.4 µg/kg.
Synthetic industrial salted waste contains 500mg/L TOC, 30g/L chloride ions and 1mg/L fluoride ions at pH 7.3. 100mL of synthetic matrix was spiked with 30 PFAS at concentrations ranging from 1 to 10 µg/kg, pH adjusted to 3 and loaded on polymeric SPE cartridges.
Sample preparation based on SPE disks
AttractSPE® disks are thin, dense, flexible and uniform SPE membranes that guarantee reduced extraction times for large sample volumes thanks to their high flow rate. They have a large exchange surface area, enabling better interactions with analytes and thus delivering excellent recovery rates.
1L of tap and river waters were spiked with 28 PFAS and loaded on a WAX SPE disks with a flowrate of 50mL/L.

Results
For salmon-like trout, excellent recovery rates were achieved, 93% and an average repeatability (RSD) of 7%.
In tap water, excellent recoveries were achieved with values exceeding 92% (except for MeFOSA, at 66%) and an average repeatability (RSD) of 5%.
In synthetic industrial salted waste, recoveries were between 80% and 120% for all PFAS except 2 of them.
For the SPE disks, the recoveries are greater than 88% with a RSD of 5%, confirming the excellent performance of the method described.

Discussion and Conclusion
A range of SPE cartridges or disks kits were used to identifying a 28 to 30 short-chain to long-chain PFAS in very complex matrices such as salmon or synthetic industrial salted waste prior to a LC-MS/MS analysis.
For most PFAS, recovery yields were evaluated over 80%.

P-00984 Marine Microplastics in Humpback Whale Blubber from the Gulf of Maine: A Pilot Study of Plastic Polymer Composition

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Introduction
Microplastics are widespread emerging pollutants in the marine environment and a health concern. Marine mammals are long-lived sentinel species often used for biomonitoring the health of our oceans. For microplastics research, marine mammals are particularly valuable as they share major exposure routes with humans, including ingestion through diet and inhalation of airborne particles at the air-water interface. Previous studies showed marine mammals are exposed to microplastics, as evidenced by their presence in the gastrointestinal tract and fecal matter. However, the accumulation of microplastics in other organs has been largely unexplored. The blubber of whales is a metabolically active tissue that serves as the primary lipid storage site in whales and represents an important reservoir for persistent environmental contaminants. This study aimed to measure for the first time the levels and types of plastic polymers in the blubber tissues from free-ranging whales.

Materials and Methods
Blubber samples of humpback whales (Megaptera novaeangliae) were obtained from skin biopsies of free-ranging whales obtained during 2021-2023 in the Gulf of Maine. A total of 12 samples were analyzed, including 9 females (3 calves, 6 adults) and 3 males (1 calf, 2 adults). Six animals were mother-calf pairs. Solid particulates were isolated from digested blubber tissue samples and combusted to identify signature mass spectra of the plastic polymers using pyrolysis gas chromatography-mass spectrometry.

Results
The results show polyethylene was the most abundant polymer in all samples analyzed, followed by polypropylene and polyvinyl chloride, which are the most abundant polymers in the oceans. Other polymer types were also present at lower levels, including styrene butadiene rubber, nylon 6, acrylonitrile butadiene styrene, polycarbonate, polyurethane and polystyrene. Among 4 mother-calf pairs, two calves had higher levels than their mothers, while two calves had lower levels.

Discussion and Conclusion
Altogether, we show for the first time the presence of plastic particles in the blubber tissues of humpback whales, indicating plastics are moving from the site of exposure into distal tissues in both adults and calves. Future research will expand this pilot study to include a greater number of humpback whales, other species and toxicological effects on already established marine mammal cell lines.

Acknowledgment
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P-00985 Preliminary study of dioxin and PCB contamination profiles and levels in insect based foods.

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Introduction
A novel food is any food that has not been consumed to a significant degree within the European Union before 15 May 1997. Because these foods lack a documented history of safe consumption, they must undergo an authorization procedure before being placed on the EU market (1).
Insects represent an emerging and still poorly characterized food matrix within the expanding novel food sector. Their use, both for human consumption and as feed, requires careful evaluation of potential chemical risks, especially in the absence of specific regulatory limits. As part of the multidisciplinary project IZSUM 02/23 RC (2), coordinated by IZSUM (Istituto Zooprofilattico Sperimentale dell'Umbria e delle Marche) and funded by the Italian Ministry of Health, ARPA Umbria—whose laboratory is already designated as the official regional reference laboratory for the determination of dioxins and PCBs in all food matrices—conducted a preliminary study aimed at assessing the presence of these contaminants in insect based products. The investigation covered 31 commercial samples, both dried and fresh, of Acheta domesticus, Tenebrio molitor, and Alphitobius diaperinus.

