This information is an attachment to the restriction proposal for PFAS (appendix to Annex E.4) and compiles ar

The aim with this overview is to summarize relevant analytical methods for the analysis of PFASs in several matri
Various sources of information have been investigated including recent peer-reviewed literature (2010-2022) an

Information on analytics of relevant publications and standards were extracted in this excel sheet. Extracted info

Please note:
1. Every matrix discussed in the report has an extra tab. Publications or standards which could be assigned to mo
2. Application notes of laboratories can be found in a seperate tab (as they usually can not be assigned to specifi
3. Sorting of the respective columns is possible (for example by year).
4. Standard methods are highlighted in **green** and are therefore easy to find.
5. The same notation (for e.g., PFAS, methods) was used as in the literature.

nalytical methods available for different matrices.

ces, including products wherein PFASs are often used, like textiles and food-contact materials etc.
d well-established standards. Additional, application notes from laboratories were collected.

rmation include sampling, pre-treatment, extraction, clean-up, measurement, quantification, LoD et

re than one category can be found in each respective tab.
c matrices).

Title	Authors
CEN/TS 15968:2010 - Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and fire fighting foams - Method for sampling, extraction and analysis by LCqMS or LC-tandem/MS	
Post-Chromatographic Dicationic Ionic Liquid-Based Charge Complexation for Highly Sensitive Analysis of Anionic Compounds by Ultra-High-Performance Supercritical Fluid Chromatography Coupled with Electrospray Ionization Mass Spectrometry	Li et al.
Determination of perfluorooctanoic acid and perfluorooctane sulfonate by automated in-tube solid-phase microextraction coupled with liquid chromatography-mass spectrometry	Saito et al.
Removing perfluorooctane sulfonate and perfluorooctanoic acid from solid matrices, paper, fabrics, and sand by mineral acid suppression and supercritical carbon dioxide extraction	Chen et al.

Concentrations and trends of perfluorinated chemicals in potential indoor sources from 2007 through 2011 in the US	Liu et al.
Determination of Perfluorinated Compounds (PFCs) in Various Foodstuff Packaging Materials Used in the Greek Market.	Zafeiraki et al.
Determination of fluorotelomer alcohols in selected consumer products and preliminary investigation of their fate in the indoor environment	Liu et al.
Emission of perfluoroalkyl carboxylic acids (PFCA) from heated surfaces made of polytetrafluoroethylene (PTFE) applied in food contact materials and consumer products	Schlummer et al.

Poly- and perfluoroalkyl substances (PFASs) in indoor dust and food packaging materials in Egypt: Trends in developed and developing countries	Shoeib et al.
The last straw: Characterization of per- and polyfluoroalkyl substances in commercially-available plant-based drinking straws	Timshina et al.
Polyfluorinated surfactants (PFS) in paper and board coatings for food packaging	Trier et al. (b)
Polyfluoroalkyl phosphate esters and perfluoroalkyl carboxylic acids in target food samples and packaging--method development and screening	Gebbink et al.

Perfluoroalkyl and polyfluoroalkyl substances in consumer products Kotthoff et al.

Closing the Mass Balance on Fluorine on Papers and Textiles Robel et al.

In-Vial Extraction Large Volume Gas Chromatography Mass Spectrometry for Analysis of Volatile PFASs on Papers and Textiles Rewerts et al.

How Do We Measure Poly- and Perfluoroalkyl Substances (PFASs) at the Surface of Consumer Products?: Environmental Science and Technology LETTERS	Tokranov et al.
Ubiquitous Occurrence of Fluorotelomer Alcohols in Eco-Friendly Paper-Made Food-Contact Materials and Their Implication for Human Exposure.	Yuan et al.
Total Fluorine Measurements in Food Packaging: How Do Current Methods Perform?	Schultes et al.
Fluorinated Compounds in U.S. Fast Food Packaging	Schaider et al.
An exploratory analysis of poly- and per-fluoroalkyl substances in pet food packaging from the United States	Chinthakindi et al.

Migration of perfluoroalkyl acids from food packaging to food simulants	Xu et al.
PFOA and PFOS Levels in Microwave Paper Packaging between 2005 and 2018.	Monge Brenes et al.
Occurrence of per- and polyfluorinated compounds in paper and board packaging materials and migration to food simulants and foodstuffs	Zabaleta et al.
Screening and identification of per- and polyfluoroalkyl substances in microwave popcorn bags	Zabaleta et al.
Method foranalysis of 68 organic contaminants in food contact paper using gas andliquid chromatography coupled with tandem mass spectrometry	Vavrous et al.

Significance of Perfluoroalkyl Substances (PFAS) in Food Packaging	Curtzwiler et al.
Fast determination of perfluorocompounds in packaging by focused ultrasound solid-liquid extraction and liquid chromatography coupled to quadrupole-time of flight mass spectrometry	Moreta et al.
Determination of perfluorinated alkyl acids in corn,popcorn and popcorn bags before and after cooking by focused ultrasoundsolid–liquid extraction, liquid chromatography and quadrupole-time offlight mass spectrometry,	Moreta et al.
An Optimized Method for the Determination of Perfluorooctanoic Acid, Perfluorooctane Sulfonate and Other Perfluorochemicals in Different Matrices Using Liquid Chromatography/Ion-Trap Mass Spectrometry	Dolman et al.
Tools to discover anionic and nonionic polyfluorinated alkyl surfactants by liquid chromatography electrospray ionisation mass spectrometry	Trier et al. (a)
Determination of perfluorooctane sulfonate and perfluorooctanoic acid in food packaging using liquid chromatography coupled with tandem mass spectrometry	Poothong et al.
Analysis of per- and polyfluorinated substances in articles	Blom et al

Analysis of PFASs and TOF in products	Borg et al.
Per- and Polyfluorinated Alkyl Substances (PFAS) in Paper and Board Food Contact Materials—Selected Samples from the Norwegian Market 2017	Granby et al.
PIGE as a screening tool for Per- and polyfluorinated substances in papers and textiles	Ritter et al.
Determination of Selected Perfluorinated Acids (PFCAs) and Perfluorinated Sulfonates (PFASs) in Food Contact Materials Using LC-MS/MS	Surma et al.
Determination of perfluorocompounds in popcorn packaging by pressurised liquid extraction and ultra-performance liquid chromatography-tandem mass spectrometry	Martínez-Moral et al.

Fast and simple determination of perfluorinated compounds and their potential precursors in different packaging materials	Zabaleta et al.
Comprehensive analysis of photoinitiators and primary aromatic amines in food contact materials using liquid chromatography High-Resolution Mass Spectrometry	Sanchis et al.
Selective and sensitive analysis by reactive easy ambient sonic-spray ionization: Synergistic combination of non-polar spray solvent and dicationic ionic liquid	Lv et al.
Impact of household cooking on release of fluorinated compounds PFOA and PFOS from Tefal coated cookware to foods	AbulFadl et al.

CEN/TS 15968:2010 - Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and fire fighting
foams - Method for sampling, extraction and analysis by LCqMS or LC-tandem/MS

Journal	year	Comments	DOI link
	2010	Also used for other matrices, sample treatmant different	
Anal Chem	2021	Method development	10.1021/acs.analchem.0c04612
Anal Chim Acta	2010	Low relevance due to focus on migration	10.1016/j.aca.2009.11.004
Chemosphere	2012	Method development	10.1016/j.chemosphere.2012.06.003

Chemosphere	2014	na	10.1016/j.chemosphere.2013.10.001
Chemosphere	2014	Reference taken from Al Amin-Review 2020, From Ramírez Carnero 2021	https://doi.org/10.1016
Chemosphere	2015	na	10.1016/j.chemosphere.2014.06.012
Chemosphere	2015	Low relevance due to focus on emission	10.1016/j.chemosphere.2014.11.036

Chemosphere	2016	Reference taken from AlAmin-Review 2020	10.1016/j.chemosphere.2015.08.066
Chemosphere	2021	Modified version of US EPA's NRMRL Solids Extraction Protocol for PFAS Isotope Dilution Analysis	10.1016/j.chemosphere.2021.130238
Environ Sci Pollut Res Int	2011	From Zafeiraki 2014	10.1007/s11356-010-0439-3
Environ Sci Pollut Res Int	2013	na	10.1007/s11356-013-1596-y

Environ Sci Pollut Res Int	2015	na	10.1007/s11356-015-4202-7
Environ Sci Technol	2017	Mass balance between PIGE and other methods	10.1021/acs.est.7b02080
Environ Sci Technol	2018	na	10.1021/acs.est.8b04304

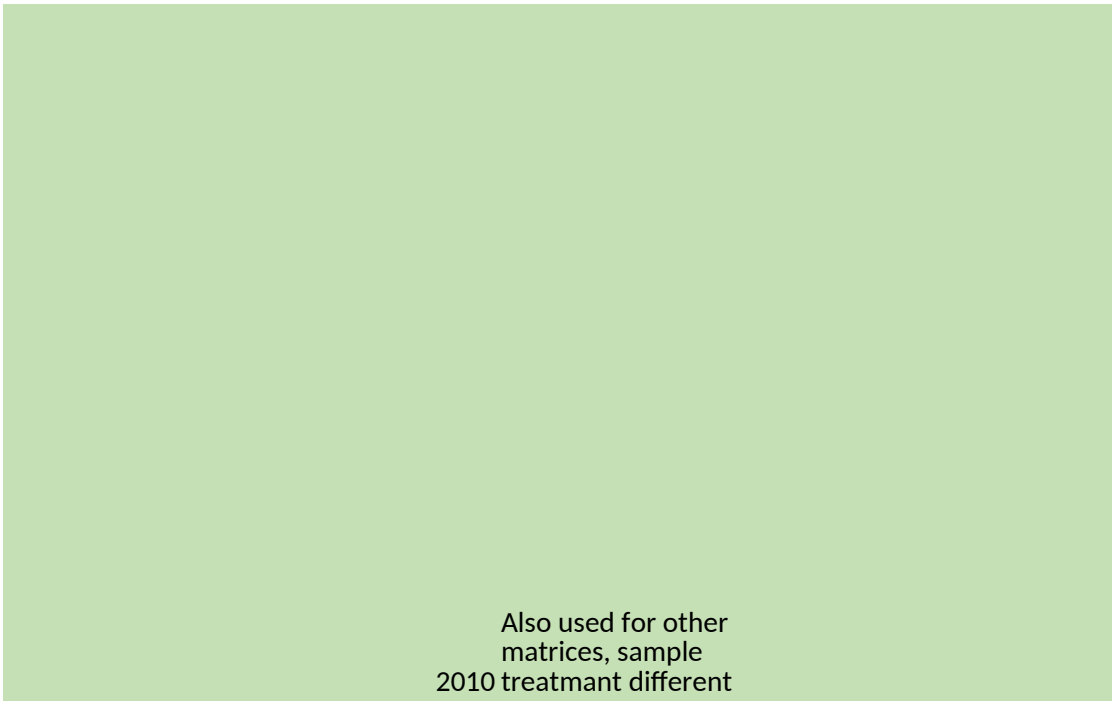
Environ Sci Technol Lett	2019	Method development for consumer products	10.1021/ acs.estlett.8b00600
Environ. Sci. Technol	2016	From Ramírez Carnero 2021	https://doi.org/10.1021
Environmental Science & Technology Letters	2019	na	10.1021/ acs.estlett.8b00700
Environmental science & technology letters	2017	na	10.1021/ acs.estlett.6b00435
Environmental Technology and Innovation	2021	na	https://doi.org/10.1016

Food Addit Contam Part A Chem Anal Control Expo Risk Assess	2013	na	10.1080/19440049.2013.789556
Food Addit. Contam. Part B	2019	2014 From Ramírez Carnero 2021, used method developed by Moreta et al.	https://doi.org/10.1080/19393210.2019.1592238
Food Chem	2020	according to method developed by Zabaleta 2017, also including migration	10.1016/j.foodchem.2020.126746
Food Chemistry	2017	Reference taken from AlAmin-Review 2020	https://doi.org/10.1016
FoodControl 60	2016	From Sanchis 2017	https://doi.org/10.1016

Integrated environmental assessment and management	2021	Method development	10.1002/ieam.4346
J Chromatogr A	2013	na	10.1016/j.chroma.2013.06.024
J. Chromatogr. A	2014	CAS from Sanchis 2017	https://doi.org/10.1016
J. Chromatogr. B	2011	From Ramírez Carnero 2021 and Zafeiraki 2014	https://doi.org/10.1016
Journal of chromatography A	2011	Method development, Applied in Trier 2011b	10.1016/j.chroma.2011.07.057
Journal of hazardous materials	2012	From Zafeiraki 2014	10.1016/j.jhazmat.2011.12.050
Nordic Council of Ministers	2015	na	http://dx.doi.org/10.60

Nordic Council of Ministers	2017 na	http://dx.doi.org/10.60
Norwegian Food Safety Authority	2018 Also migration measured	na
Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms	2017	https://doi.org/10.1016
Packaging Technology and Science	2015 na	10.1002/pts.2140
Talanta	2012 From Zafeiraki 2014	10.1016/ j.talanta.2012.09.007

Talanta	2016	Reference taken from AlAmin-Review 2020	10.1016/j.talanta.2016.02.022
Talanta	2019	Low relevance due to focus on photoinitiators/ primary aromatic amines	10.1016/j.talanta.2018.08.047
Talanta	2020	Method development with PFOA, PFOS as model analyts	10.1016/j.talanta.2020.120929
World Journal of Advanced Research and Reviews	2019	Low relevance due to focus on migration	10.30574/wjarr.2019.3.2.0060


Also used for other
matrices, sample
2010 treatmant different

PFAS	CAS (if available in publication)
PFOS, PFOSA, N-Me-FOSA, N-Et-FOSA, N-Me-FOSE alcohol, N-Et-FOSE alcohol, PFOS salt	1763-23-1 (PFOS) 754-91-6 (PFOSA) 24448-09-7 (N-Me-FOSE alcohol) 1691-99-2 (N-Et-FOSE alcohol)
PFDoA, PFUdA, PFDA, PFna, PFOA, PFHpA, PFHxA, PFPeA, PFOS, PFBS	na
PFOS, PFOA	na
PFOS, PFOA	na

9 PFCAs (C4 to C12), 5 PFASs (C4, C6, C7, C8, C10)	na
PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoA, PFBS, PFHxS, PFOS, PFTrDA, PFTeDA, PFHxDA, PFODA, PFDS	na
6:2 FTOH, 8:2 FTOH, 10:2 FTOH	na
PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUna, PFDoA	na

6:2, 8:2, 10:2 FTOH, Me-FOSA, Et-FOSA, 6:2 FTMAC, 8:2, 10:2 FTAC, 6:6, 6:8, 8:8 PFPIA, 6:2, 8:2 monoPAPs, 6:2, 8:2 diPAPs, PFOS, PFOA, PFDS, PFBS, PFHxS	na
53 semi-volatile PFAS including PFBA, PFOA, PFHxA	na
Non-targeted: FTOH, monoPAPS, diPAPS, triPAPS, S-diPAPS, SN-diPAPS, Alkyl-PAPS, 3-[2-(perfluoroalkyl)ethylthio] propionate, PFOS, PFSA, PFOSA, PFOSF, Et-PFOSA, Alkyl-PFOSA, Fluoroalkoylate, Fluoroacrylate, PFPE, di (N-ethyl perlfluoroalkyl) N-propanoic acid	na
PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFTrDA, 4 monoPAPs, 16 diPAPs including 6:2/6:2 diPAP, 8:2/8:2 diPAP, 10:2/10:2 diPAP, 7 triPAPs	na

PFBA, PFPA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUna, PFDoA, PFTrA, PFTeA, PFBS, PFHxS, PFHpS, PFOS, PFDS, 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, PFOSA	na
total fluorine, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, EtFOSE, C3--C17 PFCAs, C4, C6, C8, C10 n:2 FTCA, C4, C6, C8, C10 n:2 FTUCAs, C3, C5, C7, C9 n:3 FTCA, C2−C10 PFSAs, fluorotelomer sulfonates (C4, 6, 8, 10 FTSAs), fluoroalkyl sulfonamido acetic acids (C4−C8 FASAA), N-methyl fluoroalkyl sulfonamide acetic acids (C4−C8 MeFASAA), ethyl fluoroalkyl sulfonamido acetic acids (C4−C8 EtFASAA), disubstituted perfluoroalkyl phosphinic acids (C4/C4−C8/C8 PFPIA), disubstituted polyfluorinated phosphate esters (C4/ C4-C10/C10 diPAP), fluorotelomer mercaptoalkyl phosphate esters (C6/C6−C10/C10 FTMAP), and ethyl perfluorooctanesulfonamido ethanol-based polyfluoroalkyl phosphate diester (C8/C8 SAmPAP)	na
21 volatile PFAS including 4:2, 6:2, 8:2, and 10:2 FTOH, N-MeFOSA, NEtFOSA, N-MeFOSE, and N-EtFOSE	na

surficial fluorine content, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA, PFBS, PFHxS, PFOS, FOSA, 6:2 FtS, N-MeFOSAA, N-EtFOSAA	na
13 PFCAs, 6:2 FTOH, 8:2 FTOH, 10.2 FTOH, 12:2 FTOH, 14:2 FTOH, 16:2 FTOH, 18:2 FTOH	na
Total fluorine, targeted: PFCAs, C4-C15), PFSAs (C4, C6, C8, C10), FOSA, perfluoroalkane sulfonamidoacetic acids, FTSAs (4:2, 6:2, 8:2), fluorotelomer carboxylic acids (5:3, 7:3, 9:3), ADONa, F53-B, and polyfluoroalkyl phosphoric acid mono- and diesters (mono- and diPAPs)	na
total fluorine, 89 targeted PFASs including PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFDA, PFUna, PFDoA, PFTriA, PFBS, PFHXS, 4:2 FTS, 6:2 FTS, 10:2 FTS, 6:2-8:2 diPAP, 8:2-8:2 diPAP, C5 polyfluoro ether, C6 polyfluoro ether, 5:3 FTCA, PFHxPA, 6:6 FTMAP, ADONa, FHUEA, nMe-FBSE, nafion CA, PFOSulfinate, GenX, non-targeted	na
9 PFCAs namely PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA and 4 PFSAs namely PFBS, PFHxS, PFOS, PFDS	na

PFBS, PFHxS, PFOS, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA	na
PFOA, PFOS	na
Targeted analysis of 23 PFASs including PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, 6:2 monoPAP, 8:2 monoPAP, 6:2 diPAP, 8:2 diPAP, 6:2 FTCA, 6:2 FTUCA, 8:2 FTCA, 8:2 FTUCA, 5:3 FTCA, 7:3 FTCA	na
PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFPeDA, PFHxDA, 8:2 FTCA, 10:2 FTCA, 8:2 FTUCA, 10:2 FTUCA, 7:3 FTCA, 9:3 FTCA, 5:3 FTUCA, 7:3 FTUCA, 9:3 FTUCA	na
PFOS, PFBA, PFPeA, PFHxA, PFOA, PFna, PFDA, PFUna, PFDoA, FOSA, PFBS, PFOPA, PFHxS, PFHxPA, PFDPA	1763-23-1 (PFOS) 375-22-4 (PFBA) 2706-90-3 (PFPeA) 307-24-4 (PFHxA) 335-67-1 (PFOA) 375-95-1 (PFna) 335-76-2 (PFDA) 2058-94-8 (PFUna) 307-55-1 (PFDoA) 754-91-6 (FOSA) 29420-49-3 (PFBS) 355-46-4 (PFHxS)

PFBA, PFHxA, PFOA, PFDA	na
PFHpA, PFOA, PFna, PFOS, PFDA, PFUnDA, PFDoA	na
PFOS, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUna, PFDoA	1763-23-1 (PFOS) 375-22-4 (PFBA) 2706-90-3 (PFPeA) 307-24-4 (PFHxA) 375-85-9 (PFHpA) 335-67-1 (PFOA) 375-95-1 (PFna) 335-76-2 (PFDA) 2058-94-8 (PFUna) 307-55-1 (PFDoA)
PFOA, PFHxA, PFHpA, PFna, PFDA, PFUA	na
Non-targeted: PFCA, PFSA, PFASA, FTOH, monoPAPs, diPAPs, S-diPAPs, Fluoroethoxylate	na
PFOS, PFOA	na
PFCAs (PFBA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA), PFASs (PFBS, PFHxS, PFOS), PAPs (6:2 diPAP, 6:2 monoPAP, 8:2 diPAP, 8:2 mono-PAP), FTOH (4:2, 6:2, 8:2), FTS (4:2, 6:2)	375-22-4 (PFBA), 307-24-4 (PFHxA), 375-85-9 (PFHpA), 335-67-1 (PFOA), 375-95-1 (PFna), 335-76-2 (PFDA), 4234-23-5 (PFUnDA), 307-55-1 (PFDoDA), 72629-94-8 (PFTrDA), 376-06-7 (PFTeDA), 29420-49-3 (PFBS salt), 3871-99-6 (PFHxS salt), 1763-23-1 (PFOS salt), 2043-47-2 (4:2 FTOH), 647-42-7 (6:2 FTOH), 678-39-7 (8:2 FTOH), 57677-95-9 (6:2 diPAP), 57678-01-0 (6:2 monoPAP), 678-41-1 (8:2 diPAP), 57678-03-2 (8:2 mono-PAP), 757124-72-4 (4:2 FTS), 29420-49-3 (6:2 FTS)

TOF, targeted analysis of PFCAs (PFBA, PFHxA, PFOA, PFna, PFDA), PFSAs (PFBS, PFHxS, PFOS), FTOHs (4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH), FTAs (6:2 FTA, 8:2 FTA, 10:2 FTA), FOSAs (MeFOSA, EtFOSA), FOSEs (MeFOSE, EtFOSE)	375-22-4 (PFBA), 29420-49-3 (PFBS salt), 307-24-4 (PFHxA), 3871-99-6 (PFHxS salt), 2043-47-2 (4:2 FTOH), 757124-72-4 (4:2 FTS), 335-67-1 (PFOA), 1763-23-1 (PFOS salt), 647-42-7 (6:2 FTOH), 29420-49-3 (6:2 FTS), 31506-32-8 (MeFOSA), 4151-50-2 (EtFOSA), 2448-09-7 (MeFOSE), 1691-99-2 (EtFOSE), 375-95-1 (PFna), 335-76-2 (PFDA), 678-39-7 (8:2 FTOH)
PFCAs (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA, PFTeA, PFTrA), PFSAs (PFBS, PFHxS, PFOS, 4H-PFOS, PFDS, PFOSA), monoPAPs (6:2, 8:2), diPAPs (6:2/6:2, 8:2/8:2), FTOHs (4.2, 6:2, 8:2, 10:2)	na
total fluorine	na
PFOA, PFOS	na
PFHpA, PFOA, PFna, PFOS, PFDA, PFUnDA, PFDoA	na

PFBS, PFHxS, PFOS, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFHxPA, PFOPA, PFDPA, PFOSA, 6:2 FTCA, 8:2 FTCA, 5:3 FTCA, 7:3 FTCA, 6:2 FTUCA, 8:2 FTUCA, 6:2 mono & di PAP, 8:2 mono & di PAP	na
Post-run target screening analysis of polyfluorinated compounds	na
PFOA, PFOS	na
PFOS, PFOA	na

PFOS, PFOSA, N-Me-FOSA, N-Et-FOSA, N-Me-FOSE alcohol, N-Et-FOSE alcohol, PFOS salt	1763-23-1 (PFOS) 754-91-6 (PFOSA) 24448-09-7 (N-Me-FOSE alcohol) 1691-99-2 (N-Et-FOSE alcohol)

Sampling	sample amount used	Pre- treatment
Solids (coated materials): at least 200 cm2 or 2 g, solids (non-coated): sampled according to EN ISO 8130-9	see sampling	Sample materials need to ground as appropriate to ensure an efficient extraction process. Textile and paper shall be cut into pieces of maximum 1 cm2 before methanol is added. For grinding of polymers and granulates it is recommended to use EN ISO 6427 or ISO 9113.
32 real textile samples of different fabrics (e.g., cotton, wool, and polyester) and 6 food packaging material samples (e.g., oil-proof hamburger wrapping paper)	1 x 1 cm2, 0.5 g	na
Surface water and waste water samples, Teflon-coated frying pan from the local market was heating on a cooking stove for 5min after addition of 200mL of distilled water. Aliquots of 0.2 mL of heated water in the frying pan were pipetted into 2-mL autosampler vials and the total volume was made up to 1.0 mL with distilled water.	1 mL	filtered (0.2 µm nylon syringe)
na	na	na

95 samples from 35 consumer products including carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes. They were purchased from retail outlets in the United States between March 2007 and September 2011.	5 x 5 cm	solid products were cut into smaller subsections. Liquid products were subdivided into at least three 30-mL polypropylene vials
42 Fast-food packaging, sandwiches, cups, ice cream containers, baking paper, popcorn bags, etc. from Athens market and fast-food restaurants in Greece.	1 cm2	In the cases when the samples had a printed outside layer, this was removed when possible. Any food content was removed from the packaging, which was then rinsed with ultrapure water to remove salt and dried.
54 consumer products from U.S. open market in the years of 2011 and 2013 (carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes)	solid samples 0.05 g, liquid samples 100 µL	na
3 PTFE coated pans (claimed to be PFOA free) bought from German stores, 3 waffle irons, Sandwich marker, electric iron, iron sole plate, hair straightener	emission analyzed	pans pre-cleaned as recommended by their producers

Paper and cardboard materials (n=17) constituted fast food sandwiches wrappers for burgers; paper boxes for French fries, pizza sandsandwiches; non-stickbaking cups; microwave bags for popcorn and soup cups.Dust samples were collected from Cairo, Egypt in 2013. The samples were collected from 17 homes, 5 workplaces and 9 cars as obtained from new vacuum cleaner bags. Dust samples from cars were collected from the chairs, the roofs and the dashboards .The dust samples were wrapped in solvent-cleaned aluminum foil and further sealed in polyethylene bags for storage at 4°C until processed.	Dust: 0.1-0.2 g, FCM: 1/8-1/4'', < 1 g	Dust: sieved, FCM: Removal of the food products, the paper and cardboards were wiped with clean tissue paper, rinsed with deionized water
43 brands of straws (5 plastic, 29 paper, 9 other plant-based)	na	na
14 papers and board materials intended for contact with food at high temperatures from retailers in Denmark	1 dm2	After removal of the food product, the paper and boards were rinsed for salts with distilled, deionised water. Food contact material that had not been in contact was chosen if possible.
Targeted food samples (in their original paper or board packaging materials) were purchased at a Swedish grocery store chain (ICA supermarket) and in a McDonald's restaurant in Stockholm in spring 2012.	5 x 5 cm, 5 g homogenized food sample	Food samples that required heating prior to consumption were purchased in duplicates. One portion was analyzed as purchased (hereafter referred to as unprepared food), whereas the other portion was prepared in the microwave oven according to specifications on the packaging materials before analysis (hereafter referred to as prepared food)

115 samples of consumer products including textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes. The individual samples analysed were bought from local retailers or collected by co-workers of the institute or local clubs (e.g. ski waxes from local skiing club). The sampled products span all quality levels from entry level to cutting edge products. The selection of the samples occurred randomly.	na	na
large set of consumer products (food-contact papers, popcorn bag, outerwear textiles, childrens clothing, pillowcase, uhholstery cut from office chair) comprised of paper and textiles purchased by the Washington Department of Ecology in 2015	2 x 2 cm2 (0.3 +/- 0.01 g)	cut using methanol-rinsed scissors
7 papers consisted of all new materials purchased or acquired in 2017, including: white copier paper, five food-contact materials, and waterproof notebook paper, 9 textiles consisted of a plain white t-shirt, three office chair upholsteries from the years 1988a, 1988b, and 1993, respectively, an outdoor upholstery purchased in 2017, two articles of previously worn children's clothing (a swimsuit and outdoor vest), and an adult rain jacket purchased in 2015, as well as a piece of a used firefighter's jacket	1.5 x 1.5 cm	cut using methanol-rinsed scissors

94 consumer products that represent frequently used items on a college campus of Harvard University. These included: 45 food contact materials, 37 textiles, and 12 domestic products such as lens wipes, bandages, masks, and a shower curtain	1 ± 0.03 g	cut using methanol-rinsed scissors, mounted on carbon tape for XPS
69 paper-made FCMs (bags of popcorn, materials labelled as ecological, cupcake packaging, etc.) from Beijing retail market and online. 25 FCMs were purchased from various retail stores in Columbus, Ohio.	0.5 cm x 0.5 cm	printed outer surfaces were peeled off from the samples before extraction; for other single-layer samples, the printed portions were cut from the samples before extraction
3 french-fry bags (FF1–FF3) and 6 microwave popcorn bags (MP1–MP6) purchased in Sweden in 2012	5 cm x 5 cm	short, samples (5 cm × 5 cm) were cut into small pieces, fortified with internal standards (0.5 ng each)
407 samples of paper and paperboard food wrappers and related food packaging at U.S. fast food restaurants (2014, 2015) including food contact paper (e.g., sandwich wrappers and pastry bags), noncontact paper (e.g., outer bags), food contact paperboard (e.g., boxes for fries and pizza), paper cups (for hot or cold drinks), other beverages (e.g., milk and juice containers), and miscellaneous (e.g., lids and applesauce containers).	PIGE: 2 cm2 with 1 cm2 hole, MS: 10 cm x 10 cm	na
.A total of 48 samples (37 packaging and 11 food) from 11 different popular brands of pet (cat and dog) foods marketed in the United States. Of the 37 packaging, 22 were used for cat food, 15 were for dog food.	1 cm2	emptying the contents, packaging material was cut into small pieces

The food packaging samples were purchased, unused, directly from local retail food markets.	6 cm × 8 cm × 0.034 mm, 9.34 g m−2; 3 x 9 cm (migration)	na
Seven unique unused, unfilled, single-gusseted microwave- printed popcorn bags were obtained from multiple international suppliers. Three lunch sacks were obtained from three unique retail grocery chains (Ames, IA). The lunch sacks are not printed.	~1.5 g of homogenised sample	Sections with the adhesive were removed before sampling, pulverized, suspended (EtOAc) & spiked, mixed; evaporated
12 grease proof P/B packaging materials including a baking paper, a muffin cup, a cardboard plate and a cup, a burger wrapper, two grease proof boxes, two French fries wrappers, two burger clams and a grease proof bag, together with 7 non grease proof materials including two cardboards, two pizza boxes and three cinema popcorn bags were collected randomly from local factories, markets and restaurants between 2018 and 2019. Moreover, microwave popcorn bags were purchased in China (one) and Spain (two) from local supermarkets during 2019. Finally, unprinted pet food paper bags (collected during 2016 and 2018) were also analyzed.	1 cm^2	After removal of the food product, the paper of microwave popcorn bags was rinsed into Milli-Q water.
Microwave popcorn bags purchased from Europe (Spain, France, Austria, The Netherlands, Hungary, Germany, Italy, Ireland, Czech Republic, Sweden, United Kingdom and Portugal), America (Mexico, Brazil and United States) and Asia (China and India) during 2015–2016 (all bags were ensured to be manufactured in the corresponding country)	1 dm2, ~1 g	removal of the food product, the paper was rinsed for salts with Milli-Q water
Real samples of paper FCM were acquired from the market in the Czech Republic	1.0-1.5 g	Samples were cut into small pieces (approximately 2 x 10 mm)

Strips of unbleached kraft 0.35mm (16 pt) recycled packaging paper 2.54 × 25 cm were received from a commercial domestic manufacturer and prepared using a JDC Precision sample cutter.	2.54-cm square and two 2.54 × ~11.25-cm segments	cut using methanol-wiped Ti scissors
Different food-contact packings like microwave popcorn bag, icecream tub and cardboard cup were obtained from different local supermarkets: 6 microwave popcorn bags, 3 types of microwave popcorn,	5 g	samples were ground
Microwave popcorn bags of six different types obtained from local supermarkets in mid-2013	0.50 g, 1.00 g and 1.5 g	Before analysis, fat, salt and/or sugar were thoroughly removed from packaging and corn samples with the aid of paper towel, cornand popcorn were sieved through a 0.5 mm mesh sieve.
Popcorn bags, baking, paper, box of chips, sandwich wrap, hamburger box from Local shops and fast-food restaurants; bottled drinking water	50 mg	na
na	na	na
34 samples of food packaging material made of paper from domestic and international restaurants in Bangkok, Thailand	5 mm x 5 mm, 2 g (dry weight)	printing and outside layer of the containers were deliberately removed with the aid of a cutter.
In total 29 different samples were analysed. The sampling was concentrated on a few but wide variety of household products, such as cleaning products and polishes for indoor use and for cars and sprays to waterproof shoes or clothes, food contact paper and baking forms included some products less commonly analysed, such as ski wax, dental floss and tablecloths. The samples were purchased in the vicinity of Oslo in supermarket chains that are found all over Norway.	depending on the article: 0.05 mL, 71.5-100 cm^2 or 0.02-0.16 g	vortexing in methanol

In total 17 products were randomly selected from shelves in a number of Swedish retail stores and supermarkets for analysis (Cupcake forms, microwave popcorn bag, rinse aid, waterproofing shoe treatment, waterproofing textile treatment, shoe wax, floor polish, furniture polish, car wax). In total 29 samples of consumer products were collected in the previous study (including food contact material, textiles, lubricants, car wax, table cloth, ski wax and more)	Pressed pellets of 100-120 mg for TOF	sample was homogenized, shredded for TOF
In total 35 samples Samples of paper and board FCM were collected at importers or at retail shops in Norway. Relevant samples of paper and board FCM in direct contact with the food, for example muffin making cups, baking paper, snack paper, fast food packaging, pizza trays, coffee / tea cups, bags for microwave oven popcorn and similar products that have a grease and water repellent surface. Samples that have a layer of plastic in direct contact with the food were not included. Sampling was conducted in three Norwegian Food Safety Authority regions: “Greater-Oslo”, “East” and “South and West”.	6 cm2	na
350 consumer products purchased from 94 retail stores/vendors in April/May 2015 (paper and textile samples likely PFAS treated for water and oil repellency)	2 cm2 with 1 cm2 hole	no
Three different brands of wrapping papers, breakfast bags, baking papers and roasting bags samples, ob_x0002_tained from typical, commercially available food contact products in Poland	sheet area 1*103 cm2 of the same thickness (~0.1 mm) was cut into small pieces	na
Microwave popcorn bags of three different brands from supermarkets in Spain	0.5 g	samples were ground

Different packaging material smade of cardboard (microwave popcorn bag, grease proof paper for French fries, cardboard box for pizza, cinema cardboard box for popcorn) and plastic (milkbottle, muffin cup, pre-cooked food wrapper, cup of coffee)were obtained randomly from local markets, restaurants and cinema	1 cm2 pieces, 0.5 g	printed outside layer was removed
18 plastic empty containers were provided by two food industries of the Valencian Region (Spain) during 2016: a) six Tetrabrick were destined to contain juice (with pH<4.5) and juice with milk (with pH>4.5); b) six pouches were destined to contain milk derivates, manufactured as infant food; and c) six bags to contain musts with fruit pulp (with pH>4.5)	1 cm2	na
real textile samples of different fabrics, as well as five popcorn bucket and six oil-proof hamburger wrapping paper samples, which were collected from local markets or purchased online	not reported	na
Tefal cookware (24 cm diameter and 30mm thickness of Teflon layer which coats the inner surface of utensils), these utensils were purchased from Shedid Eng. Establishment, Cairo, Egypt.	1 g patches (tomato), 500 g patches (white beans); small square shapes (0.5-1 cm) cut from the tested utensils coated with Tefal for surface analysis	10 patches used with salt and 10 without salt for each vegetable, tomato pulp was passed through a finisher (0.5mm screen), patches white dry beans were soaked in 1 L of distilled water for 180 min. prior to cooking; tomato/ white beans were cooked in tefal utensils, samples of the respective vegetable cooked in the same container

Solids (coated materials): at least 200 cm2 or 2 g, solids (non-coated): sampled according to EN ISO 8130-9	see sampling	Sample materials need to ground as appropriate to ensure an efficient extraction process. Textile and paper shall be cut into pieces of maximum 1 cm2 before methanol is added. For grinding of polymers and granulates it is recommended to use EN ISO 6427 or ISO 9113.

Extraction	Clean up	Measurement
Sonification in methanol for textile, fabrics, leather and paper	Concentrate the extract by a factor of 10 and use a clean-up if necessary. Active carbon clean-up and/or solid phase extraction (SPE) clean-up may be used. Transfer a known volume into a suitable LC sampling vial . If necessary dilute the original solution further and repeat the analysis	LC-qMS, LC-tandemMS
supramolecular solvent (SUPRAS)-based extraction, heptanol, tetrahydrofuran, and water mixed solvents	diluted 1:1 (v/v) with methanol, filtered	UHPSFC-(+)ESI-MS/MS
In-tube solid-phase microextraction (SPME)	na	LC-MS
supercritical fluid extraction (SFE), supercritical carbon dioxide (Sc-CO2) with methanol	na	HPLC/MS

solid and liquid sample extraction (Liu 2012, US EPA Report, EPA/600/R-12/585)	na	HPLC/MS/MS
Pressurized liquid extraction (PLE) with Methanol	Solid phase extraction, evaporation to dryness, reconstitution in mobile phase	LC/(-)ESI-MS/MS
Sonification in methanol	na	GC/MS
overheated: pans put onto a stove, heated with a 3000W stove, Gaseous emissions trapped by a precleaned glass lid, SPE; normal use: Products (consumer products, sandwich maker, waffle iron) placed in the middle of the hobbock, emission test started as the oven reached 230 °C	Rinsing in triplicate using methanol (normal conditions and overheated), SPE	HPLC-ESI-MS

FCM: Soxhlet extraction, SPE; Dust: Sonification in dichloromethane	na	Dust: UPLC/(-)ESI-MS/MS, FCM: HPLC/MS/MS, GC/PCI-MS
methanol-based (0.3% methanolic ammonium hydroxide followed by rotation and centrifugation)	na	UHPLC-MS/MS analyses were completed on a Thermo Vanquish UHPLC system (Waltham, MA, USA) coupled to a Thermo Quantis triple quadrupole mass spectrometer (operated in negative selected reaction monitoring mode) with a Phenomenex Gemini C18 column and a gradient elution using water and methanol, both with 5 mM ammonium formate
Sonication with ethanol at 60 ^C	centrifugation and filtering	UHPLC/(-)ESI-QTOF/MS
SPE with methanol and water	filtered	UPLC/MS/MS

differ depending on the respective matrix: ion pair extraction, acidic-alkaine sequential extraction or SPE with acetone, hexane or methyl-t-butyl ether as solvent	differ depending on the respective matrix	PFAA: HPLC-MS/MS FTOH: GC/CI-MS
Sonification in ethyl acetate for FTOHs, heated in methanol for PFASs	na	PIGE (total fluorine), GC-MS (FTOHs), HPLC-MS/MS (PFASs), TOP assay
Sonification in methanol	na	GC-CSR-LVSI-MS, QTOF-MS (nontargeted analysis)

methanol extraction, XPS (not extracted sample/ methanol extract)	na	X-ray photoelectron spectrosopy (XPS), LC-(-)ESI-MS, LC-QTOF-MS
Sonification in methanol (heated)	WAX cartridges	FTOH: UPLC-MS/MS and/or UPLC-QTOF, PFCA: UPLC−ESI(−)−MS/ MS
targeted analysis: extraction in methanol	na	particle-induced γ-ray emission spectroscopy (PIGE), instrumental neutron activation analysis (InaA), combustion ion chromatography (CIC), UHPLC-MS/MS
PIGE: no extraction, sonification in methanol for MS	na	PIGE (total fluorine), HPLC-TOF-MS (PFAS)
extracted with methanol and ethyl acetate successively by shaking in an orbital shaker	water added, oxidation of one aliquot by TOP assay followed by SPE (after TOP), one aliquot SPE (before TOP)	TOP assay, UPLC-MS/MS (ESI)

SPE (sonication for FCM)	na	LC/(-)ESI-MS
focused ultrasonic liquid extraction (FUSLE), ethanol	dried, reconstituted with methanol	UHPLC-QTOF
see Zabaleta 2017	see Zabaleta 2017	LC-QqQ-MS/MS - Agilent 1260 series HPLC chromatograph coupled to an Agilent 6430 triple quadrupole (QqQ) mass spectrometer equipped with both electrospray (ESI) and atmospheric pressure chemical ionization (APCI) sources.
Focused ultrasonic solid–liquid extraction (FUSLE) with methanol	Envi-Carb sorbent with methanol	LC-QToF-MS
Ultrasonic solvent extraction (acetonitrile, acetone or 2-propanol), LLE	na	GC–MS/MS, HPLC–MS/MS

ultrasonic liquid extraction (FUSLE) with ethanol	dried, reconstituted with methanol	contact angle measurement, UHPLC-(-)ESI-MS/MS
ultrasound solid-liquid extraction (FUSLE) with ethanol	evaporated, reconstituted in methanol, filtered	UHPLC/QTOF-MS/MS
focused ultrasound solid–liquid extraction (FUSLE), Ethanol	na	UHPLC–(QTOF)MS/MS
Sonication with water,	off-line SPE	LC-MS, Phenyl–Hexyl column applying a water/acetonitrile gradient
na	na	UHPLC/(-)ESI-QTOF/MS and MS/MS (the mobile phases were adjusted to pH 2.8 with formic acid, and pH 9.7 with ammonia:)
PLE with methanol ald saliva	centrifugation, for saiva evaporated and reconstituted in acetonitrile	LC-MS/MS
ultrasonification in methanol	volume reduced to 2 mL, aliquot filtered	UPLC-MS/MS for ionic PDAS and PAP, GC/MSD for FTOH

LC-MS: ultrasonic extraction with matrix dependent solvents (no further information), burning for TOF and absorbtion of combustion gases in buffer solution	LC-MS: (multi)-step-sample clean-up	Targeted analysis with LC/MS-MS (Agilent HPLC 1290 Infinity Serie coupled with Agilent 6460A Triple Quad LC/MS-MSMS), TOF by IC
Sonification in ethanol (PFCA/PFSA), 50% ethanol:water (PAP, FTOH)	filtered	UPLC-MS/MS
no extraction	no	Particle-Induced Gamma Ray Emission (PIGE)
na	na	consisted two pumps, an autosampler (set at 4℃), a column oven and a system controller coupled with mass spectrometer (QTRAP 5500, AB SCIEX, All chro_x0002_matographic determinations were performed on XBridge C18 150 × 2.1 mm 3.5 µm column (Waters, Milford, MA, USA) at 45℃ with the flow rate of 0.23 ml/min. Compounds were eluted in gradient system composed of water/formic acid (99.0/1.0, phase A) and acetonitrile/formic acid (99.0/1.0, phase B). Gradient was as follows: 30% B (0.0 min), 30–80% B (0.0–5.0 min), 80% B (5.0–20.0 min), 80–30% (20.0–21.0 min) and 30% (21.00–41.0 min)
PLE with methanol	na	UHPLC/(-)ESI-QTOF-MS

Ultrasonic probe-assisted extraction (UPAE) with methanol	supernatant was filtered and evaporated to dryness	LC-QqQ-MS/MS
Destructive test: pieces were soaked in 3% acetic acid in water, w/v, during 2 h at 70 degrees followed by liquid-liquid extraction twice (with DCM)	na	UHPLC-Orbitrap-HRMS
dicationic ionic liquid (DIL) based easy ambient sonic-spray ionization (EASI), solvents (acetonitrile, methanol, acetone, isopropyl alcohol, dichloromethane, tetrahydrofuran, ethyl acetate, and hexane)	na	EASI-MS/MS
Pressurized liquid extraction (PLE) with ethanol/water (1:9 watery, 19:1 fatty)	N7A	LC/MS, XRD, EDX, ESEM

Sonification in methanol for textile, fabrics, leather and paper	Concentrate the extract by a factor of 10 and use a clean-up if necessary. Active carbon clean-up and/or solid phase extraction (SPE) clean-up may be used. Transfer a known volume into a suitable LC sampling vial . If necessary dilute the original solution further and repeat the analysis	LC-qMS, LC-tandemMS

Quantification method	Working range (ng/mL) As	Matrices
Quantify the samples by using the unextracted external calibration curve. When spiking with labelled reference solutions, the determination of the concentration is independent of possible errors made during injection. Also, errors caused by sample losses during distinct steps of sample pre-treatment or the adjustment of final sample extract volume as well as matrix effects in the sample are accounted for.	Method is applicable for a concentration range for PFOS in the extract solution of 0,5 µg/l to 50 µg/l.	Coated materials like paper, textile, leather, carpets, clothes and footwear, Non-coated materials, liquids
internal standards	N7A	32 real textile samples of different fabrics (e.g., cotton, wool, and polyester) and 6 food packaging material samples (e.g., oil-proof hamburger wrapping paper)
six-point calibration	0.05–5 ng mL−1	environmental water, elution of Teflon-coated pan
internal standard	na	solid matrices, paper, fabrics, sand

internal standardisation using mass-labeled standards	na	carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes
isotope dilution method	na	Food packaging materials
internal standards	na	carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tape
internal standardisation using mass-labeled internal standards	na	Emission from overheated pans, consumer products and FCM

internal standardisation using mass-labeled internal standards	na	Indoor dust and packaging materials
linear regression models from calibration curves built for each analyte	N7A	straws out of plastic, paper and plant-based
external calibration was used for the semi-quantification of diPAPS and S-diPAPS	na	Extracts and Migrates from food contact materials
internal standardisation using mass-labeled standards	na	food packaging materials, food

internal standardisation using mass-labeled internal standards	na	textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes
internal standards	na	papers (mainly food-contact material), textiles
internal standardisation using mass-labeled internal standards; FTOHs derivatives were quantified using the standard curve of 10:2 FTOH derivative	N7A	paper and textile

internal standards	N7A	paper and textile
internal standardisation using mass-labeled internal standards; FTOHs derivatives were quantified using the standard curve of 10:2 FTOH derivative	na	paper-made FCMs
targeted analysis: internal standardisation using mass-labeled internal standards, calibration curve (naF) for CIC, Daily calibrations of PIGE signal to TF with naF, Fluoride standard for InaA calibration,	N7A	french-fry bags, microwave popcorn bags
PIGE: PFAS standards dissolved in methanol and dried onto filter paper (external standard), TOF: peak area as a semi-quantitative indication	na	paper and paperboard food wrappers for fastfood
isotopic dilution method	0.1-100 ng/mL	pet food and the packaging material

Quantification was performed by using di-labelled 13C-PFOA as an internal standard for all PFCAs.	na	food contact papers, migration into food simulants
internal standardisation using mass-labeled internal standards	N7A	Microwave packer packaging
Quantification was performed with the selected reaction-monitoring (SRM) mode, internal standardisation using mass-labeled internal standards	N7A	paper and board (P/B) packaging materials
internal standardisation using mass-labeled internal standards	25 ng/g and 50 ng/g	Popcorn bag
internal standardisation using mass-labeled internal standards	na	Paper

External calibration curve, nonmass labeled standards, data independent acquisition (DIA)	N7A	food packaging, water and oil resistance performance
internal standardisation using mass-labeled standards	na	food-contact packaging
internal standardisation using mass-labeled standards	na	popcorn bags, popcorn
calibration standards	10 µg/mL to 1000 µg/mL	food packaging, polytetrafluoroethylene (PTFE) sealant tape and drinking water.
internal standardisation using mass-labeled standards	0.025–5 µg mL−1	industrial blends and extracts from food contact materials
calibration curve	0.05–10 µg L−1	food packaging materials, migrates
internal standardisation using mass-labeled internal standards	na	Consumer products, FCM

LC-MS: internal isotope-labeled standards (isotope dilution method)	N7A	Consumer products, Textiles, FCM
Quantitation was performed using external calibration standards added several corresponding C13-labelled internal standards	N7A	paper and board FCM
external inorganic fluorine standard (naF) and external paper and textile standards with PFOA	na	paper and textile
na	na	wrapping papers, breakfast bags, baking papers and roasting bags
internal standardisation using mass-labeled standards		popcorn packaging

internal standardisation using mass-labeled internal standards	na	Plastic and cardboard materials
no quantification	N7A	juice tetrabricks, pouches and bags
internal standardisation using mass-labeled internal standards	N7A	real textile, popcorn bucket, and oil-proof hamburger wrapping paper samples
quantitative determination was evaluated via recovery experiments	N7A	Leaching from tefal cookware

Quantify the samples by using the unextracted external calibration curve. When spiking with labelled reference solutions, the determination of the concentration is independent of possible errors made during injection. Also, errors caused by sample losses during distinct steps of sample pre-treatment or the adjustment of final sample extract volume as well as matrix effects in the sample are accounted for.	Method is applicable for a concentration range for PFOS in the extract solution of 0,5 µg/l to 50 µg/l.	Coated materials like paper, textile, leather, carpets, clothes and footwear, Non-coated materials, liquids

Reported levels (ng/mL)	info - validation of the method	Limitations
na	The recovery of labelled reference compound shall be in the range from 70 % to 125 % for the sample to be considered valid.	
PFDoA (19.85 µg kg-1) and PFOA (12.49 µg kg-1) (textile sample)	Good linearity with correlation coefficients all greater than 0.99, six replicate measurements, relative errors less than 9% compared to HPLC-ESI-MS/MS	na
PFOA: 35.3 +/- 1.2 (Tap Water Osaka), 14.6 +/- 0.1 (Yodo River Osaka), 27.3 +/- 1.1 (Frying pan) µg/mL, PFOS ND	The within-day and between-day precisions (relative standard deviations) were below 3.7 and 6.0%, respectively, 81% recovery of spiked river samples for PFOA and PFOS	na
na	Extraction efficiencies (with double extractions) close to 100% for PFOA and 80% for PFOS for both paper and fabric matrices, Linear relation amounts and response (2-1000 ng mL-1)	na

Individual PFCAs: ND-2600 ng g-1 product	na	na
PFBA: 275.84 µg kg-1 PFHxA: 341.21 µg kg-1 PFHpA: 5.19 µg kg-1		na
6:2 FTOH: ND - 331 µg g(-1), 8:2 FTOG: ND - 92 µg g(-1), 10:2 FTOH: ND - 24 µg g(-1)	Internal audit pogram (IAP) standards analzed after each calibration, Daily quality check	na
PFCAs: 4.75 ng/h (normal condition), 12190 ng/h (overheated at 370 ℃)	method blank tests before and after use	did not perform studies on the recovery of spiked samples

PFAS: 1.3 to 69 ng g−1 (Dust), Median PFOA (FCM) = 2.40 ng g−1, Median PFOS (FCM) = 0.29 ng g-1	na	na
21 PFAS were detected in the paper and other plant-based straws, with total mean PFAS concentrations (triplicate analysis) ranging from 0.043 ± 0.004 ng/straw to 29.1 ± 1.66 ng/straw (median = 0.554 ng/straw)	na	na
More than 115 polyfluorinated surfactants detected, semi-quantification of diPAPS and S-diPAPS of 0.2–0.7 mg kg-1 food for popcorn migrates	na	na
DiPAP: 0.9-36 pg/g (food), <0.001-4 ng/cm2 (FCM)	recoveries between 72–110 %	na

PFOA: up to 2000 µg/kg (ski waxes), up to 19 µg/m2 (outdoor textiles), up to 15 µg/m2 (baking paper) PFBA: up to 200 µg/kg (leather) PFBS: up to 120 µg/kg (leather)	accreditations according to DIN EN ISO/IEC 17025:2005, quality control standards	na
na	na	na
Total concentrations of ND-4000 ng/g (paper) and 67 to 180 000 ng/g (textile)	continuing calibration verification (CCV) was analyzed at the beginning of each analysis	na

PFOA: 3200 nmol m-2 (0.38 mg kg-1) (carpet), PFBA: 960 nmol m-2 (0.60 mg kg-1) (disposable bowl), 45% F from a new upholstery sample	Duplicate injection, precision experiments	na
Average concentration of total FTOH: 2990 µg kg-1		na
sum PFAS concentration: 23.9 to 2220 pg/cm2 in targeted analyses, CIC: TF = 2.05−17.8 µg/cm2, EOF = 0.22−0.49 µg/cm2	na	na
PIGE: > 200 nmol/cm2 for some samples	Five samples with detectable total F were analyzed in duplicate for PFAS to assess the reproducibility	na
ΣPFCAs concentrations before and after the TOP assay were 1.99 and 11.0 ng/g	Therecoveries of target analytes in matrix spike samples are shown in Table S3 (no access)	TOP assay may not oxidize all PFAS precursors and in some cases intermediate fluorinated compounds are formed from oxidation are not measured in routine analysis, PFAS bound strongly to the matrix were not expected to be 342 extracted by this method.

PFCAs: 700-2220 µg kg^{-1} of paper		na
PFOS < LOD PFOA: 22.1 and 12.9 ng dm-2		na
Absence of PFCAs, PFSAs and PFPAs in all P/B samples, except in a in a Spanish microwave popcorn bag (2.1 ng/g of PFHxA) and in a Chinese microwave popcorn bag, which contained 6 PFCAs in concentrations ranging between 2.7 and 47 ng/g. Some potential precursors at low concentrations (2.1–7 ng/g of 6:2 diPAP, 4 ng/g 8:2 diPAP and 1.1 ng/g 6:2 FTUCA) have been detected in several grease proof materials		na
PFBA: 250–820 ng/g, PFHxA: 174–811 ng/g, PFPeA, PFHpA, PFOA: 15 to 73 ng/g, PFHpA: 37 to 99 ng/g, PFOA: 63 to 198 ng/g	recovery values after correction with the corresponding labeled standard were in the 69–103 % and 62–98 % range	na
0.0050-0.23 mg/kg	Acceptable recoveries (70-120%) and RSDs (<20%)	na

1278 ppm (C4) to 38 ppm (C10) for avodaco oil		na
PFAA: 4-29 ng/g (PFHpA most abundant)	RSDs below 11% and 15%, respectively	na
PFCAs at 3.50 ng/g - 750 ng/g in popcorn bags (PFHxA most abundant)	The method showed good accuracy with recovery values around 100% except for thelowest chain length PFAAs, satisfactory reproducibility with RSDs under 16%,	na
PFOA: 9.1 µg kg-1 (microwave popcorn bag brand A), 2.8 µg kg-1 (PTFE sealant tape)	The obtained recovery of PFOA and PFOS when spiked to microwave popcorn bag brand A and B ranged from 79.2 to 89.6% with an RSD < 10.8%	na
na	na	na
highest PFOS: 92.48 ng dm-2 (fast-food container); highest PFOA: 16.91 ng dm-2 (ice cream cup); PFOS and PFOA migrated from food packaging samples through contact with saliva simulant were 4.80 and 4.55 ng dm(-2)	good linearity was established for PFOS and PFOA in a range of 0.05–10 g L-1, with R2 ≥ 0.9998.	na
Only PFOA, 8:2 FTOH and 6:2 FTOH were found in amounts at or above 1 µg/m2 or 10 mg/kg or mg/L		na

Overall, the levels of PFCAs and PFSAs were in the low µg/m2 and µg/l range in the products and the levels of 6:2 FTOH were in the µg/m2 range in food packaging. The products containing highest concentration of TOF were dental floss (310 g/kg), non-stick baking ware (1.7 g/m2) and table cloth (0.9 g/m2)	na	na
The sum of concentrations of 10 detected perfluorocarboxylic acids (PFCA) detected in 10 samples ranged from 0.01-13.1 µg/kg food, FTOH: 1.3 µg kg-1 of food	Accredited analytical method (FC430) developed at DTU, the fluorotelomer alcohols (FTOH) were not yet covered by accreditation	na
e.g. 78-391 nmol F/cm2 (jacket), 129-597 nmol F/cm2 (jacket high F), 161-445 nmol F/cm2 (popcorn bag)	replicate measurements on the same sample	na
Breakfast bag samples (2.54–6.60 pg/cm2), roasting bag samples (0.27–0.40 pg/cm2). The analysed perfluorinated sulfonates were not detected in any of the breakfast bag samples	Linearity, selectivity, recovery, precision, repeatability, reproducibility, LOD and limit of quantification (LOQ). linearity was observed for all analysed PFCs in the range of concentrations from 0.04 to 5 ng/ml. recovery values of 89 ± 6.3% for PFOA and 91 ± 7.2% for PFOS. RSD lower than 5%. %ME ranged from _x0001_6% to 17.5%	na
PFOA: 53-198 ng g-1	RSDs below 8%, excellent recovery values, around 100% in all cases	na

PFBA (291ng/g), PFHxA (254.5 ng/g) max concentrations of 6:2 FTCA (161.6 ng/g), 6:2 FTUCA (114.4 ng/g), 5:3 FTCA (24.6 ng/g)	na	na
na	For the isotopic pattern a fit threshold of 90%, an allowed intensity deviation of 30%, and a mass deviation of 5 ppm were used.	na
ND, PFOA: 6.5 ± 0.62 and 5.2 ± 0.56 µg/m2	calibration curves correlation coefficients of 0.9971 and 0.9993, triplicate analysis	na
PFOS: up to 52.11 ng/g (no salt), 60.33 ng/g (salt); PFOA: up to 48.44 ng/g (no salt), 54.21 ng/g (salt)	na	na

na	The recovery of labelled reference compound shall be in the range from 70 % to 125 % for the sample to be considered valid.	

LoD (ng/mL)	subgroup	Measurement - generic name
na		LC-MS/MS
0.2-1.6 µg kg-1 (LOD), 0.6-3.2 µg kg-1 (LOQ)	na	SFC-MS/MS
1.5 (PFOA) and 3.2 (PFOS) pgmL−1	na	LC-MS/MS
0.71 ng mL-1 (PFOA), 0.12 ng mL-1 (PFOS); LOQ: 2.36 ng mL-1 (PFOA), 0.39 ng mL-1 (PFOS)	na	LC-MS/MS

na	na	LC-MS/MS
0.20-0.94- ng/g	na	LC-MS/MS
quantification limit is the lowest calibration concentration	na	GC-MS
0.1 ng/h , SDL: <1.4 ng/h (PFBA), <0.8 ng/h (other PFAAs)	na	LC-MS/MS

GC-MS: LOD = 0.03-0.22 pg, LC-MS/MS: LOD = 3.9-30 pg, 0.29–2.40 ng/g, LOD(PFPiAs) = 12.5 pg, LOD(PFPAs) = 75 pg, LOD(monoPAPs) = 50 pg, LOD(diPAPs) = 25 pg	na	LC-MS/MS, GC-MS
na	na	LC-MS/MS
LOD: Migrates = 15–22 µg L-1; Extracts = 0.2–0.7 mg L-1 (0.2 mg L-1 PFOA, 0.008 mg L-1 PFOS)	na	LC-HRMS
LOD = 26-660 fg, LOQ 1-3 factors higher, MLOQ(6:2 and 8:2 monoPAPs) = 16 pg/g, MLOQ(6:2/6:2 diPAPs) = 0.6 pg/g, MLOQ(8:2/8:2 diPAPs) = 6 pg/g	na	LC-MS/MS

LOQ (PFAA) = 0.1-0.5 µg/kg or 0.02-0.5 µg/m2 LOD (FTOH) = 20000 µg/kg	na	LC-MS/MS, GC-MS
GC-MS: LOD = 0.37-2.4 µg/m2, LOQ = 1.2-8.1 µg/m2; LC-MS: LOD = 0.016-0.18 µg/m2, LOQ = 0.034-0.58 µg/m2	na	PIGE, GC-MS, LC-MS/MS, TOP assay
30 and 77 ng/g (paper), 19 to 34 ng/g /(textile)	na	GC-MS, LC-HRMS

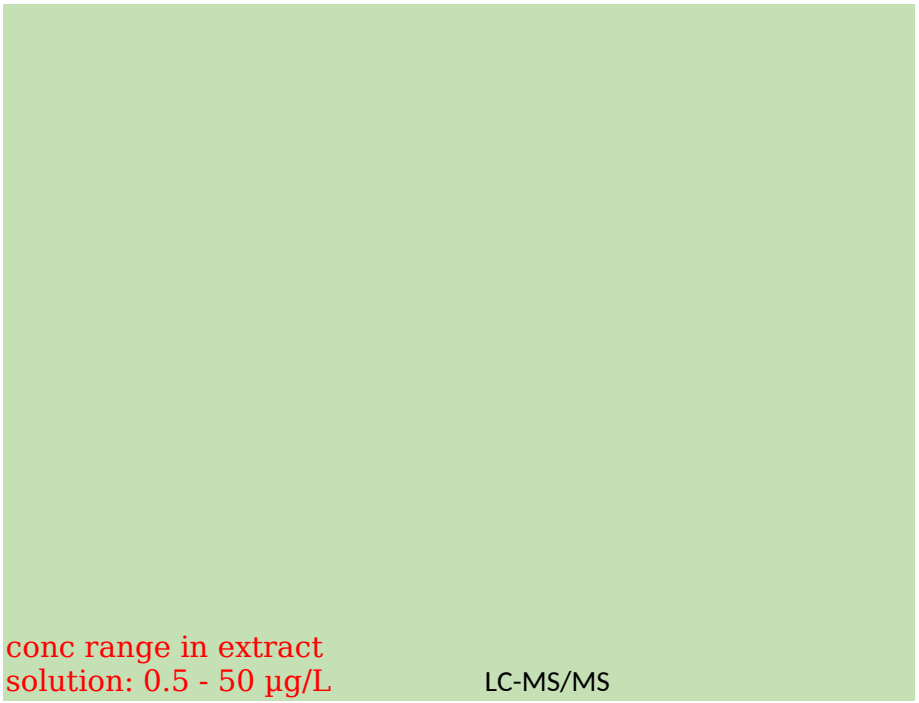
±1% for XPS, 0.063-3.7 ng g-1 (MQL) for LC-MS/MS	na	XPS, LC-MS, LC-HRMS
MQL = 0.8-13.7 ng/L (Water/Ethanol), 10.7-52.3 ng/L (Oil)	na	LC-MS/MS, LC-HRMS
CIC analysis: LOD(TF) = 4.11 µg/g (2.91 µg/dm2 for papers and 10.0 µg/dm2 for paperboard), LOD(EOF) = 0.50 µg/ml, 0.68 µg/ml (MDL); PIGE: LOD(TF) = 0.38 µg; InaA: LOD(TF) = 0.2 µg of F (for m = 0,01 g LOD = 20 µg/g)	na	PIGE, LC-MS/MS
PIGE: LOD = 16 nmol/cm2, LOQ = 50 nmol/cm2, QA/QC PIGE: LOQ ~18–23 nmol/cm2	na	PIGE, LC-HRMS
Trace concentrations of PFBA, PFPeA, PFHxA, PFHxS (0.091-0.250 ng/g) were found, LOD/LOQ values in SI (no access)	na	TOP assay, LC-MS/MS

0.02-0.05 µg L-1	na	LC-MS/MS
LOD = 1.53 (PFOA), 0.63 (PFOS) ng g-1; LOQ = 5.11 (PFOA), 2.11 (PFOS) ng g-1	na	LC-HRMS
SI (no access)	na	LC-MS/MS
MDL = 0.7–3.5 ng/g	na	LC-HRMS
0.0013-0.046 mg/kg (LOQ)	na	LC-MS/MS, GC-MS

LOP: 37 ppm (C10) to higher than 1238 ppm (C4) for contact angle measurement	na	LC-MS/MS
0.5-2.2 ng/g	na	LC-HRMS
0.19 (PFUna) - 0.5 ng/mL (PFOA)	na	LC-HRMS
LOD: 25 pg/mL (PFOS, PFOA) LOD: 50 pg/mL (PFOS, PFOA)	na	LC-MS
na	na	LC-HRMS
na	na	LC-MS/MS
LOD = 0.03-0.15 µg/m2, only qualitative for 6:2 monoPAP, 8:2 PAP, 6:2 diPAP, 8:2 diPAP	na	LC-MS/MS, GC-MS

TOF: About 10 pellets must be processed to sustain a LOQ of 1 mg/kg fluorine (LOQ fluoride = 0.1 mg/l for IC)	na	LC-MS, CIC
na	na	LC-MS/MS
13 nmol F/cm2 (papers), 24-45 nmol F/cm2 for textiles	na	PIGE
0.01 to 0.05 pg/cm2	na	LC-MS/MS
LOD = 0.6-16 ng g(-1), LOQ = 0.3-2.3 ng/mL	na	LC-HRMS

LOD = 0.001-0.6 ng/mL, LOQ = 0.005-2.3 ng/mL, MDL = 0.6–2.2 ng/L	na	LC-MS/MS
na	na	LC-HRMS
PFOA: 0.5 (LOD), 0.8 (LOQ) µg/m2, PFOS: 0.4 (LOD), 0.6 (LOQ) µg/m2	na	EASI-MS
not reported	na	LC-MS/MS, XRD, EDX, ESEM


conc range in extract
solution: 0.5 - 50 µg/L
LC-MS/MS

Title	Authors	Journal
Atmospheric Chemistry of c-C(5)HF(7) and c-C(5)F(8): Temperature-Dependent OH Reaction Rate Coefficients, Degradation Products, Infrared Spectra, and Global Warming Potentials.	Gierczak et al.	J Phys Chem A
The atmospheric concentrations and emissions of major halocarbons in China during 2009–2019	Yi et al.	Environ. Poll:
Atmospheric HCFC-22, HFC-125, and HFC-152a at Cape Point, South Africa	Kuyper et al.	Environ. Sci. Technol

Atmospheric Fate and Impact of Perfluorinated Butanone and Pentanone	Ren et al.	Environ. Sci. Technol
Reconciling reported and unreported HFC emissions with atmospheric observations	Lunt et al.	PNAS
Comparison of halocarbon measurements in an atmospheric dry whole air sample	Rhoderick et al.	Elementa (Wash D C).
Methyl-perfluoroheptene-ethers (CH3OC7F13): measured OH radical reaction rate coefficients for several isomers and enantiomers and their atmospheric lifetimes and global warming potentials	Jubb et al.	Environ. Sci. Technol

First Observations of the Fourth Generation Synthetic Halocarbons HFC-1234yf, HFC-1234ze(E), and HCFC-1233zd(E) in the Atmosphere	Vollmer et al.	Environ. Sci. Technol
Airborne Trifluoroacetic Acid and Its Fraction from the Degradation of HFC-134a in Beijing, China	Wu et al.	Environ. Sci. Technol
European Emissions of Halogenated Greenhouse Gases Inferred from Atmospheric Measurements	Keller et al.	Environ. Sci. Technol
Emissions of Halogenated Compounds in East Asia Determined from Measurements at Jeju Island, Korea	Li et al.	Environ. Sci. Technol

Rayleigh scattering measurements of several fluorocarbon gases	Zadoo et al.	J. Environ. Monit.,
Large Emissions of Perfluorocarbons in East Asia Deduced from Continuous Atmospheric Measurements	Saito et al.	Environ. Sci. Technol.

year	Comments	DOI link	PFAS
2021	na	10.1021/acs.jpca.0c10561	c-C(5)HF(7) (1H-heptafluorocyclopentene) and c-C(5)F(8) (perfluorocyclopentene)
2021	na	10.1016/j.envpol.2021.117190	CFC-11, CFC-12, HCFC-22, HCFC-141b, HCFC-142b, HFC-134a
2019	na	10.1021/acs.est.9b01612	HFC-125, HFC-152a

2019	na	10.1021/acs.est.9b02974	Perfluoro-2-methyl-3-pentanone (PF-2M3P), Perfluoro-3-methyl-2-buytanone (PF-3M2B)
2015	na	10.1016/j.scitotenv.2012.12.056	HFC 124, HFC 142b
2015	na	10.12952/journal.elementa.000075	CFC-12, CFC-113, HCFC-142b, HFC-134a
2014	na	10.1021/es500888v	Mixtures of methyl-perfluoroheptene-ethers (CH3OC7F13, MPHEs): (E)-1,1,1,2,2,4,5,5,6,6,7,7,7-tridecafluoro-3-methoxy-hept-3-ene ((E)-3m-3-ene); (Z)-1,1,1,2,2,4,5,5,6,6,7,7,7-tridecafluoro-3-methoxy-hept-3-ene ((Z)-3m-3-ene); (E)-1,1,1,2,3,4,5,5,6,6,7,7,7-tridecafluoro-4RS-methoxy-hept-2-ene; ((E)-4m-2-ene), (E)-1,1,1,2,2,3,5,5,6,6,7,7,7-tridecafluoro-4-methoxy-hept-3-ene ((E)-4m-3-ene), (Z) -1,1,1,2,2,3,5,5,6,6,7,7,7-tridecafluoro-4-methoxy-hept-3-ene; ((Z)-4m-3-ene), (E)-1,1,1,2,2,3,4,5,6,6,7,7,7-tridecafluoro-5RSmethoxy-hept-3-ene ((E)-5m-3-ene) isomers

2014	na	10.1021/es505123x	HFC-1234yf (2,3,3,3-tetrafluoroprop-1-ene, CF3CF=CH2), and HFC-1234ze(E) (E-1,3,3,3-tetrafluoroprop-1-ene trans-CF3CH=CHF), and the hydrochlorofluorocarbon HCFC-1233zd(E) (E-1-chloro-3,3,3-trifluoroprop-1-ene trans-CF3CH=CHCl)
2014	na	10.1021/es4050264	Trifluoroacetic acid (TFA)
2012	na	10.1021/es202453j	HCFC-142b (CH3CF2Cl)
2011	na	10.1021/es104124k	CFC-12, CFC-113, CFC-114; HCFC142b, HFC-134a, HFC-125, HFC-143a, HFC-365mfc, H-1211, CF4, C2F6, C3F8

2011 na	10.1039/ c1em10667h	hexafluoropropene (HFC-216), 1,1,1,2,3,3,3,-heptafluoropropane (HFC-227ea), and octafluorocyclobutane (C-318)
2010 na	10.1021/es1001488	PFC-116 (C2F6), PFC-218 (C3F8), and PFC-318 (c-C4F8)

CAS (if available in publication)	Sampling	sample amount used
na	na	5.32 × 10^15 and 4.23 × 10^16 molecule/cm−3
na	From July 2009 to July 2019, we sampled in January, April, July and October, representing winter, spring, summer and autumn, respectively (samples were not collected in July and October 2015 because of equipment failure). Air samples were collected continuously for 4–7 days in each month and at 14:00 (China standard time) simultaneously at each site every day. And they were collected quarterly using evacuated electro-polished stainless-steel canisters (3.2L Silonite SummaR Style Canisters, Entech Instruments Inc.) cleaned by a canister cleaner (Entech 3100A, Instruments Inc., USA) with high purity nitrogen in advance at Peking University. In urban sites, samples were collected at a height of 2 m on the rooftops of 8–18-story buildings (20–50m above ground). And in suburban sites, samples were collected at a height of 2 m above the ground to ensure favorable diffusion of the air mass (Barletta et al., 2006). Moreover, sampling was delayed if it was rainy, snowy or hazy. During sampling, the canister valve was opened slightly over 1–2 min to ensure the surrounding air was evenly mixed. During this period, 1902 samples were collected.	400 ml
na	na	na

na	na	na
na	One litre of ambient air is passed through the adsorbents at a trapping temperature of −30 °C, and then desorbed by heating the trap at 60 °C/s up to 300 °C, and held at this temperature for 2 min.	One litre of ambient
na	na	na
na	na	Manometrically prepared mixture (0.0023 mixing ratio in He)

na	Routine ambient measurements at the two sites are characterized by a pair of hourly ambient air sample measurements from cryogenically preconcentrated 2 L samples, bracketed by calibration standard measurements.	2 l
na	For each gas-phase sample, the two denuders were extracted with three consecutive additions of double-distilled water (10, 10, and 5 mL) by transferring each addition from the first denuder to the second, with shaking in each denuder, and a combined extract (25 mL) was obtained.	na
na	na	na
na	Ambient concentrations of halogenated compounds have been analyzed every two hour	na

na	na	na
na	na	na

Pre- treatment	Extraction	Clean up
na	SPE, PLE	na
Air samples would be concentrated in a cryogenic preconcentration system (Entech 7100A, Entech Instruments Inc., USA) before being introduced into the GC for analysis.	Briefly, 400 ml air sample was extracted into multistage traps to remove H2O, CO2 and other interfering gases,	na
Samples and standards were autonomously preconcentrated on a triple-bed microtrap (3 mg Carbotrap B, 5 mg Carboxen 1003, and 4 mg Carboxen 1000) at −50 °C in the ADS.	na	na

na	na	na
on-line sample enrichment using adsorbent material	na	na
na	na	na
The MPHE samples were purified by repeated freeze–pump–thaw cycles prior to the preparation of dilute mixtures in He-bath gas.	na	na

na	na	na
For each particle sample, the 47 mm ringed filters were weighed before and after sampling to determine particle mass (PM2.5)	Particles were then entirely extracted using two consecutive additions of double-distilled water (each 10 mL) and subjected to ultrasonication for 30 min, using an additional 5 mL of water for rinsing. The combined particle extract (25 mL) was centrifuged prior to analysis. A field blank was analyzed along with every set of samples.	na
In situ measurements	na	na
“Medusa” cryogenic preconcentration system	na	na

na	na	na
na	na	na

Measurement

FTIR (Infrared absorption processed via Fourier Transformation)

Mass spectrometry was used for analysis. It should be noted that during 2009–2019, three GC-MS instruments were used for analysis, which were Varian Saturn 2100 GC-MS, Varian Co. USA (2009.7–2015.4) described by Fang et al. (2012b), Medusa-6890/5975B GC-MS, Agilent Co. USA (2016.1–2017.4) described by Zhang et al. (2017), and Trace 1300 ISQ GC-MS, Thermo Fisher Co. USA (2017.7–2019.7).

Agilent gas chromatograph-mass spectrometer (GC-MS, 6890/5973N) with a custom-built adsorption/desorption system (ADS)

The UV−vis absorption spectra of PF-2M3P, PF-3M2B were measured using a spectrophotometer equipped with a 1200 grooves mm−1 grating and a charge-coupled device (CCD) camera. The collimated output of a 30 W deuterium lamp passed through a 100 cm long and 2.5 cm diameter Pyrex absorption cell equipped with quartz windows and focused onto the entrance slit of the spectrometer. Measurements were made over the wavelength region 220−400 nm by recording typically three overlapping regions of about 15 nm. Typically, each measurement consisted of 8−13 scans of diode array. The wavelength scale was calibrated using the emission lines from a lowpressure Hg pen ray lamps (253.7, 313.2, and 365 nm).

gas chromatography–mass spectrometry (GC–MS) preceded by on-line sample enrichment using adsorbent material. A GC–MS Agilent 6850–5975 has been equipped with auto-sampling/ pre-concentration device (Markes International, UNITY2-Air Server2) to enrich the halocarbons on a focussing trap filled with four different adsorbing materials: Carbograph 2TD, Carbograph 1TD, Carboxen 1000 and Carbosieve SIII, and kept chilled at sub-ambient temperature by a three stage Peltier cell. One litre of ambient air is passed through the adsorbents at a trapping temperature of −30 °C, and then desorbed by heating the trap at 60 °C/s up to 300 °C, and held at this temperature for 2 min. The separation is performed on a J&W GS-GasPro capillary column, 30 m×0.32 mm I.D., at 1.6 ml min−1, at constant flow; the temperature ramp is 10 min at 49 °C, then 10 °C min−1, up to 250 °C for a total run time of about 40 min.

NIST: GC-ECD, GC-MS, GC-FID
NOAA: GC-ECD, GC-MSD
KRISS: GC-ECD, GC-MSD
SIO: GC-ECD (GC-MD)b, GC-MSD (Medusa)
EMPA: Medusa-GC-MS technology (Empa-medusa or Medusa-20)

FTIR (Infrared absorption processed via Fourier Transformation) 296 K over the range 500 to 4000 cm−1

The samples were analyzed using gas chromatography - mass spectrometry (GCMS) with “Medusa-GCMS” type instruments.

TFA and the internal standard [perfluoropropionic acid (PFPA)] were derivatized to the respective acid anilide in the presence of 2,4-DFAn and DCC. Samples were cleaned and reduced to 1 mL for analysis using GC–MS (QP-2010 SE, Shimadzu, Kyoto, Japan) with ions of 225 and 275 amu for TFA and PFPA, respectively. GC separation was performed using a DB-5 ms column (30 m × 0.32 mm × 0.25 µm) with helium as a carrier gas. The initial oven temperature was 50 °C for 2 min, after which it was increased at a rate of 30 °C/min to a maximum temperature of 215 °C and then maintained at that temperature for another 10 min. The injector, transfer line, ion source, and detector temperatures were maintained at 200, 250, 200, and 250 °C, respectively. Using LC–MS/MS, extracts were directly injected into LC (UFLC XR, Shimadzu, Kyoto, Japan) interfaced to a 4000Q TRAP (MDS Sciex, Concord,Ontario, Canada) operated in the negative electrospray ionization mode. LC separation was performed using a Rspak JJ-50 2D column (2.0 mm × 150 mm × 5 µm, Shodex, Showa Denko K.K., Kawasaki, Japan) at a flow rate of 200 µL/min via an isocratic elution. For mobile phase A, we used 20% 50 mM ammonium acetate in water, and for mobile phase B, we used 80% methanol and 20% water. The MS/MS transition used to quantify TFA was m/z 112.9/68.9.

Gas chromatograph/mass spectrometer (Agilent 6890/5973) coupled to an adsorption desorption system (ADS). Air samples were taken every 2 h at a height of 9.4 m above ground

Gas chromatograph and mass selective detector (GC-MSD)13 as part of the Advanced Global Atmospheric Gases Experiment (AGAGE) network.

A Radiance Research M903 Integrating Nephelometer was equipped with a 530 nm (_x0003_40 nm FWHM) band-pass filter to constrain measurement wavelength. The nephelometer was modified in the laboratory to monitor the photomultiplier output pulse on a Tektronix TDS 1012B Two Channel Digital Storage Oscilloscope. Recorded measurements were peak-to-peak voltage signal of the pulsed light source. Measurements were the result of averaging 64 pulses. The peak-to-peak signal was found to scale linearly with gases of known scattering coefficient (air, CO2, R-134a) as illustrated in Fig. 1B. A IST traceable digital hygrometer (Fisher Scientific) was used to monitor the Celsius temperature and relative humidity at the outlet of the measurement cell to one decimal digit of precision. The internal pressure sensor of the nephelometer was used to monitor cell pressure to within 1 mbar. Conditions t measurement were generallyz 915–930 mbar, 21 _x0005_C, and 0.1% RH, however care was taken to always log the exact temperature and pressure data to account for differences in gas density between trials. HEPA filters were placed prior to the nephelometer purge inlet and at the outlet of the flow ystem to prevent particle contamination

ambient air is analyzed every hour with a fully automated preconcentration/gas chromatography/ mass spectrometry (GC/MS) system

Quantification method	Working range (ng/mL) As
The absorption spectra were quantified by a linear leastsquares fit to Beer’s law	na
A multipoint external calibration method was used to analyze target compounds. TO-14A (Spectra Gases, USA) and the standard gas provided by the National Institute of Metrology of China (NIMC) were applied for the calibration of CFCs, HCFCs and HFCs. Before analyzing the samples, calibration gas was diluted to 9 concentration levels with ultrapure nitrogen. The coefficient of determinations (R2) of the calibration curves were over 0.990 for each target compound.	na
Calibrated mole fractions were assigned to short-term working standards from an external long-term working standard tank which was calibrated using the Advanced Global Atmospheric Gases Experiment (AGAGE) Medusa GC-MS at Mace Head.	na

Lambert Beer	concentration ranges [PF-2M3P] = (0.29–2.7) × 1017, [PF-3M2B] = (0.27–3.0) ×1017
For maximum sensitivity in routine field monitoring, the MS detector is operating in selective ion mode (SIM); since many compounds have similar electron impact (EI) fragmentation paths, identification and quantification are based on two mass-over-charge ratios (m/z) per compound (target ion and at least one qualifier), in order to improve the diagnostic for determining chromatographic co-elution	The targeted trace gas species exhibit awide range of volatilities and atmospheric abundances; typical concentrations are in the ppt (10–12) range
NIST: GLS, 2nd order polynomial, linear, or bracketing NOAA:2nd order polynomial or linear KRISS: One point calibration SIO: Primary calibration in sensitivity space EMPA:Bracketing	na
The measured spectra obeyed Beer–Lambert's law with a precision of ±1% (2σ).	na

na	na
The MS/MS transition used to quantify TFA was m/z 112.9/68.9.	na
na	na
na	na

na	na
na	na

Matrices	Reported levels (ng/mL)	info - validation of the method	Limitations
Ambient air	0.18-2.21 x 10^16 molecule / cm−3)	na	na
Ambient air	HCFC-22 increased from 627 ± 405 pptv in 2009 to 743 ± 355 pptv in 2019 with a rate of 11.1 pptv yr-1 HFC-134a had a significant increase from 76 ± 30pptv to 186 ± 72 pptv (2009–2019), with a fast growth rate of 10.6 pptv yr- 1, almost twofold of 5.6 ± 0.2 pptv yr- 1 (2012–2016) globally reported by	na	na
Ambient air	HFC-125: 22.47 ± 1.78 ppt HFC-152a: 6.44 ± 5.32 ppt	na	na

Ambient air	na	na	na
Ambient air	ppt	na	na
Dried whole air sample	na	na	na
Ambient air	(0.455–10.2) × 1015 molecules cm−3	na	na

Ambient air	ppt	na	na
Ambient air	mean concentration of TFA was 1580 ± 558 pg/m3 (mean ± standard deviation)	na	na
Ambient air	1010 -1820	To detect and correct for drift in detector sensitivity, every 11th sample was taken from a real-air calibration standard.	na
Ambient air	0,1-134,6 kt/a	The compounds measured here are on calibration scales developed at the Scripps Institution of Oceanography (SIO)14 with the exception of HFC-125 and CH2Cl2 which are on the UB-98 scale (University of Bristol) and HFC-365mfc which is on the Empa-2003 scale (Swiss Federal Laboratories for Materials Science and Technology).	na

na	na	na	na
Ambient air	ppt	na	na

LoD (ng/mL)	subgroup	Measurement - generic name
na	F-Gases	FTIR
The method detection limit analyzing by Trace 1300 ISQ GC-MS was 2.3–38.8 pptv and the measurement precision was 2.2–3.4%		GC-MS
na	na	GC-MS

na	na	UV-VIS spectro
LOD: 0,13-0,52 ppt	na	GC-MS
na	na	GC-MS
na	F-Gases	FTIR

na	na	GC-MS
na	na	GC-MS
na	na	GC-MS
na	na	GC-MS

na	na	sensor
na	na	GC-MS

Title

AIRBORNE AEROSOLS IN APPLICATION OF POLYFLUORO POLYMER-BASED SKI WAXES

CEN/TS 15968:2010 - Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and fire fighting foams - Method for sampling, extraction and analysis by LCqMS or LC-tandem/MS

Perfluoroalkyl and polyfluoroalkyl substances in consumer products

Analysis of per- and polyfluorinated substances in articles

Analysis of PFASs and TOF in products

Screening of Semifluorinated n-Alkanes by Gas Chromatography coupled to Dielectric Barrier Discharge Ionization-Mass Spectrometry (GC/DBDI-MS)

Levels of per- and polyfluoroalkyl substances (PFAS) in ski wax products on the market in 20

PFAS i kemiska produkter och varor Ett tillsynsprojekt med fokus på POPs-förordningens begränsningar av PFOA och PFOS (PFAS in chemical products and articles A regulatory project focusing on the POPs Regulation restrictions on PFOA and PFOS)

Authors	Journal	year
Liesivuori et al.	Annals of Occupational Hygiene 1994 Vol. 38 I	1994
Standard	na	2010
Kotthoff et al.	Environ Sci Pollut Res Int	2015
Blom et al.	Nordic Council of Ministers	2015
Borg et al.	Nordic Council of Ministers	2017

Hagenhoff et al.	Rapid Communications in Mass Spectrometry 2	2018
Fang et al.	Environmental Science: Processes & Impacts	2019
KEMI	na	2021

comments	DOI link
na	10.1093/annhyg/38.6.931
Also used for other matrices, sample treatmant different	na
na	10.1007/s11356-015-4202-7
na	http://dx.doi.org/10.6027/na2015-91
na	http://dx.doi.org/10.6027/

na	10.1002/rcm.8139
na	10.1039/d0em00357c
Several matrices tested: Textiles, Ski wax, and other consumer products	na

name
PFOS, PFOSA, N-Me-FOSA, N-Et-FOSA, N-Me-FOSE alcohol, N-Et-FOSE alcohol, PFOS salt
PFBA, PFPA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUna, PFDoA, PFTrA, PFTeA, PFBS, PFHxS, PFHpS, PFOS, PFDS, 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, PFOSA
PFCAs (PFBA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA), PFASs (PFBS, PFHxS, PFOS), PAPs (6:2 diPAP, 6:2 monoPAP, 8:2 diPAP, 8:2 mono-PAP), FTOH (4:2, 6:2, 8:2), FTS (4:2, 6:2)
TOF, targeted analysis of PFCAs (PFBA, PFHxA, PFOA, PFna, PFDA), PFSAs (PFBS, PFHxS, PFOS), FTOHs (4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH), FTAs (6:2 FTA, 8:2 FTA, 10:2 FTA), FOSAs (MeFOSA, EtFOSA), FOSEs (MeFOSE, EtFOSE)

1-(perfluorobutyl)pentane (F4H5), 1-(perfluorobutyl)hexane (F4H6), 1-(perfluoro_x0002_butyl)octane (F4H8), and 1-(perfluorohexyl)octane (F6H8), 1-(Perfluorohexyl)tetradecane (F6H14), and
1-(perfluorooctyl)hexadecane (F8H16), 1-(Perfluorohexyl)oct-1-ene (F6H8ene)

Perfluorobutanoic acid (PFBA, C4) Perfluoropetanoic acid (PFPeA, C5) Perfluorohexanoic acid (PFHxA, C6) Perfluoroheptanoic acid (PFHpA, C7) Perfluorooctanoic acid (PFOA, C8) Perfluorononanoic acid (PFna, C9) Perfluorodecanoic acid (PFDA, C10) Perfluoroundecanoic acid (PFUnDA, C11) Perfluorododecanoic acid (PFDoDA, C12) Perfluorotridecanoic acid (PFTrDA, C13) Perfluorotetradecanoic acid (PFTeDA, C14) Perfluoropentadecanoic acid (PFPeDA, C15) Perfluorohexadecanoic acid (PFHxDA, C16) Perfluoroheptadecanoic acid (PFHpDA, C17) Perfluorooctadecanoic acid (PFODA, C18) Perfluorononadecanoic acid (C19) Perfluoroeicosanoic acid (C20) Perfluoroheneicosanoic acid (C21) Perfluorodocosanoic acid (C22) Perfluorotetracosanoic acid (C23) Perfluorotricosanoic acid (C24) Perfluoropentacosanoic acid (C25)

PFAS Tests according to CEN/TS 15968:2010
EOF not further described

CAS (if available in source)
na
1763-23-1 (PFOS) 754-91-6 (PFOSA) 24448-09-7 (N-Me-FOSE alcohol) 1691-99-2 (N-Et-FOSE alcohol)
na
375-22-4 (PFBA), 307-24-4 (PFHxA), 375-85-9 (PFHpA), 335-67-1 (PFOA), 375-95-1 (PFna), 335-76-2 (PFDA), 4234-23-5 (PFUnDA), 307-55-1 (PFDoDA), 72629-94-8 (PFTrDA), 376-06-7 (PFTeDA), 29420-49-3 (PFBS salt), 3871-99-6 (PFHxS salt), 1763-23-1 (PFOS salt), 2043-47-2 (4:2 FTOH), 647-42-7 (6:2 FTOH), 678-39-7 (8:2 FTOH), 57677-95-9 (6:2 diPAP), 57678-01-0 (6:2 monoPAP), 678-41-1 (8:2 diPAP), 57678-03-2 (8:2 mono-PAP), 757124-72-4 (4:2 FTS), 29420-49-3 (6:2 FTS)
375-22-4 (PFBA), 29420-49-3 (PFBS salt), 307-24-4 (PFHxA), 3871-99-6 (PFHxS salt), 2043-47-2 (4:2 FTOH), 757124-72-4 (4:2 FTS), 335-67-1 (PFOA), 1763-23-1 (PFOS salt), 647-42-7 (6:2 FTOH), 29420-49-3 (6:2 FTS), 31506-32-8 (MeFOSA), 4151-50-2 (EtFOSA), 2448-09-7 (MeFOSE), 1691-99-2 (EtFOSE), 375-95-1 (PFna), 335-76-2 (PFDA), 678-39-7 (8:2 FTOH)

na

na

Tests according to CEN/TS 15968:2010

Sampling	sample amount used
aerosol sampling on mixed cellulose ester membrane filters. ski-wax fume sampling was done with Tenax-polymer tubes	na
Liquids: method which will provide a representative sample of the liquid to be tested.	see sampling
115 samples of consumer products including textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes. The individual samples analysed were bought from local retailers or collected by co-workers of the institute or local clubs (e.g. ski waxes from local skiing club). The sampled products span all quality levels from entry level to cutting edge products. The selection of the samples occurred randomly.	na
In total 29 different samples were analysed. The sampling was concentrated on a few but wide variety of household products, such as cleaning products and polishes for indoor use and for cars and sprays to waterproof shoes or clothes, food contact paper and baking forms included some products less commonly analysed, such as ski wax, dental floss and tablecloths. The samples were purchased in the vicinity of Oslo in supermarket chains that are found all over Norway.	depending on the article: 0.05 mL, 71.5-100 cm^2 or 0.02-0.16 g
In total 17 products were randomly selected from shelves in a number of Swedish retail stores and supermarkets for analysis (Cupcake forms, microwave popcorn bag, rinse aid, waterproofing shoe treatment, waterproofing textile treatment, shoe wax, floor polish, furniture polish, car wax). In total 29 samples of consumer products were collected in the previous study (including food contact material, textiles, lubricants, car wax, table cloth, ski wax and more)	Pressed pellets of 100-120 mg for TOF

ski wax dissolved in cyclohexane	na
11 separate commercially available and best-selling ski wax products were purchased from one of Norway's largest sports stores in the summer of 2019. The ski wax products comprised; 3 wax blocks, 1 liquid wax and 7 powders.	10 mg
Tests according to CEN/TS 15968:2010	Tests according to CEN/TS 15968:2010

Pre- treatment

na

Dilution for AFFF: Pre-dilute the sample in separate steps with purified water or methanol (1:10 v/v, 1:100 v/v, 1:1 000 v/v) and mix sufficiently (e.g. 500 µl sample into 4 500 µl diluent). Ensure that there is no phase-separation in the sample. If necessary centrifuge the sample to precipitate non soluble particles. Dilute the pre-diluted sample 1:10 with water or methanol and an appropriate volume of internal standard solution (e.g. 100 µl diluted sample, 100 µl reference solution, 800 µl water or methanol) to have in every
dilution (1:10 v/v, 1:100 v/v, 1:1 000 v/v) the same concentration of the internal standard. Transfer an aliquot to a LC vial and analyse the sample. If high PFOS concentrations are expected, begin with the highest dilution (1:10 000 v/v) to avoid a carry over.

na

vortexing in methanol

sample was homogenized, shredded for TOF

na

na

Tests according to CEN/TS 15968:2010

Extraction	Clean up
na	na
no extraction	na
differ depending on the respective matrix: ion pair extraction, acidic-alkaine sequential extraction or SPE with acetone, hexane or methyl-t-butyl ether as solvent	differ depending on the respective matrix
ultrasonification in methanol	volume reduced to 2 mL, aliquot filtered
LC-MS: ultrasonic extraction with matrix dependent solvents (no further information), burning for TOF and absorbtion of combustion gases in buffer solution	LC-MS: (multi)-step-sample clean-up

na	na
10 mg (accurately weighed) of ski wax spiked with 0.5 ng of internal standards was extracted with 5 mL methanol. The wax/ methanol mixture was vortexed and extracted in an ultrasonic bath for 20 min and then stored at room temperature overnight. The mixture was placed in an ultrasonic bath for 20 min again the next day and then centrifuged (3000 rpm, 10 min) to facilitate sedimentation of the extracted solids. A 4 mL aliquot of the supernatant was transferred to a 13 mL polypropylene tube. The extraction of ski wax was repeated and the supernatant solutions combined. Following extraction, the 8 mL of supernatant was evaporated to approximately 200 µL and 25 µL recovery standard (M8PFOS and M8PFOA, both 20 pg µL−1) and 200 µL 4 mM NH4OAc in water were added. The extracts were then transferred to a polypropylene (PP) centrifuge tube with a nylon membrane filter and centrifuged at 13 000 rpm for 5 min. The filtered extract was transferred to an autosampler vial and stored at 4 °C until analysis.	na
Tests according to CEN/TS 15968:2010	Tests according to CEN/TS 15968:2010

Measurement
high resolution gas chromatography fluoride measurements: S176 (NIOSH, 1977) and 7903 (NIOSH, 1984)
LC-qMS, LC-tandemMS
PFAA: HPLC-MS/MS FTOH: GC/CI-MS
UPLC-MS/MS for ionic PFAS and PAP, GC/MSD for FTOH
Targeted analysis with LC/MS-MS (Agilent HPLC 1290 Infinity Serie coupled with Agilent 6460A Triple Quad LC/MS-MSMS), TOF by IC

hyphenation of GC with DBDI-MS (headspace and GC)

PFAS were quantified using an ultra-performance liquid chromatography-tandem mass spectrometer (UPLC-MS/MS) instrument (Waters, ACQUITY-UPLC/XEVO-TQS) fitted with a BEH C18 column (1.7 µm particles, 2.1 × 50 mm; waters). The mass spectrometer (MS) was operated in negative electrospray ionization multiple reaction monitoring (MRM) mode with the following MS parameters: capillary voltage 1100 V; nebulizer gas flow at 7 bars; desolvation gas flow at 600 L h−1; cone gas flow at 150 L h−1. The desolvation temperature was 350 °C. The m/z cone voltages and collision energies used for each PFAS are listed in Table S2.†

Tests according to CEN/TS 15968:2010

Quantification method
na
Quantify the samples by using the unextracted external calibration curve. When spiking with labelled reference solutions, the determination of the concentration is independent of possible errors made during injection. Also, errors caused by sample losses during distinct steps of sample pre-treatment or the adjustment of final sample extract volume as well as matrix effects in the sample are accounted for.
internal standardisation using mass-labeled internal standards
internal standardisation using mass-labeled internal standards
LC-MS: internal isotope-labeled standards (isotope dilution method)

identification

Quantification of all target analytes was performed using an internal standard calibration curve with nine points (0.008–150 ng mL−1, R2 > 0.99). Stable isotope mass labelled internal standards were available for C4–C6 and C8–C12 PFCAs, as well as for PFHxS and PFOS. C7 and C13–25 PFCAs, PFBS and PFDS were quantified using 13C2-perfluorohexanoic acid (PFHxA), 13C2-perfluorododecanoic acid (PFDoDA), 18O2-perfluorohexane sulfonate acid (18O2-PFHxS) and 13C4-perfluorooctane sulfonate acid (13C4-PFOS) as internal standards, respectively. Reference standards for native C15, C17 and C19-25 PFCAs were not available. Therefore, for quantification of C15, C17 and C19–25 PFCAs the relative response factors (relative to 13C2-PFDoDA) were calculated from the calibration curves of C14, C16 and C18 PFCAs, respectively. All reported concentrations for C15, C17 and C19–25 PFCAs should thus be considered as semi-quantitative estimates due to the lack of authentic native standards for these compounds. The method detection limit (MDL) was defined as the lowest calibration point concentration resulting in a signal-to-noise ratio of three, if the specific PFAS were not detected in the blanks. For the analytes which were detected in the blanks, MDLs were defined as the mean blank concentration plus three times the standard deviation of the blank.