Materials and Methods
A total of 31 commercially available samples, both dried and fresh, of Acheta domesticus, Tenebrio molitor, and Alphitobius diaperinus were analyzed. Extraction, purification, and determination of PCDD/Fs and PCBs were performed using GC/MS/MS, adapting methods already validated and routinely applied in official control activities. Toxic equivalent values (TEQ) were calculated using WHO TEQ, as required by current legislation (3).

Results
All samples were successfully analyzed for the full congener profile of PCDD/Fs and PCBs as well as for their quantitative determination. From a qualitative standpoint, preliminary results show that the distribution and relative abundance of individual congeners differ markedly from the profiles typically reported by EFSA(4)(5)(6) for regulated food matrices. Conversely, the observed congener profiles appear independent of both species (Acheta domesticus and Tenebrio molitor) and processing method (freezing, drying, milling). From a quantitative perspective, given the absence of specific limits and standardized analytical methods for insect based foods, the initial results were evaluated by comparing the investigated matrices with similar regulated matrices and their respective maximum limits (7).

Discussion and Conclusion
This intra and interspecific homogeneity suggests that congener distribution may be influenced by multiple factors, including:
Environmental and processing related contamination associated with the farming area;
Contamination of feeding substrates used during insect rearing;
The specific lipid composition of insects, which may play a role in modulating the bioaccumulation dynamics of persistent chlorinated organic pollutants.
This project represents only a preliminary investigation and requires further studies both to deepen the statistical assessment of contamination levels and to explore potential correlations between results and influencing factors.

Acknowledgment
We thank the Italian Ministry of Health for the funding and IZSUM for coordinating the project.

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P-00988 PFAS in the Atmosphere: Analytical Method Optimization and Preliminary Monitoring in a Region of Central Italy (Umbria).

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Introduction
Per- and polyfluoroalkyl substances (PFAS) constitute a class of emerging contaminants of growing environmental concern due to their high persistence, mobility, and potential adverse effects on human health and ecosystems [1] , [2]. Although PFAS contamination of aqueous matrices is widely documented, the atmospheric contribution to their environmental diffusion and redistribution remains poorly understood. In this context, the present study aims to perform a preliminary assessment of atmospheric PFAS contamination in a region of Central Italy (Umbria).

Materials and Methods
To this end, analytical methods were developed and optimized for the determination of PFAS in atmospheric deposition and airborne particulate matter. The two methods differ exclusively in the sample preparation phase, while instrumental measurement was performed in both cases via HPLC interfaced to an Agilent 6475 triple quadrupole mass spectrometer with a Jet Stream 6450 electrospray ionization unit (AJS-ESI) operating in multiple reaction monitoring (MRM) negative detection mode [3]. The sampling campaign, initiated in January 2026, covered both industrial sites impacted by specific emission sources (an iron and steel hub, a waste-to-energy plant, and cement factories) and urban and rural background sites, with the aim of evaluating the spatial distribution of the contaminants and providing a knowledge base for future environmental surveillance programs.

Results
Preliminary results highlighted a marked predominance of acidic PFAS compared to sulfonates, and a widespread distribution across the various sites (both industrial and background), confirming their ubiquity; the only exception is represented by fluorotelomers and new-generation PFAS, which appear to be more abundant in the investigated industrial sites. Ultimately, the developed analytical method proved to be suitable for the determination of PFAS in the air matrix, guaranteeing adequate performance in terms of sensitivity and analytical reliability. The detected concentration levels, expressed as the sum of the targeted PFAS, ranged from 5 to 35 ng\m2d in atmospheric deposition and from 4 to 10 pg/m3 in airborne particulate matter, in accordance to those reported in other literature studies on similar environmental contexts [4],[5].

Discussion and Conclusion
Although the obtained results provide an initial characterization of the presence of PFAS in the atmosphere of Umbria, the study represents a preliminary investigation. Therefore, further insights and an extension of the monitoring over a broader time frame will be necessary to evaluate seasonal trends. Furthermore, future steps will include lighter PFAS congeners, evaluating their partitioning between the gas phase and the particulate phase.