Tests according to CEN/TS 15968:2010

LoD (ng/mL)	subgroup	Measurement - generic name
The detection limit for fluoride in the air samples was 9 µg/m3	na	HR-GCMS
na	na	LC-MS/MS
LOQ (PFAA) = 0.1-0.5 µg/kg or 0.02-0.5 µg/m2 LOD (FTOH) = 20000 µg/kg	na	LC-MS/MS, GC-MS
LOD = 0.03-0.15 µg/m2, only qualitative for 6:2 monoPAP, 8:2 PAP, 6:2 diPAP, 8:2 diPAP	na	LC-MS/MS, GC-MS
TOF: About 10 pellets must be processed to sustain a LOQ of 1 mg/kg fluorine (LOQ fluoride = 0.1 mg/l for IC)	na	LC-MS/MS , CIC

single digit pg range injected on	na	GC-MS
0.1–2.5 ng g−1	na	LC-MS/MS
Tests according to CEN/TS 15968:2010	Tests according to CEN/TS 15968:2010	

usable for solid items

Title	Authors	Journal	year	Comments	DOI link
Concentrations and trends of perfluorinated chemicals in potential indoor sources from 2007 through 2011 in the US	Liu et al.	Chemosphere	2014	na	10.1016/j.chemosphere.2013.10.001
Are imported consumer products an important diffuse source of PFASs to the Norwegian environment?	Vestergren et al.	Environmental Pollution	2015	na	10.1016/j.envpol.2014.12.034
Suspect screening of 200 hazardous substances in plastic toys using ultra-high-performance liquid chromatography-hybrid quadrupole time-of-flight mass spectrometry	Meng et al.	J Chromatc	2020	na	10.1016/j.chroma.2019.460830
Perfluoroalkyl and polyfluoroalkyl substances (PFASs) in consumer productsin Norway – A pilot study	Herzke et el.	Chemosphere	2012	na	10.1016/j.chemosphere.2012.03.035

Perfluoroalkyl and polyfluoroalkyl substances in consumer products	Kotthoff et al.	Environ Sci	2015	na	10.1007/s1135
Survey of perfluorinated compounds in consumer products by liquid chromatography-tandem mass spectrometry	Lee et al.	Energy & Environment 2020 Vol. 31 Issue 4 Pages 713-729	2019	na	10.1177/0958305x19882376
CEN/TS 15968:2010 - Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and fire fighting foams - Method for sampling, extraction and analysis by LCqMS or LC-tandem/MS			2010	Also used for other matrices, sample treatmant different	
Screening for perfluoroalkyl acids in consumer products, building materials and wastes	Becanova et al.	Chemosphere	2016	na	10.1016/j.chemosphere.2016.08.1120045-6535/

Screening of textile finishing agents available on the Chinese market: An important source of per- and polyfluoroalkyl substances to the environment Surfactants and other liquid matrices	Mumtaz et al.	Frontiers of Environmental Science & Engineering 2019 Vol. 13 Issue 5	2019	na	10.1007/s11783-019-1145-0
Removal of Per- and Polyfluoroalkyl Substances (PFASs) in Aqueous Film-Forming Foam (AFFF) Using Ion-Exchange and Nonionic Resins	Fang et al.	Environ Sci Technol	2021	Focus on removal of PFAS	10.1021/acs.est.1c00769
Reconstructing the Composition of Per- and Polyfluoroalkyl Substances in Contemporary Aqueous Film-Forming Foams	Ruyle et al.	Environ Sci Technol Lett	2021	EPA method	10.1021/acs.estlett.0c00798

Determination of total oxidizable precursors in foam surfactants and foam contaminated water based on UV-activated persulfate oxidation	Fan et al.	Sci Total Environ	2021	na	10.1016/j.scitotenv.2020.142943
Assessment of PFAS fate, transport, and treatment inhibition associated with a simulated AFFF release within a WASTEWATER treatment plant	Gonzalez et al.	Chemosphere 262: 127900.	2021	na	10.1016/j.chemosphere.2020.127900

PFAS	CAS (if available in publication
9 PFCAs (C4 to C12), 5 PFASs (C4, C6, C7, C8, C10)	na
C4-C14 PFCAs, C4, C6 ,C8 ,C10 PFSAs, 4:2, 6:2, 8:2 and 10:2 FTOHs, N-ethyl perfluorooctanesulfonamidoethanol (EtFOSE), N-Methyl perfluorooctane sulfona-midoethanol (MeFOSE), N-Ethyl perfluorooctane sulfonamide(EtFOSA) and N-Methyl perfluorooctane sulfonamide (MeFOSA)	na
Perfluorobutanesulfonic acid Perfluorohexanoic acid Perfluoroheptanoic acid Perfluorooctanoic acid Perfluorononanoic acid Perfluorooctanesulfonic acid Perfluorodecanoic acid Perfluoroundecanoic acid Perfluorododecanoic acid Pentacosafluorotridecanoic acid Perfluoromyristic acid Perfluoropalmitic acid Perfluorooctadecanoic acid	na
PFAS (i.e. C4–C14 PFCAs, C4,C6,C8,C10 PFSAs, 6:2 and 8:2 fluorotelomersulfonates (FTSs), PFOSA, 4:2, 6:2, 8:2, 10:2 FTOH	na

PFBA, PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrA, PFTeA, PFBS, PFHxS, PFHpS, PFOS, PFDS, 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, PFOSA	na
PFHXA, PFHpA, PFOA, PFNA, PFDA, PFBS, PFHxS, PFOS, PFOSA, N-MeFOSA, N-EtFOSO	307-24-4, 375-85-9, 335-67-1, 375-95-1, 335-76-2, 375-73-5, 355-46-4, 1763-23-1, 754-91-6, 31506-32-8, 4151-50-2
PFOS, PFOSA, N-Me-FOSA, N-Et-FOSA, N-Me-FOSE alcohol, N-Et-FOSE alcohol, PFOS salt	1763-23-1 (PFOS) 754-91-6 (PFOSA) 24448-09-7 (N-Me-FOSE alcohol) 1691-99-2 (N-Et-FOSE alcohol)
PFPA, PFHxA, PFHpA, PFOA, PFNa, PFDA, PFUnDA, PFDoDa, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS and PFDS	na

Targeted and non-targeted PFAS	na
48 targeted PFAS (12 found: PFCAs (n = 3-7), PFSAs (n = 3-8), Cl-PFSA (n = 8)) and 63 semi-quantificated PFAS including AmPr-FASA (n = 2-6), AmPr-FASA-PrA (n = 2-6), CEtAmPr-FASA-PrA (n = 2-6), Cl-PFSA (n = 4-6), CMeAmPr-FASA (n =4-6), CMeAmPr-FAS-PrA (n = 3-6), F5S-PFAS (n = 6), FASA (n = 4,6), PFCAs (n = 5), PFSAs (n = 3,4,6,7,8,10), UPFAS (n = 7,8), KPFAS (n = 5-8), MeEtCMeAmPr-FAAd (n = 4), MeFASAA (n = 5, 6), OAmPr-FASA (n = 5,6), O-PFAS (n = 5,6), PFASi (n = 4-6), PFCPeCA (n = 6), TAmPr-FASA (n = 3-6), TAmPr-FASAPrA (n = 3-6), UPFSA (n = 6-8) and 63 semi-quantificated PFAS	na
27 targeted PFAS including PFCAs (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA), PFSAs (PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS), FTSAs (4:2, 6:2, 8:2, 10:2), FBSA, FHxSA, FOSA, non-targeted PFAS, TF (total fluorine), EOF (extractable orgonofluorine), IF (inorganic fluorine), TOP (total oxidizable precuror)	identified PFAS: 1513864-10-2 (6:2 FTSAS-sulfoxide), 88992-45-4 (6:2 FTSHA), 88992-47-6 (6:2 FTSAS), 64972-10-7 (6:2 FTTh-PrAm), 27619-97-2 (6:2 FTSA), 34455-29-3 (6:2 FTSA-PrB), 80475-32-7 (6:2 FTNO), 76201-56-4 (EtOH-Am-Pr-PFHxSAPrS), 1513864-18-9 (6:2 FTSO-OHPrTAm)

Targeted PFCAs before/after TOP asssay	na
na	na

Sampling	sample amount used	Pre- treatment
95 samples from 35 consumer products including carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes. They were purchased from retail outlets in the United States between March 2007 and September 2011.	5 x 5 cm	solid products were cut into smaller subsections. Liquid products were subdivided into at least three 30-mL polypropylene vials
45 furniture textile, carpet, clothing and food contactmaterial samples were purchased from three major retail stores inTromsø and Trondheim during the period November2012eFebruary 201	10 x 10 cm	samples were cut into small pieces and spiked with masslabeled internal standard
pulverized after freezing	0,2 g	dissolvation- precipitation of polymers
30 products in 6 different product groups: waterproofing agents, paint, coated fabrics, non-stick ware, electronics and fire fighting agents. They were purchased from retailers in Norway and Sweden.	1 g	Liquid and solid samples were homogenized

115 samples of consumer products including textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes. The individual samples analysed were bought from local retailers or collected by co-workers of the institute or local clubs (e.g. ski waxes from local skiing club). The sampled products span all quality levels from entry level to cutting edge products. The selection of the samples occurred randomly.	na	na
300 products from 16 product lines placed on the market in four industrial sectors (Coated metal wares, textile products, leather products, household products)	areas 100 cm2 cutted in 2 mm x 2 mm, for the liquid sample, 1 mL was collected	na
Solids (coated materials): at least 200 cm2 or 2 g, solids (non-coated): sampled according to EN ISO 8130-9	see sampling	Sample materials need to ground as appropriate to ensure an efficient extraction process. Textile and paper shall be cut into pieces of maximum 1 cm2 before methanol is added. For grinding of polymers and granulates it is recommended to use EN ISO 6427 or ISO 9113.
126 samples in four categories: Textiles, Floor coverings, Electrical & Electronic equipment and plastics. All bought in Czech Republic	5 g	Materials were crushed, chopped or cut into small pieces

Textile finishing agents (TFAs) samples were collected from both local and international brands	na	ultrasonic extraction
A stock AFFF solution was obtained from a U.S. Air Force Base	na	1:93,000 diluted AFFF solution
9 FT AFFF and 1 Class A foam (PFOS-CHEK, advertised as PFAS-free) were purchased from commercial sources in 2018.	na	dilutions with Mili-Q water (10000x for non-targeted, 7500x for TF and IF, 50000x for EOF and targeted)

23 industry samples	na	UV-based TOP method as faster replacement of conventional heat-based TOP assay, diluted 1000–10,000 times
na	na	auto_x0002_mated solid phase extraction (ASPE)

Extraction	Clean up
solid and liquid sample extraction (Liu 2012, US EPA Report, EPA/600/R-12/585)	na
Samples were extracted with methanol for ionic compounds and ethyl acetate for neutral PFASs two times for 15 min in an ultrasonic bath with vortex treatment in between	After centrifugation and solvent evaporation, an aliquot of1 mL extract was transferred for dispersive clean up with ENVI-Carb(50 mg, 1 mL, 100e400 mesh, Supelco, USA
na	na
methanol for ionic compounds and ethylacetate for FTOH	Centrifugation and solvent evaporation, clean up with ENVI-Carb and glacial acetic acid (for ionic PFAS)

differ depending on the respective matrix: ion pair extraction, acidic-alkaine sequential extraction or SPE with acetone, hexane or methyl-t-butyl ether as solvent	differ depending on the respective matrix
ultrasonically with methanol	filtration
Sonification in methanol for textile, fabrics, leather and paper	Concentrate the extract by a factor of 10 and use a clean-up if necessary. Active carbon clean-up and/or solid phase extraction (SPE) clean-up may be used. Transfer a known volume into a suitable LC sampling vial . If necessary dilute the original solution further and repeat the analysis
Methanol with the addition of ammonium acetate	Following extraction, samples were cleanedup according to the procedures for PFAAs analysis described indetail elsewhere (Karaskova et al., 2016).

na	na
na	na
SPE; no extraction for TOP assay	The extracts were blown to dryness using a nitrogen evaporator and reconstituted in 1 mL of LC-MS grade methanol and split between combustion ion chromatography (CIC) and LC-MS/MS.

SPE according to EPA Method 537	na
na	na

Measurement	Quantification method
HPLC/MS/MS	internal standardisation using mass-labeled standards
UPLC-MS/MS and GC-MS	internal standards
UHPLC-Q-TOF-MS, in-house accurate-mass database and a mass spectral library	na
GC-MS	internal standard

PFAA: HPLC-MS/MS FTOH: GC/CI-MS	internal standardisation using mass-labeled internal standards
The liquid chromatography–tandem mass spectrometry (LC-MS/MS) instrument used in this study was an Agilent 1290 infinity-6410A with a Zorbax Eclipse XDB C18 column (150 mm I.D, 2.1 mm length, 5.0 mm particle size).	mass labeled internal standard, calibration curve
LC-qMS, LC-tandemMS	Quantify the samples by using the unextracted external calibration curve. When spiking with labelled reference solutions, the determination of the concentration is independent of possible errors made during injection. Also, errors caused by sample losses during distinct steps of sample pre-treatment or the adjustment of final sample extract volume as well as matrix effects in the sample are accounted for.
GC-MS	internal standards

gas chromatography mass spectrometry (GC-MS) TOP assay method UPLC-TOF-MS: targeted and Kendrick mass defect method	mass-labeled internal standards
A Sciex X500R Quadrupole Time-of-Flight MS (QToF/MS) system using SWATH® Data-Independent Acquisition was operated in both positive and negative electrospray ionization (ESI+/-) mode for QToF-MS and MS/MS analysis.	Internal standardisation using mass-labeled standards and semi-quantification of 63 PFAS through suspect screening analysis
TF/EOF/IF: CIC, TOP assay, LC-MS/MS (targeted), Non-targeted: UPLC with Thermo Orbitrap Fusion mass spectrometer	Quantifiying oxidizable precursors using bayesian inference, Internal standardisation using mass-labeled standards for targeted analysis, TF and EOF: Concentrations were determined from the average peak areas of duplicate injections using an eight-point calibration curve of PFOA

LC-MS/MS, (UPLC, Dionex UltiMate 3000, USA) combined with a tandem triple quadrupole mass spectrometry (MS/MS, AB SCIEX API 3200, Canada)	isotope-labelled surrogate standards and internal standards
LC-MSMS The TOP assay was employed to verify a material balance around the precursor compounds. This assay generates hydroxyl radicals by the thermal breakdown of persulfate under basic conditions (Houtz and Sedlak, 2012).	isotopes

Working range (ng/mL) As	Matrices
na	carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes
na	Textiles, carpets and food contact materials
na	plastic toys
na	food contact paper, textile, fire fighting foam, water proofing agents and lubricants, paint, leather, carpets, non-stick ware, printed circuit boards

na	textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes
calibration 5, 10, 25, and 50.0 mg/L	coated metal wares, textile products, leather products, and household products
Method is applicable for a concentration range for PFOS in the extract solution of 0,5 µg/l to 50 µg/l.	Coated materials like paper, textile, leather, carpets, clothes and footwear, Non-coated materials, liquids
na	Textiles, matierials of wood and composite wood, plastics, foam, air conditioner components. electronic components

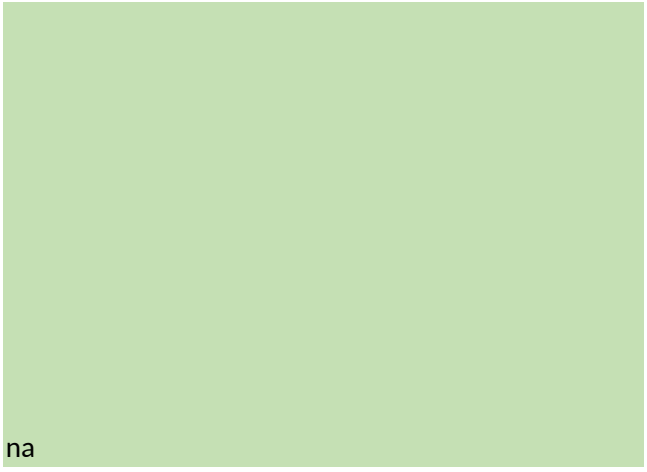
na	textile
na	AFFF
na	AFFF

na	fluorocarbon surfactants (FSs)
na	water and foam

Reported levels (ng/mL)
Individual PFCAs: ND-2600 ng g-1 product
PFOA: up to 0,914 µg/m2 Other PFCAs: up to 1,022 µg/m2 FTOHs: up to 373 µg/m2
na

PFOA: up to 2000 µg/kg (ski waxes), up to 19 µg/m2 (outdoor textiles), up to 15 µg/m2 (baking paper)
PFBA: up to 200 µg/kg (leather)
PFBS: up to 120 µg/kg (leather)

Of a total of 300 products, 51 were detected above the detection limits,
which accounted for approximately 17% of the products tested.



na

Textiles: up to 77,6 µg/kg Plastics: up to 0,384 µg/kg
OSB and wood: up to 18,3 µg/kg (PFAS found in 14 out of 14 samples)
Car interior materials: up to 3535 µg/kg

perfluorooctane sulfonate (0.37 mg/L) perfluorooctanoic acid (mean concentration: 0.29 mg/L), PFCAs by the TOP assay method was 58.83–3361.67 mg/L and 380.47–3156.07 mg/L, in ECF- and telomerization-based TFAs respectively

Together, the target analytes and suspect structures are estimated to contribute 129 µg/L of fluorine content to the diluted AFFF.

EOF in PFAS-containing AFFF ranged from 220 to 840 mM F, Targeted PFAS explained ≤1% of EOF in FT AFFF

PFCA concentrations before and after normal TOP assay were 0–4290 mg L−1 and 438–77,420 mg L−1, respectively. The PFCAs after 60 min UV-based TOP assay was 310–81,881 mg L−1

na

info - validation of the method	Limitations
na	na
Recoveries of internal standards, procedural and instrumental blanks and methoddetection limits are regularly monitored as quality criteria for theanalysis	na
correlation coefficients all greater than 0.99 average mass devia_x0002_tions for the measurements over six consecutive days (one injec_x0002_tion per day) were lower than 3.41 ppm and 4.94 ppm for ABS and PVC plastic toy samples (RSDs) calcu_x0002_lated in terms of retention time and peak area were better than 1.0% for ABS toy sample and 6.2% for PVC inter-day precision tested in six consecutive days was better than 2.5% and 11.2% for ABS and PVC recovery: 61.2%–117.0%	na
As standard procedure, laboratory blanks, method detection limits (MDLs) and recoveries were examined. For each sample, a high resolution full scan spectra was used to control positive detections (typical mass tolerance 50 ppm). No laboratory contamination for any of the analyzed compound was detected	na

accreditations according to DIN EN ISO/IEC 17025:2005, quality control standards	na
linearity of the calibration curve, instrument detection limit (IDL), method detection limit (MDL), and quality control.	na
The recovery of labelled reference compound shall be in the range from 70 % to 125 % for the sample to be considered valid.	
The accuracy of method was evaluated using a set of spiked solidblank materials (polyurethane foam (n¼6) and sand matrix blank(n¼10))	na

Calculated recoveries of the native standard were between 70% and 130%. The relative standard deviation of replicates was below 20%	na
na	na
Recoveries for each targeted PFAS 77 ranged from 72-130%, except for 8:2 FTSA (62%) and 10:2 FTSA (45%), TF: Relative standard deviations of duplicate injections <8% and method recovery 99%, EOF: relative standard deiations <5%, method recovery 96%	The availability of analytical standards has not kept pace with the new PFAS in commerce, and the existence of chemical standards does not always immediately result in the expansion of common PFAS testing panels.

na	na
recovery: 14-23% RSD 95%	na

LoD (ng/mL)	subgroup	Measurement - generic name
na	na	LC-MS/MS
The MDLs for individual substances ranged from 0.005 to0.010mgm2and 0.5 to 2mgm2for ionic and neutral PFASsrespectively.		
	na	LC-MS/MS, GC-MS
0.01–0.98 mg kg−1	na	LC-HRMS
MDLs not reported		
	na	GC-MS

LOQ (PFAA) = 0.1-0.5 µg/kg or 0.02-0.5 µg/m2 LOD (FTOH) = 20000 µg/kg	na	LC-MS/MS, GC-MS
MDLs between 0.47 and 1.42 mg/L	na	LC -MS/MS
na		LC-MS/MS
na		
	na	GC-MS

0,1-8,6 ng/mL		
	na	GC-MS, LC-HRMS
not reported		LC-HRMS
Targeted: MDL = 2.78-38,86, 116.92 (PFTeDA), 131.88 (PFNS) nM F		CIC, TOP assay, LC-HRMS

na	na	LC-MS/MS
na		LC-MS/MS

Title	Authors	Journal	year	Comments	DOI link
Multianalyte profiling of per- and polyfluoroalkyl substances (PFASs) in liquid commercial products	Favreau et al.	Chemosphere	2017	Also applied to AFFF	10.1016/j.chemosphere.2016.11.127
Concentrations and trends of perfluorinated chemicals in potential indoor sources from 2007 through 2011 in the US	Liu et al.	Chemosphere	2014	na	10.1016/j.chemosphere.2013.10.001
Are imported consumer products an important diffuse source of PFASs to the Norwegian environment?	Vestergren et al.	Environmental Pollution	2015	na	10.1016/j.envpol.2014.12.034
ANALYSIS OF PFASs AND TOF IN PRODUCTS	Daniel Borg, Jenny Ivarsson		2017	na	na

Survey of perfluoroalkyl acids (PFAAs) and their precursors present in Japanese consumer products	Ye et al.	Chemosph	2015 targeted	10.1016/j.chemosphere.2015.02.026
Suspect screening of 200 hazardous substances in plastic toys using ultra-high-performance liquid chromatography-hybrid quadrupole time-of-flight mass spectrometry	Meng et al.	J Chromatc	2020 na	10.1016/j.chroma.2019.460830
Perfluoroalkyl and polyfluoroalkyl substances (PFASs) in consumer productsin Norway – A pilot study	Herzke et el.	Chemosphere	2012 na	10.1016/j.chemosphere.2012.03.035
Perfluoroalkyl and polyfluoroalkyl substances in consumer products	Kotthoff et al.	Environ Sci	2015 na	10.1007/s1135
Survey of perfluorinated compounds in consumer products by liquid chromatography-tandem mass spectrometry	Lee et al.	Energy & Environment 2020 Vol. 31 Issue 4 Pages 713-729	2019 na	10.1177/0958305x19882376

CEN/TS 15968:2010 - Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and fire fighting foams - Method for sampling, extraction and analysis by LCqMS or LC-tandem/MS			2010	Also used for other matrices, sample treatmant different	
Screening for perfluoroalkyl acids in consumer products, building materials and wastes	Becanova et al.	Chemosphere	2016	na	10.1016/j.chemosphere.2016.08.1120045-6535/
How Do We Measure Poly- and Perfluoroalkyl Substances (PFASs) at the Surface of Consumer Products?: Environmental Science and Technology LETTERS	Tokranov et al.	Environ Sci Technol Lett	2019	Method development for consumer products	10.1021/acs.estlett.8b00600
Screening of textile finishing agents available on the Chinese market: An important source of per- and polyfluoroalkyl substances to the environment	Mumtaz et al.	Frontiers of Environmental Science & Engineering 2019 Vol. 13 Issue 5	2019	na	10.1007/s11783-019-1145-0
Analysis and characterization of novel fluorinated compounds used in surface treatments products	Frederiksson et al.	Chemosphere	2022	na	https://www.sc

PFAS	CAS (if available in publication
41 targeted PFAs including PFCAs (C4-C16), PFSAs (C4, C6, C8, C10), ipPFNS, PFPAs (C6, C8, C10), FOSA, N-Me FOSA, N-Et FOSA, FASAAs: FOSAA, N-MeFOSAA, N-EtFOSAA, N-MeFOSE, N-EtFOSE, FTSAs (4:2, 6:2, 8:2 FTS), FTOHs (4:2, 6:2, 7:2s, 8:2, 10:2), 8:2 FTI, 8:2 FTAC, 8:2 FTMAC	na
9 PFCAs (C4 to C12), 5 PFASs (C4, C6, C7, C8, C10)	na
C4-C14 PFCAs, C4, C6 ,C8 ,C10 PFSAs, 4:2, 6:2, 8:2 and 10:2 FTOHs, N-ethyl perfluorooctanesulfonamidoethanol (EtFOSE), N-Methyl perfluorooctane sulfona-midoethanol (MeFOSE), N-Ethyl perfluorooctane sulfonamide(EtFOSA) and N-Methyl perfluorooctane sulfonamide (MeFOSA)	na
Perfluorinated carboxylic acids (PFCAs): PFBA, PFHxA, PFOA, PFNA, PFDA. Perfluorinated sulfonic acids (PFSAs): PFBS, PFHxS, PFOS. Fluorotelomer alcohols (FTOHs): 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH. Fluorotelomer acrylates (FTAs): 6:2 FTA, 8:2 FTA, 10:2 FTA. Perfluorooctane sulphonamides (FOSAs): MeFOSA, EtFOSA. Perfluorooctane sulfonamidoethanols (FOSEs): MeFOSE, EtFOSE. Total Organic Fluorine (TOF).	na

Perfluoroalkane sulfonic acids (PFSAs), Precursors of perfluorooctane sulfonic acid (Precursors of PFOS) Perfluorooctane sulfonamidoethanols (FOSEs), Perfluoroalkane sulfonamides (FASAs), Perfluoroalkane sulfonamidoacetic acids (FASAAs), Perfluoroalkyl carboxylic acids (PFCAs) – Precursors of perfluoroalkyl carboxylic acids (Precursors of PFCAs), Fluorotelomer unsaturated carboxylic acids (FTUCAs), Fluorotelomer carboxylic acids (FTCAs), Fluorotelomer sulfonic acid (FTSA)	
Perfluoroalkyl phosphonic acid (PFPA)	na
Perfluoropentanoic acid Perfluorobutanesulfonic acid Perfluorohexanoic acid Perfluoroheptanoic acid Perfluorooctanoic acid Perfluorononanoic acid Perfluorooctanesulfonic acid Perfluorodecanoic acid Perfluoroundecanoic acid Perfluorododecanoic acid Pentacosafluorotridecanoic acid Perfluoromyristic acid Perfluoropalmitic acid	
Perfluorooctadecanoic acid	na
PFAS (i.e. C4–C14 PFCAs, C4,C6,C8,C10 PFSAs, 6:2 and 8:2 fluorotelomersulfonates (FTSs), PFOSA, 4:2, 6:2, 8:2, 10:2 FTOH	na
PFBA, PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrA, PFTeA, PFBS, PFHxS, PFHpS, PFOS, PFDS, 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, PFOSA	na
PFHXA, PFHpA, PFOA, PFNA, PFDA, PFBS, PFHxS, PFOS, PFOSA, N-MeFOSA, N-EtFOSO	307-24-4, 375-85-9, 335-67-1, 375-95-1, 335-76-2, 375-73-5, 355-46-4, 1763-23-1, 754-91-6, 31506-32-8, 4151-50-2

PFOS, PFOSA, N-Me-FOSA, N-Et-FOSA, N-Me-FOSE alcohol, N-Et-FOSE alcohol, PFOS salt	1763-23-1 (PFOS) 754-91-6 (PFOSA) 24448-09-7 (N-Me-FOSE alcohol) 1691-99-2 (N-Et-FOSE alcohol)
PFPA, PFHxA, PFHpA, PFOA, PFNa, PFDA, PFUnDA, PFDoDa, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS and PFDS	na
surficial fluorine content, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA, PFBS, PFHxS, PFOS, FOSA, 6:2 FtS, N-MeFOSAA, N-EtFOSAA	na
Targeted and non-targeted PFAS	na
FBSA, Me-FBSA, FHxSA, Me-FHxSA, FOSA, TFMS, PFEtS, PFPrS, PFBS, PFPeS, L-PFHxS, PFHpS, L-PFOS, PFNS, PFDS, PFDoDS, 4:2 FTSA, 6:2 FTSA, 8:2 FTSA, 3:3 FTCA, 5:3 FTCA, 7:3 FTCA, 6:2 FTUCA, 8:2 FTUCA, 10:2 FTUCA, TFA, PFPrA, PFBA, PFPeA, PFHxA, PFHpA, L-PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTDA, PFHxDA, PFOcDA, PFHxPA, PFOPA, PFDPA, 6:6 PFPiA, 6:8 PFPiA, 8:8 PFPiA, 11ClPF3OUdS, 9ClPF3ONS, T-PFECHS, C8-FASA-based copolymers, C4-FASA-based copolymers	na

Sampling	sample amount used	Pre- treatment
Household products included impregnation agents (n = 60), cleansers (n = 24), polishes (n = 18), lubricants (n = 7). A miscellaneous category of products (n = 23) was defined by various applications that included foamsuppressing agents for the chromium industry, paints, ski wax, inks and tanning substances.	500 mg for LC-MS, 200 mg for GC-MS	LC-MS: dissolved in 10 mL water, adding methanol/water, ammonium acetate (pH 4), GC-MS: dissolved in 10 mL methanol, filtration
95 samples from 35 consumer products including carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes. They were purchased from retail outlets in the United States between March 2007 and September 2011.	5 x 5 cm	solid products were cut into smaller subsections. Liquid products were subdivided into at least three 30-mL polypropylene vials
45 furniture textile, carpet, clothing and food contactmaterial samples were purchased from three major retail stores inTromsø and Trondheim during the period November2012eFebruary 201	10 x 10 cm	samples were cut into small pieces and spiked with masslabeled internal standard
In total 17 products were randomly selected from shelves in a number of Swedish retail stores and supermarkets for analysis	na	na

Five categories: car wash/coating products, sprays for fabrics and textiles, insecticides, rust inhibitors, and paints	50 mg	na
pulverized after freezing	0,2 g	dissolvation- precipitation of polymers
30 products in 6 different product groups: waterproofing agents, paint, coated fabrics, non-stick ware, electronics and fire fighting agents. They were purchased from retailers in Norway and Sweden.	1 g	Liquid and solid samples were homogenized
115 samples of consumer products including textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes. The individual samples analysed were bought from local retailers or collected by co-workers of the institute or local clubs (e.g. ski waxes from local skiing club). The sampled products span all quality levels from entry level to cutting edge products. The selection of the samples occurred randomly.	na	na
300 products from 16 product lines placed on the market in four industrial sectors (Coated metal wares, textile products, leather products, household products)	areas 100 cm2 cutted in 2 mm x 2 mm, for the liquid sample, 1 mL was collected	na

Solids (coated materials): at least 200 cm2 or 2 g, solids (non-coated): sampled according to EN ISO 8130-9	see sampling	Sample materials need to ground as appropriate to ensure an efficient extraction process. Textile and paper shall be cut into pieces of maximum 1 cm2 before methanol is added. For grinding of polymers and granulates it is recommended to use EN ISO 6427 or ISO 9113.
126 samples in four categories: Textiles, Floor coverings, Electrical & Electronic equipment and plastics. All bought in Czech Republic	5 g	Materials were crushed, chopped or cut into small pieces
94 consumer products that represent frequently used items on a college campus of Harvard University. These included: 45 food contact materials, 37 textiles, and 12 domestic products such as lens wipes, bandages, masks, and a shower curtain	1 ± 0.03 g	cut using methanol-rinsed scissors, mounted on carbon tape for XPS
Textile finishing agents (TFAs) samples were collected from both local and international brands	na	ultrasonic extraction
Two technical mixtures of Scotchgard™ Pre-2002 formulation and Scotchgard™ Post-2002 formulation were purchased from AccuStandard Inc.	na	target analysis: na

Extraction	Clean up
LC-MS: SPE with methanol/ ammonium acetate (50:50)	LC-MS: adding ammonium hydroxide in methanol (0.5 %), neutralized with acetic acid
solid and liquid sample extraction (Liu 2012, US EPA Report, EPA/600/R-12/585)	na
Samples were extracted with methanol for ionic compounds and ethyl acetate for neutral PFASs two times for 15 min in an ultrasonic bath with vortex treatment in between	After centrifugation and solvent evaporation, an aliquot of1 mL extract was transferred for dispersive clean up with ENVI-Carb(50 mg, 1 mL, 100e400 mesh, Supelco, USA
na	na

The PFAS extraction procedure and instrumental analysis for all samples was based on a previous report (Zushi et al., 2012)	na
na	na
methanol for ionic compounds and ethylacetate for FTOH	Centrifugation and solvent evaporation, clean up with ENVI-Carb and glacial acetic acid (for ionic PFAS)
differ depending on the respective matrix: ion pair extraction, acidic-alkaine sequential extraction or SPE with acetone, hexane or methyl-t-butyl ether as solvent	differ depending on the respective matrix
ultrasonically with methanol	filtration

Sonification in methanol for textile, fabrics, leather and paper	Concentrate the extract by a factor of 10 and use a clean-up if necessary. Active carbon clean-up and/or solid phase extraction (SPE) clean-up may be used. Transfer a known volume into a suitable LC sampling vial . If necessary dilute the original solution further and repeat the analysis
Methanol with the addition of ammonium acetate	Following extraction, samples were cleanedup according to the procedures for PFAAs analysis described indetail elsewhere (Karaskova et al., 2016).
methanol extraction, XPS (not extracted sample/ methanol extract)	na
na	na
target analysis: na TOP assay: remaining side-chain fluorinated copolymer were extracted after oxidation with MTBE	target analysis: na

Measurement	Quantification method
LC- MS/MS, GC-MS/MS for FTOHs, FTI, FTAC, FTMAC	internal standardisation using mass-labeled standards
HPLC/MS/MS	internal standardisation using mass-labeled standards
UPLC-MS/MS and GC-MS	internal standards
Lc-MSMS and combustion-IC	na

Fluor was determined by Ion chromatography after thermal decomposition	internal standards
UHPLC-Q-TOF-MS, in-house accurate-mass database and a mass spectral library	na
GC-MS	internal standard
PFAA: HPLC-MS/MS FTOH: GC/CI-MS	internal standardisation using mass-labeled internal standards
The liquid chromatography–tandem mass spectrometry (LC-MS/MS) instrument used in this study was an Agilent 1290 infinity-6410A with a Zorbax Eclipse XDB C18 column (150 mm I.D, 2.1 mm length, 5.0 mm particle size).	mass labeled internal standard, calibration curve

LC-qMS, LC-tandemMS	Quantify the samples by using the unextracted external calibration curve. When spiking with labelled reference solutions, the determination of the concentration is independent of possible errors made during injection. Also, errors caused by sample losses during distinct steps of sample pre-treatment or the adjustment of final sample extract volume as well as matrix effects in the sample are accounted for.
GC-MS	internal standards
X-ray photoelectron spectrosopy (XPS), LC-(-)ESI-MS, LC-QTOF-MS	internal standards
gas chromatography mass spectrometry (GC-MS) TOP assay method UPLC-TOF-MS: targeted and Kendrick mass defect method	mass-labeled internal standards
target analysis: UPLC-MS/MS target analysis: SFC-MS/MS (ultra-short chain acids C1-C3) TOP assay method QTOF MS analysis (side-chain fluorinated copolymer) total fluorine: TF analysis using CIC	semi-quantification of new PFAS based on the average responses of the adjacent compounds or by analyzing a small number of compounds from the group at known concentrations

Working range (ng/mL) As	Matrices
na	household products (impregnation agents, cleanser, polishes), lubricants, foamsuppressing agents for the chromium industry, paints, ski waxes, inks, tanning substances,
na	carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes
na	Textiles, carpets and food contact materials
na	na

na	surfactant containing consumer products
na	plastic toys
na	food contact paper, textile, fire fighting foam, water proofing agents and lubricants, paint, leather, carpets, non-stick ware, printed circuit boards
na	textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes
calibration 5, 10, 25, and 50.0 mg/L	coated metal wares, textile products, leather products, and household products

Method is applicable for a concentration range for PFOS in the extract solution of 0,5 µg/l to 50 µg/l.	Coated materials like paper, textile, leather, carpets, clothes and footwear, Non-coated materials, liquids
na	Textiles, matierials of wood and composite wood, plastics, foam, air conditioner components. electronic components
N7A	paper and textile
na	textile
na	sediment and technical mixtures

Reported levels (ng/mL)
55% of all samples contained at least one PFAS between 0.1 and 25'000 mg/kg of product, with the majority of products falling within the 100e1000 mg/kg range
Individual PFCAs: ND-2600 ng g-1 product
PFOA: up to 0,914 µg/m2 Other PFCAs: up to 1,022 µg/m2 FTOHs: up to 373 µg/m2
several orders of magnitude for the products collected 2014, 2015 and 2016, respectively, from µg/m2 to g/m2 g highest concentration of TOF were dental floss (310 g/kg), non-stick baking ware (1.7 g/m2) and table cloth (0.9 g/m2). , µg/l to mg/l, and µg/kg to g/kg

high total concentrations of PFAAs and their precursors were found in sprays for fabrics and textiles: 30 000 ng g-1 and car wash/coating products 7500 ng g-1

na

PFOA: up to 2000 µg/kg (ski waxes), up to 19 µg/m2 (outdoor textiles), up to 15 µg/m2 (baking paper)
PFBA: up to 200 µg/kg (leather)
PFBS: up to 120 µg/kg (leather)

Of a total of 300 products, 51 were detected above the detection limits,
which accounted for approximately 17% of the products tested.

na

Textiles: up to 77,6 µg/kg Plastics: up to 0,384 µg/kg
OSB and wood: up to 18,3 µg/kg (PFAS found in 14 out of 14 samples)
Car interior materials: up to 3535 µg/kg

PFOA: 3200 nmol m-2 (0.38 mg kg-1) (carpet), PFBA: 960 nmol m-2 (0.60 mg kg-1) (disposable bowl), 45% F from a new upholstery sample

perfluorooctane sulfonate (0.37 mg/L)
perfluorooctanoic acid (mean concentration: 0.29 mg/L), PFCAs by the TOP assay method
was 58.83–3361.67 mg/L and 380.47–3156.07 mg/L, in ECF- and telomerization-based TFAs respectively

The technical mixtures
stated concentration of 100 µg mL− 1 showed a fluorine content of 0.41–0.60% for Pre-2002 and 1.7–1.9% for Post-2002

info - validation of the method	Limitations
na	na
na	na
Recoveries of internal standards, procedural and instrumental blanks and methoddetection limits are regularly monitored as quality criteria for theanalysis	na
na	na

Compounds with a recovery outside of the range of 50–150% were removed from this report. Procedural blank sam_x0002_ples (n = 3) were prepared and analyzed	na
correlation coefficients all greater than 0.99 average mass devia_x0002_tions for the measurements over six consecutive days (one injec_x0002_tion per day) were lower than 3.41 ppm and 4.94 ppm for ABS and PVC plastic toy samples (RSDs) calcu_x0002_lated in terms of retention time and peak area were better than 1.0% for ABS toy sample and 6.2% for PVC inter-day precision tested in six consecutive days was better than 2.5% and 11.2% for ABS and PVC recovery: 61.2%–117.0%	na
As standard procedure, laboratory blanks, method detection limits (MDLs) and recoveries were examined. For each sample, a high resolution full scan spectra was used to control positive detections (typical mass tolerance 50 ppm). No laboratory contamination for any of the analyzed compound was detected	na
accreditations according to DIN EN ISO/IEC 17025:2005, quality control standards	na
linearity of the calibration curve, instrument detection limit (IDL), method detection limit (MDL), and quality control.	na

The recovery of labelled reference compound shall be in the range from 70 % to 125 % for the sample to be considered valid.	
The accuracy of method was evaluated using a set of spiked solidblank materials (polyurethane foam (n¼6) and sand matrix blank(n¼10))	na
Duplicate injection, precision experiments	na
Calculated recoveries of the native standard were between 70% and 130%. The relative standard deviation of replicates was below 20%	na
na	na

LoD (ng/mL)	subgroup	Measurement - generic name
LOQ: 0.5-2 ng/mL (LC-MS), 2-10 ng/ mL (GC-MS)	na	LC- MS/MS, GC-MS/MS
na	na	LC-MS/MS
The MDLs for individual substances ranged from 0.005 to0.010mgm2and 0.5 to 2mgm2for ionic and neutral PFASsrespectively.	na	LC-MS/MS, GC-MS
na	na	LC-MS/MS, IC

2 ng g_x0003_1	na	IC
0.01–0.98 mg kg−1	na	LC-HRMS
MDLs not reported	na	GC-MS
LOQ (PFAA) = 0.1-0.5 µg/kg or 0.02-0.5 µg/m2 LOD (FTOH) = 20000 µg/kg	na	LC-MS/MS, GC-MS
MDLs between 0.47 and 1.42 mg/L	na	LC -MS/MS

na		LC-MS/MS
na		
	na	GC-MS
±1% for XPS, 0.063-3.7 ng g-1 (MQL) for LC-MS/MS		XPS, LC-MS/MS, LC-HRMS
0,1-8,6 ng/mL		
	na	GC-MS, LC-HRMS
na	na	LC-MS/MS, SFC-MS/MS, LC-HRMS, CIC

Title
CEN/TS 15968:2010 - Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and fire fighting foams - Method for sampling, extraction and analysis by LCqMS or LC-tandem/MS

Perfluoroalkyl and polyfluoroalkyl substances in consumer products

Analysis of per- and polyfluorinated substances in articles

Analysis of PFASs and TOF in products

Levels of per- and polyfluoroalkyl substances (PFAS) in ski wax products on the market in 20

PFAS i kemiska produkter och varor Ett tillsynsprojekt med fokus på POPs-förordningens begränsningar av PFOA och PFOS (PFAS in chemical products and articles A regulatory project focusing on the POPs Regulation restrictions on PFOA and PFOS)

Perfluoroalkyl and polyfluoroalkyl
substances (PFASs) in consumer productsin Norway – A pilot study

Authors	Journal	year
Standard	na	2010
Kotthoff et al.	Environ Sci Pollut Res Int	2015
Blom et al.	Nordic Council of Ministers	2015
Borg et al.	Nordic Council of Ministers	2017

Fang et al.	Environmental Science: Processes & Impacts	2019
KEMI	na	2021
Herzke et el.	Chemosphere	2012

comments	DOI link
Also used for other matrices, sample treatmant different	na
na	10.1007/s11356-015-4202-7
na	http://dx.doi.org/10.6027/na2015-91
na	http://dx.doi.org/10.6027/

na	10.1039/d0em00357c
Several matrices tested: Textiles, Ski wax, and other consumer products	na
na	10.1016/j.chemosphere.2012.03.035

name
PFOS, PFOSA, N-Me-FOSA, N-Et-FOSA, N-Me-FOSE alcohol, N-Et-FOSE alcohol, PFOS salt
PFBA, PFPA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUna, PFDoA, PFTrA, PFTeA, PFBS, PFHxS, PFHpS, PFOS, PFDS, 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, PFOSA
PFCAs (PFBA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA), PFASs (PFBS, PFHxS, PFOS), PAPs (6:2 diPAP, 6:2 monoPAP, 8:2 diPAP, 8:2 mono-PAP), FTOH (4:2, 6:2, 8:2), FTS (4:2, 6:2)
TOF, targeted analysis of PFCAs (PFBA, PFHxA, PFOA, PFna, PFDA), PFSAs (PFBS, PFHxS, PFOS), FTOHs (4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH), FTAs (6:2 FTA, 8:2 FTA, 10:2 FTA), FOSAs (MeFOSA, EtFOSA), FOSEs (MeFOSE, EtFOSE)

Perfluorobutanoic acid (PFBA, C4) Perfluoropetanoic acid (PFPeA, C5) Perfluorohexanoic acid (PFHxA, C6) Perfluoroheptanoic acid (PFHpA, C7) Perfluorooctanoic acid (PFOA, C8) Perfluorononanoic acid (PFna, C9) Perfluorodecanoic acid (PFDA, C10) Perfluoroundecanoic acid (PFUnDA, C11) Perfluorododecanoic acid (PFDoDA, C12) Perfluorotridecanoic acid (PFTrDA, C13) Perfluorotetradecanoic acid (PFTeDA, C14) Perfluoropentadecanoic acid (PFPeDA, C15) Perfluorohexadecanoic acid (PFHxDA, C16) Perfluoroheptadecanoic acid (PFHpDA, C17) Perfluorooctadecanoic acid (PFODA, C18) Perfluorononadecanoic acid (C19) Perfluoroeicosanoic acid (C20) Perfluoroheneicosanoic acid (C21) Perfluorodocosanoic acid (C22) Perfluorotetracosanoic acid (C23) Perfluorotricosanoic acid (C24) Perfluoropentacosanoic acid (C25)

PFAS Tests according to CEN/TS 15968:2010
EOF not further described

PFAS (i.e. C4–C14 PFCAs, C4,C6,C8,C10 PFSAs, 6:2 and 8:2 fluorotelomersulfonates (FTSs), PFOSA, 4:2, 6:2, 8:2, 10:2 FTOH

CAS (if available in source)
1763-23-1 (PFOS) 754-91-6 (PFOSA) 24448-09-7 (N-Me-FOSE alcohol) 1691-99-2 (N-Et-FOSE alcohol)
na
375-22-4 (PFBA), 307-24-4 (PFHxA), 375-85-9 (PFHpA), 335-67-1 (PFOA), 375-95-1 (PFna), 335-76-2 (PFDA), 4234-23-5 (PFUnDA), 307-55-1 (PFDoDA), 72629-94-8 (PFTrDA), 376-06-7 (PFTeDA), 29420-49-3 (PFBS salt), 3871-99-6 (PFHxS salt), 1763-23-1 (PFOS salt), 2043-47-2 (4:2 FTOH), 647-42-7 (6:2 FTOH), 678-39-7 (8:2 FTOH), 57677-95-9 (6:2 diPAP), 57678-01-0 (6:2 monoPAP), 678-41-1 (8:2 diPAP), 57678-03-2 (8:2 mono-PAP), 757124-72-4 (4:2 FTS), 29420-49-3 (6:2 FTS)
375-22-4 (PFBA), 29420-49-3 (PFBS salt), 307-24-4 (PFHxA), 3871-99-6 (PFHxS salt), 2043-47-2 (4:2 FTOH), 757124-72-4 (4:2 FTS), 335-67-1 (PFOA), 1763-23-1 (PFOS salt), 647-42-7 (6:2 FTOH), 29420-49-3 (6:2 FTS), 31506-32-8 (MeFOSA), 4151-50-2 (EtFOSA), 2448-09-7 (MeFOSE), 1691-99-2 (EtFOSE), 375-95-1 (PFna), 335-76-2 (PFDA), 678-39-7 (8:2 FTOH)

na

Tests according to CEN/TS 15968:2010

na

Sampling	sample amount used
Liquids: method which will provide a representative sample of the liquid to be tested.	see sampling
115 samples of consumer products including textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes. The individual samples analysed were bought from local retailers or collected by co-workers of the institute or local clubs (e.g. ski waxes from local skiing club). The sampled products span all quality levels from entry level to cutting edge products. The selection of the samples occurred randomly.	na
In total 29 different samples were analysed. The sampling was concentrated on a few but wide variety of household products, such as cleaning products and polishes for indoor use and for cars and sprays to waterproof shoes or clothes, food contact paper and baking forms included some products less commonly analysed, such as ski wax, dental floss and tablecloths. The samples were purchased in the vicinity of Oslo in supermarket chains that are found all over Norway.	depending on the article: 0.05 mL, 71.5-100 cm^2 or 0.02-0.16 g
In total 17 products were randomly selected from shelves in a number of Swedish retail stores and supermarkets for analysis (Cupcake forms, microwave popcorn bag, rinse aid, waterproofing shoe treatment, waterproofing textile treatment, shoe wax, floor polish, furniture polish, car wax). In total 29 samples of consumer products were collected in the previous study (including food contact material, textiles, lubricants, car wax, table cloth, ski wax and more)	Pressed pellets of 100-120 mg for TOF

11 separate commercially available and best-selling ski wax products were purchased from one of Norway's largest sports stores in the summer of 2019. The ski wax products comprised; 3 wax blocks, 1 liquid wax and 7 powders.	10 mg
Tests according to CEN/TS 15968:2010	Tests according to CEN/TS 15968:2010
30 products in 6 different product groups: waterproofing agents, paint, coated fabrics, non-stick ware, electronics and fire fighting agents. They were purchased from retailers in Norway and Sweden.	1 g

Pre- treatment
Dilution for AFFF: Pre-dilute the sample in separate steps with purified water or methanol (1:10 v/v, 1:100 v/v, 1:1 000 v/v) and mix sufficiently (e.g. 500 µl sample into 4 500 µl diluent). Ensure that there is no phase-separation in the sample. If necessary centrifuge the sample to precipitate non soluble particles. Dilute the pre-diluted sample 1:10 with water or methanol and an appropriate volume of internal standard solution (e.g. 100 µl diluted sample, 100 µl reference solution, 800 µl water or methanol) to have in every dilution (1:10 v/v, 1:100 v/v, 1:1 000 v/v) the same concentration of the internal standard. Transfer an aliquot to a LC vial and analyse the sample. If high PFOS concentrations are expected, begin with the highest dilution (1:10 000 v/v) to avoid a carry over.

na

vortexing in methanol

sample was homogenized, shredded for TOF

na

Tests according to CEN/TS 15968:2010

Liquid and solid samples were homogenized

Extraction	Clean up
no extraction	na
differ depending on the respective matrix: ion pair extraction, acidic-alkaine sequential extraction or SPE with acetone, hexane or methyl-t-butyl ether as solvent	differ depending on the respective matrix
ultrasonification in methanol	volume reduced to 2 mL, aliquot filtered
LC-MS: ultrasonic extraction with matrix dependent solvents (no further information), burning for TOF and absorbtion of combustion gases in buffer solution	LC-MS: (multi)-step-sample clean-up

10 mg (accurately weighed) of ski wax spiked with 0.5 ng of internal standards was extracted with 5 mL methanol. The wax/ methanol mixture was vortexed and extracted in an ultrasonic bath for 20 min and then stored at room temperature overnight. The mixture was placed in an ultrasonic bath for 20 min again the next day and then centrifuged (3000 rpm, 10 min) to facilitate sedimentation of the extracted solids. A 4 mL aliquot of the supernatant was transferred to a 13 mL polypropylene tube. The extraction of ski wax was repeated and the supernatant solutions combined. Following extraction, the 8 mL of supernatant was evaporated to approximately 200 µL and 25 µL recovery standard (M8PFOS and M8PFOA, both 20 pg µL−1) and 200 µL 4 mM NH4OAc in water were added. The extracts were then transferred to a polypropylene (PP) centrifuge tube with a nylon membrane filter and centrifuged at 13 000 rpm for 5 min. The filtered extract was transferred to an autosampler vial and stored at 4 °C until analysis.	na
Tests according to CEN/TS 15968:2010	Tests according to CEN/TS 15968:2010
methanol for ionic compounds and ethylacetate for FTOH	Centrifugation and solvent evaporation, clean up with ENVI-Carb and glacial acetic acid (for ionic PFAS)

Measurement
LC-qMS, LC-tandemMS
PFAA: HPLC-MS/MS FTOH: GC/CI-MS
UPLC-MS/MS for ionic PFAS and PAP, GC/MSD for FTOH
Targeted analysis with LC/MS-MS (Agilent HPLC 1290 Infinity Serie coupled with Agilent 6460A Triple Quad LC/MS-MSMS), TOF by IC

PFAS were quantified using an ultra-performance liquid chromatography-tandem mass spectrometer (UPLC-MS/MS) instrument (Waters, ACQUITY-UPLC/XEVO-TQS) fitted with a BEH C18 column (1.7 µm particles, 2.1 × 50 mm; waters). The mass spectrometer (MS) was operated in negative electrospray ionization multiple reaction monitoring (MRM) mode with the following MS parameters: capillary voltage 1100 V; nebulizer gas flow at 7 bars; desolvation gas flow at 600 L h−1; cone gas flow at 150 L h−1. The desolvation temperature was 350 °C. The m/z cone voltages and collision energies used for each PFAS are listed in Table S2.†

Tests according to CEN/TS 15968:2010

GC-MS

Quantification method
Quantify the samples by using the unextracted external calibration curve. When spiking with labelled reference solutions, the determination of the concentration is independent of possible errors made during injection. Also, errors caused by sample losses during distinct steps of sample pre-treatment or the adjustment of final sample extract volume as well as matrix effects in the sample are accounted for.

internal standardisation using mass-labeled internal standards

internal standardisation using mass-labeled internal standards

LC-MS: internal isotope-labeled standards (isotope dilution method)

Quantification of all target analytes was performed using an internal standard calibration curve with nine points (0.008–150 ng mL−1, R2 > 0.99). Stable isotope mass labelled internal standards were available for C4–C6 and C8–C12 PFCAs, as well as for PFHxS and PFOS. C7 and C13–25 PFCAs, PFBS and PFDS were quantified using 13C2-perfluorohexanoic acid (PFHxA), 13C2-perfluorododecanoic acid (PFDoDA), 18O2-perfluorohexane sulfonate acid (18O2-PFHxS) and 13C4-perfluorooctane sulfonate acid (13C4-PFOS) as internal standards, respectively. Reference standards for native C15, C17 and C19-25 PFCAs were not available. Therefore, for quantification of C15, C17 and C19–25 PFCAs the relative response factors (relative to 13C2-PFDoDA) were calculated from the calibration curves of C14, C16 and C18 PFCAs, respectively. All reported concentrations for C15, C17 and C19–25 PFCAs should thus be considered as semi-quantitative estimates due to the lack of authentic native standards for these compounds. The method detection limit (MDL) was defined as the lowest calibration point concentration resulting in a signal-to-noise ratio of three, if the specific PFAS were not detected in the blanks. For the analytes which were detected in the blanks, MDLs were defined as the mean blank concentration plus three times the standard deviation of the blank.