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Exposome of Emerging Contaminants in the Global Environment

P-00990 Determination of 139 Liquid Crystal Monomers (LCM) and related compounds by GC-HRMS in environmental samples in and around E-waste treatment facilities in Norway

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Introduction
Specialty chemicals used in computer or smartphone displays have increasingly been reported in environmental media in the past five years. Many are either fluorinated or brominated organic compounds. Most published studies have focused on their occurrence and fate in China, while data from Europe remains scarce. In 2024, a screening campaign was conducted in Norway with aim to determine a large and versatile selection of such substances (139 substances) in dust, air, water, soil, moss and biota in and around two electronic waste treatment facilities [1].

Materials and Methods
Authentic specimens were purchased for majority of compounds (110) from various vendors and were used without further purification. Indoor and outdoor dust, indoor and outdoor air, process water and surface water samples were taken by common methods. Indiscriminate extraction with appropriate organic solvent or their mixtures (acetone, ethylacetate, hexane, acetonitrile) was employed without further clean up. Samples were either concentrated or diluted depending on the matrix content in the extract. Q Exactive GC (Orbitrap) in EI full-scan mode was the primary analytical method. Targeted SIM (t-SIM) acquisition was simultaneously applied for approximately 20 priority compounds. The moderately polar column TG-5MS was used, and retention indices were employed to predict retention times for suspect screening.

Results
All 110 reference standards were readily amenable to GC-analysis, and produced EI mass spectra and retention times consistent with literature data or predictions. Retention indices could be predicted with good accuracy using a linear regression model based on 10–12 structural descriptors (SD = 17 RI units over an RI range of approximately 2000). Of the 139 target compounds, 73 were detected in at least one matrix. Indoor air and dust showed the highest detection frequencies and concentrations, with a pronounced indoor–outdoor gradient. Maximum concentrations reached 20,000 pg m^{-3} in indoor air, 1,000 pg m^{-3} in ambient air, 1,000 ng g^{-1} in indoor dust, 300 ng g^{-1} in outdoor dust, 100 ng g^{-1} in soil, 70 ng g^{-1} in moss, 700 ng L^{-1} in process water, and 40,000 ng L^{-1} in stormwater. More than half of the investigated organofluorine LCMs were detected.

Discussion and Conclusion
This pilot study represents, to our knowledge, the first broad screening of LCM and OLED compounds in the Norwegian environment, and the results should be considered indicative given the limited and non-representative sample set. The follow-up study (underway) with matrix-specific method optimization will provide more definitive information on the presence of these substances in Norwegian environment.

Acknowledgment
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P-00992 Exposure of currently used pesticides (CUP)and potential harmful effects for the nature and human health

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Introduction
Pesticides are widely used in agriculture and forestry to control fungi, pests, and weeds. Over several decades concerns have been raised about the harmful effects that pesticides may have on the environment and human health. Formerly used organochlorine pesticides (DDT, HCH og HCB) were therefore banned and replaced with more biodegradable pesticides (currently used pesticide (CUPs)). Due to the physical chemical properties of CUPs, they can be transported away from the areas where they are used, and found in groundwater, surface water, soil and air. CUPs are monitored in fruit and vegetables in Norway. However, little is known regarding exposure to people and areas close to agriculture land treated with CUPs. The purpose of this study is to increase knowledge about the levels of exposure for people who have their everyday life in the vicinity of areas treated with CUPs. The focus for the project is on a variety of crop categories within Norway, and the study areas selected include a fruit-growing area in Ullensvang, a grain area in Romerike and a potato growing area along the Glomma in Grue municipality.

Materials and Methods
Air samples are collected by using both active and passive air samplers. The active air samplers collect both the gaseous and particle fraction in the air. In this study we use a so-called Kleinfiltergäret (KFG), where air is drawn into a sample medium (porous polymer material (XAD-2) and glass fiber filter). Samples were taken for one week every month during the growing season. In order to asssess the spatial variation, passive air samplers (PAS) were deployed in a wider area around the selected locations. PAS comprises samplers consisting of a polyurethan foam (PUF) disk between two metal domes and XAD-2 inside a metal holder. The PUF samplers is exposed for three months while the XAD samples is exposed throughout the entire season. Furthermore, deposition of CUPs on surfaces in the various areas is collected using wipes (glass fiber filtre) and a frame (2*1 m) treaded with fishing rope/cotton.
Human exposure to CUPs is carried out with both active samplers (aerosol fraction) and passive samplers using silicone wristbands, where CUPs are absorbed in the wristbands. Farmers who use CUPs on their fruit, grain, and potato crops, in the three relevant areas (Ullensvang, Grue, Romerike), is the focus group. Additionally, the general population living near treated crop fields will be investigated qualitatively using silicone wristbands. The study also includes assessment of exposure which will be compared against available toxicity endpoints to assess whether the findings pose any direct health risk to users and/or the general public.

Results
All samples will be chemically analyzed using GC-MS/MS and LC-MS/MS multi-methods.

Discussion and Conclusion
The key outputs of the project are improved understanding on how pesticides spread in agricultural environments, and assessment of human exposure levels (users and nearby populations). Moreover, insights into risk reduction measures and evaluation of sampling methodologies.

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EFSA EU food-feed legislation

P-00994 Practical aspects analysing PFAS according to Article 5 PPWR

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Introduction
From 12 August 2026, food-contact packaging containing PFAS above the PPWR (Packaging and Packaging Waste Regulation) limit values for non-polymeric and polymeric PFAS cannot be placed on the EU market. Conformity assessment involves non-polymeric PFAS limits of 25 ppb for individual substances and 250 ppb for total non-polymeric PFAS, and a 50 ppm limit for total organic fluorine (TOF). The European Commission mentioned using pyrolysis GC/MS and TOP-Assay as tier 2 and 3 methods as part of a three-step compliance verification, but there is no standardised procedure for testing. From an analysts point of view there is obviously a need for reliable testing procedures for all kinds of matrices which are present in packaging and packaging waste. The aim of the work was to investigate some practical aspects when analysing PFAS according to Article 5 PPWR.

Materials and Methods
The authors analysef TF and TOF as well as non-polymeric PFAS. C-IC's were used from two different suppliers (Thermo and A1 environsciences) for TF analysis (as an option with an optimised pre-combustion step at 525 °C for 2 h for TOF analysis acording to Diallo et al.) and HPLC-MS (Waters XEVO TQ absolut) for target analysis of PFAS. TOP assay was performed according to Houtz et al. paper samples were extracted prior to the TOP assay with methanol using an Thermo ASE 200 extractor.
The investigated samples comprise a set of paper and plastic materials known for the presence of non-polymeric and polymeric PFAS and their precursor substances. Some samples contained also anorganic fluorine.

Results
The method recently presented by Diallo et al. is a robust method for indirect TOF determination. It works both for paper and plastics matrices. Compared to other methods it delivers more reliable results. It is important to note that another approach, the aqueous extraction (which is used to remove inorganic fluorine) often overestimates TOF. The quality of the quantitation of Pyrolysis-GC-MS is relatively poor especially for the paper matrix.
The paper matrix disturbs the TOP assay if it is directly applied. We found that the use of ASE prior to the TOP assay with methanol leeds to reliable results for the paper matrix. ASE is also a good choice most plastic materials except polyolefines. Since the TOP assay leeds to the formation of only a limited number mostly fluorobarboxylic acids from various sources it is recommendable to analyse an aliquot of the ASE extract without TOP assay application as a fourth tier step.

Discussion and Conclusion
Our results support the need for an implementation of standardised procedures for the analysis of packaging and packaging waste materials. The Commission`s opinion is only a first step on the way to develop a reliable workflow for the analysing of PFAS according to Article 5 PPWR. The analytical methods have to be adapted especially to different matrices. Based on the results we recommend a modification of the EU commissions workflow with regard to the analysing of PFAS according to Article 5 PPWR.

Acknowledgment
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Determination of PFAS in emissions and ambient air

P-00996 Is atmospheric half-life time of carbon tetrafluoride the same as it was 33 or 47 years ago?

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Introduction
Carbon tetrafluoride (CF4) is the simplest stable binary compound of carbon and fluorine. It was first reported in 1890 independently by Chabrié [1] and by Moissan [2].
A century later the compound was shown to have natural sources, its presumably equilibrium concentration in the atmosphere was ca 40 ppt in pre-industrial times [3,4].
Nowadays CF4 is regarded as one of the most stable chemical compounds with an estimated atmospheric lifetime of ≥50,000 years (Houghton et al, 2001). This number is being reproduced in numerous background documents on climate change and in relation to stability of "PFAS", in peer-reviewed papers and in non-scientific publications alike.
Is the number correct?