Tests according to CEN/TS 15968:2010

internal standard

LoD (ng/mL)	subgroup	Measurement - generic name
na	na	LC-MS/MS
LOQ (PFAA) = 0.1-0.5 µg/kg or 0.02-0.5 µg/m2 LOD (FTOH) = 20000 µg/kg	na	LC-MS/MS, GC-MS
LOD = 0.03-0.15 µg/m2, only qualitative for 6:2 monoPAP, 8:2 PAP, 6:2 diPAP, 8:2 diPAP	na	LC-MS/MS, GC-MS
TOF: About 10 pellets must be processed to sustain a LOQ of 1 mg/kg fluorine (LOQ fluoride = 0.1 mg/l for IC)	na	LC-MS/MS , CIC

0.1–2.5 ng g−1	na	LC-MS/MS
Tests according to CEN/TS 15968:2010	Tests according to CEN/TS 15968:2010	
MDLs not reported		
	na	GC-MS

Title	Authors	Journal
Surface-enhanced Raman scattering (SERS) detection of fluorosurfactants in firefighting foams	Fang et al.	RSC Advances
Potentiometric detection of AFFFs based on MIP	Fang et al.	Environmental Technology & Innovation
Removal of Per- and Polyfluoroalkyl Substances (PFASs) in Aqueous Film-Forming Foam (AFFF) Using Ion-Exchange and Nonionic Resins	Fang et al.	Environ Sci Technol

Reconstructing the Composition of Per- and Polyfluoroalkyl Substances in Contemporary Aqueous Film-Forming Foams	Ruyle et al.	Environ Sci Technol Lett
Determination of total oxidizable precursors in foam surfactants and foam contaminated water based on UV-activated persulfate oxidation	Fan et al.	Sci Total Environ
Assessment of PFAS fate, transport, and treatment inhibition associated with a simulated AFFF release within a WASTEWATER treatment plant	Gonzalez et al.	Chemosphere 262: 127900.
Spatial Trends of Anionic, Zwitterionic, and Cationic PFASs at an AFFF-Impacted Site	Nickerson et al.	Environ. Sci. Technol. 2021, 55, 1, 313–323

Chemical Characterization of a Legacy Aqueous Film-Forming Foam Sample and Developmental Toxicity in Zebrafish (Danio rerio)	Annunziato et al.	Environ Health Perspect
Characterization of the Chemical Contents of Fluorinated and Fluorine-Free Firefighting Foams Using a Novel Workflow Combining Nontarget Screening and Total Fluorine Analysis	Dubocq et al.	Environ Sci Technol
Rapid Characterization of Emerging Per- and Polyfluoroalkyl Substances in Aqueous Film-Forming Foams Using Ion Mobility Spectrometry-Mass Spectrometry	Luo et al.	Environ Sci Technol
Rejection of per- and polyfluoroalkyl substances (PFASs) in aqueous film-forming foam by high-pressure membranes	Liu et al.	Water Res
A profile analysis with suspect screening of per- and polyfluoroalkyl substances (PFASs) in firefighting foam impacted waters in Okinawa, Japan	Yukioka et al.	Water Research

Per- and Polyfluoroalkyl Substances in Representative Fluorocarbon Surfactants Used in Chinese Film-Forming Foams: Levels, Profile Shift, and Environmental Implications	Mumtaz et al.	Environmental Science & Technology Letters
Gas-Phase Detection of Fluorotelomer Alcohols and Other Oxygenated Per- and Polyfluoroalkyl Substances by Chemical Ionization Mass Spectrometry	Riedel et al.	Environ Sci Technol Lett
A new method to search for per- and polyfluoroalkyl substances (PFASs) by linking fragmentation flags with their molecular ions by drift time using ion mobility spectrometry	Yukioka et al.	Chemosphere
Deep seepage of per- and polyfluoroalkyl substances through the soil of a firefighter training site and subsequent groundwater contamination	Dauchy et al.	Chemosphere

Discovery of 40 Classes of Per- and Polyfluoroalkyl Substances in Historical Aqueous Film-Forming Foams (AFFFs) and AFFF-Impacted Groundwater	Barzen-Hanson et al.	Environ Sci Technol
Per- and polyfluoroalkyl substances in firefighting foam concentrates and water samples collected near sites impacted by the use of these foams	Dauchy et al.	Chemosphere
Multianalyte profiling of per- and polyfluoroalkyl substances (PFASs) in liquid commercial products	Favreau et al.	Chemosphere
Chemical oxidization of some AFFFs leads to the formation of 6:2FTS and 8:2FTS	Fang et al.	Environmental Toxicology and Chemistry
Identification of Novel Fluorinated Surfactants in Aqueous Film Forming Foams and Commercial Surfactant Concentrates	D'Agostino et al.	Environmental Science & Technology
Zwitterionic, Cationic, and Anionic Fluorinated Chemicals in Aqueous Film Forming Foam Formulations and Groundwater from U.S. Military Bases by Nonaqueous Large-Volume Injection HPLC-MS/MS	Backe et al.	Environmental Science & Technology

Persistence of perfluoroalkyl acid precursors in AFFF-impacted groundwater and soil	Houtz et al.	Environmental science & technology
Organic fluorine content in aqueous film forming foams (AFFFs) and biodegradation of the foam component 6 : 2 fluorotelomermercaptoalkylamido sulfonate (6 : 2 FTSAS)	Weiner et al.	Environmental Chemistry
Identification of Novel Fluorochemicals in Aqueous Film-Forming Foams Used by the US Military	Place et al.	Environmental Science & Technology
CEN/TS 15968:2010 - Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and fire fighting foams - Method for sampling, extraction and analysis by LCqMS or LC-tandem/MS		na

Total oxidisable precursor assay towards selective detection of PFAS in AFFF	Amin et al.	Journal of Cleaner production
Perfluoroalkyl and polyfluoroalkyl substances (PFASs) in consumer productsin Norway – A pilot study	Herzke et el.	Chemosphere

year	Comments	DOI link
2016b	method development for pre-screening	10.1039/C5RA26114G
2016a	method development for pre-screening	10.1016/j.eti.2015.12.003
2021	Focus on removal of PFAS	10.1021/acs.est.1c00769

2021 EPA method	10.1021/acs.estlett.0c00798
2021 na	10.1016/j.scitotenv.2020.142943
2021 na	10.1016/j.chemosphere.2020.127900
2021 na	10.1021/acs.est.0c04473

2020	Modified EPA Method 537.1 for targeted PFAS by Eurofins, in publication only non-targeted method is discussed	10.1289/EHP6470
2020	na	10.1021/acs.est.9b05440
2020	na	10.1021/acs.est.0c04798
2020	na	10.1016/j.watres.2020.116546
2020	na	10.1016/j.watres.2020.116207

2019	according to EPA Method 537	10.1021/acs.estlett.9b00154
2019		10.1021/acs.estlett.9b00196
2019	New method of linking fragment ions with their molecular ions by drift time using ion mobility spectrometry for PFAS based on fragmentation flagging	10.1016/ j.chemosphere.2019.124644
2019	na	10.1016/ j.chemosphere.2018.10.003

2017	Also applied to consumer products and groundwater (other sample treatment)	10.1021/acs.est.6b05843
2017	Also applied to water samples from AFFF impacted sites	10.1016/ j.chemosphere.2017.05.056
2017	Also applied to consumer products, lubricants	10.1016/ j.chemosphere.2016.11.127
2015	na	10.1002/etc.3115
2014	na	10.1021/es403729e
2013	na	10.1021/es3034999

2013	na	10.1021/es4018877
2013	na	10.1071/en13128
2012	na	10.1021/es301465n
2010	Also used for other matrices, sample treatmant different	na

2021	Recommendations for enhancement of the TOP assay are also provided	10.1016/ j.jclepro.2021.129568
2012	na	10.1016/ j.chemosphere.2012.03.035

PFAS	CAS (if available in publicat
PFOA, PFOS, 6:2 FTS	na
PFOA, PFOS, 6:2 FTS	na
48 targeted PFAS (12 found: PFCAs (n = 3-7), PFSAs (n = 3-8), Cl-PFSA (n = 8)) and 63 semi-quantificated PFAS including AmPr-FASA (n = 2-6), AmPr-FASA-PrA (n = 2-6), CEtAmPr-FASA-PrA (n = 2-6), Cl-PFSA (n = 4-6), CMeAmPr-FASA (n =4-6), CMeAmPr-FAS-PrA (n = 3-6), F5S-PFAS (n = 6), FASA (n = 4,6), PFCAs (n = 5), PFSAs (n = 3,4,6,7,8,10), UPFAS (n = 7,8), KPFAS (n = 5-8), MeEtCMeAmPr-FAAd (n = 4), MeFASAA (n = 5, 6), OAmPr-FASA (n = 5,6), O-PFAS (n = 5,6), PFASi (n = 4-6), PFCPeCA (n = 6), TAmPr-FASA (n = 3-6), TAmPr-FASAPrA (n = 3-6), UPFSA (n = 6-8) and 63 semi-quantificated PFAS	na

27 targeted PFAS including PFCAs (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA), PFSAs (PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS), FTSAs (4:2, 6:2, 8:2, 10:2), FBSA, FHxSA, FOSA, non-targeted PFAS, TF (total fluorine), EOF (extractable orgonofluorine), IF (inorganic fluorine), TOP (total oxidizable precuror)	identified PFAS: 1513864-10-2 (6:2 FTSAS-sulfoxide), 88992-45-4 (6:2 FTSHA), 88992-47-6 (6:2 FTSAS), 64972-10-7 (6:2 FTTh-PrAm), 27619-97-2 (6:2 FTSA), 34455-29-3 (6:2 FTSA-PrB), 80475-32-7 (6:2 FTNO), 76201-56-4 (EtOH-Am-Pr-PFHxSAPrS), 1513864-18-9 (6:2 FTSO-OHPrTAm)
Targeted PFCAs before/after TOP asssay	na
na	na
anionic, zwitterionic, and cationic poly- and perfluoroalkyl substances (PFASs)	na

100 non-targeted PFAS, 26 targeted PFAS: PFOS, PFHxS, PFPeS, PFBS, PFHpS, PFHxA, PFOA, PFPeA, PFHpA, PFBA, PFNS, PFDS, FOSA, PFNA, PFDA, PFUnA, PFDoA, PFTriA, PFTeA, NMeFOSAA, NEtFOSAA, 4:2 FTS, 6:2 FTS, 8:2 FTS, Perfluoro-1-hexanesulfonamide, N-(3-(Dimethylamino) propyl)tridecafluoro hexanesulphonamide	na
Non-targeted, 17 targeted PFASs: PFBA, PFPeA, PFBS, PFHxA, PFHpA, PFHxS, PFOA, 6:2 FTSA, PFNA, PFOSA, PFOS, PFDA, PFUnDA, PFDS, PFDoDA, PFTrDA, PFTDA, PFHxDA, PFOcDA, total fluorine/ inorganic fluorine	na
Non-targeted	na
Targeted analysis of 10 PFASs, suspect screening	na
na	na

Taregted: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, 4:2 FTS, 6:2 FTS, 8:2 FTS	na
4:2, 6:2, 8:2, and 10:2 FTOH, PFOA, PFBA, HFPO-DA	na
Targeted analysis of 34 PFASs (12 PFCAs, 3 PFSAs, 3 PAPs, 3 FTSs, 5 FTCAs, 3 FTUCAs, 3 FASAs, 2 FASAAs)	na
11 PFCAs (CnF2nþ1COO_x0003_, n ¼ 3e13), 5 PFSAs (CnF2nþ1SO3 _x0003_, n ¼ 4, 6, 7, 8, 10), 3 n:2 FTSAs (CnF2nþ1C2H4SO3 _x0003_, n ¼ 4, 6, 8), 3 fluorotelomer carboxylic acids (n:2 FTCAs, CnF2nþ1 CH2COO_x0003_, n ¼ 6, 8, 10), 3 fluorotelomer unsaturated carboxylic acids (n:2 FTUCAs, CnF2nCHCOO_x0003_, n ¼ 6, 8, 10), 5:3 ACID (C5F11(CH2)2COO_x0003_), perfluorooctane sulfonamide (FOSA, C8F17SO2NH2), Perfluorooctane sulfonamidoacetic acid (FOSAA, C8F17SO2NHCH2COOH), N-Methyl perfluorooctane sulfonamido_x0002_acetic acid (MeFOSAA, C8F17SO2N(CH3)CH2COOH), N-Ethyl per_x0002_fluorooctane sulfonamidoacetic acid (EtFOSAA, C8F17SO2N(C2H5) CH2COOH), 6:2 Fluorotelomer sulfonamide alkylbetaine (6:2 FTAB, C6F13C2H4S(O)2N(H)C3H6N(CH3)2CH2CO2H) and 6:2 Fluorotelomer sulfonamide propyl N$N dimethylamine (6:2 FtSaAM, C6F13C2H4S(O)2N(H)C3H6N(CH3)2)	na

Non-targeted: 57 classes of PFASs (40 new classes with over 240 individual PFAS) including N-SP-FASA, N-SPAmP-FASA, N-SHOPAmP-FASA, N-SPHOEAmP-FASA, N-SPAmP-FASAPS, N-DiHOPAmHOB-FASA, N-diHOPAmHOB-FASAPS, N-HOEAmP-FASAPS, N-HOEAmP-FASE, N-HOEAmHOP-FASA, N-HOEAmP-FASA, N-TAmP-N-MeFASA, N-TAmP-FASA, N-TAmP-FASAP, N-CMAmP-FASAP, N-CMAmP-FASA, CHAmEt-FA, CMAmB-FA	na
154 PFAS, 32 targeted PFAS including PFCAs (n = 3-13), PFSAs (n = 4,6,7,8,10), FTSAs (4:2, 6:2, 8:2), FTCAs (6:2, 8:2, 10:2), FTUCAs (6:2, 8:2, 10:2), 5:3 ACID, FOSA, FOSAA, MeFOSAA, EtFOSAA, 6:2 FTAB, 6:2 FtSaAM, total concentration of PFAA precursors	na
41 targeted PFAs including PFCAs (C4-C16), PFSAs (C4, C6, C8, C10), ipPFNS, PFPAs (C6, C8, C10), FOSA, N-Me FOSA, N-Et FOSA, FASAAs: FOSAA, N-MeFOSAA, N-EtFOSAA, N-MeFOSE, N-EtFOSE, FTSAs (4:2, 6:2, 8:2 FTS), FTOHs (4:2, 6:2, 7:2s, 8:2, 10:2), 8:2 FTI, 8:2 FTAC, 8:2 FTMAC	na
PFOS, PFOA, 6:2 FTS, 8:2 FTS	na
Non-targeted: 103 PFAS compounds in 22 classes with chain length from C3-C15 including PFAAB, FTSAB, FTSAS (6:2, 8:2), FTAB (4:2, 6:2, 8:2, 10:2, 12:2), FTB, FTSHA, PFASAC, PFASNO	na
4:2 FtTAoS, 6:2 FtAoS, 8:2 FtTAoS, 6:2 FtTHN+. 6:2 FtSaB, 8:2 FtSaB, 10:2 FtSaB, 6:2 FtSaAm, 8:2 FtSaAm, 5:1:2 FtB, 7:1:2 FtB, 9:1:2 FtB, 5:3 FtB, 7:3 FtB, 9:3 FtB, 4:2 FtS, 6:2 FtS, 8:2 FtS, PFBSaAm, PFPeSaAm, PFHxSaAm, PFHpSaAm, PFOSaAm, PFBSaAmA, PFPeSaAmA, PFHxSaAmA, PFHpSaAmA, PFOSaAmA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrA, PFTeA	na

22 PFAA precursors, transformation products, perfluorinated sulfonates and carboxylates including 6:2 FtS, 8:2 FtS, FOSA, PFNA, PFOA, PFHpA, PFHxA, PFPeA, PFBA, PFOS, PFHpS, PFHxS, PFBS	na
Total organofluorine, PFCAs (C4–14), PFSAs (C4, 6, 8–10), FTSA, FTSAS (4:2, 6:2, 8:2), 6 : 2 FTSAS-sulfoxide (FTSAS-SO) and sulfone (FTSASSO2), perfluorooctanesulfonamidoacetate (FOSAA), N-methyl perfluorooctanesulfonamidoacetate (MeFOSAA), N-ethyl perfluorooctanesulfonamidoacetate (EtFOSAA) and 6 : 2 fluorotelomer unsaturated acids (FTUCAs, 4 : 2, 6 : 2, 8:2, 10:2, 3:5, 5:3, 7:3)	na
temerization-based fluorinated surfactants including 4:2, 6:2, 8:2, and 10:2 fluorotelomer sulfonamide with dimethyl quaternary amine and carboxylic acid functional groups	na
PFOS, PFOSA, N-Me-FOSA, N-Et-FOSA, N-Me-FOSE alcohol, N-Et-FOSE alcohol, PFOS salt	1763-23-1 (PFOS) 754-91-6 (PFOSA) 24448-09-7 (N-Me-FOSE alcohol) 1691-99-2 (N-Et-FOSE alcohol)

Targeted PFCAs, PFSAs and fluorotelomer sulfonic acids before/after TOP asssay	na
PFAS (i.e. C4–C14 PFCAs, C4,C6,C8,C10 PFSAs, 6:2 and 8:2 fluorotelomersulfonates (FTSs), PFOSA, 4:2, 6:2, 8:2, 10:2 FTOH	na

Sampling	sample amount used
groundwater from Williamstown (Australia) spiked with PFOA	na
na	na
A stock AFFF solution was obtained from a U.S. Air Force Base	na

9 FT AFFF and 1 Class A foam (PFOS-CHEK, advertised as PFAS-free) were purchased from commercial sources in 2018.	na
23 industry samples	na
na	na
Soil and groundwater from an aqueous film-forming foam (AFFF)-impacted site	na

A legacy AFFF, a 3% application formula, was acquired through the MA-DEP. The formulation and manufacturer of this mixture were unknown.	na
A selection of firefighting foams from four categories was included in this study: (i) aqueous filmforming foams (AFFFs; n = 10), (ii) alcohol resistant aqueous film-forming foam (AR-AFFFs; n = 11), (iii) alcohol-resistant film-forming fluoroprotein (AR-FFFP; n = 1), and (iv) firefighting foams used for both class A and B fires (AB foam; n = 2). The foams were marketed as organofluorine-containing (n = 14) or as organofluorine-free (n = 10). All products were provided by European manufacturers.	na
Ten samples of AFFF formulations from seven brands were used in these studies. AFFF formulations were selected from the Department of Defense's qualified product list32 and are assumed to be in active usage; however, individual usage rates for the specific products tested here are not available.	20 µL diluted sample
	na
influent water (source waters were river or dam water), ozonation tank effluent, biological activated carbon (BAC) filtration effluent, groundwater treated by hardness reduction, and treated water	na

Various fluorosurfactants from Shanghei Vatten, China: 3 products that are sold in the domestic market (mainly PFOS based) and 4 alternative products of short chain PFAS-based products that are sold solely in foreign countries	na
4 commercially available fluoro products: three fluoro surfactants and an aqueous film-forming firefighting foam	20–500 µL
household fire estinguisher liquid	na
44 soil cores and 17 groundwater samples from fire fighting areas	na

AFFF samples obtained from U.S. military bases, 3M AFFF from 1988	1 mL diluted sample
Nine firefighting foam concentrates: Five concentrates were AR-AFFFPs, two were AR-AFFFs, one was a FFFP and one was fluorine-free (manufactured after 2002)	na
62 commercial AFFFs were colleted between 2012 and 2013 in Switzerland and divided into two sets according to the sampling source. A first set was derived from stock solution in fire installation (n = 27) of industrial sites storing chemicals andpetroleum products. A second set was originating from commercially available AFFF between 2012 and 2013 (n = 35) from 6 producers.	500 mg for LC-MS, 200 mg for GC-MS
3 new formulations of AFFFs, branded as Angus-fire Tridol, Ansulite, and Angus-fire Tridol	0.1 mL after oxidation
10 fluorinated AFFF concentrates, 9 of which were obtained from fire sites in Ontario, Canada, and two commercial fluorinated surfactant concentrates	na
12 AFFF formulations and 19 groundwater samples obtained from five different military bases within the United States	AFFF: 1.5 mL aliquot dilute, Groundwater: 3 mL

Archived samples of AFFF formulations manufactured by 3M, Ansul, Chemguard, National Foam, and Buckeye were obtained from U.S. military bases. Groundwater and soil samples were collected in October 2011 from a 1200 m by 600 m area encompassing the burn pit.	na
11 AFFF used to extinguish fires in Ontario, Canada, and one commercial product from 3M	na
74 QPL-listed AFFF samples with manufacturing dates ranging from 1984 to 2011. Sampling from 21 different US Navy and Air Force military bases within the United States. Sampling instructions specifically stated to sample AFFF from their original product container in order to avoid mixtures of products.	FAB: 10:1 with methanol, UPLC/QTOF: ~12 ppb, 20 µL sample injection size
Liquids: method which will provide a representative sample of the liquid to be tested.	see sampling

FFF samples were provided by the Department of Defence, Australia, including Orchidee (#1), Wormald (#2), and Ansulite (#3 and #4)	1 mL sample, diluted in TOP assay reagent (9 mL)
30 products in 6 different product groups: waterproofing agents, paint, coated fabrics, non-stick ware, electronics and fire fighting agents. They were purchased from retailers in Norway and Sweden.	1 g

Pre- treatment	Extraction
incubated GO membrane in an aqueous solution containing fluorosurfactant (FS), dye and AgNP for an assembly of dye-FS-AgNP-GO	na
na	na
1:93,000 diluted AFFF solution	na

dilutions with Mili-Q water (10000x for non-targeted, 7500x for TF and IF, 50000x for EOF and targeted)	SPE; no extraction for TOP assay
UV-based TOP method as faster replacement of conventional heat-based TOP assay, diluted 1000–10,000 times	SPE according to EPA Method 537
auto_x0002_mated solid phase extraction (ASPE)	na
na	na

1:1,000 serial dilution of the 3% sample	na
Sample was mixed to avoid foam formation and were let to rest for a short time period before pipetting and diluting first with deionized water (DI) and then with methanol. A final dilution factor of 100 was obtained for target analysis and for CIC analysis of “organofluorine-free foams” and 10,000 for CIC analysis of organofluorinecontaining foams with a mixture of water:methanol (1:1). For ISE measurement: 20 mL of deionized water, 20 mL of buffer solution, and 100 µL of the foam were mixed in a beaker using a stirring bar	na
AFFF formulations were diluted 100-fold in deionized water.	na
solid-phase extracted by a concentrator (Waters corporation) through an Oasis WAX cartridge	na

direct PFAS analysis: sample diluted, pH adjusted to 5-9; TOP assay (total oxidizable precursor): diluted with deionized water (1:10000 on average), potassium persulfate and sodium hydroxide (6 h at 85 °C) (PFAA precursors to PFCAs)	SPE for not oxidized samples
direct sampeling without pre-treatment	na
diluted 1:100 in methanol	na
solid phase extraction (SPE) (cartridge Strata X-AW 200mg/6 mL; Phenomenex®, France) according to a method previously described (Boiteux et al., 2016) The TOP assay was conducted on aqueous samples using the methods described by Glover et al. (2018).	na

diluted by a factor of 99 000 in 30% methanol (v/v) in water	na
diluted in water (5000 to 10 million fold), oxidatiive conversion method to transform PFAA precursors to PFCAs: hydroxyl radicals generated by the thermolysis of persulfate under alkaline pH conditions	only for oxidated samples: SPE
LC-MS: dissolved in 10 mL water, adding methanol/water, ammonium acetate (pH 4), GC-MS: dissolved in 10 mL methanol, filtration	LC-MS: SPE with methanol/ ammonium acetate (50:50)
diluted in water, oxidation with KMnO4 and HCl (30 d)	na
FTICR-MS: diluted between 1000 and 100 000 times	Ion Exchange SPE
AFFF: diluting into methanol (100,000- and 10 million-fold), Groundwater: sonicated	AFFF: no extraction, Groundwater: micro-LLE

AFFF: two sequential thousand-fold dilutions in methanol, Groundwater: Mixed 1:1 with methanol, dilution	Soil: sonification in methanol
TOF: diluted 1000-fold with water, LC-MS: diluted by at least 20 000 to 200 000-fold	LC-MS/MS: ion-pair method, GC-MS: XAD cartridges
diluted to lower concentration with methanol, mixed with 3-NBA for FAB	no extraction
Dilution for AFFF: Pre-dilute the sample in separate steps with purified water or methanol (1:10 v/v, 1:100 v/v, 1:1 000 v/v) and mix sufficiently (e.g. 500 µl sample into 4 500 µl diluent). Ensure that there is no phase-separation in the sample. If necessary centrifuge the sample to precipitate non soluble particles. Dilute the pre-diluted sample 1:10 with water or methanol and an appropriate volume of internal standard solution (e.g. 100 µl diluted sample, 100 µl reference solution, 800 µl water or methanol) to have in every dilution (1:10 v/v, 1:100 v/v, 1:1 000 v/v) the same concentration of the internal standard. Transfer an aliquot to a LC vial and analyse the sample. If high PFOS concentrations are expected, begin with the highest dilution (1:10 000 v/v) to avoid a carry over.	no extraction

1 mL sample was added into a TOP assay reagent of 9 mL containing 0.066 M of $K_2S_2O_8$ and 0.15 M of NaOH in a 15 mL centrifuge tube. The mixture was then heated at ~85 ◦C for ~6 h in a temperature-controlled water bath. After the oxidative reaction step, the sample was cooled down to room temperature. The pH of the sample was adjusted to pH 5–9 with concentrated HCl to halt the TOP assay reaction (optimal at pH> 12) and enable the app-based test (optimal at neutral pH). To further halt the reaction, the sample was treated for ~10 min with ultra-sonication. The samples were then stored at 4 ◦C prior to analysis	no extraction
Liquid and solid samples were homogenized	methanol for ionic compounds and ethylacetate for FTOH

Clean up	Measurement
After loading, the SERS substrate was washed with water and gently dried with nitrogen blow	surface-enhanced Raman scattering (SERS)
na	Potentiometic detection based on molecular imprinted polymer (MIP), SEM/EDX
na	A Sciex X500R Quadrupole Time-of-Flight MS (QToF/MS) system using SWATH® Data-Independent Acquisition was operated in both positive and negative electrospray ionization (ESI+/-) mode for QToF-MS and MS/MS analysis.

The extracts were blown to dryness using a nitrogen evaporator and reconstituted in 1 mL of LC-MS grade methanol and split between combustion ion chromatography (CIC) and LC-MS/MS.	TF/EOF/IF: CIC, TOP assay, LC-MS/MS (targeted), Non-targeted: UPLC with Thermo Orbitrap Fusion mass spectrometer	
na	LC-MS/MS, (UPLC, Dionex UltiMate 3000, USA) combined with a tandem triple quadrupole mass spectrometry (MS/MS, AB SCIEX API 3200, Canada)	
na	LC-MSMS The TOP assay was employed to verify a material balance around the precursor compounds. This assay generates hydroxyl radicals by the thermal breakdown of persulfate under basic conditions (Houtz and Sedlak, 2012).	
na	LC-QTOF-MS Acquisition for Soil Analysis LC-MS/MS Acquisition for Groundwater Analysis	

na	UHPLC (mobile phase consisted of a) 2mM ammonium acetate; and b) 2mM acetonitrile). The Xcalibur™ (version4.1; Thermo Fisher Scientific) with Qualbrowser was used for the peak detection, and Compound Discoverer software (version 3.0.0; Thermo Fisher Scientific) with mz Cloud was used for the non-target screening of PFAS compounds.
na	UPLC-qTOF-ESI-MS (non-targeted), UPLC-MS/MS (targeted), combustion ion chromatograph (CIC) for total fluorine, ion-selective electrode (ISE) for inorganic fluorine
na	LC-IMS-MS (IMS-QTOF with ESI), MS/MS using a triple, quadrupole mass spectrometer LC-QToF-MS; SCIEX (Framingham, MA) X500R QTOF system
na	profile analysis with suspect screening against two lists in the NORMAN Suspect List Exchange in firefighting foam impacted environmental and drinking water LC-QTOF-MS in full scan mode (m/z = 50–1700)

na	UPLC-MS/MS
na	ToF-CIMS
na	LC/IM-QTOF-MS
na	LC-MSMS performance of the analytical method are given in Boiteux et al. (2016)) and TOPA The total oxidizable precursor (TOP) assay was performed ac_x0002_cording to the protocol described by Houtz and Sedlak (2012))

na	LC-qTOF-ESI-MS
na	HPLC-ESI-MS (coupled to QTAP in case of 6:2 FTAB, 6:2 FtSaAM)
LC-MS: adding ammonium hydroxide in methanol (0.5 %), neutralized with acetic acid	LC- MS/MS, GC-MS/MS for FTOHs, FTI, FTAC, FTMAC
heated, dried, dissolved in water	Before and after oxidation: HPLC-MS, astk CARE testing kit (visible test of anionic surfactant concentration), ion chromatography,
TOF: convert organic fluorine into HF in AQF combustion furnace at 900–1000 °C	TOF-CIC, QTOF-MS, FTICR-MS, LC-MS/MS
Groundwater: Methanol added	LVI-HPLC-MS/MS

Precursor Oxidation Assay with hydroxyl radical (potassium persulfate in NaOH), For soil ENVI-CARB clean-up, neutralized with HCl and amended with methanol	LC-MS/MS
TOF: convert organic fluorine into HF in AQF combustion furnace at 900–1000 °C,	TOF-CIC, GC-MS (6:2 FTOH, 6:2 FTSH), LC-MS/MS, 19F NMR
na	FAB-MS, UPLC/QTOF-MS
na	LC-qMS, LC-tandemMS

no clean-up	HPLC-MS/MS and app-based sensor
Centrifugation and solvent evaporation, clean up with ENVI-Carb and glacial acetic acid (for ionic PFAS)	GC-MS

Quantification method	Working range (ng/r	Matrices	Reported levels (ng/mL)
no quantification	na	AFFF	na
no quantification	10 µM - 10 mM	AFFF	na
Internal standardisation using mass-labeled standards and semi-quantification of 63 PFAS through suspect screening analysis	na	AFFF	Together, the target analytes and suspect structures are estimated to contribute 129 µg/L of fluorine content to the diluted AFFF.

Quantifiying oxidizable precursors using bayesian inference, Internal standardisation using mass-labeled standards for targeted analysis, TF and EOF: Concentrations were determined from the average peak areas of duplicate injections using an eight-point calibration curve of PFOA	na	AFFF	EOF in PFAS-containing AFFF ranged from 220 to 840 mM F, Targeted PFAS explained ≤1% of EOF in FT AFFF
isotope-labelled surrogate standards and internal standards	na	fluorocarbon surfactants (FSs)	PFCA concentrations before and after normal TOP assay were 0–4290 mg L−1 and 438–77,420 mg L−1, respectively. The PFCAs after 60 min UV-based TOP assay was 310–81,881 mg L−1
isotopes	na	water and foam	na
na	na	soil and water	Zwitterionic and cationic compounds composed a majority of the total PFAS mass (up to 97%) in firefighter training area (FTA) soil Perfluorohexane sulfonamide, a potential transformation product of sulfonamide-based PFASs, was present at high concentrations (maximum 448 ng/g in soil, 3.4 mg/L in groundwater).

26 PFAS quantified by modified EPA Method 537.1 by Eurofins	na	AFFF	PFOS was measured at the highest concentration (9,410 mg/L) followed by PFHxS (1,500 mg/L)
Targeted standardisation using mass-labeled standards, Free inorganic fluoride (IF) was quantified using a fluoride ion-selective electrode (ISE)	na	AFFF	Organofluorine surfactants varied between 0.4 and 41.2 mg/L. Among the organofluorine-containing foams, 6:2 FTSA showed a high relative contribution.
no quantification	na	AFFF	na
Targeted: standards	na	AFFF	
time-aligned in Profinder 8.0 software (Agilent) (Table S2). Suspects were screened against molecular formulas in the NORMAN Suspect List Exchange (Nos. 25, 46), a list of PFASs in the OECD PFASs global database compiled by the U.S. EPA (No. 25, 2019), and a list of PFASs discovered by non-target HRMS	na	foam contaminated water	Long-chain perfluoroalkyl acids (PFAAs) and some of their precursors were specifically found around the firefighting training area The concentration of PFOS in river water was 65–196 ng/L, PFHxS was 88–444 ng/L, PFOA was 0.4–19 ng/L, perfluorohexanoic acid (PFHxA) was 25–78 ng/L

internal standardisation using mass-labeled standards	na	FS, AFFF	Domestic products PFSAs: 0.02–101 g L−1 (mainly PFOS), Alternative products PFASs: ND - 2.1 g L−1 (mainly PFHxS)
Instrument calibrations	na	FS, AFFF	6:2 FTOH up to 948 ng µL-1
no quantification	na	household fire extinguisher liquid	na
na	na	soil and water	highest total PFAS concentrations (up to 357 mg/g) The highest total PFAS concentrations were recorded in the monitoring wells located in the perimeter of the firefighter training site and in the spring located downgradient in the direction of groundwater flow. They ranged from 300 to 8300 ng/L

no quantification	na	AFFF	na
internal standardisation using mass-labeled standards	na	firefighting foam	22500-3188000 µg/L
internal standardisation using mass-labeled standards	na	AFFF	PFOS Median: 635 mg/kg
calibration curve using standard solutions of PFOA, PFOS, 6:2FTS, and 8:2FTS	na	AFFF	6:2 FTS up to 1010 ppm (mg/L) after oxidation, no PFOS
TOF-CIC: external calibration, no quantification for MS	na	AFFF	TOF: up to 55 µg of F
internal standardisation using mass-labeled standards	na	AFFF, groundwater	AFFF: up to 550 ng/L for PFPeSaAm, Groundwater: up to 6900 ng/L for 6:2 FtTAoS, 360,000 for PFHxS

isotope dilution with isotopically labeel standards, fluorotelomer precursors with C6 homologue, estimation for no standard avaliable	na	AFFF, groundwater, soil	AFFF: oxidation of PFAA generate 5.9 - 10.8 g/L carboxylates, Groundwater: PFOS = 19 µg/L, PFOA = 26 µg/L, PFHXS = 71 µg/L, PFHxA = 36 µg/L; Soil: PFOS = 2400 µg/kg, PFHxS = 66 µg/kg
TOF: conductivity detector, LC-MS: PFCAs/ FTUCAs: internally calibrated using corresponding mass-labelled standards (PFOS, PFDoDA), 6:2 FTSA/6:2 FTSAS: External calibration	na	AFFF	TOF: 475 to 18 000 µg F mL-1, 6:2 FTSAS > 1000 µg mL-1
no quantification		AFFF	not reported
Quantify the samples by using the unextracted external calibration curve. When spiking with labelled reference solutions, the determination of the concentration is independent of possible errors made during injection. Also, errors caused by sample losses during distinct steps of sample pre-treatment or the adjustment of final sample extract volume as well as matrix effects in the sample are accounted for.	Method is applicable for a concentration range for PFOS in the extract solution of 0,5 µg/l to 50 µg/l.	Coated materials like paper, textile, leather, carpets, clothes and footwear, Non-coated materials, liquids	na

Quantification was performed by producing a calibration curve using standard solutions (external) of PFOA and PFOS (only linear isomers) with correlation coefficients higher than 0.99.		AFFF	range 10 - 500 µg/L
internal standard	na	food contact paper, textile, fire fighting foam, water proofing agents and lubricants, paint, leather, carpets, non-stick ware, printed circuit boards	

info - validation of the method	Limitations
na	na
na	na
na	na

Recoveries for each targeted PFAS 77 ranged from 72-130%, except for 8:2 FTSA (62%) and 10:2 FTSA (45%), TF: Relative standard deviations of duplicate injections <8% and method recovery 99%, EOF: relative standard deiations <5%, method recovery 96%	The availability of analytical standards has not kept pace with the new PFAS in commerce, and the existence of chemical standards does not always immediately result in the expansion of common PFAS testing panels.
na	na
recovery: 14-23% RSD 95%	na
na	na

na	na
several quality control tests, replicate, blank samples,... Robustness: two different chromatographic analyses gave comparable mass spectra	na
na	na
na	na
na	na

strictly following the quality assurance and quality control procedure	na
na	na
na	na
	na

na	na
na	na
na	na
results from 2 laboratories were consistent	na
	na
na	na

na	na
relative standard deviations for the same sample analysed on different days were less than 10%for total fluorine and less than 5% for inorganic fluorine	na
	A limitation of the FAB-MS/QTOF-MS method is that it can only capture the major components and that minor (approximately <0.1%) fluorochemical compounds may go undetected
The recovery of labelled reference compound shall be in the range from 70 % to 125 % for the sample to be considered valid. The dilution error introduced by this method should be much smaller than the analytical error involved in the method. As a general rule the dilution error should be less than 1 %.	na

For quality assurance and quality control (QA/QC), at least three samples were run in parallel for each test including one for the ‘‘Before’’, one for the ‘‘Control’’ and one for the ‘‘After’’ sample. Moreover, TOP assay results using HPLC presented in this work were also validated with assistance from ALS Global, to compare with the results in our laboratory, including using HPLC and app-based sensors. Laboratory duplicate, method blank, laboratory control spike and matrix spike were generally conducted to monitor the test recovery and the acceptance limits	The possible reasons for the variations: (i) further oxidation might release an ultrashort chain of PFAS that currently cannot be quantitatively monitored; (ii) incomplete oxidation of PFAS precursors due to the presence of organic matter; (iii) the random nature of TOP assay oxidation that can be affected by many parameters, including the TOP assay reagent amount and the initial concentration of PFAS.
As standard procedure, laboratory blanks, method detection limits (MDLs) and recoveries were examined. For each sample, a high resolution full scan spectra was used to control positive detections (typical mass tolerance 50 ppm). No laboratory contamination for any of the analyzed compound was detected	na

LoD (ng/mL)	subgroup	Measurement - generic name
~50 ppb (~120 nM for PFOA)		SERS
down to 100 nM (~41 ppb for PFOA)		sensor (MIP, SEM/EDX)
not reported		LC-HRMS

Targeted: MDL = 2.78-38,86, 116.92 (PFTeDA), 131.88 (PFNS) nM F		CIC, TOP assay, LC-HRMS
na	na	LC-MS/MS
na		LC-MS/MS
na		LC-HRMS

MDL= 6750-250000 ng/L	LC-MS/MS
Targeted: MDL = 1-2 µg/L, CIC: MDL = 0.2 m/L, ISE: MDL = 800 µg/L	LC-HRMS
not reported	LC-HRMS (with ion mobility)
SI (no access)	LC-HRMS
na	LC-HRMS

LOD = 0.09-0.60 ng mL-1, LOQ = 0.11-1.79 ng mL-1	LC-HRMS
detection limit: 1.4-7.9 pptv	LC-HRMS
not reported	LC-HRMS
na	LC-MS/MS

not reported	LC-MS/MS
LOQ = 5000 µg/L for targeted PFASs	LC-HRMS
LOQ: 0.5-2 ng/mL (LC-MS), 2-10 ng/mL (GC-MS)	LC-MS, GC-MS
LOD ~0.2 ppm, astkCARE testing kit: LOD = 0.1 ppm	LC-MS/MS
not reported	LC-HRMS, LC-HRMS
Median LOD = 1.7 ng/L (0.71 ng/L for PFDS - 67 ng/L for 6-2 FtSaAm), LOQ = 2.4 - 221 ng/L	LC-MS/MS

Soil preparation: LOD = 0.4 to 3 µg/kg, Groundwater preparation: LOD = 0.1 to 0.5 µg/L	LC-MS/MS
LOQ = 0.05 - 1 µg/mL, 1 µg/mL for 6:2 FTCA, 5:3 FTCA, other analytes < 0.2 µg/mL	CIC, GC-MS, LC-MS/Ms, 19F NMR
FAB-MS analysis has poor sensitivity (approximately mg/L levels)	FAB-MS, LC-HRMS
na	LC-MS/MS

HPLC-MS/MS and app-based sensor in the range of 10 - 500 µg/L		LC-MS/MS, sensor
MDLs not reported		
	na	GC-MS

Title

Per- and polyfluoroalkyl substances in serum and associations with food consumption and use of personal care products in the Norwegian biomonitoring study from the EU project EuroMix

Automated online solid-phase extraction liquid chromatography tandem mass spectrometry investigation for simultaneous quantification of per- and polyfluoroalkyl substances, pharmaceuticals and personal care products, and organophosphorus flame retardants in environmental waters

Per- and polyfluoroalkyl substances and fluorine mass balance in cosmetic products from the Swedish market: implications for environmental emissions and human exposure

Fluorinated Compounds in North American Cosmetics

Correction to “Fluorinated Compounds in North American Cosmetics”

Occurrence of perfluorinated carboxylic acids (PFCAs) in personal care products and compounding agents

Faktablad – PFAS i kosmetiska produkter

Risk assessment of fluorinated substances in cosmetic products

Authors	Journal	year
Thepaut et al.	Environmental Research 2021 Vol. 195	2021
Zhong et al.	Journal of Chromatography A 2019 Vol. 1602 Pages 350-358	2019

Schultes et al.	Environmental Science-Processes & Impacts 2018 Vol. 20 Issue 12 Pages 1680-1690	2018
Whitehead et al.	Environ. Sci. Technol. Lett. 2021, 8, 538−544	2021
Whitehead et al.	Environ. Sci. Technol. Lett. 2021, 8, 1104−1105	2021
Yukiko Fujii et al.	Chemosphere	2013

Naturskyddsföreningen (Nature Conservation Association)	na	na
The Danish Environmental Protection Agency	na	20018

comments (t, nt, o)	DOI link
na	10.1016/j.envres.2021.110795
na	10.1016/j.chroma.2019.06.012

na	10.1039/c8em00368h
na	10.1021/acs.estlett.1c00240
Due to a calibration problem with the targeted analysis affecting only the Canadian products (n = 17), in our original article (https://pubs.acs.org/doi/10.1021/acs.estlett 1c00240), data for Canadian products were requantified using the isotopically labeled surrogate standards	https://pubs.acs.org/doi/10.1021/acs.
	10.1016/j.chemosphere.2013.06.0
na	

na	https://old.naturskyddsforeningen.se/sites/default/files/dokument-media/bilaga_press_och_webb.pdf
na	https://www2.mst.dk/Udgiv/publicati

PFAS

6:2PAP, 8:2PAP, 6:2diPAP, 8:2diPAP,
PFHxPA, PFOPA, PFDPA, PFBS, PFHxS, PFHpS, PFOS, PFDS,
PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA,
PFDoDA, PFTrDA,
PFTeDA, PFOSA, MeFOSA and EtFOSA

perfluorobutanoic acid (PFBA); perfluoropentanoic acid (PFPeA); perfluorohexanoic acid (PFHxA); perfluoroheptanoic acid (PFHpA); perfluorooctanoate (PFOA); perfluorononanoic acid (PFNA); perfluorodecanoic acid (PFDA); perfluoroundecanoic acid (PFUnDA); perfluorododecanoic acid (PFDoDA); perfluorotridecanoic acid (PFTrDA); perfluorobutanesulfonate (PFBS); perfluoropentanesulfonate (PFPeS); perfluorohexanesulfonate (PFHxS); perfluoroheptanesulfonate (PFHpS); perfluorooctanesulfonate (PFOS) perfluorodecanesulfonate (PFDS); 4:2 fluorotelomer sulfonic acid (4:2 FTS); 6:2 fluorotelomer sulfonic acid (6:2 FTS); 8:2 fluorotelomer sulfonic acid (8:2 FTS); N_x0002_ethylperfluorooctanesulfonamide (EtFOSA); N-methylperfluorooctanesulfonamide (MeFOSA); chlorinated polyfluorinated ether sulfonate (6:2F-53B);

linear isomers of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFHxS, PFOS, FOSA, 6:2 FTSA, 6:2 monoPAP, 8:2 monoPAP, 6:2/6:2 diPAP and 8:2/8:2 diPAP. Level 2 was given to the following 13 targets for which a native standard was available but not an exactly matched isotopically labelled standard: PFTrDA, ADONA, 9Cl-PF3ONS, 11Cl-PF3OUdS, PFBS, PFDS, FOSAA, 4:2 FTSA, 8:2 FTSA, 4:2 monoPAP, 10:2 monoPAP, 4:2/4:2 diPAP and 6:2/8:2 diPAP.