Results
The value takes roots from two independent estimates of Cicerone (1979) [5] and Ravishankara et al. (1993) [6]. Both estimates were based on a postulate that in absence of measurable natural elimination pathways, destruction of CF4 in high-temperature combustion is the major way of its elimination. Naturally, the half-life time of 50,000 years was based on combustion data of late 70-s and early 90-s. Combustion of carbon fuel roughly doubled by 2026. This means the currently used value of 50,000 years is obsolete and must be revised. Furthermore, the assumptions used [5,6] were rather weak and arbitrary. No experimental data was used: neither for quantitation of air consumption during combustion, nor for destruction rate of carbon tetrafluoride in different types of combustion units. In fact, the original suggested estimate for atmospheric residence time was more careful ">10,000 years" [5]. That estimate was sufficient for the time as it merely presumed negligible degradation of CF4 in comparison to other atmospheric contaminants.
Unlike 33 or 47 years ago, analytical methods of today allow for inexpensive and accurate quantitation of CF4.

Discussion and Conclusion
Atmospheric residence time of CF4 of 50,000 years was a rough estimate, and should not be mentioned without a note, when listed along the experiment-based data.
Atmospheric residence time shall not be confused with half-life time.
The estimate was made for combustion rates ca 50% of current ones, and the value should be corrected asap (e.g., cut down to "ca 25,000 years") in all background documents related to climate change and to stability of "PFAS".
Availability of analytical methods for high-throughput analysis of carbon tetrafluoride in air and exhaust in combination with extensive knowledge on the scale and peculiarities of high-temperature combustion around the globe gives an opportunity to obtain an experimental value for atmospheric half-life time of carbon tetrafluoride in high-temperature combustion processes for science-based assessment of its contribution to climate change. It is equally important to test experimentally the original hypothesis of high-temperature combustion being the major pathway of elimination of CF4 from the atmosphere.

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P-00998 "Engineered alum-based derived biochar-Co-Al layered double hydroxide composite for dual-mode adsorption and visible-light photocatalytic removal of emerging contaminants"

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Introduction

Water pollution is emerging as a significant public health issue, mainly due to anthropogenic activities (1). Pollutants enter and deteriorate aquatic systems through both surface water and groundwater sources because they are often hydraulically interconnected (2). A wide range of organic matter, nutrients, heavy metals, halogens, micro-organic pollutants (e.g., PAHs, pesticides, pharmaceuticals), radioactive substances, thermal pollutants and pathogenic microorganisms play a major role in polluting water bodies (3).

In recent decades, pharmaceutical residues have gained attention as emerging contaminants due to their persistence, bioactivity, and potential risks to aquatic ecosystems and human health (4). Increased global pharmaceutical consumption has resulted in their frequent detection in water bodies at ng/L–µg/L levels, mainly due to incomplete removal in wastewater treatment plants (WWTPs) (5,6). These contaminants can alter aquatic organism behaviour and impair reproductive functions (7). Although advanced treatment technologies such as ozonation, membrane filtration (8), Fenton/Photo-Fenton processes (9), UV irradiation (10), and adsorption (11) have shown effectiveness, sustainable and cost-efficient solutions remain limited.

Municipal wastewater treatment generates large quantities of sewage sludge, particularly from coagulation-flocculation processes using iron- and aluminium-based coagulants (12). Improper disposal of water treatment sludge (WTS), especially in developing countries like India, leads to secondary pollution and environmental degradation (13). Growing concerns over disposal costs, regulatory constraints, and health risks have motivated research into sludge Carbonization and reuse (14).

Aluminium-based derived biochar presents a sustainable option; however, its standalone adsorption capacity is insufficient for complete removal of emerging contaminants. To address this limitation, incorporation with layered double hydroxides (LDHs)-two-dimensional anionic materials containing divalent (Mg^{2+}, Zn^{2+}, and Cu^{2+}) and trivalent (Fe^{3+}, Al^{3+}, and Ce^{3+}) metal cations-offers a promising solution (15). Transition-metal-based LDHs, particularly Co-Al-LDH, exhibit excellent photocatalytic performance, chemical stability, and low toxicity (15,16). Their photocatalytic efficiency has been further enhanced through coupling with carbonaceous materials such as biochar (17).