Total fluorine, Targeted analsis of PFPrA, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFHxDA, GenX, PFPrS, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFECHS, Cl-PFOS, 6:2 FTCA, 8:2 FTCA, 4:2 FTSA, 6:2 FTSA, 8:2 FTSA, 6:2 Cl-PFESA, 8:2 Cl-PFESA, FBSA, FHxSA, FOSA, MeFOSA, EtFOSA, 6:2 PAP, 8:2 PAP, 6:2 diPAP, 6:2/8:2 diPAP, 8:2 diPAP, 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, MeFOSE, EtFOSE, 6:2 FTAc, 8:2 FTAc, 10:2 FTAc, 6:2 FTMAc, 8:2 FTMAc

na

Target PFAS included PFHxA,PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA

16 different PFAS were analysed: (PFBS, PFHxS, PFOS, PFDS, PFOSA, 6:2 FTS, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTriDA, PFTeDA, and PFHxDA

TOF and targeted analysis of
Perfluorobutanoic acid (PFBA)
Perfluoropentanoic acid (PFPeA)
Perfluorohexanoic acid (PFHxA)
Perfluoroheptanoic acid (PFHpA)
Perfluorooctanoic acid (PFOA)
Perfluorononanoic acid (PFNA)
Perfluorodecanoic acid (PFDA)
Perfluoroundecanoic acid (PFUnA)
Perfluorododecane acid (PFDoA)Perfluorotridecanoic acid (PFTrA)
Perfluorotetradecanoic acid (PFTeA)
Perfluoro-3,7-dimethyloctanoic acid (PF-3,7-DMOA)
7H-Dodecafluoroheptanoic acid (HPFHpA)
Perfluorobutane sulfonate (PFBS)
Perfluorohexane sulfonate (PFHxS)
Perfluoroheptane sulfonate (PFHpS)
Perfluorooctane sulfonate (PFOS)
Perfluorooctane sulfonamide (PFOSA)
Perfluorodecane sulfonate (PFDS)
4:2 Fluorotelomer sulfonate (4:2 FTS)
6:2 Fluorotelomer sulfonate (6:2 FTS)
8:2 Fluorotelomer sulfonate (8:2 FTS

CAS (if available in source)
na
na

na

na

na

na

na

na

Sampling	sample amount used
Participants (44 males and 100 females) kept detailed diaries on their food consumption and their PCP use for two non-consecutive days. All urine (24 h) and blood samples were collected at the end of each study day	50 µL of blood
na	na

thirty-one CPs from five product categories (cream, foundation, pencil, powder and shaving foam)	0.1 g for LC-MS (injected (5 µl)), 100 µl sample extracts for TF/EOF, 5 mg of neat CP material for TF analysis and 0.05–0.8 g of CP material for EOF depending on the expected fluorine concentration.
231 cosmetic products, 29 for targeted analysis	50–100 mg for targeted analysis
na	na
16 commercially available cosmetic samples and 10 sunscreen products distributed by eight different companies. In addition to these end consumer products, we also obtained commercially available compounding agents, including mica and talc, which were treated with PAPs.	1–200 mg depending on the PFCA concentration

22 cosmetic products from nine different brands, The products come from well-known brands and were randomly selected. All products had declared contents of fluorine.	na
18 products that had declared content of the selected PFAS	0.1 g for LC-MS, 1 g for TOF

Pre- treatment

na

An automated Agilent 1260 Infinity Flexible Cube was employed to achieve online preconcentration of all analytes

LC-MS: samples vortexed

used without homogenizing the entire mass or volume

na

na

na

homogenised, tablets pressed for TOF

Extraction	Clean up
na	na
na	na

LC-MS: sonication in methanol/NaOH (method adapted from Powley et al. (2005))	LC-MS: concentrated, Supelclean ENVI-carb. Before injection, the samples were vortexed, centrifuged and transferred to a micro vial.
targeted analysis: sonicating twice with 4:1 hexane–isopropanol and twice with 1:1 methanol–acetonitrile	Targeted analysis: Envi-Carb for cleanup, concentrated again under nitrogen, and filtered
na	na
ion-pair extraction	No further clean-up was conducted

na	na
LC-MS: sonification with methanol, no extraction for TOF	LC-MS: activated carbon was added to the sample extract to eliminate interfering sample matrix components, some additionally purified by solid-phase extraction (SPE)

Measurement

a high throughput online solid phase extraction ultra-high_x0002_performance liquid chromatography tandem mass spectrometry
(UHPLC–MS/MS) method as described by Poothong et al. (2017a)

An Agilent 1260 series RPLC was used to perform chromatographic analyses. The analytical separation was achieved using an Agilent Poroshell 120EC-C18 (3.0 × 50 mm, 2.7 µm) column maintained at 30 °C. A delay column (Agilent Eclipse Plus C18, 4.6 × 50 mm, 5.0
µm) was installed after the mixing valve of the binary pump. The second valve was switched at 4 min. For chromatographic elution, the mobile phase was composed of acetonitrile (ACN) and water with 0.05% formic acid, and the flow rate was 0.30 mL min-1
. The gradient elution profile was programmed as follows: 0-4 min, 5% ACN; 4-9 min, 5-60% ACN; 9-16 min, 60-100%
ACN; and, 16-21 min, 100% ACN. A 9 min re-equilibration period was included before the next analysis, resulting in an overall method run time of 30 min An Agilent 6470 triple quadruple mass spectrometer with a Jet Stream electrospray ionization (ESI) source was operated under dynamic multiple reaction monitoring (DMRM) mode with a retention time (RT) window of 1-2 min.

liquid chromatography_x0002_tandem mass spectrometry, as well as extractable organic fluorine (EOF) and total fluorine (TF) by combustion ion chromatography (CIC) Extracts were injected (5 ml) onto an Acquity UPLC (Waters Corp., Milford, MA) equipped with BEH C18 guard (5 _x0003_ 2.1 mm, 1.7 mm particle size) and analytical (50 _x0003_ 2.1 mm, 1.7 mm) column operated at 40 _x0004_C. Detection of PFASs was carried out using a triple quadrupole mass spectrometer (Xevo TQ-S, Waters Corp, Mil_x0002_ford, MA) operated in negative electrospray ionization mode according to a method reported by Gebbink et al TF and EOF measurements were carried out at SU using a Thermo-Mitsubishi combustion ion chromatograph (CIC). Sample extracts (100 ml) were placed in a ceramic sample boat containing glass wool for better dispersion of the fluids while neat CP material was weighed directly into the sample boat. All boats were baked prior to sample combustion to minimize background contamination. The samples were combusted slowly in a combustion furnace (HF-210, Mitsubishi) at 1100 _x0004_C under a flow of oxygen (400 l min_x0001_1) and argon mixed with water vapor (200 l min_x0001_1) for approximately 5 minutes. Combustion gases were absorbed in MilliQ water during the entire length of the combustion process using a gas absorber unit (GA-210, Mitsubishi). An aliquot of the absorption solution (18 or 200 ml, depending on sample concentration) was injected onto an This journal is © The Royal Society of Chemistry 2018 Environ. Sci.: Processes Impacts, 2018, 20, 1680–1690 | 1683 Paper Environmental Science: Processes & Impacts Open Access Article. Published on 01 November 2018. Downloaded on 1/21/2019 4:25:52 AM. This article is licensed under a Creative Commons Attribution-NonCommercial 3.0 Unported Licence. View Article Online ion chromatograph (Dionex Integrion HPIC, Thermo Fisher Scientific) equipped with an anion exchange column (Dionex IonPac AS19 2 _x0003_ 50 mm guard column and 2 _x0003_ 250 mm analytical column, 7.5 mm particle size) operated at 30 _x0004_C.

total fluorine using PIGE, targeted LC-MS/MS and GC-MS

total fluorine using PIGE, targeted LC-MS/MS and GC-MS

GC/ECNI/MS in selected ion monitoring mode (Agilent 6890GC/5973MSD inert, Agilent Technologies Japan, Ltd., Tokyo, Japan)

LC/HRMS-MS

LC-MS/MS, IC for TOF

Quantification method	Working range (ng/n	Matrices
Multivariable linear regressions were performed between each food and PCP category and each chemical and were sex_x0002_stratified when the consumption of food or use of PCPs was significantly different between men and women.	na	serum and urine
na	na	drinking water, surface water and waste water

Quantification of TF and EOF was carried out using a linear six-point calibration curve of PFOS ranging from 0.5 to 100 µg ml−1	0.5 to 100 µg ml−1	moisturizing creams (abbreviated CRE), founda_x0002_tions (FOUN), powders and eye shadows (POW), eye pencil (PEN) and shaving foams (SHAV)
surrogate standards	na	various cosmetic samples
isotopically labeled surrogate standards	na	foundation, lip, mascara
internal mass-labeled standards and external calibration standards	na	cosmetic samples (Manicure, (powder) foundation, Lip rouge), suncream samples

na	na	cosmetic samples
internal standards for LC-MS	na	cosmetic samples

reported levels (ng/mL)	info - validation of the method
PFHxS, PFHpS, PFOS, PFDS, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, and 6:2diPAP were detected in 75–100% of the serum samples. PFHxPA, 8:2diPAP, PFHxA, PFOSA, and PFBF were detected in 52–68% of the serum samples, while MeFOSA, 8:2PAP, 6:2PAP, PFPeA, and PFTeDA were detected in 3–29% of the samples. Some chemicals (PFOPA, PFDPA, PFHxA and EtFOSA) were below the LOD in all serum samples On average, they were found at 5.7, 1.7, 0.9, and 0.8 ng/mL in females and 9.3, 2.1, 1.3, and 1.1 ng/mL in males	The accuracy of the method ranged between 90% and 114%
six other PFAS (e.g., PFBS, PFHxA, PFOA, PFOS, PFNA, and PFUnDA) were detected in surface water at concentration below 18 ng L-1 . PFOAwas the only PFAS detected in the DWTP influent. Besides the six PFAS mentioned above, PFPeA, PFHpA, PFDA, and 6:2 F-53B were also detected in WWE at concentrations ranging from 2 to 48 ng L-1	accuracy with 82% of analytes exhibiting 70-130% recovery linearity (R2 was higher than 0.984 Analyte recovery and intra-day precision were evaluated in triplicate Recovery was determined by comparing the concentration measured by the online SPE-LC-MS/MS method, calculated using the calibration curve for ultrapure water (above), with the initial spiking levels. recoveries of 70-130%. The intra-day precision of each analyte at the three spiking levels was evaluated as the relative standard deviation (RSD) of the replicate measurements. The inter-day precision was reported for each matrix as the RSD of 15 replicates magnitude of MEs on ESI for some analytes

Foundations and powders contained 25 different PFASs with the most frequently detected being perfluorinated carboxylic acids (perfluoroheptanoic acid and perfluorohexanoic acid) and polyfluoroalkyl phosphate esters (PAPs). S14PAP concentrations up to 470 mg g_x0001_1 creams, pencil and shaving foams did not contain measurable concentrations of any of the 39 PFASs targeted. The highest TF concentrations were found in powders (547–19 200 mg g_x0001_1), closely followed by creams (<LOD – 11 100 mg g_x0001_1) and foundations (326–3120 mg g_x0001_1).	PFASs measured by LC-MS/MS, triplicate spike/ recovery experiments were performed by fortifying a PFAS-free cosmetic (FOUN07) at two forti□cation levels Method accuracy, as assessed through spike/recovery experi_x0002_ments, ranged from 71 to 126% for most PFASs Results of the inter-laboratory comparison on a subset of 18 samples (unforti□ed) revealed good agreement between labs, with a coefficient of determination of 0.9605 for 11 targeted PFAS measuremen
foundations, mascaras, and lip products had the highest proportion of products with high total fluorine ≥0.384 µg F/cm2 PFAS concentrations ranged from 22–10,500 ng/g product weight	matrix spike recoveries of individual analytes were all within 80%–115%
foundations, mascaras, and lip products had the highest proportion of products with high total fluorine **≥0.466 µg F/cm2** PFAS concentrations ranged from **0.23–**10,500 ng/g product weight	na
The maximum concentrations of total PFCAs were 5.9 µg g−1 for cosmetics and 19 µg g−1 for sunscreens.	total analyte recoveries ranging from 60% to 83%

Total PFAS from 0.13 ng/g to 7,730 ng/g	na
The highest concentration of a single substance was 3,340 ng/g PFHxA, There was a relatively large difference between the content of the individual PFAS and the concentration of organic fluorine in the products.	na

Limitations	LoD (ng/mL)	subgroup
na	0.002 ng/mL and 0.090 ng/mL	Cosmetics
na	The method detection limits (MDLs) ranged from 0.16 to 5.13 ng L-1	na

some of the listed fluorinated ingredients (e.g. fluorinated silanes, polymeric substances) were not quantified due to the lack of MS-based methods and/or authentic standards	TF: LOD = 91.1 µg g−1, EOF: LOD = 1.02 to 6.65 µg g−1	na
na	LOD (PIGE): 0.127 µg F/cm2, MDLs ranged from 0.01 ng/g for PFPeS to 12.0 ng/g for 8:2 FTOH 0,05 ng/g	na
na	na	na
concentrations of PAPs were not determined	MDL = 0.7 (PFTeDA) - 66 (PFHxA) ng g−1, MQL = 2.3 - 176 ng g−1	na

na	na	na
na	na	na

Measurement
- generic name

LC-MS/LMS

LC-MS/LMS

LC-MS/LMS, CIC

LC-MS/MS, GC-MS

PIGE, LC-MS/MS, GC-MS

GC-MS

LC-HRMS

LC-MS/MS, CIC

	Authors	Journal	year
Effects of outdoor weathering and laundering on the detection and classification of fluorinated oil-and-water-repellent fabric coatings	Dolan et al.	Journal of Forensic Science	2021
Detection and diversity of fluorinated oil- and water-repellent coatings on apparel fibers	Dolan et al.	Journal of Forensic Science	2021
Hydrolysis of FTOH precursors, a simple method to account for some of the unknown PFAS	Nikiforov et al.	Chemosphere	2021
Combined use of total fluorine and oxidative fingerprinting for quantitative determination of side-chain fluorinated polymers in textiles	Liagkouridis et al.	Analytical Chemistry	2021
Post-Chromatographic Dicationic Ionic Liquid-Based Charge Complexation for Highly Sensitive Analysis of Anionic Compounds by Ultra-High-Performance Supercritical Fluid Chromatography Coupled with Electrospray Ionization Mass Spectrometry	Li et al.	Anal Chem	2021

Side-chain fluorotelomer-based polymers in children car seats	Wu et al.	Environmental Pollution	2021
Solid phase extraction of per- and polyfluoroalkyl substances (PFAS) from clothing	Machery-Nagel	Application Notes	2020
The effect of weathering on per- and polyfluoroalkyl substances (PFASs) from durable water repellent (DWR) clothing	Van der Veen et al.	Chemosphere	2020
Selective and sensitive analysis by reactive easy ambient sonic-spray ionization: Synergistic combination of non-polar spray solvent and dicationic ionic liquid	Lv et al.	Talanta	2020
Elemental Fluorine Detection by Dielectric Barrier Discharge Coupled to Nano electrospray Ionization Mass Spectrometry for Nontargeted Analysis of Fluorinated Compounds	Zheng et al.	Analytical Chemistry	2020

Another Pathway for Firefighter Exposure to Per- and Polyfluoroalkyl Substances: Firefighter Textiles	Peaslee et al.	Environmental Science & Technology letters	2020
Total oxidizable precursor assay in the determination of perfluoroalkyl acids in textiles collected from the United States	Zhu et al.	Elsevier	2020
Derivatization of Perfluorocarboxylic Acids with N,N-Dimethylformamide Dimethylacetal Prior to GC-MS Analysis	Strozynska et al.	Chromatographia 2020 Vol. 83 Issue 3 Pages 477-482	2020
Rapid analysis of perfluorinated carboxylic acids in textiles by dielectric barrier discharge ionization-mass spectrometry	Wang et al.	Microchemical Journal 2020 Vol. 155	2020
How Do We Measure Poly- and Perfluoroalkyl Substances (PFASs) at the Surface of Consumer Products?	Tokranov et al.	Environ Sci Technol Lett	2019
Release of Side-Chain Fluorinated Polymer-Containing Microplastic Fibers from Functional Textiles During Washing and First Estimates of Perfluoroalkyl Acid Emissions	Schellenberger et al.	Environmental science & Technology	2019

Survey of perfluorinated compounds in consumer products by liquid chromatography-tandem mass spectrometry	Lee et al.	Energy & Environment 2020 Vol. 31 Issue 4 Pages 713-729	2019
Classifying single fibers based on fluorinated surface treatments	Dolan et al.	Analytical and Bioanalytical Chemistry volume	2019
Previously unidentified sources of perfluoroalkyland polyfluoroalkyl substances from building materials and industrial fabrics	Janousek et al.	Environmental Science Processes & Impact	2019
Per- and polyfluorinated compounds in saleswomen's urine linked to indoor dust in clothing shops	Wu et al.	Science of the Total Environment	2019
ISO 23702-1:2018 - Leather — Organic fluorine — Part 1: Determination of the non-volatile compound content by extraction method using liquid chromatography/ tandem mass spectrometry detector (LC-MS/ MS)			2018

Development of Extraction Methods for the Analysis of Perfluorinated Compounds in Leather with High Performance Liquid Chromatography Tandem Mass Spectrometry	Zhang et al.	5th Annual International Conference on Material Science and Environmental Engineering, edited by K. Wang	2018
Closing the Mass Balance on Fluorine on Papers and Textiles	Robel et al.	Environ Sci Technol	2017
Analysis of PFASs and TOF in products	Daniel Borg, Jenny Ivarsson	Nordic Council of Ministers	2017
PIGE as a screening tool for Per- and polyfluorinated substances in papers and textiles	Ritter et al.	Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms	2017

In-Vial Extraction Large Volume Gas Chromatography Mass Spectrometry for Analysis of Volatile PFASs on Papers and Textiles	Rewerts et al.	Environ Sci Technol	2017
Development and validation of a method for the quantification ofextractable perfluoroalkyl acids (PFAAs) and perfluorooctanesulfonamide (FOSA) in textiles	Van der Veen et al.	Talanta	2016
Screening for perfluoroalkyl acids in consumer products, building materials and wastes	Becanova et al.	Chemosphere	2016
Systematic determination of perfluoroalkyl and polyfluoroalkyl substances (PFASs) in outdoor jackets	Gremmel et al.	Chemosphere	2016
Perfluorooctane sulfonate (PFOS) andperfluorooctanoic acid (PFOA) contamination from textiles	Supreeyasunthron et al.	Journal of Environmental Science and health, Part A	2016
Polyfluoroalkyl substances (PFASs) in textiles for children	The Danish Environmental Protection Agency		2015

Rapid fluorometric determination of perfluorooctanoic acid by its quenching effect on the fluorescence of quantum dots	Liu et al.	journal of Luminescense	2015
Analysis of per- and polyfluorinated substances in articles	Blom et al	Nordic Council of Ministers	2015
Rapid screening and identification of multi-class substances of very high concern in textiles using liquid chromatography-hybrid linear ion trap orbitrap masss pectrometry	Zhang et al.	Journal of Chromatography A	2015
Perfluoroalkyl and polyfluoroalkyl substances in consumer products	Kotthoff et al.	Environ Sci Pollut Res Int	2015
Determination of fluorotelomer alcohols in selected consumer products and preliminary investigation of their fate in the indoor environment	Liu et al.	Chemosphere	2015

Are imported consumer products an important diffuse source of PFASs to the Norwegian environment?	Vestergren et al	Environmental Pollution	2015
Concentrations and trends of perfluorinated chemicals in potential indoor sources from 2007 through 2011 in the US	Liu et al.	Chemosphere	2014
Understanding the exposure pathways of per- and polyfluoralkyl substances (PFASs) via use of PFASs-containing products – risk estimation for man and environment	UMWELTBUNDESAMT		2014
Detection of fluorotelomer alcohols in indoor environments and theirrelevance for human exposure	Schlummer et al.	Environmental International	2013
Removing perfluorooctane sulfonate and perfluorooctanoic acid from solid matrices, paper, fabrics, and sand by mineral acid suppression and supercritical carbon dioxide extraction	Chen et al.	Chemosphere	2012

Perfluoroalkyl and polyfluoroalkyl substances (PFASs) in consumer productsin Norway – A pilot study	Herzke et el.	Chemosphere	2012
Chemistry for any weather	Greenpeace		2012
CEN/TS 15968:2010 - Determination of extractable perfluorooctanesulphonate (PFOS) in coated and impregnated solid articles, liquids and fire fighting foams - Method for sampling, extraction and analysis by LCqMS or LC-tandem/MS			2010
Combined Use of Total Fluorine and Oxidative Fingerprinting for Quantitative Determination of Side-Chain Fluorinated Polymers in Textiles	Liagkouridis et al.	Environmental Science and technology	2022

DIN EN 17681-1 Textiles and textile products - Organic fluorine. Part 1: Determination of non-volatile compounds by extraction method using liquid chromatography.	2021
DIN EN 17681-2 - Textiles and textile products - Organic fluorine - Part 2: Determination of volatile compounds by extraction method using gas chromatography	Draft Edition 2021-07

Comments	DOI link
Effects of weather and laundering were tested by pyrolysis	
pyrolysis were used	
Test was done to find our what kind of PFAS you actually find when you do a TOF-analyses	https://doi.org/10.1016/j.chemosphere.2021.130044
This content is an early or alternative research output and has not been peer-reviewed at the time of posting.	10.33774/chemrxiv-2021-jpxbh
	10.1021/acs.analchem.0c04612

	https://doi.org/10.10
basis of the methodology of DIN 38407-42	https://www.mn-net.com/media/pdf/3e/87/76/AN-07-2020-SPE-of-PFAS-from-clothing-EN.pdf
Increase of detected PFAS after weathering	https://doi.org/10.1016/j.chemosphere.2020.126100
Method development with PFOA, PFOS as model analyts	10.1016/j.talanta.2020.120929
novel atmospheric-pressure elemental ionization method where fluorinated compounds separated by gas chromatography (GC) are converted to Na(2)F(+) for nontargeted detection	https://dx.doi.org/10.

https://dx.doi.org/10.

https://doi.org/10.1016/j.envpol.2020.114940

10.1007/s10337-019-03850-6

10.1016/j.microc.2020.104773

Method development for consumer products	10.1021/acs.estlett.8b00600
The amount of released fibres is the primary topic of this article	10.1021/acs.est.9b04165

10.1177/0958305x19882376

10.1007/s00216-019-01596-6

10.1039/c9em00091g

https://doi.org/10.1016/j.scitotenv.2019.02.287

10.1088/1757-899x/
301/1/012046

Mass balance between PIGE and other methods	10.1021/ acs.est.7b02080

http://dx.doi.org/10.

https://doi.org/10.10

	10.1021/ acs.est.8b04304
Development of method	http://dx.doi.org/ 10.1016/ j.talanta.2015.09.02 1
	10.1016/ j.chemosphere.2016. 08.1120045-6535/
	10.1016/ j.chemosphere.2016. 06.043 0045-6535/
	http:// dx.doi.org/ 10.1080/10934529. 2015.1128713
Also migration of PFASs to saliva and washing investigated	https://www2.mst.dk

Method improvement	10.1016/ j.jlumin.2015.01.045 0022-2313/
na	http://dx.doi.org/10.6
New analytical method was established and validated for the analysis of 19 substances of very high concern (SVHCs) in textiles	http://dx.doi.org/ 10.1016/ j.chroma.2015.01.07 7
	10.1007/s11356-015-4202-7
	10.1016/ j.chemosphere.2014. 06.012

	10.1016/ j.envpol.2014.12.034
	10.1016/ j.chemosphere.2013. 10.001
	https:// www.umweltbundes amt.de/en/ publikationen/ understanding-the- exposure-pathways- of-per
	10.1016/ j.envint.2013.03.010
Method development:	10.1016/ j.chemosphere.2012. 06.003

10.1016/
j.chemosphere.2012.
03.035

https://www.greenpe

Also used for other matrices, sample treatmant different

https://pubs.acs.org/

Method includes not only the standard PFAS but also others; MeFOSE, EtFOSE, 4:2-FTOH, 6:2-FTOH, 8:2-FTOH, 10-2 FTOH and PF-3,7-DMOA, 7HPHpA, 4HPFUnA and HPFO-DA-X (acyl halides). Stability: The stability of PFAS in methanol is 6 months, but the stability of PFAS in methanol/water is only 1-2 days, especially for the FTOH substances. Therefore, a dilution on a working day basis is necessary

PFAS	CAS (if available in publication)
Fluorine from fluorinated pyrolysis products	na
Fluorinated pyrolysis products	na
FTOH polymers	na
total fluorine, Side-chain fluorinated polymers (SFPs) after TOP assay as PFAAs	na
PFDoA, PFUdA, PFDA, PFNA, PFOA, PFHpA, PFHxA, PFPeA, PFOS, PFBS	na

12 PFCAs (including PFOA) 8 PFSA's (including PFOS) 3 fluorotelomer acids 12 neutral PFAS	na
40 PFAS: 3,6-OPFHpA, PFBA, PF4OPeA, PFPeA, PF5OHxA, FBSA, L-PFBS, PFHxA, PFEESA, 4:2FTS, HFPO-DA, L-PFPeS, PFHpA, NaDONA, FHEA, FHxSA, PFHxSK, PFOA, 6:2FTS, L-PFHpS, PFNA, FOEA, FOSA, PFOSK, PFDA, 8:2FTS, 9Cl-PF3ONS, L-PFNS, PFUdA, N-MeFOSAA, FDEA, N-EtFOSAA, L-PFDS, PFDoA, 11Cl-PF3OUdS, PFTrDA, PFTeDA, 6–2diPAP, 6-2-8–2diPAP, 8–2diPAP, MPFBA, M5PFPeA, M3PFBS, M5PFHxA, M2–4FTS, M4PFHpA, MFHEA, M3PFHxS, M8PFOA, M2–6:2FTS, M9PFNA, MFOEA, M8FOSA, M8PFOS, M6PFDA, M2–8:2FTS, M7PFUdA, d3-N-MeFOSAA, MFDEA, d5-N-EtFOSAA, MPFDoA, M2PFTeDA	na
PFBA, PFPeA, PFHxA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, L-PFBS, L-PFHxS, L-PFHpS, L-PFOS, FOSA, 4:2 FTSA, 6:2 FTSA, 8:2 FTSA, 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 6:2 FTAC, 8:2 FTAC, 10:2 FTAC, 6:2 FTMAC, 8:2 FTMAC, 10:2 FTMAC,	na
PFOA, PFOS	na
nontargeted detection, good efficiency regardless of the chemical structure	na

Total fluorine, Targeted analysis of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFBS, PFOS, 6:2 FTS, 8:2 FTS	na
PFBS, PFHxS, PFOS, PFDS, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, precursors (TOP assay)	na
perfuorocarboxylic acids (PFCA, C4–C12)	na
PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA	na
surficial fluorine content, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFBS, PFHxS, PFOS, FOSA, 6:2 FtS, N-MeFOSAA, N-EtFOSAA	na
total fluorine	na

PFHXA, PFHpA, PFOA, PFNA, PFDA, PFBS, PFHxS, PFOS, PFOSA, N-MeFOSA, N-EtFOSO	307-24-4, 375-85-9, 335-67-1, 375-95-1, 335-76-2, 375-73-5, 355-46-4, 1763-23-1, 754-91-6, 31506-32-8, 4151-50-2
Fluorine from fluorinated pyrolysis products	
PFCAs (C4–C14), PFSAs (C4–C8,C10 and C12),n:2 fuorotelomer sulfonates (n: 2 FTS,n=4, 6 and 8), n:2FTOHs (n=6, 8 and 10), 2H,2H-perfuorodecanoic acid (8 : 2FTCA), PFOSA, 2H,2H,3H,3Hperfuoroundecanoic acid (8 : 3 FTCA),7H-perfuoroheptanoic acid (7HPFHpA), perfuoro-3,7-dimethyloctanoic acid (PF37DMOA)	na
PFBS, PFHxS, PFHpS, PFOS, PFDS, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoA, PFTrDA, PFTeDA	na
PFOS, PFOA, PFDoDA, PFHxS, PFNA, PFTeDA, PFTrDA, PFUnDA, PFBS, PFDA, PFHpA, PFHxA, PFBA, PFPeA, PFOSA	1763–23–1 (PFOS), 355–46–4 (PFHxS), 335–67–1 (PFOA), 375–95–1 (PFNA), 2058–94–8 (PFUnDA), 307–55–1 (PFDoDA), 72629–94–8 (PFTrDA), 376–06–7 (PFTeDA), 375–73–5 (PFBS), 375–22–4 (PFBA), 2706–90–3 (PFPeA), 307–24–4 (PFHxA), 375–85–9 (PFHpA), 335–76–2 (PFDA), 754–91–6 (PFOSA)

PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrDA, PFTeDA, PFOS, PFOSA	na
total fluorine, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, EtFOSE, C3--C17 PFCAs, C4, C6, C8, C10 n:2 FTCA, C4, C6, C8, C10 n:2 FTUCAs, C3, C5, C7, C9 n:3 FTCA, C2–C10 PFSAs, fluorotelomer sulfonates (C4, 6, 8, 10 FTSAs), fluoroalkyl sulfonamido acetic acids (C4–C8 FASAA), N-methyl fluoroalkyl sulfonamide acetic acids (C4–C8 MeFASAA), ethyl fluoroalkyl sulfonamido acetic acids (C4–C8 EtFASAA), disubstituted perfluoroalkyl phosphinic acids (C4/C4–C8/C8 PFPIA), disubstituted polyfluorinated phosphate esters (C4/ C4-C10/C10 diPAP), fluorotelomer mercaptoalkyl phosphate esters (C6/C6–C10/C10 FTMAP), and ethyl perfluorooctanesulfonamido ethanol-based polyfluoroalkyl phosphate diester (C8/C8 SAmPAP)	na
TOF, targeted analysis of PFCAs (PFBA, PFHxA, PFOA, PFNA, PFDA), PFSAs (PFBS, PFHxS, PFOS), FTOHs (4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH), FTAs (6:2 FTA, 8:2 FTA, 10:2 FTA), FOSAs (MeFOSA, EtFOSA), FOSEs (MeFOSE, EtFOSE)	375-22-4 (PFBA), 29420-49-3 (PFBS salt), 307-24-4 (PFHxA), 3871-99-6 (PFHxS salt), 2043-47-2 (4:2 FTOH), 757124-72-4 (4:2 FTS), 335-67-1 (PFOA), 1763-23-1 (PFOS salt), 647-42-7 (6:2 FTOH), 29420-49-3 (6:2 FTS), 31506-32-8 (MeFOSA), 4151-50-2 (EtFOSA), 2448-09-7 (MeFOSE), 1691-99-2 (EtFOSE), 375-95-1 (PFNA), 335-76-2 (PFDA), 678-39-7 (8:2 FTOH)
total fluorine	na

21 volatile PFAS including 4:2, 6:2, 8:2, and 10:2 FTOH, N-MeFOSA, NEtFOSA, N-MeFOSE, and N-EtFOSE	na
E.g. PFBA, PFHxA, PFOA, PFNA, PFDA, PFUnDA, PFDoDa, PFGxS, PFOS, FOSA, PFPeA, PFHxA, PFTeDA, PFDS, PFHxS, L-PFOS	na
PFPA, PFHxA, PFHpA, PFOA, PFNa, PFDA, PFUnDA, PFDoDa, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS and PFDS	na
PFBa, PFPeA, PFHxA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, (6:2, 8:2 an 10:2 FTOH), PFBS PFHxS, PFHpS, PFOS, PFDS, FOSA, N-MeFOSA, N-EtFOSA, N,MeFOSe, N-EtFOSE	na
PFOS, PFOA	na
39 PFASs: PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFDS, PFOSA, MeFOSA, EtFOSA, MeFOSE, EtFOSE, PFPA, PFHxA, PFHpA, PF, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, 4:2 FTOH, 6:2 FTOH, 10:2 FTOH, 6:2 FTCA, 8:2 FTCA, 10:2 FTCA, 8:2 FTMAC, 10:2 FTMAC, 4:2 FTAC, 6:2 FTAC, 8:2 FTAC, 10:2 FTAC, 4:2 FTSA, 6:2 FTSA, 8:2 FTSA	na

PFOA	na
PFCAs (PFBA, PFHxA, PFHpA, PFOA, PFna, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA), PFASs (PFBS, PFHxS, PFOS), PAPs (6:2 diPAP, 6:2 monoPAP, 8:2 diPAP, 8:2 mono-PAP), FTOH (4:2, 6:2, 8:2), FTS (4:2, 6:2)	375-22-4 (PFBA), 307-24-4 (PFHxA), 375-85-9 (PFHpA), 335-67-1 (PFOA), 375-95-1 (PFna), 335-76-2 (PFDA), 4234-23-5 (PFUnDA), 307-55-1 (PFDoDA), 72629-94-8 (PFTrDA), 376-06-7 (PFTeDA), 29420-49-3 (PFBS salt), 3871-99-6 (PFHxS salt), 1763-23-1 (PFOS salt), 2043-47-2 (4:2 FTOH), 647-42-7 (6:2 FTOH), 678-39-7 (8:2 FTOH), 57677-95-9 (6:2 diPAP), 57678-01-0 (6:2 monoPAP), 678-41-1 (8:2 diPAP), 57678-03-2 (8:2 mono-PAP), 757124-72-4 (4:2 FTS), 29420-49-3 (6:2 FTS)
APFO, PFOA, PFUdA, PFDoA, PFTrA, PFTeA	na
PFBA, PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrA, PFTeA, PFBS, PFHxS, PFHpS, PFOS, PFDS, 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, PFOSA	na
6:2 FTOH, 8:2 FTOH, 10:2 FTOH	na

C4-C14 PFCAs, C4, C6 ,C8 ,C10 PFSAs, 4:2, 6:2, 8:2 and 10:2 FTOHs, N-ethyl perfluorooctanesulfonamidoethanol (EtFOSE), N-Methyl perfluorooctane sulfona-midoethanol (MeFOSE), N-Ethyl perfluorooctane sulfonamide(EtFOSA) and N-Methyl perfluorooctane sulfonamide (MeFOSA)	na
9 PFCAs (C4 to C12), 5 PFASs (C4, C6, C7, C8, C10)	na
(a) PFCAs (C4 – C14), PFSAs (C4, C6, C7, C8, C10) and FOSA-derivatives (FOSA, N-MeFOSA and N-EtFOSA), (n) FTOHs (6:2-, 8:2-, 10:2-FTOH) and FOSE-derivatives (N-MeFOSE and N-EtFOSE)	na
FTOH's. N, N-Me2FOSA, N-MeFOSA, N-EtFOSA, N-MeFOSA, N-ETFOSE	na
PFOS, PFOA	na

PFAS (i.e. C4–C14 PFCAs, C4,C6,C8,C10 PFSAs, 6:2 and 8:2 fluorotelomersulfonates (FTSs), PFOSA, 4:2, 6:2, 8:2, 10:2 FTOH	na
PFCAs, FTOHs	na
PFOS, PFOSA, N-Me-FOSA, N-Et-FOSA, N-Me-FOSE alcohol, N-Et-FOSE alcohol, PFOS salt	1763-23-1 (PFOS) 754-91-6 (PFOSA) 24448-09-7 (N-Me-FOSE alcohol) 1691-99-2 (N-Et-FOSE alcohol)
TOP assay: PFPrA, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFBS, PFHxS, PFOS, PFDS, 6:2 FTS and 8:2 FTS	na

PFBA, PFPeA, PFHxA, PFOA, APFO, Na-PFOA, K-PFO, Ag-PFO, F-PFO,PFNA, PFDA, PFUnA, PFDoA, PFTrA, PFTeA, PFBS,PFHxS, PFHpS, PFOS, PFOS-X, PFOSA, N-MeFOSA, N-EtFPSA, N-MeFOSE, 4:2-FTS, 6:2-FTS, 8:2-FTS; 10:2-FTS, N-EtFOSE, PFOSF, 4:2-FTS, 6:2-FTS, 8:2-FTS, 10:2-FTS, PF-3,7-DMOA, PFDS, 7HPFHpA, 4HPFUnA	375-22-4, 2706-90-3, 307-24-4, 375-85-9, 335-67-1, 3825-26-1, 335-95-5, 2395-00-8, 335-93-3, 335-60-0, 375-95-1, 335-76-2, 2058-94-8, 307-55-1, 72629-94-8, 376-06-7, 375-73-5, 355-46-4, 375-92-8, 1763-23-1, 2795-39-3, 29457-72-5, 29081-56-9, 70225-14-8, 56773-42-3, 754-91-6, 31506-32-8, 4151-50-2, 24448-09-7, 2043-47-2, 647-42-7, 678-39-7, 865-86-1, 1691-99-2, 307-35-7, 75124-72-4, 27619-97-2, 39108-34-4, 120226-60-0, 251099-16-8, 172155-07-6, 335-77-3, 335-77-3, 1546-95-8, 34598-33-9
PFOA, its salts and PFOA-related compounds, namely Me-PFOA, Et-PFOA, 6:2 FTA, 8:2 FTA, 10:2 FTA, 6:2 FTMA, 8:2 FTMA	376-27-2 (Me-PFOA), 3108-24-5 (Et-PFOA), 17527-29-6 (6:2 FTA), 27905-45-9 (8:2 FTA), 17741-60-5 (10:2 FTA), 2144-53-8 (6:2 FTMA), 1996-88-9 (8:2 FTMA), 307-98-2 (7:1 FTA)

Sampling	sample amount used
Nine oil-and-water repellent garments purchased from commercial vendors with fluorinated fabric coatings	
In addition, the durability of two fluorinated stain-resistant spray-on coatings, namely Scotchgard™ Fabric Crafts Protector and Forcefield	Weathering: Threads Laundering: 5-10 x 30 mm
12 textiles marketed as stain-resistant bought in USA	threads
Four polyester samples.	30 mg in small pieces
In addition to the three reference textiles, 7 medical textiles were obtained from Stockholm Healthcare (Region Stockholm). These included 1 surgical drape, 4 surgical gowns, and ambulance jacket all determined to contain an unknown fluoropolymer coating during	30 mg (2.7 cm2)
32 real textile samples of different fabrics (e.g., cotton, wool, and polyester) and 6 food packaging material samples (e.g., oil-proof hamburger wrapping paper)	1 x 1 cm2, 0.5 g

18 children's car seats	50-100 mg
na	1.0 g
13 samples. textile samples originating from outdoor clothing (one pair ofoutdoor trousers, seven jackets, four fabrics for outdoor clothes,and one outdoor overal. All purchased in Sweden	Circular pieces with a diameter of 35.3 mm (equals 9.79 cm2
real textile samples of different fabrics, as well as five popcorn bucket and six oil-proof hamburger wrapping paper samples, which were collected from local markets or purchased online	na
clothing fabrics	10 mg

30 samples of both used and unused fire fighting turnout gear from USA	250 mg
160 textiles purchased in USA.	2 x 2 cm
waxed dental foss, textile, sewage sludge	
15 real textile samples of different fabric	na
94 consumer products that represent frequently used items on a college campus of Harvard University. These included: 45 food contact materials, 37 textiles, and 12 domestic products such as lens wipes, bandages, masks, and a shower curtain	1 ± 0.03 g
2 textile samples were coated with 2 different DWR products	8 x 8 cm

300 products from 16 product lines placed on the market in four industrial sectors (Coated metal wares, textile products, leather products, household products)	areas 100 cm2 cutted in 2 mm x 2 mm, for the liquid sample, 1 mL was collected
The samples included fabrics pre-coated by a wet process (A1 and B1 from 3M) and by a plasma process (D1 and E1 from P2i), as well as coatings applied in the lab to white cotton (Testfabrics, West Pittston, PA, USA).	10 mm fiber
23 samples of building materials. 28 samples of industrial textiles. Mostly purchased directly but in some cases the manufacture's supplied the articles	1 gram
58 indoor dust samples and 73 urine samples from saleswomen	100 mg dust 0,5 ml urine
Take a leather sample by mass using ≥ 1 g of leather.	1,0 g ± 0,1 g of the leather pieces

leather samples	1 g
large set of consumer products (food-contact papers, popcorn bag, outerwear textiles, childrens clothing, pillowcase, uhholstery cut from office chair) comprised of paper and textiles purchased by the Washington Department of Ecology in 2015	2 x 2 cm2 (0.3 +/- 0.01 g)
In total 17 products were randomly selected from shelves in a number of Swedish retail stores and supermarkets for analysis (Cupcake forms, microwave popcorn bag, rinse aid, waterproofing shoe treatment, waterproofing textile treatment, shoe wax, floor polish, furniture polish, car wax). In total 29 samples of consumer products were collected in the previous study (including food contact material, textiles, lubricants, car wax, table cloth, ski wax and more)	Pressed pellets of 100-120 mg for TOF
350 consumer products purchased from 94 retail stores/vendors in April/May 2015 (paper and textile samples likely PFAS treated for water and oil repellency)	2 cm2 with 1 cm2 hole

7 papers consisted of all new materials purchased or acquired in 2017, including: white copier paper, five food-contact materials, and waterproof notebook paper, 9 textiles consisted of a plain white t-shirt, three office chair upholsteries from the years 1988a, 1988b, and 1993, respectively, an outdoor upholstery purchased in 2017, two articles of previously worn children's clothing (a swimsuit and outdoor vest), and an adult rain jacket purchased in 2015, as well as a piece of a used firefighter's jacket	1.5 x 1.5 cm
Three jackets and three fabric from outdoor clothes from six different suppliers were purchased from Sweden	Circular pieces with a diameter of 35,3 mm
126 samples in four categories: Textiles, Floor coverings, Electrical & Electronic equipment and plastics. All bought in Czech Republic	5 g
16 outdoor jackets were bought between August 2011 to March 2012	5 x 10 cm
32 textiles were purchased from stores in thailand: Diapers, shirts, pants, footwear, towels, uniforms, upholstry, carpetsl blankets, umbrellas, sunshades and tents	Approx. 2 gram
Twenty-two products were purchased and initially analysed for the content of total fluorine. Added to this were further eight samples from car seats, purchased as part of another study of chemicals in car seats, which was also carried out by DEPA.	10 cm2

Diluted PFOA	
textile samples was also used	5 cm x 5 cm
In total 29 different samples were analysed. The sampling was concentrated on a few but wide variety of household products, such as cleaning products and polishes for indoor use and for cars and sprays to waterproof shoes or clothes, food contact paper and baking forms included some products less commonly analysed, such as ski wax, dental floss and tablecloths. The samples were purchased in the vicinity of Oslo in supermarket chains that are found all over Norway.	depending on the article: 0.05 mL, 71.5-100 cm^2 or 0.02-0.16 g
The test samples were three texiles spiked with pure chemials	0,5 g of textile (5 mm x 5 mm)
115 samples of consumer products including textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes. The individual samples analysed were bought from local retailers or collected by co-workers of the institute or local clubs (e.g. ski waxes from local skiing club). The sampled products span all quality levels from entry level to cutting edge products. The selection of the samples occurred randomly.	na
54 consumer products from U.S. open market in the years of 2011 and 2013 (carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes)	solid samples 0.05 g, liquid samples 100 µL

45 furniture textile, carpet, clothing and food contactmaterial samples were purchased from three major retail stores inTromsø and Trondheim during the period November2012eFebruary 201	10 x 10 cm
95 samples from 35 consumer products including carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes. They were purchased from retail outlets in the United States between March 2007 and September 2011.	5 x 5 cm
five impregnating agents and 16 outdoor jackets	2 squares 5 x 10 cm
Air samples at 11 indoor sites taken in shops, offices, in a car, in a kitchen, workshops.They also tested liquid care products for textiles and shoes and emissions from surface-treated textiles	1 dm2 of textile for extraction test air emissions; 5-25 m3 of air
not reported	na

30 products in 6 different product groups: waterproofing agents, paint, coated fabrics, non-stick ware, electronics and fire fighting agents. They were purchased from retailers in Norway and Sweden.	1 g
13 items of outdoor clothing bearing well-known outdoor brand names	na
Solids (coated materials): at least 200 cm2 or 2 g, solids (non-coated): sampled according to EN ISO 8130-9	see sampling
three reference textiles, seven medical textiles were obtained from Stockholm Healthcare (Region Stockholm). These included one surgical drape (6A), four surgical gowns (12, 17A, 21, and R10), and one ambulance jacket (35A), all determined to contain an unknown fluoropolymer coating during initial screening experiments, as well as a fluorine-free surgical drape (1A), which was used as a control.	TF - analysis: 0.3 - 0.8 mg TOP assay: 3.5 - 14 mg

according to EN ISO5089	Take a fabric test specimen in order to get at least 1 g of material and an area of at least 100 cm2.
sampling is carried out according to EN ISO 5089	If the material is not suitable to provide area-based test specimens (fibres, yarns), take a test specimen by mass, using at least 1 g of material

Pre- treatment	Extraction
weathering: Single threads from samples were exposed outdoor to wind, sun and rain for 12 weeks and were sampled at 4-week intervals	
Laundering: Small swatches were washed 9 times	no extraction, pyrolysis
single fibers were removed using gloves and tweezers	no extraction, pyrolysis
hydrolysis with 4% sodium hydroxide in water-methanol mixture (1:9) at 60 _x0003_C for 16 h	Methanol
cut using methanol-rinsed scissor, oxidation with Potassium persulfate and NaOH (TOP assay)	SPE in methanol
	supramolecular solvent (SUPRAS)-based extraction, heptanol, tetrahydrofuran, and water mixed solvents

Samples cut into small pieces and pre-cleaned with dichloromethane and methanol	hexane/isopropanol followed by methanol/acetonetril
homogenized sample, add standard for determining recovery rates	ultrasonication in methanol, SPE
Two pieces were cut out of each fabric. Oneof the pieces (9 cm12 cm) was exposed in an ATLAS weather-Ometer Ci 3000 to elevated UV radiation, humidity, and tempera-ture for 300 h (Table 2), which can be compared to the lifespan ofthe outdoor clothing	Methanol
na	dicationic ionic liquid (DIL) based easy ambient sonic-spray ionization (EASI), solvents (acetonitrile, methanol, acetone, isopropyl alcohol, dichloromethane, tetrahydrofuran, ethyl acetate, and hexane)
dillution	ethyl acetate

Cut into small pieces	NaOH and methanol
5 squares from each sample were cut into pieces and pooled	Methanol & ethyl acetate
Derivatization was carried out by adding 50 µl of 0.4 M DMF-DMA solution to 200 µl PFCA solution or sample extract. Then the vials were closed and the sample was directly injected into GC–MS system	All samples were weighed (100–500 mg) and shaken for 10 min after the addition of MTBE (2–5 mL). Subsequently, the samples were extracted for 30 min in an ultrasonic bath
no pre-treatment	no extraction
cut using methanol-rinsed scissors, mounted on carbon tape for XPS	methanol extraction, XPS (not extracted sample/ methanol extract)
Fabrics were treated coated with DWR and washed several times	No extraction

na	ultrasonically with methanol
Samples were prepared by separating a thread from a swatch of fabric. The thread was then unwound with tweezers and a single fiber was removed. The fiber was placed on a glass slide and taped at both ends to pull the fiber taut. The fiber length was then measured with a stainless steel ruler and cut into 10 mm using an X-ACTO knife.	no extraction, pyrolysis
samples were cut and dried.	liquid–solid extraction (LSE) or solid phase extraction (SPE). All solids were extracted via LSE. Coating 2 was available as an aqueous solution and directly enriched using SPE. LSE was performed with methanol (MeOH) and water.
Dust: visible hair was removed. After Air drying it was stored at -20 until analysis Urine was stored at -20 until analysis	ANC
na	Solvent Extraction (MeOH)

Leather samples were cut as close to the scalp as possible	ultrasound liquid extraction followed by SPE on Oasis Wax
papers and textiles were cut from the original material using methanol-rinsed scissors	Sonification in ethyl acetate for FTOHs, heated in methanol for PFASs
sample was homogenized, shredded for TOF	LC-MS: ultrasonic extraction with matrix dependent solvents (no further information), burning for TOF and absorbtion of combustion gases in buffer solution
no	no extraction

papers and textiles were cut from the original material using methanol-rinsed scissors	Sonification in methanol
Prior to extraction dust particles were rinsedfrom the samples by adding 5 mL water to the pp tubes andtransferring the samples immediately into fresh 15 mL pp-tubes.	Methanol
Materials were crushed, chopped or cut into small pieces	Methanol with the addition of ammonium acetate
samples weighed and cut to small pieces.	N-hexane
Sampes cut into pieces and placed in desiccator	Methanol
Before extraction, the samples had 13C or deuterium-labelled substances added.	ultrasonication in ethyl acetate (GC-MS), methanol (LC-MS/MS)

textile cut into pieces	na
vortexing in methanol	ultrasonification in methanol
small samples	ultrasound extraction with methanol
na	differ depending on the respective matrix: ion pair extraction, acidic-alkaine sequential extraction or SPE with acetone, hexane or methyl-t-butyl ether as solvent
na	Sonification in methanol

samples were cut into small pieces and spiked with masslabeled internal standard	Samples were extracted with methanol for ionic compounds and ethyl acetate for neutral PFASs two times for 15 min in an ultrasonic bath with vortex treatment in between
solid products were cut into smaller subsections. Liquid products were subdivided into at least three 30-mL polypropylene vials	solid and liquid sample extraction (Liu 2012, US EPA Report, EPA/600/R-12/585)
The squares were weighed precisely and cut to small pieces. Each sample was spiked with a mixture of internal standards.	(a) sonication in acetone/acetonitrile, (n) sonication MeOH
textile samples were doped with the internal standards(13C-labelled	Textile samples were extracted with hexane in ultrasonic bath
na	supercritical fluid extraction (SFE), supercritical carbon dioxide (Sc-CO2) with methanol

Liquid and solid samples were homogenized	methanol for ionic compounds and ethylacetate for FTOH
na	methanol for HPLC, MTBE for GC
Sample materials need to ground as appropriate to ensure an efficient extraction process. Textile and paper shall be cut into pieces of maximum 1 cm2 before methanol is added. For grinding of polymers and granulates it is recommended to use EN ISO 6427 or ISO 9113.	Sonification in methanol for textile, fabrics, leather and paper
TF-analysis: In brief, textile samples (0.3–0.8 mg each, depending on the textile density) were cut using scissors (prerinsed with methanol and then dried) **TOP assay**: a 2.7 cm2 (30 mg) piece of reference textile or a 1.0 cm2 (3.5–14 mg, depending on the fabric density) piece of a medical textile was cut using scissors (prerinsed with methanol and then dried)	TF-analysis: na TOP assay: after addidition of Milli-Q water (30mL). Potassium persulfate (0.48 g) and NaOH (0.456 mL of a 10 N solution) were then added, and the solution was vortexed and placed in the oven at 85 °C for 6 h. Thereafter, the samples were allowed to cool and the pH was adjusted using concentrated HCl

The test specimen shall be cut into pieces of ≤ 1 cm2	extracted in an ultrasonic bath with methanol
The test specimen shall be cut into pieces of ≤ 1 cm2. The sampling preparation based on area is described in prEN 17681-1:2021.	extracted in an ultrasonic bath with methanol

Clean up	Measurement
no clean up	GC-MS
no clean up	GC-PARCI-MS
no clean up	GC-MS
extracts were concentrated	UPLC-MS/MS, CIC
diluted 1:1 (v/v) with methanol, filtered	UHPSFC-(+)ESI-MS/MS

Cleaned-up with Envi-Carb graphite by vortexing for 1 minY. Wu, G.Z. Miller, J. Gearhart et al.Environmental Pollution 268 (2021) 1154772	HPLC-MS, LC-MS and GC/MS (with/without TOP assay, UV treatment), PIGE
na	HPLC-MS / MS
na	LC-MS/MS
na	EASI-MS/MS
na	GC-MS

na	LC-MS/MS and particle induced gamma-ray emission (PIGE)
The extract was divided into two equal aliquots of 5 mL each into new 15 mL PP tubes. One aliquot was subjected to solid phase extraction (SPE) for the analysis of PFAAs prior to oxidation, and the remaining 5-mL aliquot was subjected to chemical oxidation by the TOP assay	HPLC-MS/MS
	GC–MS
no clean up	dielectric barrier discharge ionization (DBDI) coupled with a benchtop ion trap mass spectrometer
na	X-ray photoelectron spectrosopy (XPS), LC-(-)ESI-MS, LC-QTOF-MS
no clean up	CIC

filtration	LC-MS/MS
	GC-PARCI-MS
MeOH extracts were directly injected for FTOH determination or further enriched for non-volatile PFASs.	HPLC-MS/MS
Dust was extracted three times.	HPLC-MS/MS
na	LC-MS/MS

	LC-MSMS Acquity UPLCTM BEH C18 (1.7µm, 2.1×100mm. The column temperature was set to 35 °C. A gradient program was employed using 5 mM aqueous formic acid solution and methanol mobile phases. The flow rate of 0.08 mL/min and the volume injected was 5µL. The gradient started at 35% methanol
This clean-up approach was referred to the method published by Olatz Zuloaga	followed by an 8 min ramp to 87 % methanol. At 20 min, the ramp was decreased to 85 % methanol and at 25 min the ramp was decreased to 80 % methanol
	PIGE (total fluorine), GC-MS (FTOHs), HPLC-MS/MS (PFASs), TOP assay
LC-MS: (multi)-step-sample clean-up	Targeted analysis with LC/MS-MS (Agilent HPLC 1290 Infinity Serie coupled with Agilent 6460A Triple Quad LC/MS-MSMS), TOF by IC
no	Particle-Induced Gamma Ray Emission (PIGE)

na	GC-CSR-LVSI-MS, QTOF-MS (nontargeted analysis)
no further cleaning.	LC-MS/MS
Following extraction, samples were cleanedup according to the procedures for PFAAs analysis described indetail elsewhere (Karaskova et al., 2016).	GC-MS
Following extractoin samples were washed with hexane	HPLC-MS/MS
na	HPLC-MS/MS
na	GC-MS, LC-MS/MS, CIC

na	quenching effect on the fluorescence of quantum dots
volume reduced to 2 mL, aliquot filtered	UPLC-MS/MS for ionic PDAS and PAP, GC/MSD for FTOH
na	MS, HPLC-LTQ/Orbitrap
differ depending on the respective matrix	PFAA: HPLC-MS/MS FTOH: GC/CI-MS
na	GC/MS

After centrifugation and solvent evaporation, an aliquot of1 mL extract was transferred for dispersive clean up with ENVI-Carb(50 mg, 1 mL, 100e400 mesh, Supelco, USA	UPLC-MS/MS and GC-MS
	HPLC/MS/MS
(a) evaporated, filtered, (n) SPE	HPLC-MS/MS
The presence of these precursors in samples, especially in extracts, could not be ruled out here, even though the applied cleaning procedure according to Szostek and Prickett (2004) seems to significantly reduce the FTOH precursor levels in samples	GC-MS
na	HPLC/MS

Centrifugation and solvent evaporation, clean up with ENVI-Carb and glacial acetic acid (for ionic PFAS)	GC-MS
na	HPLC-MS/MS, GC-MS, SEM
Concentrate the extract by a factor of 10 and use a clean-up if necessary. Active carbon clean-up and/or solid phase extraction (SPE) clean-up may be used. Transfer a known volume into a suitable LC sampling vial . If necessary dilute the original solution further and repeat the analysis	LC-qMS, LC-tandemMS
TF-analysis: na TOP assay: solid phase extraction (SPE). Oasis WAX SPE cartridges	TF determination was carried out using an AQF-2100H combustion unit (Mitsubishi) that was coupled to a Dionex ICS-2100 Integrion IC instrument (Thermo Scientific) TOP assay: LC-MS/MS