Recent studies demonstrate that biochar-modified LDHs significantly improve charge separation, adsorption capacity, and photocatalytic degradation of organic pollutants (18,19). However, the application of derived biochar coupled with LDHs as a dual-modality adsorption-photocatalytic system for emerging contaminant removal remains underexplored.

Therefore, the study focuses on developing an environmentally sustainable Co-Al-LDH engineered alum-based derived biochar composite (LDH@EBC) to achieve efficient adsorption and visible-light-assisted photocatalytic degradation of emerging contaminants. The work aims to provide systematic insights into the dual-modality removal mechanisms, addressing critical research gaps in sustainable wastewater treatment.

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P-01001 Multi-Class PFAS Screening in Mussels from the Atlantic Portuguese Coast

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Introduction
Portugal has an extensive Atlantic coastline and a strong tradition of mussel production and consumption. However, comprehensive biomonitoring data on per- and polyfluoroalkyl substances (PFAS) in coastal Mytilus galloprovincialis remain limited. Previous studies in Portugal have largely focused on perfluorooctane sulfonic acid (PFOS) in mussels from north-central estuaries, leaving substantial gaps in spatial coverage and compound-specific information. This lack of baseline data limits the use of mussels as sentinels of PFAS contamination and constrains dietary exposure risk assessment.
In this study, 36 target PFAS, including perfluoroalkyl carboxylic acids (PFCAs), perfluoroalkane sulfonic acids (PFSAs), fluorotelomer sulfonic acids (FTSAs), sulfonamides, and emerging ether-based substitutes (PFEAs), were quantified in mussel soft tissues collected in 2022 from 12 sites along the Portuguese Atlantic coast, spanning from Viana do Castelo in the north to Vila Nova de Milfontes in the south. Determination of PFAS in the samples was performed by liquid chromatography–tandem mass spectrometry (LC-MS/MS) with isotope-labelled internal standard correction.
Six PFAS were detected above method detection limits: PFOS, perfluorododecanoic acid (PFDoA), perfluorotridecanoic acid (PFTrDA), perfluorotetradecanoic acid (PFTeDA), perfluorohexane sulfonamide (FHxSA), and perfluorooctane sulfonamide (FOSA). The PFAS profile was dominated by long-chain PFCAs, particularly C12–C14 homologues, consistent with residue patterns reported from other Atlantic and Mediterranean coastal regions of Europe. Total PFAS concentrations ranged from 0.28 ng g^{-1} dry weight at Forte Barra to 4.7 ng g^{-1} dry weight at Tróia near the mouth of the Sado Estuary, which exhibited the highest contamination levels. PFOS was detected exclusively in mussels collected near the Sines industrial port complex, with a mean concentration of 0.15 ng g^{-1} dry weight, suggesting the influence of a localised point-source. None of the investigated PFEAs, including HFPO-DA, ADONA, and chlorinated ether sulfonates, were detected.
All samples complied with the maximum levels established for the sum of PFOS, PFOA, PFNA, and PFHxS (EFSA-4 PFAS) in bivalve molluscs under Commission Regulation (EU) 2023/915. These results provide the first baseline assessment of PFAS contamination in M. galloprovincialis along the Portuguese Atlantic coast and identify the Sado Estuary region as a priority area for continued monitoring of long-chain PFCAs.

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P-01003 Long-term atmospheric POP measurements in the Arctic and Antarctic: Trends, source regions and implications for future regulations

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Introduction
Persistent organic pollutants (POPs) are subject to long-range atmospheric transport and are routinely detected in remote polar environments despite global restrictions on their production and use. Long-term atmospheric measurements are essential for evaluating the effectiveness of the Stockholm Convention. In this study, we investigated more than 20 years of atmospheric measurement data of legacy POPs, including PCBs, DDTs, HCB, chlordanes and HCHs from the Arctic monitoring stations Alert (Canada), Villum/Station Nord (Greenland), Zeppelin (Svalbard), Pallas (Finland) and Stórhöfði (Iceland), together with ten years of data from the Norwegian Antarctic monitoring station Trollhaugen.

Materials and Methods
Long-term time trends were quantified using the newly developed Linear Spline Trend Estimator (SPLINTER), a segmented regression approach that identifies periods with different rates of change. This tool replaces the Digital Filtration (DF) Technique previously used in time trend analysis (Hung et al., 2016) and is also being applied in the on-going AMAP assessment. To examine the source regions of those contaminants, model simulations were combined with the measurement data, utilizing the Lagrangian particle dispersion model FLEXPART in backward mode (Pisso et al. 2019). Emission sensitivities were contrasted during periods with the highest and lowest observed concentrations to identify possible source regions. This analysis gives indications of potential sources and their temporal variability independent of the knowledge of emissions.

Results
Most compounds show significant declining trends at the Arctic sites, reflecting the reduction in primary emissions following international regulation. The strongest and most consistent decreases are observed for the HCHs. However, the magnitude of the trends differs among compounds and stations, and some substances show periods of stabilization and increase. Compared to the Arctic sites, trends at Trollhaugen are generally decreasing at a slower rate, suggesting differences in source influences and environmental reservoirs between the two polar regions.
Transport modelling with FLEXPART suggests that air masses originating from Europe and Asia are associated with high atmospheric concentrations of PCBs at Zeppelin, while low concentrations are associated with local air masses. This highlights the continued importance of long-range transport from historically contaminated regions. Similar analyses for other compounds provide additional insight into the geographical origins of observed concentration episodes and help explain differences in trends between sites.

Discussion and Conclusion
The results show that atmospheric concentrations of many legacy POPs continue to decline, providing evidence of the long-term effectiveness of international control measures. At the same time, the slower decline of some compounds suggests that secondary emissions from environmental reservoirs may be becoming increasingly important.

Acknowledgment
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P-01005 Spatial distribution of PCB-11 in background air across Europe

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Introduction
Intentional production of polychlorinated biphenyls (I-PCBs) has been regulated for decades and primary emissions have decreased. However, emissions of unintentionally produced PCBs (U-PCBs) from combustion processes or as byproducts in production processes are less likely to have declined to the same extent. Among the identified U-PCBs, PCB-11 has been reported to be frequently detected in urban air. The congener is mainly associated with pigment and dye manufacturing and may also form in combustion and thermic processes. PCB-11 has also been detected in more remote sites, but less is known about the presence of PCB-11 in background air. The key objective of this study was to assess the spatial distribution of PCB-11 in European background air.

Materials and Methods
In our study, polyurethane foam based passive air samples (PUF-PAS) were collected at 101 sampling sites across 33 countries along a European-Arctic transect (35 °N to 81 °N, 51°W to 47 °E) during summer 2016. The samples were analyzed for PCB-11, in addition to the 30 PCBs reported in (Lunder Halvorsen et al., 2023), by using a gas chromatograph coupled to a high resolution mass spectrometer. A nested multimedia transport and fate model (NEM) were applied to support the interpretation of measurements. The concentrations were compared with concentrations of PCB congeners typically associated with (i) the historical production of technical mixtures and (ii) other U-PCBs.

Results
PCB-11 was detected at higher concentrations than most I-PCBs in background air all over Europe including the Arctic, with higher concentrations typically observed in central- and eastern Europe than in northern Europe (Figure). A weak correlation between concentrations of PCB-11 and the most abundant I-PCBs with similar chemical fate properties confirms that differences between emission sources of PCB-11 and I-PCBs exist. Elevated concentrations close to major urban areas indicate that emissions of PCB-11 may be associated with population density

Discussion and Conclusion
The presence of PCB-11 across the European continent, including the Arctic support that PCB-11 has significant long-range atmospheric transport potential. This highlights that future air monitoring efforts on PCBs also should include PCB-11 along with I-PCBs, in which complementary sampling strategies to PAS-PUF (e.g. PAS-XAD, AAS-PUF and AAS-XAD) should be considered.

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Determination of PFAS in emissions and ambient air

P-01007 PFAS in Air: Challenges, Standards and Analytical Workflows

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Introduction
PFAS (per- and polyfluoroalkyl substances) are a group of highly persistent chemicals that are now recognized as a global concern. While much attention has focused on water and soil, PFAS can also be emitted into the air during industrial processes, product use, and waste handling. Once airborne, they may travel long distances, making air a critical pathway for dispersion and exposure.
Testing for PFAS in air is challenging. They can exist both as vapours and bound to particles, they occur at very low concentrations, and background contamination can easily compromise results. For industry and environmental consultants tasked with source emission testing and environmental monitoring, understanding these challenges and the expectations of regulators is essential.
For years, we accepted the trade off: single quad GC MS with 10 L samples gives you 20 300 pg/L, but ambient PFAS sit at 2 200 fg/L. Scaling to 300L scales background interference faster than signal. The result is uninterpretable data.