If the extract is turbid, centrifuge and decant the supernatant or filter it to a vial for LC/MS/MS analysis.	LC-MS/MS
Centrifuge the final extract of the test specimen and decant the supernatant to a vial for GC analysis.	GC-MS/MS, GC-MS/PCI or GC-MS/EI

Quantification method	Working range (ng/mL) As	Matrices
na		Textiles
na		textile
internal standard method with 13C and/or 2H isotope-labeled 4:2, 6:2, 8:2 and 10:2 FTOHs		textile
Conversion between PFAS concentrations and fluorine equivalent concentrations	na	textiles
internal standards		32 real textile samples of different fabrics (e.g., cotton, wool, and polyester) and 6 food packaging material samples (e.g., oil-proof hamburger wrapping paper)

Internal standard		foam and textiles
internal standards, Calibration curves	calibration 0.1 ng/ mL and 10.0 ng/mL	textiles
Internal standard	na	Textiles
internal standardisation using mass-labeled internal standards		real textile, popcorn bucket, and oil-proof hamburger wrapping paper samples
na	na	na

Internal standard	na	Textiles
internal standard	na	Textiles
		textile, sewage sludge
		textiles
internal standards		paper and textile
na		textiles

mass labeled internal standard, calibration curve	calibration 5, 10, 25, and 50.0 mg/L	coated metal wares, textile products, leather products, and household products
Internal standard	na	textiles, paint, foan, glue, foil, coatings
An external calibration curve ranging from 0.1, 1, 5,10, 50 and 100 ng ml−1enabled us to discern the concentration ofeach extract.		urine and dust
Prepare suitable calibration solutions using methanol, target compound solutions and the internal standard solution (suitable mass-labelled internal standards)	na	Leather

calibration curve	e calibration curve in the range from 0.2 to 5 ng/mL	leather
internal standards		papers (mainly food-contact material), textiles
LC-MS: internal isotope-labeled standards (isotope dilution method)		Consumer products, Textiles, FCM
external inorganic fluorine standard (NaF) and external paper and textile standards with PFOA		paper and textile

internal standardisation using mass-labeled internal standards; FTOHs derivatives were quantified using the standard curve of 10:2 FTOH derivative		moisturizing creams (abbreviated CRE), founda_x0002_tions (FOUN), powders and eye shadows (POW), eye pencil (PEN) and shaving foams (SHAV)
Quantification was performed againstfive calibration solutions (0.1, 0.5, 2, 10,50 ng/mL) in methanol: water (1:1, v/v) prepared from a singlestock solution and the isotope-labeled ISs		Textiles
internal standards		Textiles, matierials of wood and composite wood, plastics, foam, air conditioner components. electronic components
internal standards		Textiles
Internal standard (standard solutions)		Textiles
linear regression through the execution of a series of calibration standards containing both labelled and unlabelled substances	na	textiles for children

na	0.5 to 40µmol L-1	extraction of textiles
internal standardisation using mass-labeled internal standards	na	Consumer products, FCM
internal standards		extraction of textiles
internal standardisation using mass-labeled internal standards		textiles (outdoor materials), carpets, cleaning and impregnating agents, leather samples, baking and sandwich papers, paper baking forms and ski waxes
internal standards		carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tape

internal standards		Textiles, carpets and food contact materials
internal standardisation using mass-labeled standards		carpet, commercial carpet-care liquids, household carpet/fabric-care liquids, treated apparel, treated home textiles, treated non-woven medical garments, floor waxes, food-contact paper, membranes for apparel, and thread-sealant tapes
internal standards, Calibration curves	na	Outdoor jackets
internal standard		air samples, textiles
internal standard		solid matrices, paper, fabrics, sand

internal standard		food contact paper, textile, fire fighting foam, water proofing agents and lubricants, paint, leather, carpets, non-stick ware, printed circuit boards
na	na	Outdoor jackets
Quantify the samples by using the unextracted external calibration curve. When spiking with labelled reference solutions, the determination of the concentration is independent of possible errors made during injection. Also, errors caused by sample losses during distinct steps of sample pre-treatment or the adjustment of final sample extract volume as well as matrix effects in the sample are accounted for.	Method is applicable for a concentration range for PFOS in the extract solution of 0,5 µg/l to 50 µg/l.	Coated materials like paper, textile, leather, carpets, clothes and footwear, Non-coated materials, liquids
The approach uses the total oxidizable precursor (TOP) assay for fingerprint-based structural elucidation and TF measurements (CIC) for quantification	na	6 unknown side-chain fluorinated (SFP) coated medical textiles from Sweden

Internal standard method	range of 0,000 1 - 0,01 µg/ml (0,001 – 1 µg/ml for the FTOH substances)	in textile materials (fibres, yarns, fabrics) and coated fabrics.
The calibration is based on solutions containing the compounds of interest and internal standard solution of PFDodiAOMe	The calibration curve for a substance is valid only for the measured concentration range.	textile materials (fibres, yarns, fabrics) and coated fabrics

Reported levels (ng/mL)	info - validation of the method	Limitations
no levels were stated. They concluded that it was still possible to detect PFAS after weathering and laundering.	na	
They were able to find fluorinated polymers in 10 out of 12 samples	na	
FTOHs were found in much higher concentrations after hydrolyses compared to after normal extraction	na	
ranged from 28 mg F/m2 (803 µg F/g, textile 21) to 560 mg F/m2 (6560 µg F/g textile 35A)	good agreement with reference values	The inefficiency of the TOP assay on the oxidation of SFPs is also a notable area for improvement, but since we relied on TF measurements for quantification, this is not considered a limitation of the current methodology.
PFDoA (19.85 µg kg-1) and PFOA (12.49 µg kg-1) (textile sample)	Good linearity with correlation coefficients all greater than 0.99, six replicate measurements, relative errors less than 9% compared to HPLC-ESI-MS/MS	

Foam: ND-3,64 ng/g Fabric: ND - 93,4 ng/g Composite: ND-155 ng/g	For the LC/MS and GC/MS analyses, a procedural blank and a matrix spike (spiking amount: 20 ng each of targeted PFAS) was processed along with every batch of 5e7 samples to evaluate the background contamination from laboratory operations	
na	Most of the PFAS show recovery rates between 80 % to 100 %	na
Before weathering: Volatile PFASs: max. 350 µg/m2, ionic PFASs: max 45 µg/m2 After weathering: Volatile PFASs: max. 7000 µg/m2, ionic PFASs: max 4500 µg/m2	The extraction and analysis method for the volatile PFASs was validated by assessment of the repeatability and the recovery. All textile samples of the repeatability and recovery assessment were extracted and analysed in the same series. For both assessments the same calibration curves were used. To assess the repeatability of the method, two textile samples were extracted in triplicate on the same day.	na
ND, PFOA: 6.5 ± 0.62 and 5.2 ± 0.56 µg/m2	calibration curves correlation coefficients of 0.9971 and 0.9993, triplicate analysis	
na	na	

With PIGE (total fluorine measured): Used gear: up to 15.000 ppm Unused gear: up to 21500 ppm MS/MS: MDL - 850 ppb	Calibration ranges are typically from 0.5 ng/g – 500 ng/g and process blanks were analyzed for each matrix, and 10 ng/g spike recovery measurement was performed for each analyte every eight samples.	na
sum of 13 PFAS: LOD - 285 ng/g	Quantification of PFAAs was based on an isotopic dilution method. Linear calibration (1/x weighted regression) curves were constructed for each analyte at 12 different concentrations (ranging from 0.02 to 200 ng/mL), and the calibration curves exhibited excellent correlation coefficients for all chemicals (r 2 > 0.999). A mid-point calibration standard and methanol were injected after every 10 samples to monitor for drift in instrumental sensitivity and carry-over of target chemicals between samples	na
1,7-12 ng/g	RSD: 1,9-6,2%,	
PFOA: 3200 nmol m-2 (0.38 mg kg-1) (carpet), PFBA: 960 nmol m-2 (0.60 mg kg-1) (disposable bowl), 45% F from a new upholstery sample	Duplicate injection, precision experiments	
∼1330 µg F/m2 for PA and 243 µg F/m2 for PES/CO fabrics	In addition, blanks and replicate-certified reference materials were included during CIC measurements to ensure absence of background contamination as well as accuracy and precision of the method.	

Of a total of 300 products, 51 were detected above the detection limits, which accounted for approximately 17% of the products tested.	linearity of the calibration curve, instrument detection limit (IDL), method detection limit (MDL), and quality control.	
awning: 260 µg/kg Seat Cover (car): 2-50 µg/kg Coatings: 20-70 µg/kg Foul (for facedes): 2-30 µg/kg	Blank samples were prepared with every extraction batch.	
Dust: 0 - 38,76 ng/g urine: 0 - 2000 ng/l	To eliminate the impact of background contamination, the instru-ments and apparatus that might possibly contain PFC sources, wesubstituted polyethylenefor all thefluoropolymer materials.One proce-dural blank was prepared after every ten samples. The mean value aver-aged over all the blanks was deducted from each result to correct forbackground levels	
na	na	The extent of matrix interferences varies considerably depending on the nature of the samples,

	recoveries of all compounds spiked at 5 ng/L concentration level were in the range of 65-96%,	
na	with a better RSD lower than 19% (n = 7).	na
Overall the levels of PFCAs in textiles were in the low µg/m2 range and the level of 6:2 FTOH in the mg/m2 range		
78-391 nmol F/cm2 (jacket), 129-597 nmol F/ cm2 (jacket high F), 161-445 nmol F/cm2 (popcorn bag) and more	replicate measurements on the same sample	

Total concentrations of ND-4000 ng/g (paper) and 67 to 180 000 ng/g (textile)	continuing calibration verification (CCV) was analyzed at the beginning of each analysis	
no levels. Only recovery after different methods used	The selected method was validated by a recovery assessment,by assessment of the repeatability, and the determination of thereproducibility	
Textiles: up to 77,6 µg/kg Plastics: up to 0,384 µg/kg OSB and wood: up to 18,3 µg/kg (PFAS found in 14 out of 14 samples) Car interior materials: up to 3535 µg/kg	The accuracy of method was evaluated using a set of spiked solidblank materials (polyurethane foam (n¼6) and sand matrix blank(n¼10))	
PFAS: 0,03-719 µg/m2 PFOA: 0,02-171 µg/m2 FTOH's 0,001-698 µg/m2	replicate measurements on the same sample	
PFOS: 0,04 - 0,45 µg/m2 PFOA: 0,42 - 10,97 µg/m2	5 replicates of each sample	
The total concentration of the examined PFASs varied from 18 to 407 µg/m². Total fluorine in products over detection limit 8,000 to 365,000 µg/m²	Laboratory blanks consisting of reagents with the labelled standards added were extracted and analysed each time samples were analysed. In addition, the liquids used for migration and washing tests were also analysed to check for any blank values. In addition, recovery samples consisting of spiked textile, artificial saliva and laundry water were prepared.	na

	textile samples with PFOA was used to validate	
Recovery of PFOA between 97 and 113%	the reliability of the method. Recovery of PFOA between 97 and 113%	
Only PFOA, 8:2 FTOH and 6:2 FTOH were found in amounts at or above 1 µg/m2 or 10 mg/ kg or mg/L		na
	A validation was performed and several parameters such as linearity, matrix effect, LOQ, recovery and precision were studied	
PFOA: up to 2000 µg/kg (ski waxes), up to 19 µg/ m2 (outdoor textiles), up to 15 µg/m2 (baking paper) PFBA: up to 200 µg/kg (leather) PFBS: up to 120 µg/kg (leather)	accreditations according to DIN EN ISO/IEC 17025:2005, quality control standards	
6:2 FTOH: ND - 331 µg g(-1), 8:2 FTOG: ND - 92 µg g(-1), 10:2 FTOH: ND - 24 µg g(-1)	Internal audit pogram (IAP) standards analzed after each calibration, Daily quality check	

PFOA: up to 0,914 µg/m2 Other PFCAs: up to 1,022 µg/m2 FTOHs: up to 373 µg/m2	Recoveries of internal standards, procedural and instrumental blanks and methoddetection limits are regularly monitored as quality criteria for theanalysis	
Individual PFCAs: ND-2600 ng g-1 product		
In all analyzed jackets PFASs were determined in a range of 0.03 µg/m2 to 719 µg/m2	Recoveries not for all PFAS exaptable	Problems mainly occurred for long-chained PFCAs (PFTrA and PFTeA) and PFDS, for which no isotope-labelled internal standard was available.
Air samples: <0.04 ng/m3 to 285.8 ng/m3 , with 8:2 FTOH being the dominant congener	all samples wereanalysed with labelled FTOH standards enriched at the beginning ofthe analytical procedure and after doping N,N-Me2FOSA into thefinalextract.	
na	extraction efficiencies (with double extractions) close to 100% for PFOA and 80% for PFOS for both paper and fabric matrices	

	As standard procedure, laboratory blanks, method detection limits (MDLs) and recoveries were examined. For each sample, a high resolution full scan spectra was used to control positive detections (typical mass tolerance 50 ppm). No laboratory contamination for any of the analyzed compound was detected	
Significant levels of PFOA (> 1 µg/m2) 15) were found in six of 14 samples	na	na
na	The recovery of labelled reference compound shall be in the range from 70 % to 125 % for the sample to be considered valid.	
Four products contained C6-fluorotelomer-based SFPs (concentration range of 36–188 mg of C6F13/m2), one contained a C4-sulfonamide-based SFP (718 mg of C4F9/m2), and one contained a C8-fluorotelomer-based SFP (249 mg of C8F17/ m2)	Laboratory background contamination was monitored by including procedural blanks (30 mL of MilliQ water; n = 3) with every TOP assay batch. A triplicate control of textile in milli-Q water without addition of oxidant was also performed with every TOP batch. Finally, to ensure the efficacy of the TOP assay when processing unknown textiles, samples of the nonfluorinated textile (1A) were spiked with 30 ng of individual PFAA precursors (6:2 and 8:2 fluorotelomer sulfonates; both n = 3) in methanol, dried, and then subjected to the TOP assay. TF measurements were analyzed together with a certified reference material (BCR-461, fluorine in clay), which showed good zgreement with reference values [average of n = 3 replicates = 552 ± 7.3 (standard deviation) mg of F/kg vs a reference of 568 ± 60 mg of F/kg]	The inefficiency of the TOP assay for oxidizing SFPs is also a notable area for improvement (e.g., by modifying the concentration of persulfate)

na	na	na
na	na	na

LoD (ng/mL)	subgroup	Measurement - generic name
na		
		GC-MS
na		
		GC-MS
na		
		GC-MS
		LC-MS/MS, CIC
0.2-1.6 µg kg-1 (LOD), 0.6-3.2 µg kg-1 (LOQ)		LC-MS/MS

na	
	LC-MS/MS, GC-MS, TOP assay, PIGE
na	
	LC-MS/MS
Limits of detection (LODs) of the ionic PFASs were between 0.02and 0.1mgm2, and LODs of the volatile PFAS were 0.3mgm2.	LC-MS/MS
PFOA: 0.5 (LOD), 0.8 (LOQ) µg/m2, PFOS: 0.4 (LOD), 0.6 (LOQ) µg/m2	LC-MS/MS
LOD -3.5–19.4 pg of fluorine	
	GC-MS

MDL: 1,29-7,79 ng/g	LC-MS/MS
LOD = 285 ng/g	
	LC-MS/MS
0,2 ng/ml	GC-MS
5-10 µg/kg	DBDI
±1% for XPS, 0.063-3.7 ng g-1 (MQL) for LC-MS/MS	XPS, LC-MS/MS, LC-HRMS
na	
	CIC

MDLs between 0.47 and 1.42 mg/L	LC-MS/MS
	GC-MS
not in report	
	LC-MS/MS
LOD: 0,02 ng/ml - 1,28 ng/ml	
	LC-MS/MS
quantification limit for PFOS of 0,2 mg/ kg is achieved	
	LC-MS/MS

0.09-0.96 ng/L	LC-MS/MS
GC-MS: LOD = 0.37-2.4 µg/m2, LOQ = 1.2-8.1 µg/m2; LC-MS: LOD = 0.016-0.18 µg/m2, LOQ = 0.034-0.58 µg/m2	PIGE, GC-MS, LC-MS/MS, TOP assay
TOF: About 10 pellets must be processed to sustain a LOQ of 1 mg/kg fluorine (LOQ fluoride = 0.1 mg/l for IC)	LC-MS/MS
13 nmol F/cm2 (papers), 24-45 nmol F/cm2 for textiles	PIGE

30 and 77 ng/g (paper), 19 to 34 ng/g /(textile)	GC-MS, LC-HRMS
LOQs were reported (0.01–0.4mg/m2	LC-MS/MS
na	
	GC-MS
The limits of quantification ranged from 10 to 400 ng/m	LC-MS/MS
limits not mentioned	
	LC-MS/MS
LOD = 20 mg/kg for total fluorine	
	GC-MS, LC-MS/MS, CIC

limit of detection 0.3µmol L	?
LOD = 0.03-0.15 µg/m2, only qualitative for 6:2 monoPAP, 8:2 PAP, 6:2 diPAP, 8:2 diPAP	LC-MS/MS, GC-MS
LOQ between 2 and 20 mg/kg	
	LC-HRMS
LOQ (PFAA) = 0.1-0.5 µg/kg or 0.02-0.5 µg/m2 LOD (FTOH) = 20000 µg/kg	LC-MS/MS, GC-MS
quantification limit is the lowest calibration concentration	GC-MS

The MDLs for individual substances ranged from 0.005 to0.010mgm2and 0.5 to 2mgm2for ionic and neutral PFASsrespectively.	LC--MS/MS
na	LC-MS/MS
LOQ = 0.05 - 2 ng/ mL	LC-MS/MS
(LOQs) were 5 mg/ kg in most cases and 20 mg/kg in af few samples	GC-MS
0.71 ng mL-1 (PFOA), 0.12 ng mL-1 (PFOS); LOQ: 2.36 ng mL-1 (PFOA), 0.39 ng mL-1 (PFOS)	LC-MS/MS

MDLs not reported		
		GC-MS
na		
		LC-MS/MS, GC-MS, SEM
na		LC-MS/MS
na	na	TOP assay, CIC

0.1 - 0.25 ng/mL (LOQ) except for the FTOH compounds a higher LOQ is obtained 20 ng/mL	LC-MS/MS	
it is feasible to reach limits of detection (LoD) of 100 µg/kg and limits of quantification (LoQ) of 250 µg/kg	GC-MS	

Title

TOF-SIMS analysis of perfluoropolyether lubricant smear transferred from disk surface following laser heating

TOF-SIMS ANALYSIS OF ACCUMULATED PFPE LUBRICANT SMEAR FOLLOWING LASER HEATING

TOF-SIMS characterization of lubricants used in magnetic recording media

A novel method for film thickness measurement of perfluoropolyether lubricant by secondary ion mass spectroscopy

QUANTITATIVE SECONDARY ION MASS-SPECTROMETRY OF FLUOROCARBON POLYMERS

Laser Desorption Ionization-Time-of-Flight Mass Analysis of Perfluoropolyether Monolayer Directly from Hard Disk Medium Surface

Development of Extraction Methods for the Analysis of Perfluorinated Compounds in Leather with High Performance Liquid Chromatography Tandem Mass Spectrometry

A pilot study of per- and polyfluoroalkyl substances in automotive lubricant oils from the United States

Quantification of heavy perfluorinated organics by mass spectrometry

Perfluoropolyether characterization by nuclear magnetic resonance spectroscopy and gel permeation chromatography

Condition monitoring of perfluoropolyether (PFPE) lubricated components

STUDY OF THE FORMATION AND BREAK OF LUBRICANT BRIDGE IN THE HEAD DISK INTERFACE USING MOLECULAR DYNAMIC METHOD

Multianalyte profiling of per- and polyfluoroalkyl substances (PFASs) in liquid commercial products

Authors	Journal	year
Tani et al.	Microsystem Technologies-Micro-and Nanosystems-Information Storage and Processing Systems 2020 Vol. 26 Issue 1 Pages 79-88	2020
Tani et al.	Amer Soc Mechanical Engineers	2018
Zhang et al.	Applied Surface Science 2004 Vol. 231 Pages 336-341	2004
Zhu et al.	Applied Surface Science 2002 Vol. 189 Issue 1-2 Pages 53-58	2002
Lorenz et al.	Surface Science 1991 Vol. 250 Issue 1-3 Pages 112-122	1991
Kudo et al.	Analytical Chemistry 2011 Vol. 83 Issue 14 Pages 5563-5569	2011
Zhang et al.	5th Annual International Conference on Material Science and Environmental Engineering, edited by K. Wang	2018
Zhu et al.	Environmental Technology & Innovation 2020 Vol. 19 Pages 8	2020
Saprygin et al.	Journal of Analytical Chemistry 2010 Vol. 65 Issue 14 Pages 1469-1474	2010
Karis et al.	Journal of Fluorine Chemistry 2002 Vol. 118 Issue 1-2 Pages 81-94	2002
Silvestri et al.	Society Machinery Failure Prevention Technology 1997	1997

Dai et al.	Amer Soc Mechanical Engineers	2016
Favreau et al.	Chemosphere	2017

comments (t, nt, o)	DOI link
non-targeted	10.1007/s00542-019-04447-7
na	https://doi.org/10.1115/ISPS-MIPE201
non-targeted	10.1016/j.apsusc.2004.03.085
non-targeted	10.1016/s0169-4332(01)01032-7
non-targeted	10.1016/0039-6028(91)90714-4
non-targeted	10.1021/ac2005422
targeted	10.1088/1757-899x/301/1/012046
na	10.1016/j.eti.2020.100943
non-targeted	10.1134/s1061934810140054
non-targeted	10.1016/s0022-1139(02)00197-5
na	no link

na	10.1109/TMAG.2016.2626459
Also applied to AFFF	10.1016/j.chemosphere.2016.11.127

Name
na
na
Films of lubricants, perfluoropolyether (PFPE) Fomblin Z-DOL, Z-TETRAOL, AM3001, and cyclo triphosphazene X-1P
na
na
na
perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnA), perfluorododecanoic acid (PFDoA), perfluorotridecanoic Acid (PFTrDA), perfluorotetradecanoic acid (PFTeDA) and perfluorooctanesulfonate (PFOS), perfluorooctane sulfonamide (PFOSA)
C4–C12; perfluorobutanoic acid (PFBA), perfluoro-n-pentanoic acid (PFPeA), per_x0002_fluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), PFOA, perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnDA), and perfluorododecanoic acid (PFDoDA)] and four PFSAs [C4–C10; perfluorobutanesulfonate (PFBS), perfluorohexanesulfonate (PFHxS), PFOS, and perfluorodecanesulfonate (PFDS)]
na
na
na

na

41 targeted PFAs including PFCAs (C4-C16), PFSAs (C4, C6, C8, C10), ipPFNS, PFPAs (C6, C8, C10), FOSA, N-Me FOSA, N-Et FOSA, FASAAs: FOSAA, N-MeFOSAA, N-EtFOSAA, N-MeFOSE, N-EtFOSE, FTSAs (4:2, 6:2, 8:2 FTS), FTOHs (4:2, 6:2, 7:2s, 8:2, 10:2), 8:2 FTI, 8:2 FTAC, 8:2 FTMAC

CAS (if available in source)
na
na
na
na
na
na
na
na
na
na
na
na

na

na

Sampling	sample amount used
perfluoropolyether (PFPE) lubricant D-4OH with a Demnum main chain and two hydroxyl functional units per end group	na
	na
magnetic recording media	na
direct	na
direct	na
PFPEs used were “Fomblin Z-Tetraol	na
leather samples	1 g
automotive lubricant oils and hydraulic fluids	1g
solutions on the basis of Freon_x0002_113, which contained PFC or PFPE in an amount ranging from 0.2 to 1000 µg/mL	na
commercial PFPEs	na
direct	na

na	na
Household products included impregnation agents (n = 60), cleansers (n = 24), polishes (n = 18), lubricants (n = 7). A miscellaneous category of products (n = 23) was defined by various applications that included foamsuppressing agents for the chromium industry, paints, ski wax, inks and tanning substances.	500 mg for LC-MS, 200 mg for GC-MS

Pre- treatment	Extraction
na	na
na	na
na	na
na	na
na	na
NaTFA solution (0.2 mg/mL in THF/HFIP = 1:1) was sprayed on the disk surface	na
ultrasound liquid extraction followed by SPE on Oasis Wax	na
na	na
na	na
na	na
na	na

na	na
LC-MS: dissolved in 10 mL water, adding methanol/water, ammonium acetate (pH 4), GC-MS: dissolved in 10 mL methanol, filtration	LC-MS: SPE with methanol/ ammonium acetate (50:50)

Clean up	Measurement
na	time-of-flight secondary ion mass spectrometry
na	
na	TOF-SIMS
na	TOF-SIMS
na	Secondary ion mass spectrometry (SIMS) i
na	LDI-TOF-MS
na	LC-MSMS Acquity UPLCTM BEH C18 (1.7µm, 2.1×100mm. The column temperature was set to 35 °C. A gradient program was employed using 5 mM aqueous formic acid solution and methanol mobile phases. The flow rate of 0.08 mL/min and the volume injected was 5µL. The gradient started at 35% methanol followed by an 8 min ramp to 87 % methanol. At 20 min, the ramp was decreased to 85 % methanol and at 25 min the ramp was decreased to 80 % methanol
na	LC-MS/MS Betasil C18 100 mm × 2.1 mm, 5.0 µm column. The mobile phase consisted of methanol (A) and 20 mM ammonium acetate in water (B). The optimized mobile phase gradient flow was as follows: 10% A from 0.0 to 0.1 min, 10% to 30% A from 0.1 to 1.0 min, 30% to 99% A from 1.0 to 8.0 min, 99% A from 8.0 to 12.0 min, 99% to 10% A from 12.0 to 12.5 min, and 10% A from 12.5 to 17.5 min, which was set at a flow rate of 0.3 mL/min. total oxidizable precursor (TOP) assay
na	a gas chromatograph or by means of direct probe under particular temperature conditions
na	nuclear magnetic resonance (NMR) spectroscopy and gel permeation chromatography (GPC)
na	na

na	na
LC-MS: adding ammonium hydroxide in methanol (0.5 %), neutralized with acetic acid	LC- MS/MS, GC-MS/MS for FTOHs, FTI, FTAC, FTMAC

Quantification method	Working range (ng/mL) As	Matrices
qualitative	na	na
	na	na
monitor the thickness and molecular weights of the lubricant	na	lubricant
thickness is determined by etching time for the lubricant backbone fragments CF2O and C2F4O to converge or by monitoring the maximum position of the deth profile of CH fragment	na	lubricant
na	na	polyperfhtoroether films o
qualitative	na	disk surface
na	na	leather
na	na	lubricants
na	na	lubricant
characterize, chain composition end groups, and molecular weight distribution	na	lubricant
na	na	na

na	na	na
internal standardisation using mass-labeled standards	na	household products (impregnation agents, cleanser, polishes), lubricants, foamsuppressing agents for the chromium industry, paints, ski waxes, inks, tanning substances,

reported levels (ng/mL)	info - validation of the method	Limitations
na	na	na
na	na	na
na	na	na
11-79 A	good linearity	na
6-160 A	na	na
na	na	na
na	recoveries of all compounds spiked at 5 ng/L concentration level were in the range of 65-96%, with a better RSD lower than 19% (n = 7).	na
Following oxidation, lubricant extracts yielded ∑PFAA concen_x0002_trations up to two orders of magnitude higher (range: 196–8300 ng/g; mean: 1840 ng/g) than those measured prior to oxidation (5.96–344 ng/g; 71.6 ng/g)	excellent regression coefficients for all chemicals (r2 > 0.999). Six procedural blanks, three for un-oxidized extracts and three for oxidized extracts, were analyzed with the real samples. recoveries of PFAAs were 84.9%–121% and 77.1%–119% for non-oxidative and oxidative methods	na
na	na	na
na	na	na
na	na	na

na	na	na
55% of all samples contained at least one PFAS between 0.1 and 25'000 mg/kg of product, with the majority of products falling within the 100e1000 mg/kg range	na	na

LoD (ng/mL)	subgroup	Measurement - generic name
na	na	LC-HRMS
na	na	
na	na	TOF-SIMS
na	na	TOF-SIMS
na	na	TOF-SIMS
na	na	
0.09-0.96 ng/L	na	LC-MS/MS
0.010 to 0.160 ng/g	na	LC-MS/MS
0.1 µg/mL	na	GC-MS
	na	NMR, GPC
na	na	

na	na
LOQ: 0.5-2 ng/mL (LC-MS), 2-10 ng/mL (GC-MS)	na
LC-MS/MS, GC-MS	

Title	Authors
Concentrations of organic contaminants in industrial and municipal bioresources recycled in agriculture in the UK.	Rigby et al.
Oxidative Conversion as a Means of Detecting Precursors to Perfluoroalkyl Acids in Urban Runoff	Houtz et al.
Markers of anthropogenic contamination: A validated method for quantification of pharmaceuticals, illicit drug metabolites, perfluorinated compounds, and plasticisers in sewage treatment effluent and rain runoff	Wilkinson et al.

National Estimate of Per- and Polyfluoroalkyl Substance (PFAS) Release to U.S. Municipal Landfill Leachate	Lang et al.
Waste water treatment plants as sources of polyfluorinated compounds, polybrominated diphenyl ethers and musk fragrances to ambient air	Weinberg et al.

Occurrence and Phase Distribution of Neutral and Ionizable Per- and Polyfluoroalkyl Substances (PFASs) in the Atmosphere and Plant Leaves around Landfills: A Case Study in Tianjin, China	Tian et al.
Per- and polyfluoroalkyl substances and the contribution of unknown precursors and short-chain (C2-C3) perfluoroalkyl carboxylic acids at solid waste disposal facilities	Wang et al.
National inventory of perfluoroalkyl substances in archived U.S. biosolids from the 2001 EPA National Sewage Sludge Survey	Venkatesana et al.

Temporal trends of perfluoroalkyl substances in limed biosolids from a large municipal water resource recovery facility	Armstrong et al.
Release and fate of fluorocarbons in a shredder residue landfill cell: 2. Field investigations	Scheutz et al.
Temporal trends of persistent organic pollutants in digested sewage sludge (1993-2012)	Zennegg et al.

Occurrence and point source characterization of perfluoroalkyl acids in sewage sludge	Alder et al.
First Report of a Chinese PFOS Alternative Overlooked for 30 Years: Its Toxicity, Persistence, and Presence in the Environment	Wang et al.

Search for over 2000 current and legacy micropollutants on a wastewater infiltration site with a UPLC-high resolution MS target screening method	Wode et al.
Extended Suspect and Non-Target Strategies to Characterize Emerging Polar Organic Contaminants in Raw Wastewater with LC-HRMS/MS	Gago-Ferrero et al.
Contamination of groundwater with per- and polyfluoroalkyl substances (PFAS) from legacy landfills in an urban re-development precinct	Hepburn et al.
Novel and legacy poly- and perfluoroalkyl substances (PFASs) in indoor dust from urban, industrial, and e-waste dismantling areas: The emergence of PFAS alternatives in China	Zhang et al.

Survey of perfluorinated alkyl acids in Finnish effluents, storm water, landfill leachate and sludge — Perkola et al.

Contribution of precursor compounds to the release of per- and polyfluoroalkyl substances (PFASs) from waste water treatment plants (WWTPs) — Eriksson et al.

Perfluoroalkyl compounds in municipal WWTPs in Tianjin, China—concentrations, distribution and mass flow	Sun et al.
Orthogonal zirconium diol/C18 liquid chromatography-tandem mass spectrometry analysis of poly and perfluoroalkyl substances in landfill leachate	Allred et al.
Rapid characterization of perfluoralkyl carboxylate, sulfonate, and sulfonamide isomers by high-performance liquid chromatography-tandem mass spectrometry	Benskin et al.

Incorporating perfluoroalkyl acids (PFAA) into a geochemical index for improved delineation of legacy landfill impacts on groundwater	Hepburn et al.
Occurrence and distribution of brominated flame retardants and perfluoroalkyl substances in Australian landfill leachate and biosolids	Gallen et al.
Quantitative determination of fluorochemicals in municipal landfill leachates	Huset et al.

Characteristic distribution patterns of perfluoroalkyl substances in soils according to land-use types	Sim et al.
Leachate emissions of short- and long-chain per- and polyfluoralkyl substances (PFASs) from various Norwegian landfills	Knutsen et al.
Occurrence of per- and polyfluoroalkyl substances and unidentified organofluorine in leachate from waste-to-energy stockpile - A case study	Björklund et al.
Investigating landfill leachate as a source of trace organic pollutants	Clarke et al.

Perfluoroalkyl substances (PFASs) in leachate, fly ash, and bottom ash from waste incineration plants: Implications for the environmental release of PFAS.	Liu et al.
Organic contaminants of emerging concern in leachate of historic municipal landfills	Propp et al.
Waste type, incineration, and aeration are associated with per_x0002_and polyfluoroalkyl levels in landfill leachates	Solo-Gabriele et al.

ASTM E3274-21 - Standard Guide for Management of Investigation-Derived Waste Associated with PFAS	na
Identification of Novel Polyfluorinated Ether Sulfonates as PFOS Alternatives in Municipal Sewage Sludge in China	Ruan et al.
A validated analytical method for the determination of perfluorinated compounds in surface-, sea- and sewagewater using liquid chromatography coupled to time-of-flight mass spectrometry	Wille et al.

DIN 38407-42:2011 - Standard methods for the examination of water, waste water and sludge	na
DIN 38414-14 - German standard methods for the examination of water, waste water and sludge – Sludge and sediments (group S) – Part 14: Determination of selected polyfluorinated compounds (PFC) in sludge, compost and soil – Method using high performance liquid chromatography and mass spectrometric detection (HPLC-MS/MS) (S 14)	na

Per- and Polyfluoroalkyl Substances in Landfill Leachate: Patterns, Time Trends, and Sources — Benskin et al.

Quantitative analysis of poly- and perfluoroalkyl compounds in water matrices using high resolution mass spectrometry: Optimization for a laser diode thermal desorption method — Munoz et al.

Gas chromatography-tandem mass spectrometry with atmospheric pressure chemical ionization for fluorotelomer alcohols and perfluorinated sulfonamides determination	Portolés et al.
Perfluoroalkyl acids in municipal landfill leachates from China: Occurrence, fate during leachate treatment and potential impact on groundwater	Yan et al.
Perfluorinated alkyl substances (PFASs) in northern Spain municipal solid waste landfill leachates	Fuertes et al.

Australia-wide assessment of perfluoroalkyl substances (PFASs) in landfill leachates	Gallen et al.
Suspect and Nontarget Screening of Per- and Polyfluoroalkyl Substances in Wastewater from a Fluorochemical Manufacturing Park	Wang et al.

Ultra-Short-Chain Perfluoroalkyl Acids Including Trifluoromethane Sulfonic Acid in Water Connected to Known and Suspected Point Sources in Sweden	Björnsdotter et al.
Perfluoroalkyl Acid Characterization in U.S. Municipal Organic Solid Waste Composts	Choi et al.

Brominated flame retardants and perfluoroalkyl substances in landfill leachate from Ireland	Harrad et al.
Determination of Per- and Polyfluoroalkyl Substances in Craft Villages and Industrial Environments of Vietnam	Phung et al.

ASTM D7979-20 - Standard Test Method for Determination of Per- and Polyfluoroalkyl Substances in Water, Sludge, Influent, Effluent, and Wastewater by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS)	na
The fate of poly- and perfluoroalkyl substances in a marine food web influenced by land-based sources in the Norwegian Arctic	Ali et al.

Characterization of the thermolysis products of Nafion membrane: A potential source of perfluorinated compounds in the environment	Feng et al.
New Analytical Methods Developed for Determination of Perfluorinated Surfactants in Waters and Wastes	Trojanowicz et al.
Analysis of perfluorinated compounds in sewage sludge by pressurized solvent extraction followed by liquid chromatography-mass spectrometry	Llorca et al.
Investigation of waste incineration of fluorotelomer-based polymers as a potential source of PFOA in the environment	Taylor et al.

Silicon photovoltaic modules at end-of-life: Removal of polymeric layers and separation of materials.	Fiandra et al.
Perfluorochemicals in wastewater treatment plants and sediments in Hong Kong	Ma et al.
Wide-scope target analysis of emerging contaminants in landfill leachates and risk assessment using Risk Quotient methodology	Nika et al.
Contaminants in landfill soils - Reliability of prefeasibility studies	Hölzle

Polyfluoroalkyl compounds in landfill leachates	Busch et al.
Focused ultrasound solid–liquid extraction of perfluorinated compounds from sewage sludge	Martínez-Moral et al.

Spatial distribution and importance of potential perfluoroalkyl acid precursors in urban rivers and sewage treatment plant effluent - Case study of Tama River, Japan	Ye et al.
Screening for 32 per- and polyfluoroalkyl substances (PFAS) including GenX in sludges from 43 WWTPs located in the Czech Republic - Evaluation of potential accumulation in vegetables after application of biosolids	Semerád et al.
Per- and polyfluoroalkyl substances in selected sewage sludge in Nigeria	Sindiku et al.
Toward Comprehensive Per- and Polyfluoroalkyl Substances Annotation Using FluoroMatch Software and Intelligent High-Resolution Tandem Mass Spectrometry Acquisition	Koelmel et al.

Evaluation of extraction workflows for quantitative analysis of per- and polyfluoroalkyl substances: A case study using soil adjacent to a landfill	Ahmadireskety et al.
Concentrations, Distribution, and Persistence of Perfluoroalkylates in Sludge-Applied Soils near Decatur, Alabama, USA	Washington et al.
Characterizing and Comparing Per- and Polyfluoroalkyl Substances in Commercially Available Biosolid and Organic Non-Biosolid-Based Products	Lazcano et al.

Target and Nontarget Analysis of Per- and Polyfluoralkyl Substances in Wastewater from Electronics Fabrication Facilities	Jacob et al.
End-of-life of silicon PV panels: A sustainable materials recovery process	Fiandra et al.
A pilot study on the assessment of trace organic contaminants including pharmaceuticals and personal care products from on-site wastewater treatment systems along Skaneateles Lake in New York State, USA	Subedi et al.
Release and fate of fluorocarbons in a shredder residue landfill cell: 1.Laboratory experiments	Scheutz et al.
Identifying an unknown compound in flue gas of semiconductor industry - Forensics of a perfluorocarbon	Wang et al.

Screening for perfluoroalkyl acids in consumer products, building materials and wastes	Bečanová et al.
Validation of quantitative measurements and semi-quantitative estimates of emerging perfluoroethercarboxylic acids (PFECAs) and hexfluoroprolyene oxide acids (HFPOAs)	McCord et al.

A single analytical method for the determination of 53 legacy and emerging per- and polyfluoroalkyl substances (PFAS) in aqueous matrices	Coggan et al.
Sample preparation optimization by central composite design for multi class determination of 172 emerging contaminants in wastewaters and tap water using liquid chromatography high-resolution mass spectrometry	Ofrydopoulou et al.
Determination of emerging and priority industrial pollutants in surface water and wastewater by liquid chromatography-negative electrospray ionization tandem mass spectrometry	Martín et al.
Parameters affecting the formation of perfluoroalkyl acids during wastewater treatment	Guerra et al.

Poly- and perfluoroalkyl substances in wastewater: Significance of unknown precursors, manufacturing shifts, and likely AFFF impacts — Houtz et al.

Detection, Occurrence, and Fate of Fluorotelomer Alcohols in Municipal Wastewater Treatment Plants — Chen et al.

Development and Applications of Novel DGT Passive Samplers for Measuring 12 Per- and Polyfluoroalkyl Substances in Natural Waters and Wastewaters	Fang et al.
Perfluoroalkyl acids in selected wastewater treatment plants and their discharge load within the Lake Victoria basin in Kenya	Chirikona et al.

Fluoro-functionalized paper-based solid-phase extraction for analysis of perfluorinated compounds by high-performance liquid chromatography coupled with electrospray ionization–tandem mass spectrometry	He et al.
Municipal landfill leachates: a significant source for new and emerging pollutants	Eggen et al.

Contamination by perfluorinated compounds in water near waste recycling and disposal sites in Vietnam	Kim et al.
Legacy and emerging per- and polyfluoroalkyl substances (PFASs) in Australian biosolids.	Moodie et al.

A mass estimate of perfluoroalkyl substance (PFAS) release from Australian wastewater treatment plants	Gallen et al.
Identification of novel micropollutants in wastewater by a combination of suspect and nontarget screening	Hug et al.
Are perfluoroalkyl acids in waste water treatment plant effluents the result of primary emissions from the technosphere or of environmental recirculation?	Filipovic et al.

An investigation into per- and polyfluoroalkyl substances (PFAS) in nineteen Australian wastewater treatment plants (WWTPs)	Coggan et al.
Applicability of the direct injection liquid chromatographic tandem mass spectrometric analytical approach to the sub-ngL(-1) determination of perfluoro-alkyl acids in waste, surface, ground and drinking water samples	Ciofi et al.
Side-chain fluorinated polymer surfactants in biosolids from wastewater treatment plants	Letcher et al.

Strategies to Characterize Polar Organic Contamination in Wastewater: Exploring the Capability of High Resolution Mass Spectrometry

Schymanski et al.

Per- and polyfluoroalkyl substances (PFASs) in water, soil and plants in wetlands and agricultural areas in Kampala, Uganda	Dalahmeh et al.
Perfluorooctanoic acid and perfluorooctane sulfonate released from a waste water treatment plant in Bavaria, Germany	Becker et al.

Application of an immobilized ionic liquid for the passive sampling of perfluorinated substances in water Wang et al.

Which type of pollutants need to be controlled with priority in wastewater treatment plants: Traditional or emerging pollutants? Zhou et al.

Multi-residue method for the determination of over 400 priority and emerging pollutants in water and wastewater by solid-phase extraction and liquid chromatography-time-of-flight mass spectrometry	Robles-Molina et al.
Trace determination of perfluorooctane sulfonate and perfluorooctanoic acid in environmental samples (surface water, wastewater, biota, sediments, and sewage sludge) using liquid chromatography – Orbitrap mass spectrometry	Zacs et al.
HPLC–MS/MS methods for the determination of 52 perfluoroalkyl and polyfluoroalkyl substances in aqueous samples	Gremmel et al.
Identification and Fate of Aqueous Film Forming Foam Derived Per_x0002_and Polyfluoroalkyl Substances in a Wastewater Treatment Plant	Houtz et al.

Journal	Year	Comments
The Science of the total environment	2021	(i) land applied materials: treated sewage sludge (biosolids), meat and bone meal ash (MBMA), poultry litter ash (PLA), paper sludge ash (PSA) and compost-like-output (CLO), and (ii) bedding materials: recycled waste wood (RWW), dried paper sludge (DPS), paper sludge ash (PSA) and shredded cardboard
Environmental Science & Technology	2012	33 urban runoff samples
Chemosphere. 2016 Sep;159:638-646	2016	6 sewage treatment works (STW) effluent discharges as well as concentrations in 5 rain-driven street runoffs and field drainages

Environ Sci Technol. 2017 Feb 21;51(4):2197-2205	70 PFASs in 95 samples of leachate were 2017 measured in a survey of U.S. landfills
Environmental Pollution Volume 159, Issue 1, January 2011, Pages 125-132	2011 air samples

Environmental Science & Technology, 19 Jan 2018, 52(3):1301-1310	2018	air, dry deposition, and plant leaves at two different landfills
The Science of the total environment	2019	ambient air and leachate
J Hazard Mater. 2013 May 15; 0: 413–418	2013	biosolids

Journal of Environmental Management 165 (2016) 88e95	2016	biosolids from a municipal water resource recovery facility (WRRF)
Waste Manag	2010	determine the gas composition, attenuation, and emission of fluorocarbons in a monofill shredder residue landfill cell by field investigation
Environ Int	2013	digested sewage sludge long-chain perfluorinated acids

Chemosphere	2015 digested sewage sludges
Environmental Science & Technology	2013 effluent and influent

Water Res	2015	Emerging contaminants Pharmaceuticals Pesticides Carbamazepine Wastewater reuse
Environ Sci Technol. 2015 Oct 20;49(20):12333-41	2015	Extended Suspect and Non-Target
Environmental pollution (Barking, Essex : 1987)	2019	groundwater surrounding legacy landfills
Environmental pollution (Barking, Essex : 1987)	2020	indoor dust samples collected from urban, industrial, and e-waste dismantling areas

Environmental science and pollution research international	2013	industry effluent landfill leachate and sludge
Journal of environmental sciences (China)	2017	influent and effluent sewage water and sludge

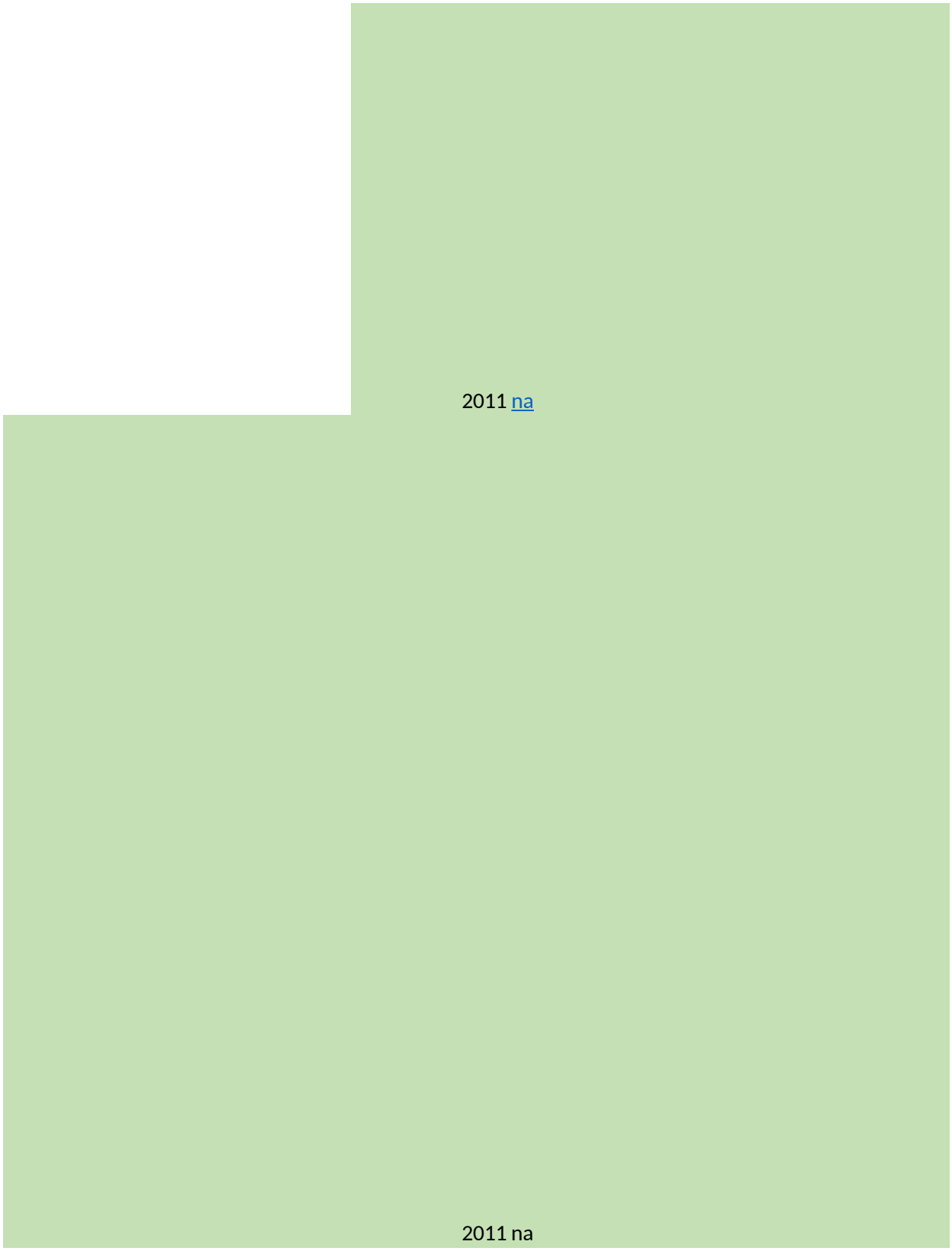
Environ Sci Pollut Res Int. 2012 Jun;19(5):1405-15	2012 influents and effluents and sludge samples
J Chromatogr A	landfill 2014 (Leachates coming from landfills)
J Chromatogr A	2012 landfill leachate

The Science of the total environment	2019 landfill leachate
Journal of hazardous materials	2016 landfill leachate and biosolids
Chemosphere	2011 landfill leachates

Chemosphere	2021	landfills
Environmental science. Processes & impacts	2019	landfills (leachate and sediment from ten Norwegian landfills)
Chemosphere	2021	leachate from a Waste-to-Energy stockpile
Chemosphere	2015	leachate samples analyzed and gemfibrozil was detected in samples from four of the five-landfill sites.

The Science of the total environment	2021	leachate, fly ash and bottom ash produced from three MSW incineration plants in southern China.
Environmental pollution (Barking, Essex : 1987)	2021	leachate-impacted groundwater
Waste Management Volume 107, 15 April 2020, Pages 191-200	2020	leachates from municipal solid waste (MSW), construction and demolition (C&D), MSW ash (MSWA), and a mixture of MSWA and MSW with landfill gas condensate (MSWA/MSW-GC)

	2021 Management of Waste, no analytical method
Environ Sci Technol. 2015 Jun 2;49(11):6519-27	2015 municipal sewage sludge samples
Journal of Chromatography A Volume 1217, Issue 43, 22 October 2010, Pages 6616-6622	2010 na


2011 na
2011 na

Environ Sci Technol. 2012 Nov 6;46(21):11532-40	2012	na
Analytica Chimica Acta Volume 881, 30 June 2015, Pages 98-106	2015	na

J Chromatogr A. 2015 Sep 25;1413:107-16	2015 na
Sci Total Environ. 2015 Aug 15;524-525:23-31	2015 na
Chemosphere, Volume 168, February 2017, Pages 399-407	2017 na

Journal of Hazardous Materials Volume 331, 5 June 2017, Pages 132-141	2017	na
Environmental Science & Technology	2018	na

Environ. Sci. Technol. 2019, 53, 11093−11101	2019	na
Environmental Science and Technology Letters 6(6): 372-377.	2019	na

Science of The Total Environment Volume 695, 10 December 2019, 133810	2019	na
J Anal Methods Chem. 2021 Apr 21;2021:5564994	2021	na

	2015 (2020 revised)	na
Environ. Sci.: Processes Impacts, 2021,23, 588	2021	na

Sci Rep	2015	Nafion N117 membrane thermolysis products in water and methanol Additionally, this study provides an analytical justification of the LC/ESI-MS/MS method for characterizing the degradation products of polymer electrolyte membranes
Croat. Chem. Acta 84 (3) (2011) 439–446.	2011	New methods developed for the determination using the HPLC with fluorescence detection and capillary electrophoretic methods are discussed, as well as the new method for the determination of total organic fluorine (TOF).
Journal of chromatography. A	2011	new validated protocol sewage sludge
Chemosphere. 2014 Sep;110:17-22	2014	no focus on PFAS analysis but on combustion

Waste Manag	2019	preliminary mechanical treatment to remove fluorinated polymers determining the quantity and quality of the recovered materials The gaseous products of the polymeric degradation have been characterized by gas chromatography-mass spectrometry (GC-MS) analysis.
Environmental pollution (Barking, Essex : 1987)	2010	quantification of PFCs in environmental samples without having to make internal modifications to a liquid chromatography system
J Hazard Mater	2020	Raw and treated leachate
Waste Manag	2017	reliability of prediction of the two investigation methods fluorine (leachate)

Environmental pollution (Barking, Essex : 1987)	2010 samples of untreated and treated leachate
Talanta	2013 sewage sludge

Water Res. 2014 Dec 15;67:77-85	2014 sewage treatment plant (STP) effluents
Chemosphere	2020 sludge
Chemosphere Volume 92, Issue 3, July 2013, Pages 329-335	2013 sludge from wastewater treatment plants
Analytical chemistry	software application 2020 landfill leachate as well as in leachate foam

The Science of the total environment	2021	soil adjacent to a landfill
Environmental Science & Technology, 15 Oct 2010, 44(22):8390-8396	2010	soil samples from sludge
Environmental Science & Technology 2020 Vol. 54 Issue 14 Pages 8640-8648	2020	targeted

Environ Sci Technol 2021 Vol. 55 Issue 4 Pages 2346-2356	2021	targeted and untargeted
Waste Manag	2019	The elemental compositions of the PV sample and the residue condensed organic products have been determined. The gaseous degradation products have been characterized by gas chromatographic analysis (GC).
Water Res. 2015 Apr 1;72:28-39	2015	This pilot study showed the occurrence of organic contaminants including pharmaceuticals and personal care products (PPCPs), perfluoroalkyl surfactants (PFASs), polybrominated diphenyl ethers (PBDEs), and polychlorinated biphenyls (PCBs) in septic effluents, adjacent lake water samples, household drinking water in homes that use lake water or a well adjacent to the lake as a source of drinking water
Waste Manag. 2010 Nov;30(11):2153-62	2010	Waste from the open SR landfill cell at the AV Miljø landfill in Denmark was sampled at three locations.
Chemosphere	2020	waste gas ideal method to pre-screen the presence of PFCs before a non-distinguishable TNMOC analyzer is applied to approximate the VOC level as part of the integrated effort to monitor VOC in flue gas

Chemosphere 164 (2016) 322e329	2016 wastes
Journal of chromatography. A	2018 wastewater

Analytical and Bioanalytical Chemistry	2019	wastewater
J Chromatogr A	2021	wastewater (developed for application to wastewater)
Anal Bioanal Chem	2014	wastewater (effluent wastewater)
Journal of hazardous materials	2014	wastewater (liquid and solid samples from five different wastewater treatment types)

Water research	2016	wastewater (municipal wastewater samples) Effluent samples
Environ Sci Technol. 2017 Aug 15;51(16):8953-8961	2017	wastewater (Municipal Wastewater Treatment Plants) influent, secondary effluent, and sludge

Environ Sci Technol	2021 wastewater (WWTP)
Environmental monitoring and assessment	2015 wastewater and sludge

J Chromatogr A. 2019 Sep 13;1601:79-85 2019 wastewater samples

Sci Total Environ 2010 water- and particle phase of landfill leachates perfluorinated compounds (PFCs)

Environmental monitoring and assessment	2013	water near waste recycling municipal dumping site e-waste recycling site
Chemosphere	2021	WWTP (Biosolids samples were collected from 19 Australian WWTPs)

Arch Environ Contam Toxicol. 2019 Feb;76(2):206-215	2019	WWTP (effluent from a wastewater treatment plant) wastewater from firefighter training area

Chemosphere. 2018 Oct;208:975-983	2018	WWTP (influent, effluent and biosolids samples from 14 WWTPs)
Environmental Pollution	2014	WWTP (wastewater treatment plant effluent)
Chemosphere	2015	WWTP influent, effluent and sludge

Heliyon	2019	WWTP solid and aqueous samples. Method development
Talanta	2018	WWTP (8 influents and 11 effluents of wastewater treatment plants)
J Hazard Mater	2020	WWTP (biosolids samples from twenty pan-Canadian wastewater treatment plants (WWTPs))

Environmental Science & Technology, 14 Jan 2014, 48(3):1811-1818	2014	WWTP (detected peaks from 10 Swiss wastewater treatment plant samples) included non targeted and suspect screening

Science of the Total Environment 631–632 (2018) 660–667	2018	WWTP (effluent from Bugolobi wastewater treatment plant)
Environmental science and pollution research international	2010	WWTP (In a previous study, the concentrations of PFOA and PFOS in grab samples collected from the waste water treatment plant (WWTP) of Bayreuth)

Journal of Chromatography A, 1515 (2017) 45–53	2017	WWTP (influent and effluent of a wastewater treatment plant)
Environment international	2019	WWTP (influent, effluent, and excess sludge from six WWTPs)

J Chromatogr A. 2014 Jul 11;1350:30-43	2014
J Chromatogr A . 2016 Nov 18;1473:109-121	2016
Analytical and Bioanalytical Chemistry	2017
Chemosphere. 2018 Oct;208:975-983	2018

DOI link	PFAS
10.1016/j.scitotenv.2020.142787	PFOA (335-61-1), PFDA (335-76-2), PFDoDA (307-55-1), PFHxS (355-46-4), PFOSA (754-91-6), PFNA (375-95-1), PFUnDa (2056-94-8), PFBS (375-73-5), PFOS (1763-23-1)
10.1021/es302274g	PFPeA PFDA PFUnA PFDoA PFBS PFHxS PFDS FOSA N-EtFOSAA N-MeFOSAA 8:2 FtS PFAS PFTrA PFTeA N-EtFOSE
10.1016/j.chemosphere.2016.06.039	PFBS, PFNA. PFOA, PFOS

10.1021/acs.est.6b05005	PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, 6:2 FTCA, 8:2 FTCA, 3:3 FTCA , 5:3 FTCA, 7:3 FTCA, PFBS, PFPS , PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA , MeFBSAA , MeFPeSAA , MeFHxSAA , MeFHpSAA , MeFOSAA, EtFBSAA , EtFPeSA , EtFHxSAAe , EtFOSAA; 10:2 FTCA, 6:2 FTUCA, 8:2 FTUCA, 9:3 FTCA , PFHpS , 4:2 FTSA , FBSAA , FPeSAA , FHxSAA , FHpSAA , EtFHpSAA; PFUnDA, PFDoDA, PFTriDA, PFTeDA , PFPeDA , PFHxDA , PFHpDA , PFOcDA , 4:2 FTCA , 4:2 FTUCA , 10:2 FTUCA , PFNS , PFDS, FOSAA , 4:4 PFPIA , 4:6 PFPIA , 6:6 PFPIA, 6:8 PFPIA, 8:8 PFPIA, 4:4 diPAP , 4:6 diPAP , 6:6 diPAP, 6:8 diPAP , 8:8 diPAP, 8:10 diPAP , 10:10 diPAP , 6:2 FTMAP , 6:2/8:2 FTMAP , 8:2 FTMAP , 8:2/10:2 FTMAP , 10:2 FTMAP , 8:8 SAmPAP
10.1016/j.envpol.2010.09.023	na

10.1021/acs.est.7b05385	6:2, 8:2, and 10:2 FTOHs; N-methyl and N-ethyl (N-Me/Et) FOSAs; N-methyl and N-ethyl (N-Me/Et) FOSEs, 6:2 and 8:2 diPAPs; TFA, PFPrA, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, and PFDoDA); C4, C6, and C8 perfluoroalkane_x0002_sulfonic acid (PFSA) analogue
10.1016/j.scitotenv.2019.135832	TOP (total oxidazable precursors) C2-C3 PFAA-precursors
10.1016/j.jhazmat.2013.03.016	Perfluorobutanoate (PFBA) Perfluoropentanoate (PFPeA) Perfluorohexanoate (PFHxA) Perfluoroheptanoate (PFHpA) Perfluorooctanoate (PFOA) Perfluorononanoate (PFNA) Perfluorodecanoate (PFDA) Perfluoroundecanoate (PFUnDA) Perfluorododecanoate (PFDoDA) Perfluorobutane sulfonate (PFBS) Perfluorohexane sulfonate (PFHxS) Perfluorooctane sulfonate (PFOS) Perfluorooctane sulfonamide (PFOSA)

10.1016/j.jenvman.2015.09.023	perfluorobutanoic acid (PFBA), perfluropentanoic acid (PFPeA), pefluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), PFOA, per-fluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), per- fluoroundecanoic acid (PFUnA), perfluorobutanesulfonic acid (PFBS), perfluorohexanesulfonic acid (PFHxS), PFOS, and per- fluorodecanesulfonic acid (PFDS)
10.1016/j.wasman.2010.03.033	CFC-11, CFC-12, HFC-134a, HCFC-141b, HFC-245fa, HCFC-21, HCFC-22, HCFC-31, HFC-32, and HFC-41
10.1016/j.envint.2013.08.020	na

10.1016/j.chemosphere.2014.07.045	perfluorobutanoic acid (PFBA), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorooctanoic acid (PFOA), perfluorononaoic acid (PFNA), perfluorodecanoic acid (PFDA), sodium perfluorobutane sulfonate (PFBS), sodium perfluorohexane sulfonate (PFHxS), sodium perfluorooctane sulfonate (PFOS)
10.1021/es401525n	chlorinated polyfluorinated ether sulfonate (locally called F-53B, C8ClF16O4SK), PFOS

10.1016/j.watres.2014.11.034	PFOA
10.1021/acs.est.5b03454	Perfluorheptanoic acid Perfluorooctanoic acid Perfluorononanoic acid
10.1016/j.envpol.2019.02.018	17 PFAS: PFBA; PFPeA;FFHxA; PFHpA; PFOA; PFNA; PFDA ; PFUnDA; PFDoDA; PFBS; PFPeS; PFHxS; PFHpS; PFOS; PFDS; 6:2 FTS; 8:2 FTS
10.1016/j.envpol.2020.114461	25 PFAS: PFBA, PFPeA. PFHxA, PFHpA, PFOA, PFNA, PFDA, PFunDA, PFDoDA, PFBS, PFOS, 6:2 FTUCA, 8:2 FTUCA, 6:2 Cl-PFESA, 8:2 Cl_PFESA

10.1007/s11356-013-1518-z	PFHxA, PFOA, PFOS, PFDA
10.1016/j.jes.2017.05.004	PFCA, PFSA, FTSA, FTCA, FTUCA: PAP, PFPA, PFPiA

10.1007/s11356-011-0727-6	PFDoA PFUnA PFDA PFNA PFOA PFHpA PFHxA PFPeA PFBA PFOS PFHxS
10.1016/j.chroma.2014.07.056	70 different PFASs
10.1016/j.chroma.2012.05.077	(PFPA), perfluorohexanoate (PFHxA) perfluoroheptanoate (PFHpA), perfluorononanoate (PFNA), perfluorodecanoate (PFDA), perfluoroundecanoate (PFUnA), perfluorododecanoate (PFDoA), perfluorotetradecanoate (PFTA) and perfluorobutanesulfonate (PFBS)

10.1016/j.scitotenv.2019.02.203	16 PFAA
10.1016/j.jhazmat.2016.03.031	PFOA , PFOS , PFHxA , PFNA , PFDA , PFBS , PFUnDA , PFDoDA , PFTrDA , PFTeDA
10.1016/j.chemosphere.2010.11.072	PFBA PFPA PFHxA PFOA PFNA PFDA PFUnDA PFDoDA PETrDA PFTDA FPUEA PFBS PFHxS PFOS PFDS FtS MEFBSA MeFBSAA FOSA FOSAA ME-FODAA Et-FOSAA

10.1016/j.chemosphere.2021.130167	PFPeA, PFHxA, PFHpA, PFOA, PFNa, PFDA, PFUDA, PFDoDA, PFTrDA, PFTeDA, PFHxDA, PFBS, PFHxS, PFOS, PFDS
10.1039/C9EM00170K	28 PFASs short-chain PFCAs(PFBA, PFPeA and PFHxA), a short-chain PFSA (PFBS), long-chain PFCAs (PFHpA, HPFHpA, PFOA, PFNA, PFDA, PF-3,7-DMOA, PFUnDA, PFDoA, PFTrA, PFTA and PFHxDA), long-chain PFSAs (PFHxS, PFHpS, PFOS and PFDS), as well as fluo-rotelomer sulfonates (FTSAs: 4 : 2 FTSA, 6 : 2 FTSA and 8 : 2FTSA), a fluorotelomer alcohol (FTOH: 8 : 2 FTOH) and PFOS-precursors (perfluorosulfonamides (FOSAs): FOSA, EtFOSA,MeFOSA and perfluoroalkylsulfonamide alcohols (FOSEs):EtFOSE and MeFOSE
10.1016/j.chemosphere.2021.130380	34 PFAS- E.g. PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, 4:2 FTSA, 6:2 FTSA, 8:2 FTSA Also EOF (Extractable organofluorine) were measured
10.1016/j.chemosphere.2015.02.030	PFOA PFOS

10.1016/j.scitotenv.2021.148468	(PFBA), (PFPeA), (PFHxA), (PFHpA), (PFOA), (PFNA), (PFDA), (PFUdA), (PFDoA), (PFTrDA), (PFTeDA), (PFBS), (PFHxS), (PFHpS), (PFOS), (PFDS), (PFHxPA), (PFOPA), (PFDPA), (6:2 diPAP), (8:2 diPAP), M2PFOA), (M4PFOS)). M2PFOA
10.1016/j.envpol.2021.116474	PFBA, PFOA, PFDoDA, PFBS, PFDS, PFPeA, PFNA, PFTriDA, PFHxS, PFECHS, PFHxA, PFDA, PFTeDA, PFOS, FOSA, PFHpA, PFUnA
10.1016/j.wasman.2020.03.034	7 carboxylic acids, 3 sulfonic acids, and 5:3 fluorotelomer carboxylic acid

	PFOS PFOA
10.1021/acs.est.5b01010	Cl-PFAESs, F-PFAESs, PFSAs, FTSAs
10.1016/j.chroma.2010.03.054	PFBS PFHxS PFOS PFDS PFPAa PFHxA PFHpA PFOA PFNA PFDA PFUnA PFDoA PFTeA PFOSA

PFBA
PFPeA
PFHxA
PFHpA
PFOA
PFNA
PFDA
PFBS
PFHxS
PFOS

C4-C10 PFCA
C4-C8 PFSA

10.1021/es302471n	PFBS, PFHxS, PFOS, PFDS, PFBA, PFPeA, PFHxA, PFHpA, PFOS, PFNA, PFDA; PFUnDA, PFDoDA, PFTDA, FOSA, FOSAA, MeFOSAA, EtFOSAA, 6:2 FTCA, 8:2 FTCA, 10:2 FCTA, 6:2 FTUCA, 8:2 FTUCA, 10:2 FTUCA
10.1016/j.aca.2015.04.015	PFHxA, PFHpA, PFOA, PFNA. PFDA, PFOS

10.1016/j.chroma.2015.08.016	4:2 FTOH, 6:2 FTOH, 8:2 FTOH and 10:2 FTOH, N-MeFOSA, N-EtFOSA, N-MeFOSE and N-EtFOSE
10.1016/j.scitotenv.2015.03.111	pentafluoropropionic acid (PFPrA), perfluorobutyric acid (PFBA), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnA), perfluorododecanoic acid (PFDoA), perfluorotetradecanoic acid (PFTA), perfluoro-1-butanesulfonic acid potassium salt (PFBS), perfluorohexanesulfonic acid potassium salt (PFHxS) and perfluorooctanesulfonic acid (PFOS)
10.1016/j.chemosphere.2016.10.072	PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTeDA, PFBS, PFHxS, PFOS

10.1016/j.jhazmat.2017.02.006	PFOA, PFOS, perfluorohexanoate (PFHxA), perfluoroheptanoate (PFHpA), perfluorononanoate (PFNA), perfluorodecanoate (PFDA), perfluorounde_x0002_canoate (PFUnDA) perfluorododecanoate (PFDoDA) and perfuorohexanesulfonate (PFHxS)
10.1021/acs.est.8b03030	legacy PFASs, known PFASs, and newly reported PFASs (emerging). In total 90 PFAS from 15 classes.

10.1021/acs.est.9b02211	TFA PFPrA PFBA PFPeA PFHxA PFHpA PFOA PFNA PFDA PFUnDA PFDoDA PFTrDA PFTeDA PFHxDA PFOcDA TFMS PFEtS PFPrS PFBS PFPeS PFHxS PFHpS PFOS PFNS PFDS PFDoDS 4:2 FTSA 6:2 FTSA 8:2 FTSA
na	na

10.1016/j.scitotenv.2019.133810	perfluorooctane sulfonate (PFOS), perfluorobutane sulfonate (PFBS), perfluorohexane sulfonate (PFHxS), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluoro-1-octanesulfonamide (FOSA), N-methylperfluoro-1-octanesulfonamide (MeFOSA), N-ethylperfluoro-1-octanesulfonamide (EtFOSA), 2-(N-methylperfluoro1-octanesulfonamido)-ethanol (MeFOSE), and 2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol (EtFOSE)
10.1155/2021/5564994	PFHxA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFOS, PFHxS

PFTreA
PFTriA
PFDoA
PFUnA
PFDA
PFOS
PFNA
PFecHS
PFOA
PFHxS
PFHpA
PFHxA
PFBS
PFPeA
PFBA
FHEA
FOEA
FDEA
FOUEA
FHpPA
FHUEA

PFBA
PFHxA
PFHpA
PFOA
PFNA
PFDA
PFUnDA
PFDoDA
PFTrDA
PFTeDA
PFBS
PFHxS
PFOS
6:2 FTS
FOSA
N-MeFOSE
N-MeFOSA
N-EtFOSE
N-EtFOSA

10.1039/d0em00510j

10.1038/srep09859	PFCA analogues (CnF2n+1COOH, n=1-18)
10.5562/cca1776	perfluorinated carboxylic acids (PFCAs
10.1016/j.chroma.2011.01.085	PFBA PFPeA PFHxA PFHpA PFOA PFNA PFDA PFUdA PFDoA PFTeDA PFHxDA PFODA PFBS PFHxS PFOS PFDS PFOSA
10.1016/j.chemosphere.2014.02.037	na

10.1016/j.wasman.2019.02.004	Polyvinyl fluoride (PFVF) Polyvinylidene fluoride (PVDF) Ethylene-terafluoethylene (ETFE) Perfluoroalkoxy (PFA) Perfluoroalkoxy (PCTFE) Fluorinated ethylene_x0002_propylene (FEP)
10.1016/j.envpol.2010.01.013	PFBuS PFHxS PFHpS PFOS PFDS PFBA PFPeA PFHxA PFHpA PFOA PFNA PFDA PFUnDA PFDoA PFTrA PFTA FOSA N-MeFOSA N-EtFOSA
10.1016/j.jhazmat.2020.122493	PFBuS, PFHxA, PFOA, PFPeA, PFHpA, PFDeA, PFHxS
10.1016/j.wasman.2016.08.024	na

10.1016/j.envpol.2009.12.031	PFBS PFHxS PFOS PFDS PFBA PFHxA PFHpA PFOA PFNA PFDA PfUnA PFOSA
10.1016/j.talanta.2013.02.020	PFHpA, PFOA, PFNA, PFOS, PFDA, PFUnA, PFDoA

10.1016/j.watres.2014.09.014	PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA
10.1016/j.chemosphere.2020.128018	11 PFCAs, 4 PFSAs, 3 FOSAs, 3 FOSAAs, 3 FTAs, 4 FTSs and 4 recent replacements of PFOS and PFOA
10.1016/j.chemosphere.2013.04.010	PFHxA PFHpA PFOA PFNA PFDA PFUnDA PFDoDA PFBS PFHxS PFOS MPFHxA M8PFOA M9PFNA M6PFDA M7PFUnDA MPFDoDA MPFHxS M8PFOS
10.1021/acs.analchem.0c01591	27 PFAS

10.1016/j.scitotenv.2020.143944	51 PFAS - included nine PFSA(C3-C10, C12),and thirteen PFCA(C4-C14, C16, C18), twenty four perfluoroalkylated (PFAA) precursors (4:2, 6:2, 8:2 and 10:2 FTS; 6:2, 8:2 and 10:2 FTCA(FHEA, FOEA, FDEA, respectively); 8:2 and 10:2 FTUA (FOUEA, and FDUEA, respectively); 6:6 and 6:8 PFPi; 6:2, 8:2 and 6:2/8:2 diPAP, diSAmPAP; FBSA;FHxSA;N-AP-FHxSA;FOSA; N-MeFOSA; N-EtFOSA; FOSAA; N-MeFOSAA; N-EtFOSAA), and five other PFAS (8Cl-PFOS; 6:2 and 8:2 Cl-PFESA (9Cl-PF3ONS and 11Cl-PF3OUdS, respectively); NaDONA; and PFECHS
10.1021/es1003846	na
10.1021/acs.est.9b07281	

10.1021/acs.est.0c06690	The 25 target PFASs included 11 perfluorocarboxylic acids (PFCAs), seven perfluorosulfonic acids (PFSAs), three fluorotelomer sulfonic acids (FTSs), one perfluoroalkylsulfonamide (FOSA), two polyfluorosulfonamido acetic acid derivatives (N-MeFOSAA and N-EtFOSAA), and perfluoro-2-methyl-3-oxahexanoic acid (GenX).
10.1016/j.wasman.2018.11.035	_x0004_ fluorinated polymer
10.1016/j.watres.2014.10.049	PFDS PFOSA PFHxA PFHpA PFOA PFNA PFDA PFUnDA PFDoDA
10.1016/j.wasman.2010.03.035	trichlorofluoromethane (CFC-11) and dichlorodifluoromethane (CFC-12), dichlorofluoromethane (HCFC-21), chlorodifluoromethane (HCFC-22), chlorofluoromethane (HCFC-31), difluoromethane (HFC-32), and fluoromethane (HFC-41)
10.1016/j.chemosphere.2020.128504	C4F8, CF4, C2F6 and other

10.1016/j.chemosphere.2016.08.112	PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS, PFDS
10.1016/j.chroma.2018.03.047	perfluoroether carboxylic acids (PFECAs)

10.1007/s00216-019-01829-8	53 PFAS from 14 compond classes (full list in article)
10.1016/j.chroma.2021.462369	water samples were spiked with PFAS in order to see if the method could detect them
10.1007/s00216-014-7689-8	[PFOS, PFOA, perfluoroheptanoic acid (PFHpA), perfluorohexanoic acid (PFHxA), perfluoropentanoic acid (PFPeA), perfluorobutanoic acid (PFBuA)]
10.1016/j.jhazmat.2014.03.016	PFAAs, including PFOA, PFOS, and the perfluorinated analogues: perfluorobutane sulfonic acid (PFBS), perfluorohexane sulfonic acid (PFHxS), perfluorooctane sulfonamide (PFOSA), perfluorobutanoic acid (PFBA), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnA), and perfluorododecanoic acid (PFDoA)

10.1016/j.watres.2016.02.055	PFBA PFPeA PFHxA PFHpA PFOA PFNA PFDA PFBS PFHxS PFOS
10.1021/acs.est.7b00315	(4:2, 6:2, 8:2, 10:2, 12:2, and 14:2 FTOH

10.1021/acs.est.0c08092	PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, 6:2 FTSA, GenX
10.1007/s10661-015-4425-6	perfluorohexane sulfonate (PFHxS) perfluoro-1-octanesulfonate (PFOS) perfluorodecane sulfonate (PFDS) perfluorooctane sulfonic acid (PFOSA) perfluorobutanoic acid (PFBA) perfluoropentanoic acid (PFPeA) perfluoro-n-hexanoic acid (PFHxA) perfluoro-n-heptanoic acid (PFHpA) perfluoro-noctanoic acid (PFOA) perfluoro-n-nonanoic acid (PFNA) perfluoro-n-decanoic acid (PFDA) perfluoron-undecanoic acid (PFUnDA) perfluoro-n-dodecanoic acid (PFDoDA).

10.1016/j.chroma.2019.06.019	PFBA, PFOA, PFDA, PFOS
10.1016/j.scitotenv.2010.07.049	PFCs (PFBS, PFHxS, PFOS,

10.1007/s10661-012-2759-x	PFBS PFHxS PFHpS PFOS PFDS PFOSA PFBA PFPA PFHxA PFHpA PFOA PFNA PFDA PFUDA PFDDA PFTrDA PFTeDA
10.1016/j.chemosphere.2020.129143	44 PFAS

6:2 FTSAS
6:2 FTSAS-SO
8:2 FTSAS-SO
8:2 FTAB
10:2 FTAB
6:2 FtSaMAm
6:2 FtSa
4:2 FtSaAm
8:2 FtSaAm
5:3 FtB
7:3 FtB
9:3 FtB
5:1:2 FtB
7:1:2 FtB
9:1:2 FtB
6:2 FtTHN+
8:2 FtTHN+
6:2 FtTHN+−SO
8:2 FtTHN+−SO
PFHxSAmA PFOSAm
PFHxSAm
FHxSA
PFNS
PFPeS

10.1007/s00244-018-0585-z.

10.1016/j.chemosphere.2018.06.024	PFOA, PFOS, perfluorohexanoate (PFHxA), perfluoroheptanoate (PFHpA), perfluorononanoate (PFNA), perfluorodecanoate (PFDA), perfluoroundecanoate (PFUnDA) perfluorododecanoate, (PFDoDA) and, perfuorohexanesulfonate (PFHxS)
10.1016/j.envpol.2013.07.048	2 perfluorinated acids
10.1016/j.chemosphere.2014.07.082	Perfluorobutanoic acid (PFBA), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnDA), perfluorododecanoic acid (PFDoDA), perfluorobutane sulfonic acid (PFBS), perfluorohexane sulfonic acid (PFHxS), perfluorooctane sulfonic acid (PFOS), perfluorodecane sulfonic acid (PFDS) and perfluorooctane sulfonamide (FOSA).

10.1016/j.heliyon.2019.e02315	53 PFAS: E.g. 11 PFCAs and 8 PFSAs
10.1016/j.talanta.2017.08.052	Perfluorobutanesulphonic acid (PFBuS, CAS no. 375-73-5), per_x0002_fluoropentanoic acid (PFPeA, CAS no. 2706-90-3), perfluorohexanoic acid (PFHxA, CAS no. 307-24-4), perfluorohexanesulphonic acid (PFHxS, CAS no. 355-46-4), perfluoroheptanoic acid (PFHpA, CAS no. 375-85-9), perfluorooctanoic acid (PFOA, CAS no. 335-67-1), perfluoro-n-(1,2,3,4 13C4)octanoic acid (MPFOA), perfluoroactanesul_x0002_phonic acid (PFOS, CAS no. 1763-23-1), and perfluoro-1-(1,2,3,4 13C4) octanesulphonate (MPFOS), perfluorononanoic acid (PFNA, CAS no. 375-95-1), perfluorodecanoic acid (PFDA, CAS no. 335-76-2)
10.1016/j.jhazmat.2020.122044	PFBS PFOS FBSA FOSA sum of PFAS 22

10.1021/es4044374 na

10.1016/j.scitotenv.2018.03.024	PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTriDA, PFTeDA, PFHxDA, PFOcDA, PFBS, PFHxS, PFOS, PFDS, FOSA, MeFOSA, EtFOSA, MeFOSE, EtFOSE, FOSAA, MeFOSAA, EtFOSAA and 6:2 fluorotelomersulfonate (FTSA)
10.1007/s11356-010-0335-x	PFOA PFOS

10.1016/j.chroma.2017.08.001	PFHxA, PFDoDA, PFHxS, PFOA, PFOS
10.1016/j.envint.2019.104982	17 PFASs,: PFBA PFPeA PFHxA PFHpA PFOA PFNA PFDA PFUnDA PFDoDA PFTrDA PFTeDA PFHxDA PFODA PFBS PFHxS PFOS PFDS

10.1016/j.chroma.2014.05.003	PFOA, PFNA, PFOS, Pentafluoropropionic acid fragment, PFBA, Perfluoropentanoic acid fragment, PFHpA, PFDA, Perfluoroundecanoic acid, Perfluoroundecanoic acid fragement
10.1016/j.chroma.2016.10.060	PFOA, PFOS
10.1007/s00216-016-0110-z	PFCA n:2-FTCA FTUCA PFPA PFSA FTS FASA FASE FTOH mono-PAP FASAA FTEOC
10.1016/j.chemosphere.2018.06.024	4:2 FtS 6:2 FtS 8:2 FtS FPePA FHUEA FOUEA FOSA MeFOSAA EtFOSAA PFBS PFHxS PFOS PFDS PFBA PFPeA PFHxA PFHpA PFOA PFNA PFDA PFUA PFDoA

CAS (if available in publication)	Sampling
written with the names	22 samples of eight representative types of bioresources were collected for investigation. These included land applied materials:biosolids(anaerobically digested sewage sludge) (n=3), CLO (n=2), MBMA (n=3) and PLA(n=3).
na	Urban runoff samples were collected between November 2010 and March 2011 at sites around the San Francisco Bay (SF Bay), California. A total of 33 samples from 12 storms and 10 sites were analyzed. Samples were collected during the rise, peak, and fall of the storm hydrograph.
na	Effluent samples (n =12) were collected in duplicate from six STWs along three rivers. Runoff samples were collected from grass field drainage (n =3) and street runoff (n =2) during periods of rainfall. Grab samples were collected (200 mL) in amber glass bottles. All bottles were washed three times with 50/50 acetonitrile:acetone (v/v) followed by three washes with milli-Q water and were rinsed with sample water before collection. Water samples were collected from STW effluent outfalls and drainage pipes (both field and street) directly prior to entering the river flow. After collection, samples were stored at 4 ◦C in the dark until vacuum filtration (within 8 h of collection) using GF/F glass membrane filters.

na	samples were collected from 18 landfills either directly from a valve after flushing, or using a polyethylene baler for leachate obtained from manholes and ponds
na	Air sampling was conducted above the aeration tanks of two WWTPs. At each site, a high volume samplers operated directly above the aeration tanks; prior to the sampling, cartridges for PFC analyses were spiked with 50 mL of an internal standard solution

na	Limed biosolids samples were collected from a large municipal WRRF in the Mid-Atlantic region of the US
na	Two deep gas probes were installed permanently in the center of waste cell 1.5.1 in order to sample and analyze the composition of the gas generated within the waste. Each gas probe had two individual screens ranging from 2–3 m to 4–5 m below ground surface
na	na

na	Sewage Sludge samples from 45 WWTPs in Switzerland between August and December (2011) in 3 sampling campaigns, with 3 samples collected from 21 plants, 2 samples from 22 plants and 2 samples from 1 plant. The interval between sampling events was of at least 1 month. Sites determination was selected based on the ocurrence of known or assumed PFAS related industrial and comercial activities. Samples of anaerobically stabilized sewage sludge (digested sludge) were collected (digested during 20–30 d). The water content of the digested sludge was approximately 95%.
na	surface water samples (5 L for each sampling point) were taken from the Oujiang River, at Wenzhou city, China the vicinity of where the discharge from a municipal WWTP enters the river. This WWTP is known to receive wastewater from the electroplating industry, where both F-53B and PFOS are assumed to be in use. Wastewater samples were also collected “upstream”, at a small WWTP which treats the raw effluents of electroplating plants before they enter the municipal sewer system.

na	groundwater sampling in an area used to treat raw sewage in Berlin.
na	waste water
na	Groundwater samples were collected from thirteen shallow monitoring bores using a low flow pump with dedicated low-density poly ethylene (LDPE) tubing, into 250 mL polypropylene bottles. Sampling locations (n= 13) included sites installed directly in waste material and down-gradient from landfills, some of which exhibited evidence of leachate contamination.
na	Dust samples from e-waste dismantling areas, from communal flats near an industrial park, from student dormitoreis

	MWWTP2 and MWWTP3) on six occasions in 1 year, i.e. once every 2 months. The MWWTPs treat mostly domestic water but also industrial wastewater (Table 1). In addition, a target industry's (metal plating) wastewater was sampled four times. Storm water, landfill leachate and municipal sewage sludge were sampled twice. Storm water was collected from the Porolahti creek, where the storm water sewage gathers urban runoff from an industrial area. The sampling times were November 2009 and April 2010. Landfill leachate was sampled from the equal- ising tank at Ämmässuo waste disposal site in October 2009 and June 2010. MWWTP3 sludge was sampled in January and June 2010. The wastewater of the target industry is treated in MWWTP3, and the landfill leachate in MWWTP2. All treated effluents are discharged into the Gulf of Finland except MWWTP1, which is discharged into the Archipelago Sea (Gulf of Bothnia). Wastewater and landfill leachate were collected as 24 h composite samples into high-density polyethylene containers. The MWWTP samples were adjusted to flow rate, and kept at +4 °C during sampling. Landfill leachate and IWWTP1 sam- ples were adjusted for time (grab samples once an hour). The canisters were kept cold during the sampling. Storm water, sludge and target industry wastewater samples were taken as grab samples. The MWWTP sludge was sampled before digestion to plastic containers. Samples were transported to the laboratory within 24 h of sampling. Water samples were mixed and divided into bottles for various analyses (PFAA
na	samples in polypropylene bottles).
	3 municipal waste water treatment plants. Sludge samples were collected as composite sam_x0002_ples during one day in October in the years 2012, 2014, and 2015
na	from all three WWTPs.

		For each sampling point, water and sludge samples were collected and stored in high density, methanol rinsed, and air-dried polypropylene bottles. Water samples were prepared by centrifugation at 3,000 rpm for 10 min followed by filtration using 0.45-µm nylon membranes, and stored at −20°C until extraction. Sludge samples were dried in a freeze dryer and homogenized with a mortar
na		and pestle.
		six landfills were sampled and a total of seven leachate samples were collected.
		Two samples came from two different refuse cells in the same landfill (sites B1 and B2) and one sample came from
na		an evaporation pond (site F)
		Leachate (4L) was obtained April 13, 2010 from a Municipal Landfill

na	A total of 128 groundwater samples were collected from thirty-eight shallow monitoring bores over five sampling campaigns in November 2015, May, June and August 2016 and May 2017 in Melbourne, Australia. Samples were collected using a low-flow bladder pump with dedicated low-density poly ethylene (LDPE) tubing
na	Biosolid samples were collected from16WWTPs located insix of the eight states and territories of Australia
na	six leachate samples were collected from four lined landfills in the US prior to leachate treatment. All samples were collected by grab methods involving either bailer, peristaltic pump, or collection from a tap. Leachates were collected in 125 mL polypropylene bottles from the landfills and shipped overnight on ice where they remained frozen until analysis.

na	Korea. 57 soil samples were collected from industrial complexes (n=33), landfills (n=8), farmlands (n=4),woodlands (n=4), and mountains (n=8) in 2017. Industrialsampling sites were located within chemical (n=12), textile(n=6), electronics (n=11), and metal (n=4).
na	Samples taken from 10 Norwegian landfills between April and June 2018 Sediment samples were taken from sedimentation pods of presten
na	Flow proportional sampling was carried out during two-weekperiods in May, June, August, September and October of 2019
	Landfill leachate samples

na	Leachate (n = 26), fly ash (n = 20), and bottom ash (n = 24) samples were collected from three MSW incineration plants (referred to as Plant A, Plant B, and Plant C) located in Shenzhen, China
In the supplementary data	2-5 samples of leachate-impacted groundwater were collected at each of 20 closed landfills in Canada
na	Pretreatment and the ultimate disposal of leachate differed for each facility. Ultimate disposal at two landfill facilities consisted of on-site aeration with disposal to a WWTP. For two other landfill facilities, the leachate was discharged to a WWTP without on-site treatment. At one facility, the leachate was discharged to deep well injection without on-site treatment.Leachate was collected in two half-liter high density polyethylene (HDPE) bottles per sampling location. One collection bottle was used for subsequent PFAS analysis and the other was used to measure pH and chemical oxygen demand (COD). The purpose of these analyses was to define bulk physical–chemical characteristics as the leachates are produced by different waste types.

na	na
na	grab sewage sludge samples were collected from individual wastewater treatment plants, freshly digested sludge samples (approximately 500 g for each sample, wet weight, w.w.) from the WWTP dehydration process were packed in aluminum foil, sealed in polypropylene bags, and immediately express-delivered to our laboratory
na	Water samples were collected at each sampling site using Go-Flo bottles® (General Oceanics Inc., Miami, Florida, USA) at a depth of 4–5 m. Go-Flo bottles® avoid sample contamination at the surface, internal contamination, loss of sample on the deck, and exchange of water from different depths. Samples were stored at 4 ◦C in the dark before analysis.

375-22-4 2706-90-3 307-24-4 375-85-9 335-67-1 375-95-1 335-76-2 375-73-5 355-46-4 1763-23-1	Take samples as specified in DIN 38402-11, DIN 38402-12, DIN 38402-13, DIN 38402-15 and DIN ISO 5667-5 Use only cleaned vessels for sampling and fill them completely with the water sample
375-22-4 2706-90-3 307-24-4 375-85-9 335-67-1 375-95-1 335-76-2 375-73-5 355-46-4 1763-23-1	According to DIN 38402-24, DIN 38414-11, DIN EN ISO 5667-13

na	Leachate from WWTP was collected from the leachate lift station (a sump that collects leachate from the drainage layer of the landfill and perimeter ditches before it is pumped off site for treatment) using a stainless steel bailer or a pump.
na	Surface and raw wastewater samples were collected in high density polyethylene bottles carefully cleaned with HPLC water and MeOH.

na	water (influent, effluent)
na	Raw leachate grab samples (unfiltered, 2 L) were taken from the leachate lift station before the leachate was pumped off-site for treatment. Leachate treatment facilities at the study sites employed a two-stage process that integrated an external membrane bioreactor (MBR) unit with a post-treatment reverse osmosis (RO) or nanofiltration (NF) unit. Treated leachate samples (unfiltered, approximately 2 L of each sample type) including the bioreactor mixture, ultrafiltration (UF) effluent, NF effluent and RO effluent were taken during the treatment process as 24 h composites. All samples were collected in polyethylene (PE) bottles pre-washed with methanol. Samples were then stored at 4 °C and extracted for anal- ysis within four weeks of sampling. PTFE (polytetrafluoroethylene)-based materials were avoided throughout the sampling and analysis to avoid potential sample contamination
na	leachates from 4 municipal solid waste landfill sites

na	leachate
	Water samples from one of the largest fluorochemical industrial parks in China, located in Changshu, Jiangsu Province, near the Yangtze River. Influent and effluent samples were collected by peristaltic pump for 4 h from the WWTP of the fluorochemical industrial park. Three water samples each were collected from downstream of the YangtzeRiver near the WWTP and the Yangtze River in the Nanjing
na	section.

na	Water samples were collected from various locations with known or suspected PFAS contamination for screening of ultra-short-chain PFAAs. Three different types of samples were collected at FFTS : outflowing water from rock shelter and groundwater before and after treatment with granular activated carbon (GAC) filters.
na	na

na	na
na	surface samples were taken from canals near textile dyeing, paper recycling workshops and plastics recycling workshops

29420-49-3 3871-99-6 1763-23-1 375-22-4 2706-90-3 307-24-4 375-85-9 335-67-1 375-95-1 335-76-2 2058-94-8 307-55-1 72629-94-8 376-06-7 67584-42-3 812-70-4 70887-84-2 27854-31-5 53826-12-3)	Grab samples are collected in polypropylene containers. Sample containers and contact surfaces with PTFE shall be avoided.
na	Water, sediment and biota (polychaetes, pelagic zooplankton, crabs, fish, glaucous gulls) samples were collected from locations impacted by a firefighting training site (FFTS) and a landfill as well as from a reference site;

na	thermolysis products of Nafion N117 in different temperature ranges.
na	
na	5 different sewage sludge samples (sludges 1–5) were collected during April 2010 in a domestic WWTP in Catalonia, Spain
na	na

na	materials recovery from silicon-based PV modules. Representative samples of the polymers were taken from the PV module by manual removal with a stylet
na	wastewater, sludge, and sediment samples were collected in 3 different WWTP in Hong Kong
na	Eight raw and seventeen treated grab leachate samples after biolo-gical treatment with activated sludge process and/or advanced treat-ment with RO were collected from eight landfills in Northern Greece
na	sampling was done in 3 landfills with municipal waste solid and construction and demolition debris in Germany. Using to methods: grab cranes following regular grid and drilling using no clear pattern.

na	Untreated and treated landfill samples were collected in 250 mL polypropylene (PP) bottles at 22 landfills sites in Germany.	
na	Dehydrated sewage sludge samples were obtained from dif- ferent waste-water treatment plants of La Rioja. The samples were frozen and protected from light. Spiked samples at a concentration level of 50 and 16 ng g—1 of each analyte were used to optimise the FUSLE conditions and to study the features of the method, respectively. These samples were prepared by adding an analyte standard solution in methanol and the mixture was thoroughly homoge- nised. Then, the samples were freeze-dried, ground and stored in darkness at 4 1C.	

na	Sampling was conducted according to the Bureau of Sewerage, Tokyo Metropolitan Government (2012), the middle and downstream water reportedly consisted of approximately 50% STP effluents. The collected samples were decanted into methanol-rinsed 3 L high density polyethylene (HDPE) bottles and were kept in ice for up to 12 h. Upon arrival at the laboratory, the samples were stored at 4 ◦C until analysis. Care was taken to avoid the usage of any PTFEecoated materials.
na	Samples of sewage treatment sludge were collected during a two-year sampling period (2018e2019) from 43 different WWTPs located in the Czech Republic
na	Sludge samples were collected from wastewater treatment plants and the respective sewage stabilization ponds in amber glass flasks in order to preserve the chemical composition of the samples, by protecting the samples from light, humidity and other external factors. The sludge samples had a water content of approximately 95%. Prior to extraction, the samples were air-dried, ground and homogenized by sieving through a stainless steel 2-mm sieve before extraction. When not undergoing extraction procedures, dried and sieved samples were stored in a freezer at 20 °C.
na	Samples from landfill leachate collected from an active MSW landfil in Florida US.