Results
By integrating thermal desorption preconcentration, triple quadrupole MS/MS and contamination proof workflows, the authors demonstrate a robust route to quantitative identification at fg/L levels without sacrificing data quality. The recent ILS data confirm that when you control every interface (sorbent tubes, canisters, gas lines, syringes, septa), the linearity is maintained even at the lowest calibration points

Discussion and Conclusion
This presentation is designed to give a clear overview of the current landscape for monitoring PFAS in air. It will outline practical considerations for sampling and analysis, highlight the importance of contamination control, and provide updates on U.S. and international efforts toward method development, standardization, and regulatory guidance. Example workflows using thermal desorption coupled with gas chromatography-mass spectrometry (TD–GC–MS) will also be discussed, showing how these techniques can be applied to real-world testing of PFAS in air.

P-01009 Assessing national policy alignment with the Stockholm Convention on persistent organic pollutants using natural language processing: a preliminary study in Brazil

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Introduction
Persistent organic pollutants (POPs) are toxic and bio-accumulative substances regulated by the Stockholm Convention, whose Annexes A, B and C set obligations for elimination, restriction and reduction of unintentional releases. Translating these obligations into national policy depends not only on legal incorporation, but also on technical, operational, logistical and financial implementation capacity, especially for developing countries. Assessing how far national legislation reflects treaty obligations is typically manual, time-consuming and difficult to reproduce [1]. We adapt an AI-assisted policy-alignment framework to the POPs domain. Each obligation from Annexes A, B and C and relevant Convention articles is represented as a natural-language statement; Brazilian legal and policy documents are segmented and matched to these obligations through natural language processing. In this preliminary version, the Regulatory Alignment Index relies primarily on lexical similarity (TF-IDF), wile semantic and transformer-based representations are being evaluated as complementary approaches [2,3]; similar approaches have recently been applied to treaty compliance assessment using large language models [4]. A Regulatory Alignment Index quantifies the extent to which Convention obligations are reflected in the legal corpus. Obligation criticality is weighted using the Analytic Hierarchy Process (AHP), and a conformity gap is estimated as the difference between weighted criticality and textual alignment. The index reflects textual regulatory alignment rather than implementation, enforcement or actual compliance. Criticality is weighted by the Analytic Hierarchy Process, and a conformity gap is computed as criticality minus textual coverage. Interpretation of the conformity gap is further informed by registered exemptions and implementation barriers identified in the National Implementation Plan (NIP).

Materials and Methods
The framework was applied to seven comprised Brazilian legal and policy instruments: Legislative Decree No. 204/2004; Decree No. 5,472/2005; Law No. 12,305/2010; CONAMA Resolution No. 436/2011; Brazil's 2015 National Implementation Plan for the Stockholm Convention; CONAMA/MMA Resolution No. 499/2020; Law No. 14,250/2021; and Law No. 14,785/2023) against 24 obligations derived from the Convention text. The corpus was segmented into obligation-matching units and processed to compute textual alignment, conformity gaps and an exploratory typology of gaps. Obligation rankings were compared with the 2023 NIP as an institutional anchor; Cohen's k (0.34) was interpreted as fair exploratory agreement suitable for preliminary proof-of-concept validation rather than definitive human-coded validation.

Results
Annex A (elimination) concentrated the largest conformity gap. The preliminary typology distinguished obligations with high textual gaps and high apparent feasibility, interpreted as possible regulatory-priority gaps, from obligations whose resolution may depend on implementation capacity, financing, logistics, technical assistance or phased timelines. PCBs are therefore interpreted cautiously: the observed conformity gap likely reflects challenges in inventory completion, removal, storage, transport, treatment and final disposal rather than simply the availability of industrial substitutes. For POP-pesticides, the analysis avoids assuming a generalized lack of substitutes; sulfluramid/PFOS-related uses are treated as a specific case requiring further assessment of substitution performance and non-target impacts.

Discussion and Conclusion
These findings are preliminary and currently rely primarily on the lexical layer of the framework. Semantic matching, entailment analysis, transformer-based runs and capacity-barrier signals are still coarse and not yet validated against a full human-coded reference. The proposed index reflects textual policy attention and regulatory coverage in the selected documents, not actual implementation, enforcement, substitution, budget execution or compliance with the Convention. Sensitivity analysis, corpus expansion and human-coded validation are in progress.

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