	The landfill soil (top 15 cm) was randomly collected down the slope of the landfill, from the working area (external to the top liner area) using a 3 m × 3 m grid. Five subsamples (four corners plus the center) were taken and mixed to make one homogenized composite soil sample	
na		
	soil samples were collected. The sampling equipment, composed of stainless steel, was washed three times with Optima-grade methanol (MeOH) prior to use. The samples were stored in certified-clean 500-mL, wide-mouth high-density polyethylene (HDPE) containers. The sampling equipment and containers were determined to be free of contamination for the intended analytes before the sampling trip by rinsing a representative of each item type with 60/40 (volume/volume) acetonitrile/ water (ACN/H2O) and analyzing the rinses. Surface-soil samples were collected from the 0- to 10-cm interval using sampling spoons, hand augers, and pans. Subsurface-soil samples were collected by Geo-probe from intervals bounded between the 23- to 56-cm and the 152- to 165-cm depths (Table SI1).	
na		
17 PFAAs		

na	waste waters at 3 positions
na	Samples taken from a typical PV panel with polycrystalline silicon wafers
na	Septic water and tap water were collected from four dwellings at lakefront sites whereas lake water was collected along the shoreline of the residences from a deck, ~40 feet from the lakeshore
na	monofill shredder residue; the waste was sampled from a depth of 1–1.5 m below the surface. Large samples (75– 88 kg) were collected in an effort to reduce sampling error caused by heterogeneity of the waste and stored in 218 L steel drums sealed with airtight lids.
na	Flue gas from semiconductor industry

na	wastes of electrical & electronic equipment (WEEE) collected at a sorting plant
na	Fluorochemical contaminated water samples were acquired from North Carolina Department of Environmental Quality (NCDEQ) at a location near the industrial waste out fall for a local fluorochemical manufacturer, as well as from downstream drinking water treatment plants. Location 1 was the source water drawn from the Cape Fear River for a downstream water treatment facility and Location 2 was finished drinking water delivered to Wilmington, NC. Each sample was collected in a one liter HDPE bottle and stabilized by pH adjustment with nitric acid. Samples were stored at room temperature, extracted and analyzed within five days of the sampling date.

list of cas is included in article	wastewater, surface water, and drinking water from Australia
na	Tap water and wastewater
na	Effluent wastewater (n=6) and surface water (n=6) samples were collected from a wastewater treatment plant located in Seville (South of Spain) and from Guadalquivir River (Seville, Spain)
na	Raw influent (RI), primary effluent (PE), and final effluent (FE) samples were collected in 20 Canadian WWTP. Primary sludge (PS) was sampled from the underflow of the primary clarification tank and waste biological sludge (WBS) was collected from the underflow of the secondary clarification tank. Treated biosolid was sampled after the final treatment step. PS, WBS and biosolids were collected as grab samples. Wastewater and biosolids samples were sub-sampled into 1000 ml wide-mouth high-density polyethylene bottles and shipped to the laboratory on ice by overnight courier.

na	Single grab samples of treated final effluent were collected during peak diurnal flow in September and October 2014 from eight WWTPs that discharge to SF Bay
na	influent, secondary effluent, and sludge adn mass flow samples of 12 municipal WWTPs

na	na	
na	Wastewater and sewage sludge from hospital and WWTPs were collected from six towns (Bungoma, Busia, Kakamega, Kisumu, Kisii, and Mumias) in Kenya that lie within the Lake Victoria basin in January to March 2013	

na	na
na	in 3 engineered landfils, leachates and sediments were sampled.

na	Water samples were collected from Hanoi city and its surrounding areas, Vietnam (dry season). The sampling locations in Hanoi included areas near a municipal dumping site and a municipal wastewater discharge station. Samples were also collected from creeks, rivers, and ponds at an e-waste recycling site (ER; Bui Dau, n010), a lead battery recycling site (BR;Dong Mai, n07), and a rural control site (RU;Duong Quang, n06) in Hung Yen province
na	Biosolids were collected from 19 participating WWTPs from three Australian states

na	wastewater from firefghting exercises, effluent from the WWTP, runnof water (RW), lagoon water and water used for diluting foam concentrates (WFF), HDPE bottles

na	influent, effluent and biosolids samples from 14 WWTP
na	Grab water samples were collected at the outlet of the WWTP Bitterfeld-Wolfen, Saxony-Anhalt, Germany
na	Influent water, effluent water and sewage sludge samples were collected from three WWTPs in three different Swedish cities

CAS no in article	wastewater, surface water, and drinking water samples
375-73-5, 2706-90-3, 307-24-4, 355-46-4, 375-85-9, 335-67-1, 1763-23-1, 375-95-335-76-2	8 drinking waters (DW), 12 ground waters (GW), 13 surface waters (SW), 8 influents and 11 effluents of wastewater treatment plants (WWTPIN and WWTPOUT)
na	Biosolids samples were collected from twenty WWTPs in eight provinces across Canada. Grab samples were collected using stainless steel pails and stored in pre-cleaned amber glass jars (Systems Plus, Baden, ON, Canada). WWTPs consisted of five advanced treatment (AT) plants, twelve secondary treatment (ST) plants, and three primary treatment with chemical addition (PT) plants. Advanced treatment (AT) included biological nutrient removal processes, which removes nitrogen and phosphorous in addition to oxygen demand through a series of different microbial environments.

na	Flow-proportional effluent samples (24 h) were collected from 10 WWTPs

na	Wastewater, surface water, soil and plant samples, grab samples of wastewater were collected in duplicate from the influent and effluent of Bugolobi WWTP, surface water grab samples (50 cm below the water surface) were collected manually (using a rope and bucket) in duplicatestored in plastic bottles, which were pre-washed thoroughly with distilled water and ethanol prior to use; plant samples (yam roots, maize cobs, sugarcane stems)
na	Grab water samples were collected in spring from the municipal WWTP of Bayreuth. From 14 March to 18 May 2007, five grab water samples were collected from the WWTP (4×250 mL) and the river (4×500 mL) every other week on Wednesday (10:00 h, influent and primary treated waste waters). 48 h after the first sampling (duration of the waste water treatment process), samples of effluent of the WWTP and of river water, 0.1 km upstream and 1 km downstream of the WWTP, were collected.

na	imidazole ionic liquids immobilized on silica gel were synthesized through a chemical bonding method, and the immobilized dodecylimidazolium ionic liquid was selected as the receiving phase material in a POCIS (polar organic chemical integrative sampler) like passive sampler to monitor five perfluoroalkyl substances (PFASs) in water
na	Influent, effluent and excess sludge samples were collected from six WWTPs (W1-W6) along the Yanghe River during four sampling campaigns

na	water	
	bags and stored at −18 ◦C as duplicate laboratory samples. After the freeze-drying procedure, solid samples were thoroughly homogenized and stored at +4 ◦C prior to the analysis. Organic extracts of the samples were analyzed within three days of sample	
na	preparation.	
	effluent water sample from a municipal WWTP in Germany and 24-h composite influent sample and the corresponding 24-h composite effluent sample of an industrial WWTP in	
na	Europe were collected and used in this study.	
na	influent, midpoint, and effluent samples	

sample amount used

Details in the Supplementary Information

na

na

na

na

na

na

na

1L

na

na

na

5 mL

na

na

250mL

200 mg

na

na

na

1L

4L

250 mL

leachate samples (50 mL), biosolifds(0.5g)

125 mL

2-5 g freeze dried soil

na

4L

Grab samples (1 L)

Leachate: 5 mL.
Ash: 200 mg

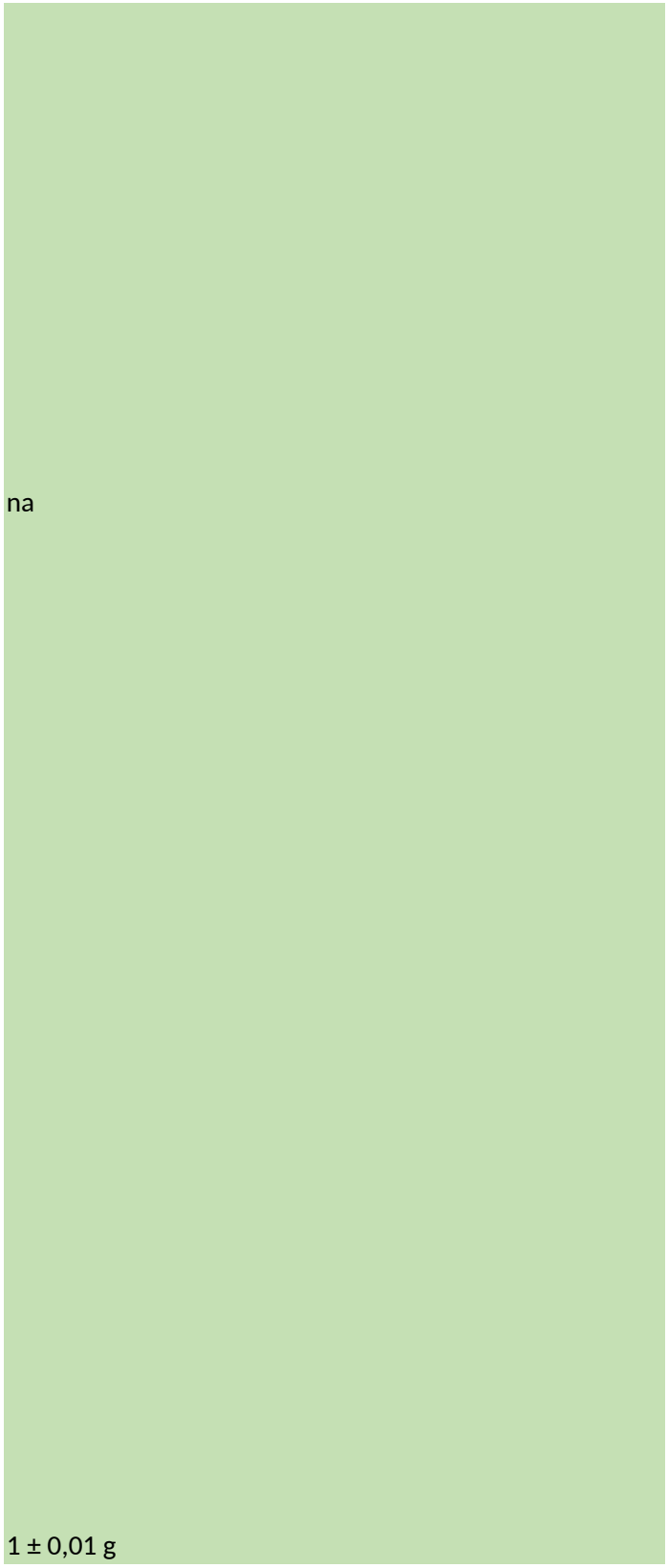
200 ml

200 mL

na

na

na


na
1 ± 0,01 g

4L

na

na

na

na

na

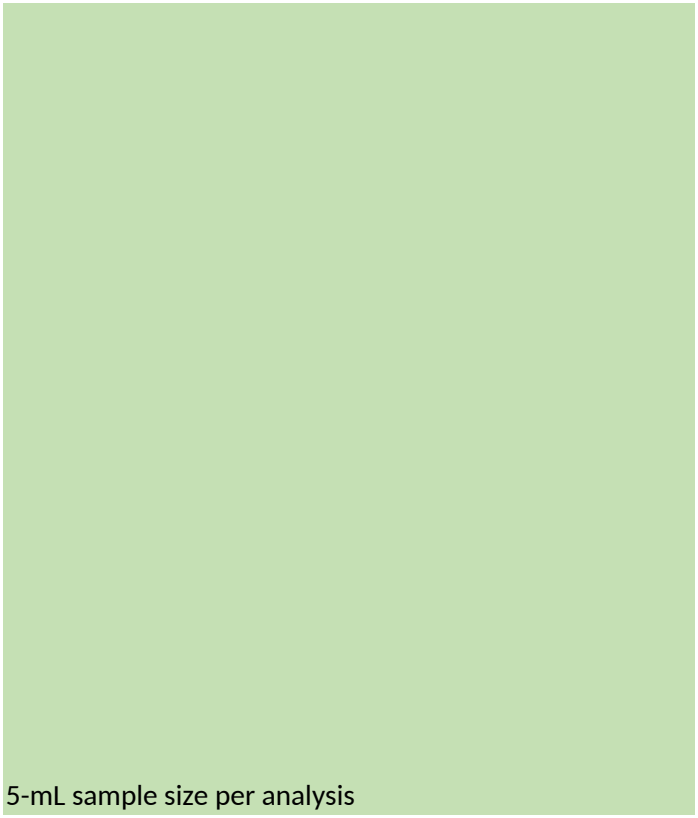
1L

4L

na

na

1 L



5-mL sample size per analysis

na

na

na

na

na

5mg

na

2 ml

composite samples were mixed into one 10L sample

250 mL

na

na

1 g sludge

na

na

5.0 g soil

na

organic composts

na

110 g

na

na

300 ml air

1L

na

250 ml

500 ml tap water or 200 ml waste water

na

400 mL - 1000 mL

500ml- 1L

na

na

na

na

1 Liter

2 x 100L

0.5-1 g

250 mL

na

20L

na

250 mL

na

na

na

na

WWTP (4×250 mL) and
the river (4×500 mL)

na

inffluent and effluent: 4 L, 1L and 100 mL

na

na

1L

na

Pre- treatment	Extraction
Details in the Supplementary Information	Details in the Supplementary Information
na	solid phase extraction (SPE) (Oasis WAX SPE cartridges, 6 cm3 , 150 mg, 30 µm; Waters, Milford, MA) as described by Taniyasu et al.2
Membrane filters were soaked in 10% nitric acid for 12 h (to degrade any organic compounds within or on the filter) followed by three rinses under vacuum filtration with 50:50 acetonitrile:acetone (v/ v) and three rinses with HPLC water.	Solid Phase Extraction (SPE) of 200 mL sample water was carried out using Phenomenex Strata-X cartridges preconditioned with 3 mL 50:50 acetonitrile/acetone (v/v), washed with 3 mL HPLC- grade H2O and loaded at a rate of 5 mL/min. Loaded cartridges were dried under vacuum for 15 min and eluted with 2 7 mL aliquots of 50:50 acetonitrile/acetone (v/v) at a rate of 1 mL/min. Extracts were evaporated to dryness using rotary evaporation and reconstituted with 1 mL of (80:20 HPLC H2O/acetonitrile, v/v) spiked with internal standards to 25 ng/mL.

na	leachate samples were centrifuged, titrated to pH 7–8, and extracted with trifluoroethanol and ethyl acetate.
na	PUF/XAD-2/PUF cartridges were cold extracted three times (1 h, 1 h, 30 min) using methyl-tert butyl ether (MTBE)/acetone 1:1 (v:v). The extract volume was reduced to 150 mL by rotary evaporators and a gentle stream of nitrogen. Prior to the measurement, 50 mL of an injection standard solution containing 13C HCB and TCB D3 (c 400 pg mL—1) were added. Prior to the extraction of particle-phase PFCs, 50 mL of standard solutions containing 18O2 PFHxS, 13C PFOS, 13C PFBA, 13C PFHxA, 13C PFOA, 13C PFNA, 13C PFDA, 13C PFUnDA and 13C PFDoDA (c = 200 pg mL—1) were added to the filters. PFCs were extracted by fluidized bed extraction using methanol. The extract volume was reduced to 150 mL. Prior to the measurement, 50 mL of an injection standard (EtFOSAA D5 (c = 400 pg mL—1) were added.

	at 15,000 g for 10 min. A 500 µL supernatant was transferred into an auto-sampler vial before analyzed. Plant leaves: Leaf samples were purified by deionized water to remove the particulate matter on the surface, and then were processed with vacuum freeze drying technique. Then one gram of freeze-dried and homogenized leaves and 5 ng of each mass-labeled standard were added in a PP tube. For ionic PFASs, 5 mL of methanol was added and the mixture was sonicated for 30 min at 40 ˚C. Then the tube was centrifuged at 4200 g for 10 min. This procedure was repeated once and the supernatants were combined. The combined extracts were cleaned up with GCB-Carbon cartridge and dried under a gentle stream of pure nitrogen to 500 µL before being transferred into an auto-sampler vial. For neutral PFASs, 5 mL of 2 mM sodium hydroxide and 2 mL of ethyl acetate were added and the tube was shaken for 12 h in the dark and then centrifuged at 4200 g for 10 min. This procedure was repeated twice and the supernatants were combined. The combined extracts were dried by anhydrous sodium sulfate and further dried under a gentle stream of pure nitrogen to 500 µL. Then the concentrate was cleaned up with 25 mg dispersive Envi-Carb (120/400 mesh, CNW Technologies, Germany) and centrifuged at 15,000 g for 10 min. A 100-µL aliquot of the supernatant was transferred into an auto-sampler vial before being analyzed.
na	
All information in the Supplementary Information	All information in the Supplementary Information
na	EPA Method 1694

Solids from primary treatment as well as the secondary and nitrification treatment processes are thickened, combined, and dewatered through centrifugation. Lime is added to this sludge mixture on a dry weight basis of approximately 15e20% to neutralize pathogenic organisms, classifying the product as Class B biosolids	All limed biosolids samples were extracted on a wet weight basis; extraction according to a referenced publication; samples were spiked with 15 ng of 13C5-PFPeA, 13C8-PFOA, and 13C8-PFOS
na	na
na	na

	Dried sewage sludge samples (500 mg) were transferred into a 15 mL polypropylene tube. After addition of 0.5 mL water, the sludge samples were spiked with 40 mL of 0.5 ng /mL internal standard mixture of 13C4-PFBA, 13C2-PFHxA, 13C4-PFOA, 13C2-PFDA, 18O2-PFHxS, 13C4-PFOS with an absolute amount of 20 ng per each compound.
The sewage sludge samples were dried at 40 C for 7–10 d (depending on the water content) in porcelain bowls, finely ground (<0.5 mm) and stored in polyethylene bottles at room temperature. As the PFAAs were sorbed onto the sludge matrix.	The samples were sequentially extracted three times with 2.5, 1.5, and 1.0 mL of methanol (Sun et al., 2011a). Each extraction was performed by shaking the slurry for 10 min, sonication for 20 min at 40 degrees C and centrifugation at 3500 rpm for 8 min.
filtered through glass microfiber filters	solid phase extraction (SPE)

na	on-line-solid phase extraction (SPE)
na	na
Each 250 mL sample was filtered using glass fibre filters (1.2 mm,Millipore, Ireland) pre-rinsed with ultrapure water	solid-phase extraction (SPE).
air-dried and filtered	MTBE

		100 % methanol (MeOH), which was used to prevent the complex matrix of the leachates from getting into the extract. Both cartridge types were conditioned with 20 mL MeOH and 5 mL Milli-Q water. After the sam- ples were loaded, the Bond Elut Plexa cartridges were washed with 3 mL of 40 % MeOH (Aq), dried with a vacuum, and the analytes extracted with 3.0 mL of 1 % NH3 in MeOH. The WAX cartridges were washed with 2 mL of 2 % formic acid and 2 mL of MeOH, and the analytes were extracted with 3.0 mL of 1 % NH3 in MeOH. The extracts were cleaned with 100 mg activated carbon (Supelclean ENVI-Carb 120/400); 0.5 mL of ex- tract was diluted with 0.5 mL of Milli-Q water into a vial, and spiked with recovery standard (13C4-PFOA).
		Freeze-dried sewage sludge samples (1 g) were placed in a polypropylene tube and spiked with surrogate stand- ards and 200 mM NaOH solution. After the samples were soaked for 30 min, the analytes were extracted with methanol according to the method applied in the PERFORCE project (de Voogt et al. 2006). The method is based on studies by Powley et al. (2005). Methanol extraction was repeated twice for each sample. The extracts were combined, and evaporated to 1.0 mL with Personal Evaporator EZ-Envi (Genevac, Ipswich, UK). The extracts were purified with activated carbon. For LC-MS analysis, 0.5 mL of extract was diluted 1:1 with Milli-Q water and the recovery standard 13C4-PFOA was added.
na		
The water samples were filtered with GF/B glass fiber filters before extraction (Whatman).		SPE was performed using WAX sorbents according to ISO/DIS 25101 with some modifications

na	The filtrated water samples were spiked with 5 ng of 13C8-PFOA and 13C4-PFOS as internal standards. The spiked samples were then loaded onto Oasis WAX cartridges preconditioned with 4 mL 0.1% NH4OH methanol solution and 4 mL Milli-Q water sequentially. The flow rate was maintained at 1 drop/s through the cartridge. The cartridge was then cleaned up with 4 mL of 25 mmol/L sodium acetate buffer (pH 4) and dried completely under vacuum. The target compounds were eluted by 4 mL of 0.1% NH4OH methanol solution into a polypropylene tube and were concentrated under nitrogen to a final volume of 0.5 mL. The sludge samples: Dried samples of 0.5 g sludge was weighted into 15 mL polypropylene tube and soaked with 0.5 mL ionized water before spiked with 5 ng of 13C8-PFOA and 13C4- PFOS as internal standards. The sludge was extracted three times with 2.5, 1.5, and 1.0 mL of methanol. Each extraction was performed by shaking for 10 min, sonicating at 40°C for 20 min and centrifuging at 3,500 rpm for 8 min. The extracts were combined, and 300 mg Envicarb particles was added directly into the extract and shaken gently for 20 min to clean up the extract. The solution was separated from Envicarb particles by centrifugation at 3,500 rpm for 30 min and concentrated under nitrogen to a final volume of 0.5 mL.
homogenized and centrifuged	micro-LLE was similar to that described by Backe et al. (2013) with adjustments. Unlike the method of Backe et al. (2013), no sodium chloride was added.
na	Extractions were performed on unfiltered subsamples (3 × 50 mL) using solid-phase extraction (SPE)

na	na
na	extracted twice with methanol, vortexed and centrifuged. Samples were further extracted with a mixture of DCM: hexane.
na	solid-phase extraction

soil samples were freeze-dried and mixed to obtain homogenous samples	Methanol
(sediment: centrifugation in methanol	SPE-methanol
Samples were initially collected in 2 LHDPE bottles and transported to the laboratory, where they weredivided into 250 mL aliquots in HDPE bottles and stored at18Cuntil analysis.	H4OH in MeOH
Samples were filtered through a 0.7 lm glass fiber filters (Whatman, England) before storage at 4 _x0003_C until extraction.	Samples were extracted and concentrated before analysis using an AutoTrace 280 automated SPE system from Dionex Corporation, similar to previously published methods (Anumol et al., 2013)

Leachate was centrifuged at 10,000 rpm for 15 min. Ash: homogenized in a solvent cleaned pestle and mortar	Leachate: supernatant was extracted using Oasis WAX cartridges Ash: Methanol
Samples were filtered (0.45-µm polyethersulfone membranes) and preserved	Solid phase extraction
addition of internal standards that were isotopically labeled followed by a filtration step (Whatman GF/A glass fiber), and then followed by a solid phase extraction (SPE) process using Oasis WAX cartridges (Huset et al. 2011, Backe and Field 2012). Transfer of the samples from the sampling bottles used in the field to the filtration flask followed EPA standard protocols requiring volume measurement and a methanol rinse	solid phase extraction (WAX Cartridges)

na	na
samples were then lyophilized, homogenized, and preserved at −20 °C until analysis, dispersive solid phase extraction (DSPE) method for the analysis of PFASs in environmental matrices	na
sample preparation protocol was based on the ISO 25101/2006 method	Depending on the aqueous matrix, different volumes of water were extracted. In case of surface- and sewagewater, 50 mL water was extracted, while 250 mL was used for seawater samples. The 13C-labelled internal standards were supplemented to every sample prior to extraction to a final concentration of 100 ng L−1. Solid-phase extrac- tion was carried out using OASIS HLB cartridges (6 cm3, 200 mg, Waters, Milford, MA). The cartridges were pre-conditioned with 2 mL methanol and 2 mL Biosolve water. After loading, the car- tridges were rinsed with 2 mL Biosolve water for surface- and sewagewater. For seawater, 3 2 mL Biosolve water was applied. Subsequently, the cartridges were dried under vacuum for 10 min. Elution was achieved using 2 2 mL methanol. Next, extracts were concentrated to 0.5 mL under a gentle stream of nitrogen. Finally, 0.5 mL of 2.5 mM ammonium acetate in water was added before transfer to LC–MS vials. Samples were stored at 4 ◦C before analysis.

The samples are analysed in the unfiltered state. The pH value of the sample should lie in the range between pH 6 and pH 8 and shall be adjusted with sodium hydroxide solution or sulfuric acid, if necessary

When preparing the sample, observe the specifications of the Sewage Sludge Ordinance (AbfKlärV) and the Federal Soil Protection Ordinance (BBodSchV). A sufficiently homogeneous laboratory sample must be available for taking a partial sample (test sample). Observe the specifications according to DIN 19747 for taking partial samples. The sample must not be dehydrated before homogenization, e.g. by centrifugation, as the soluble fraction of some PFCs cannot be neglected.
 Homogenize water sediments and thin-bodied sewage sludges by stirring and take a subsample, if necessary with continued stirring.
 For soil, compost, pressed sludge and animal feed, reduce laboratory sample according to DIN 19747, e.g. by means of cross-rugation divider (8.6).
 Sort out foreign materials and record gravimetrically; if necessary, examine these materials separately.
 Take a partial sample and dry it; measure the partial sample in such a way that, if possible, at least a dry mass of 5 g can be expected.
The subsample must be representative of the laboratory sample and, for soil samples, should be at least 1/4 of the mass of the laboratory sample. In the case of homogeneous, fine-grained and free-flowing materials, the subsample may be less.
 Preferably freeze-dry sewage sludge according to DIN 38414-22 (8.5), other samples if necessary at 40 °C in a drying oven, depending on the water content.

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WAX (weak anion exchange)
Solid Phase Extraction (Use at least 60 mg of the solid phase material (7.3) for a sample volume of e.g. 50 ml)

Sonication with MeOH

na	50-mL subsamples (n = 3/time point) were adjusted to pH 7 using ammonium hydroxide and then spiked with isotopically labeled internal standards. Oasis WAX cartridges (Waters, 150 mg, 6 cc) were preconditioned with 5 mL of 0.1% ammonium hydroxide in MeOH, followed by 5 mL of MeOH and 5 mL of Millipore water prior to use. Samples were loaded at a rate of 1 drop/second, and then cartridges were washed with 5 mL of 0.1% ammonium hydroxide in water. PFASs were eluted with 14 mL of acetonitrile (ACN), followed by 5 mL of 0.1% ammonium hydroxide in MeOH, and the eluants were combined.
na	Samples of 250 mL of wastewater were successively passed through 2.6mm and 0.3mm glass-fiber (GF/F) membrane filters using a Nalgene filtration unit. Extraction of the suspended particulate matter (SPM) was conducted according to a sediment extraction procedure adapted from Bertin et al. . Briefly, filters were sonicated twice with 5 mL of MeOH (20 min). Extracts were cleaned-up with graphite (0.25 g), and evaporated to dryness under a N2 flow and moderate heating (40 °C). After reconstitution in 250mL of a 20 ng mL-1 internal standard solution in EtOAc, extracts were sonicated, vortexed and a 200mL aliquot was transferred to a 1.5 mL glass vial. The extraction of the wastewater filtrate was conducted as follows: Strata X-AW cartridges were conditioned with 8 mL of MeOH/ NH4OH 0.2% in water (v/v) and 2 4 mL of HPLC water. After sample loading, cartridges were rinsed with 5 mL of HPLC water, dried for 1 h under vacuum, and centrifuged (3 min, 5000 rpm). Analytes were recovered with 2 4 mL of MeOH/NH4OH 0.2% in water (v/v), the eluates being directly passed through graphite cartridges (coconut charcoal, 2 g) previously conditioned with 10 mL of MeOH. Extracts were finally evaporated to dryness and reconstituted in 250mL of a 20 ng mL-1 internal standard solution in EtOAc.

na	SPE-methanol	
na	The raw and treated leachate samples were centrifuged at 11,000 ×g for 15 min to remove large particles before extraction. The amount of PFAAs absorbed onto particles (except for the bioreactor mixture) was considered low because of the small amount of particles (less than 200 mg L−1) present in the leachate. After centrifugation, the supernatants of leachate samples were spiked with internal standards prior to extraction using a solid phase extraction (SPE) method. The supernatant and solid sludge from the bioreactor mixture were analyzed separately. Sludge samples were further air-dried and extracted according to a method developed in our previous study (Li et al., 2010), which includes sonication solvent extraction, SPE and dispersive carbon sorbent cleanup.	
na	filtered with 0.7 mm fiberglass filters (GFF, ChmLab) to eliminate particulate matter. An aliquot of 70 mL of each leachate sample was spiked in duplicate with IS MPFAC-MXA (30 ng of each analyte, see Table S1) prior to solid phase extraction (SPE) in order to correct losses and matrix effect	

na	Following measurement of pH, samples (50 mL) were adjusted to approximately pH 7 with hydrochloric acid, spiked with 10 ng of M8-PFOA and M8-PFOS and shaken to mix. Samples were loaded onto HLB or Strata-X cartridges (pre-conditioned with dichloromethane (DCM), methanol and MilliQ water) at a rate <10 mL per minute. Cartridges were dried under vacuum, and then eluted with 2 mL acetone, 7 mL methanol followed by 6 mL of DCM. The eluent was concentrated to approximately 1 mL under N2 and transferred for further clean up onto pre-conditioned Supelco Envi_x0002_carb cartridges (250 mg; 3 mL) using methanol. Cartridges were eluted with acetone (2 mL), methanol (6 mL) and DCM (5 mL). Samples were concentrated to 1 mL, transferred to a glass vial and spiked with 10 ng of the labelled recovery standard (MPFAC-MXA) for LCMS/MS analysis.
na	250 mL of influent and 500 mL of effluent were separately used for solid-phase extraction.

na	filtered water samples were extracted by weak anion-exchange solid-phase extraction (WAX-SPE) following the ISO25101 method with some modifications.
were extracted using a method modified from ref	na

na	50 mL aliquots were loaded onto Oasis WAX cartridges (6 mL/150 mg, Waters) at 1 drop/s. Samples were spiked with known quantities of internal standards (M8PFOS, M8PFOA, M8FOSA, MPFHxS, MPFNA, d-N-MeFOSA, d-N-EtFOSA (Wellington Laboratories)). The cartridges were dried under vacuum for 30 min, and eluted with 4 mL methanol, followed by 5 mL methanol (0.1% NH4OH). Eluents were concentrated at 35 °C under a gentle stream of nitrogen to ca. 0.5 mL and loaded onto an ENVI-carb (3 mL/250 mg, Sigma Aldrich) SPE cartridge. PFAS were eluted with 2 mL methanol (0.1% NH4OH) and concentrated to 200 µL containing 10 ng of MPFOS (Wellington Laboratories) and transferred to inserted LC vials.
na	Water quality—Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA)—method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry” - ISO 25101 : 2009

Standards and samples shall be in a 50:50 methanol:water solution containing 0.1 % acetic acid.	Direct Injection
Polychaetes were depurated overnight in seawater in order to separate sediment-bound PFAS from accumulated PFAS.	Sediment and biota samples were extracted with methanol. Water and melted snow samples were extracted on Oasis® Waters (Mildford, MA, USA) weak-anion exchange (WAX) SPE cartridges (6 mL volume, 0.5 g).

na	na
na	na
na	pressurized solvent extraction was carried out in a PSE 240V
na	na

thermal treatments at 600°C	no extraction but elimination was the goal
	Waste water samples: Extracted based on a slightly modified version of the method (liquid solvent extraction) reported by So et al. (2004). Modifications: larger Oasis HLB extraction cartridges (0.5 g) were used rather than the 0.2 g cartridges used in the previous study, as high concentrations of PFC were expected. For sediments and sludges: modified version of the method proposed by Powley et al. (2005) was used (methanol extraction, supernatant acidification and pre-concentration).
dried at 105 °C overnight and ground befor being homogenized by a solvent-rinsed blender.	
samples were filtered through pre-ashed glass-fiberfilters	Solid-phase Extraction
na	na

na	solid-phase extraction (SPE) as described elsewhere (Taniyasu et al., 2005; Ahrens et al., 2009b) with a few modifications.
na	A SONOPLUS 2070 focused ultrasound system (20 kHz, 70 W) equipped with a MS73 titanium microtip was used. 0.5 g of sample was placed with 8 mL of acetonitrile in a 34-mm glass tube and internal standards (M8PFOA and MPFOS) were added. Then FUSLE was performed twice for 20 s, at a pulsation of 0.5 and 65% of power. Extractions were carried out at 0 1C in an ice-water bath. After the extraction step, FUSLE extract was centrifuged for 5 min at 3000 rpm using an Orto Alresa Digicen centrifuge. The sample was washed twice with 4 mL of solvent each. Rinses were added to the extract and it was evaporated to dryness under a nitrogen stream using a Turbo Vap II concentrator (Zymark, Hopkinton, MA, USA). The residue was reconstituted in 2 mL of LC–MS grade methanol and extracts were filtered through a 0.2 mm nylon filter before the UPLC–MS/MS analysis.

125 mL unfiltered water samples were transferred to 125 mL HDPE bottles. One sample from each site was subsampled in triplicate (n = 3) and was added with 2 g (60 mM) of potassium persulfate and 1.9 mL of 10 N NaOH (150 mM). The HDPE bottles were placed in a temperature controlled oil bath (Personal He10 SH; TAITEC, Saitama, Japan) at 85 ◦C for 6 h. Then, the samples were cooled to room temperature in an ice bath prior to analysis. The pH of the samples was adjusted between 5 and 9 by concentrated HCl prior to the extraction.	Isotope labeled surrogate standards, 4 ng were added to the samples and blanks prior to the extraction in order to correct their recovery rates for each batch analysis.
The collected sludge samples were freeze-dried, thoroughly homogenized	Solid-phase extraction (SPE)
	1 g sample sludge was spiked with 1 ng mass labeled Internal Standard (IS) and transferred to a 50 mL polypropylene vial and extracted first with 4 mL 1% acetic acid in MeOH with sonication for 15 min followed by extraction with 4 mL 50/50 v/v MeOH and AcN, each time, the supernatant was collected. The combined extracts were then dried using a gentle stream of N2 gas before dilution with HPLC grade water for SPE extraction (using Oasis WAX cartridges (Waters, 6 cc/150 mg)). The elute from SPE was dried by passing a gentle stream of N2 gas, and subsequently reconstituted using 1:1 volume ratio of MeOH and Ammonium acetate solution to a volume of 200 lL, a procedure which involved addition of recovery internal standard, to make the final volume of 200 lL.
na	
Part of the samples (n=3) were concentrated in the lab with sintered glass aquarium air stones used to produce bubble air and to produce substancial foaming. The foam was collected for analysis. The other part of the samples (n=3) had no pre-treatment.	na

To obtain a homogeneous matrix, the thawed soil sample in the container was manually mixed twice (gloves were worn), each session lasting 5 min.	2 methods: Methanol or acetonitrile (they were equally good)
sieved through a MeOH- washed, 2-mm, stainless-steel sieve and extracted in triplicate	na
	ENVI-Carb cleanup extracted in triplicate using a method described by Choi et al. (2019)

na	na
thermal degradation at 500°C	no extraction but elimination was the goal
na	also eluted with 5 mL of methanol containing 0.1% ammonia. The eluents were combined and concentrated to ~500 mL under a gentle stream of nitrogen at 35 °C using a TurboVap® Evaporator (Zymark, Inc., Hopkinton, MA, USA). The final volume of the extract was adjusted to one milliliter in an amber glass vial, and 10 mL of the extract was injected into HPLC-MS/MS for the analyses of PPCPs and PFASs.
na	na
na	na

	extracted with methanol with the addition of ammonium acetate (final concentration 5 mM) using warm Soxhlet extraction	
samples were cut and dried		

Samples were filtered using1-µm glass fiber filters	Solid-phase Extraction
na	Solid phase extraction
Samples were filtered through a 1.2-µm glass-fiber membrane filter (Whatman, Mainstone, UK), and the I.S. were added to achieve concentrations of 1 µg /L	Solid-phase extraction
vortexing, centrifuged and filtered	Solid phase extraction (SPE)

oxidized for indirect measurement of PFAA pre_x0002_cursors according to a previously developed method (Houtz and Sedlak, 2012; Houtz et al., 2013)	concentrating them with solid phase extraction (SPE) (Oasis WAX SPE cartridges, 3 cm3 , 60 mg, 30 mm; Waters, Milford, MA)	
	For FTOH analysis in sludge, 0.5 g dw of freeze-dried samples spiked with 50 µL of D4-4:2 FTOH (10 µg/L), 13C2D2-6:2 FTOH (10 µg/L), 13C2D2-8:2 FTOH (10 µg/L), and 13C2D2-10:2 FTOH (10 µg/L) was added to 15 mL PP centrifuge tubes. The samples were left to stand for 24 h at room temperature in the dark, and then 4 mL of ACN was added for extraction. After shaking for 20 min at 300 rpm and sonication for 20 min (40 °C), the extract was separated by centrifugation at 4000 rpm for 10 min. One milliliter of the extract was diluted with 4 mL of ultrapure water and then loaded on WAX cartridges which had been conditioned by 3 mL of ACN and 3 mL of ultrapure water. Then, 200 µL of DCM containing 30 mg/mL DNS and 30 mg/mL DMAP was added to the eluate, which was then shaken vigorously for 1 min. The resulting mixture was kept at 65 °C for 60 min, and then 3 mL of ultrapure water and 6 mL of hexane were added. After 10 min of shaking at 300 rpm, the organic layer was separated by centrifugation at 4000 rpm for 10 min. The extraction process was repeated twice, and the combined extracts were loaded onto silica cartridges conditioned with 8 mL of DCM and 8 mL of hexane. The dansylated FTOHs were eluted with 8 mL of hexane:DCM (v/v, 1:1), blown to dryness, and then dissolved in 0.2 mL of ACN for UPLC-MS/MS analysis.	
na		

na	MeOH
sludge samples were dried in an oven at 105 °C to constant weight (typically 24 h) and the water loss was determined gravimetrically. The dried samples were then ground and homogenized by sieving through a stainless steel 2-mm sieve before extraction. Dried and sieved samples were stored in a freezer at −20 °C.	Sludge extraction: Methanol and internal standards were adedd and vortex mixed, sonicated and centrifuged. Supernatants were transfered and extraction was repeated. Supernatants were concentrated and dried under nitrogen stream. water samples: Water samples were extracted by SPE with Oasis WAX cartridges (Waters, 6 cc/150 mg) as described by Taniyasu et al. (2005) and Orata et al. (2009).

na	50 mL of trichloro(1H,1H,2H,2H-perfluorooctyl)silane was dissolved in 50 mL of hexane. Scraps of paper (60 × 40 mm, length × width) were immersed in the above solution for 5 min in an ultrasonic bath at room temperature for fluoro-functionalization. The fluoro-functionalized paper was then washed withn-hexane,methanol,methanol + water (1 + 1, v/v), and methanol successively in an ultrasonic bath and was dried at 60C. Pieces of the fluoro-functionalized paper (600 mg, cut to 3 × 4 mm, length × width) and 100 mL of water sample were put into a centrifuge tube. The tube was retained shaken for 1 h on a water bath thermostatic oscillator at room temperature. The paper was picked out from the solution by a tweezer and then washed with water to remove impurities adsorbed on the paper surface by non fluorous-fluorous interaction. The PFCs adsorbed on the fluoro functionalized paper were desorbed in 2 mL of acetonitrile under ultrasonication for 5 min. The desorption step was repeated three times. The combined desorption solution was dried using a N2 stream. The residue was redissolved in 1 mL of acetonitrile. The sample solution was then filtered through a 0.7-µm membrane, and 10 mL of the filtrate was injected in a HPLC-MS/MS.
na	About 2 g of dry sample was spiked with 20 µL internal standard, 13C PFOS and 13C PFOA (0.5 ng/ µL). 1 mL of 200 mM NaOH in methanol was added and soaked for 30 min. Then, 100 µL 2 M HCl in methanol was added followed by another 9 mL of methanol. The mixture was thoroughly mixed and then extracted on a wrist-action-shaker for 30 min. After centrifugation (2000 rpm, 5 min), 1 mL of supernatant methanol extract was treated with 25 mg ENVI-Carb mixed in 50 µL glacial acetic acid. After thorough mixing and centrifugation (10,000 rpm, 10 min), 20 µL recovery standard, 0.1 ng/µL 3,5-is(trifluoromethyl)phenyl acetic acid, and 0.5 mL of 4 mM NH4 OAc in water were added to the final extract

mixing in methanol	Solid-phase extraction was carried out as described by Taniyasu et al. (2005) with minor modifications
Prior to analyses, samples were freeze dried and homogenised to afine powderusing a ceramic homogeniser	Methanol

na	nonfiltered water samples (250 mL) were spiked with labeled internal standards and concentrated by solid phase extraction (SPE); Offline enrichment was conducted on an automated system. PFASs were eluted from the cartridges by the successive use of 1 mL of methanol (MeOH), 4 mL of ammonium hydroxide (0.1% (v/v) (NH4OH) in MeOH, and 2 mL of NH4OH 0.1% (v/v) in isopropanol/dichloromethane (30/70) before being combined and concentrated under a nitrogen stream to a fnal volume of 100 µL

	Water: samples were adjusted to pH 7 and loaded onto HLB or Strata-X cartridges and spiked with the internal standard (10 ng of M8-PFOA and M8-PFOS). Cartridges were dried under vacuum, and then eluted with 2 mL acetone, 6 mL methanol followed by 5 mL of DCM. The eluent was further cleaned up on Supelco Envicarb cartridges (250 mg; 3 mL). Samples were concentrated to 1 mL, transferred to a glass vial and spiked with 10 ng of the labelled recovery standard (MPFAC-MXA) for LC-MS/MS analysis. Biosolid sub-samples from each site were freeze dried, ground to a fine powder and pooled equally by weight before accelerated solvent extraction. Florisil (5 g) and biosolid samples (0.25 g) were weighed into 100mL stainless steel ASE cells and filled with hydromatrix. Cells were spiked with the internal standard (10 ng of M8- PFOA and M8-PFOS) and then extracted using three cycles of methanol and DCM (2:1). The extracts were transferred to a round bottomed flask and concentrated to approximately 1mL on a rotary evaporator. Concentrated extracts were subjected to further clean up on Envicarb cartridges (250 mg; 3 mL) using methanol. Cartridges were eluted with acetone (2 mL), methanol (6 mL) and DCM (5 mL). Samples were concentrated to 1 mL, spiked with the recovery standard (10 ng of MPFAC-MXA) and transferred to a vial for LC-MS/MS analysis.
na	
	solid-phase extracted (SPE) with 4 g of Chromabond HR-X sorbent (MachereyeNagel) in Omnifit columns (Diba Industries Ltd.)
na	
	with methanol, briefly votex mixed, sonicated, centrieuged and again extracted with methanol. Supernatants concentrated under nitrogen stream at 40 degrees C.
dried at 105 degrees C and homogenized.	

na	Solid phase extraction
na	na
air dried and grounded with 60 mesh sieve.	The sample preparation and extraction method has been described by Chu and Letcher, 2017; Chu et al., 2016, with some modifications: The sample was spiked with internal standards and ultrasonicated and extracted three times by 4 mL 0.2 % formic acid in ACN solution each time at 60 °C. The extracts were combined, concentrated to 2 mL and diluted by 8 mL water. The diluted extract was cleaned up and fractioned by Oasis WAX SPE cartridges (60 mg × 3 cc, Waters Limited, ON, Canada).

na		A sample volume of 0.25 L was adjusted to pH 6.5 with formic acid or ammonia and pressure-filtered through a 0.7 µm glass fiber filter (Whatman). Isotope-labeled IS (103 total, 100 ng, details in the SI) were spiked to each sample prior to enrichment with mixed-bed multilayer solid-phase extraction cartridges comprising Oasis HLB, Isolute ENV+, Strata-X-AW, and Strata-X-CW (exact details in Kern et al.19) via vacuum extraction at 10 mL/ min. The analytes were then extracted from the dried cartridges with a 6 mL basic (2% of 25% ammonia) followed by a 3 mL acidic mixture (1.7% of 100% formic acid) of ethyl acetate/methanol (50:50 V/V). The neutral combined extract was concentrated to 100 µL under a gentle nitrogen stream, adjusted to 1 mL with HPLC-grade water, filtered through a 0.45 µm regenerated cellulose filter into a 2 mL vial and stored at 4 °C prior to analysis.

	and then 4 mL of Millipore water, the cartridges were loaded with 500 mL of water sample at a flow rate of one drop per second. After percolation, the cartridges were washed with 4 mL of 25 mM ammonium acetate buffer (pH 4) in Millipore-water and centrifuged at 3000 rpm for 2 min. The PFASs were then eluted from the cartridges with 4 mL of methanol, followed by 4 mL of 0.1% ammonium hydroxide in methanol. The samples were concentrated to 1 mL under a gentle nitrogen stream and transferred to brown amber vials for instrumental analysis. For extraction of solid and plant samples, 3 g of each of the pooled samples were weighed into a 50 mL PP-tube and 2 mL of a 100 mM sodium hydroxide in methanol/ Millipore water solution (80/20, v/v) were added. The mixture was left to stand for 30 min and then 20 mL of methanol and 100 µL of IS mixture (c = 20 pg µL−1) were added. The mixture was shaken in a wrist-action shaker for 60 min at 200 rpm and centrifuged at 3000 rpm for 5 min. The supernatant was then decanted into a new PP-tube. This procedure was repeated once again by adding 10 mL of methanol to the original PPtube, shaking for 30 min at 200 rpm and centrifuging at 3000 rpm for 5 min. The supernatant was then decanted into the new PP-tube, 0.1 mL of 4 M hydrochloric acid was added and the tube was shaken by hand and centrifuged at 3000 rpm for 5 min. The sample wasconcentrated under a nitrogen stream to 1 mL.
na	
	Solid-phase extraction (SPE) was done as described (Becker et al. 2008), modified as follows: to waste water 250 µL of a 100-µg/L mixture of 13C-PFOA and 13C-PFOS each, to river water 100 µL of a 10-µg/L mixture of 13C-PFOA and PFOS each was added.
Particulate matter was removed by centrifugation	

		Each IIL sampler was rinsed with distilled water to remove the materials adhering to the membrane surfaces and then vacuum freeze-dried. Then, the sampler was disassembled, and the IIL-silica gel or HLB sorbent powder was transferred carefully into an all-glass syringe (3 cc) previously blocked with glass fibre cotton on the bottom. Additional glass fibre cotton was pressed tightly on the powder. After that, the sorbent powder was eluted with 6 mL of elution agent (methanol containing 5% ammonium hydroxide). Procedural blanks were performed by pretreating the unused sor- bents (IILs and HLB) in the same process as the samples, and were examined together with samples to control for potential contami- nation from laboratory materials and solvents. For PFASs in the active sampling water samples, 500 mL water samples were filtered by 0.45 μm cellulose nitrate membrane fil- ters before a WAX-SPE process.
na		
wastewater samples: pretreated by filtering.		
Excess sludge samples were ground with ceramic mortars and pestles after being completely dried and then filtered through 0.15-mm nylon sieves prior to extraction.		solid-phase extraction (SPE) based on methods previously reported by Chen et al. (2018) and Yuan et al. (2014).

na	solid phase extraction (SPE) step using polymeric cartridges (Oasis HLB) with 200 mL of water sample loaded
na	methanolic extracts were transferred to a 50 mL graduated glass volumetric flask, diluted with reagent grade water to 50 mL, 50 _x0002_L of formic acid was added to each sample and the samples were applied to the SPE cartridges for pre-concentration and clean-up.
na	sold-phase extraction
na	Samples were stored up to 5 days at the WWTP at 4 °C, transported to the laboratory, and analyzed and extracted within 2 days of receipt. Due to the concentrated nature of the samples, they were analyzed for target PFASs without preconcentration in a 50:50 methanol sample mixture amended with a surrogate standard stock solution used for quantitation with isotope dilution. Aliquots were taken an inch below the water level after samples were gently agitated.

Clean up	Measurement	Quantification method
Details in the Supplementary Information	Details in the Supplementary Information	Details in the Supplementary Information
rinsed with 4 mL of HPLC-grade water and dried under vacuum for approximately 1 h	HPLC coupled with an Agilent 6410 triple quadrupole mass spectrometer operating in negative electrospray ionization mode.	isotopically labeled surrogate standards
na	HPLC-MS/MS	internal standard

na	LC/MS/MS	internal standard
na	neutral and ionic PFC was performed by GC-MS and HPLC-MS/MS	internal standard

na	The 16 ionizable PFASs were analyzed using HPLC–MS/MS (Agilent Technologies, U.S.A.) and the 7 neutral PFASs were analyzed using GC–MS	internal standard
All information in the Supplementary Information	GC-MS	internal standard
EPA Method 1694	EPA Method 1694	na

sample loading, cartridges were conditioned with 10 mL of ACN:MeOH (50:50 v/v). Extracts were loaded and collected. Car- tridges were washed with 3 mL of MeOH. This wash was also collected. Eluates were concentrated to 4 mL under a gentle stream of nitrogen, diluted in 175 mL of organic-free water, and acidified to a pH of approximately 4 using formic acid. Diluted and acidified samples were loaded onto Oasis® WAX (500 mg, 6 mL) SPE cartridges (Waters, Milford, MA, USA) at a rate of one drop per five seconds. Cartridges were previously conditioned with 10 mL of MeOH and 10 mL of organic-free water. After sample loading, car- tridges were washed with 2.5 mL of 0.01% formic acid in MeOH. Compounds were then eluted and collected with two 10 mL washes of 0.5% NH4OH in MeOH.	Sample extracts were analyzed via HPLC-MS/MS to measure for PFAS compounds using a Waters 2690XE separations module (Waters Corporation, Milford, MA, USA) attached to a Quattro Ul- tima benchtop triple quadrupole mass spectrometer (Micromass Limited, Manchester, UK) with an electrospray interface. Chro- matographic separation was obtained by injecting 10 mL of extract onto a Zorbax C8 (150 × 4.6 mm) reversed-phase liquid chromatography column in-line with a 4.6 × 12.5 mm guard column (Agilent, Santa Clara, CA, USA) at a temperature of 40 ◦C (Powley et al., 2005). The mobile phase consisted of (A) 2 mM ammonium acetate in organic-free water and (B) MeOH and was run at a flow of 0.5 mL/min. The mass spectrometer source parameters were: capillary voltage 3.10 kV in electrospray negative (ES-); extractor voltage 1 V; RF lens 0.1 V; source temperature 140 ◦C; desolvation temperature 400 ◦C. Nitrogen was used as both the nebulizer (145 L/h) des- olvation gas (450 L/h). Acquisition was done in the multiple- reaction monitoring mode (MRM). Peak integration and quantita-tion were performed automatically using MassLynx4.0 (Micromass Limited, Manchester, UK).	via MS with internal standard 13C5-PFPeA, 13C8-PFOA, and 13C8-PFOS prior to extraction as surrogate spikes and 13C5-PFHxA, 13C5-PFNA, and 13C3- PFHxS
na	GC-MS	na
na	na	na

clean-up was performed according to (DIN 38414-14, 2011) The combined extracts were enriched by solid-phase extraction (SPE) on a Strata-X-AW cartridge	Liquid chromatography tandem high resolution mass spectrometry (LC–MS/MS)	Calibration standards (n = 7) were prepared in methanol with a final nominal concentration ranging from 0.1 to 300 ng /L of standard mix solution (from 0.1 to 100 ng /L for PFCAs and 0.5 to 300 ng/ L for PFSAs
extracts were reduced using a gentle stream of nitrogen, diluted to 1 mL with ultrapure water and filtered	LC–MS/MS, ZORBAX Eclipse XDB C18 column (5 µm × 2.1 mm × 150 mm, Agilent, CA) using an UltiMate 3000 HPLC (Dionex by Thermo Fisher Scientific Inc., MA), API 3200 triple quadrupole mass spectrometer (AB SCIEX, ON, Canada)	Potassium L-PFOS and 13C4- and 13C8-labeled L-PFOS, as recovery and injection standards

na	UPLC-HRMS	standards
na	LC-QTOF-MS	na
na	liquid chromatograph (LC) coupled with an Agilent technologies 6495B tandem mass spectrometer (MS/MS) in negative electrospray ionisation mode (ESI)	analytical standards
extraction was repeated with MTBE	HPLC-MS/MS	Internal standard

na	UPLC-MS-MS	internal standard
wash with 4 mL sodium acetate (NaAc) buffer solution (pH 4), followed by 4 mL of 20% methanol.	Ultra Performance Liquid Chromatography (UPLC) system coupled to a triple quadruple mass spectrometer XEVO TQ-S (Waters Corporation, Milford, USA), in negative electrospray ionization mode	Quantification of PFCAs, PFSAs, FTCA/FTUCAs, FTSAs, monoPAPs, diPAPs, and FOSA/FOSEs was performed by isotope dilution with mass-labeled internal standards.

na	HPLC-MS-MS	internal standard
na	orthogonal LC-MS/MS	Isotopically-labeled internal standards
na	HPLC–MS/MS	characterized isomeric mixtures of PFOS and PFOA, isotopically labeled internal standards (ISs; Table S1) and six point calibration curves.

na	PC Titrator (alkalinity), dual column gas chromatography with flame ionization detector (dissolved methane), and inductively coupled plasma mass spectrometry (cations).	na
na	AB/Sciex API 5500Q mass spectrometer (AB/Sciex, Concord, Ontario, Canada) coupled to a Shimadzu Nexera HPLC system (Shi_x0002_madzu Corp., Kyoto, Japan) w	details of PFASs analysis described in Galen et al., 2014
dispersive-carbon sorbent cleanup	liquid chromatography/tandem mass spectrometry (LC/MS/MS)	internal standards.

Cartridge was washed with 6 mL of 25 mM ammoniumacetate	HPLC-MS/MS	Internal standard
ENVI-carb clean-up	UPLC-MS/MS.	Internal standard
na	UPLC-MS/MS.	internal standard
	Liquid chromatography and Mass spectrometry	

Leachate: cartridges washed using 4 mL of ammonium acetate buffer	LC-MS/MS	internal standard
na	UHPLC-MS/MS	internal standard
Methanol	na	Internal standard

na	na	na
na	HRMS; API	na
na	LC–ToF-MS	internal standard

Concentrate the eluate to dryness, e.g. in a nitrogen stream. Dissolve the residue in e.g. 1 ml using a mixture of solvent and water in accordance with the composition of the reference solutions. If necessary, filter the extract through a syringe filter and use a partial volume for the analysis.	LC-MS/MS	Calibration using a external or internal standard
SPE WAX (optional) Elution with MeOH 0.1% NH3	HPLC-ESI(-)-MS/MS	External and internal stan

na	HPLC-MS/MS	Quantification was based on isotope dilution when an exact isotopically labeled standard was available (10 PFASs), otherwise an internal standard approach was used.
na	LDTD/APCI-Orbitrap-MS	internal standard

	(APCI) combined with GC-MS/MS with triple quadrupole analyzer GC- (APCI)QTOF MS GC-(EI) MS and GC-(CI) GC-(APCI) MS MS	
SPE	HPLC-MS/MS	na
100 mg of EnviCarb activated carbon and 50 mL of glacial acetic acid were added in a centrifuge tube and vortex mixed along with the sample extract for 30 s. Centrifugation was carried out at 11000 rpm and extracts were then filtered (0.22 mm) and transferred to a 15 mL PP tube to be further evaporated until dryness under a gentle stream of dry nitrogen gas. The final volume was adjusted to 200 mL of Milli-Q water:methanol (70:30 v/v) prior to injection	HPLC-QqQ MS/MS Quattro Micro triple quadrupole	internal standard

na	LC-MS/MS	na
na	High-performance liquid Chromatography and high-resolution hybrid QTOF mass spectrometer (Triple TOF 5600, AB SCIEX, Foster City, CA, U.S.A.) operated with a negative electrospray ionization (ESI−).	PFASs standards and internal standards

na	SFC-MS/MS, UPLC/MS-MS	Mass labelled internal standards and recovery standards
na	The TOP assay is an indirect method for semi_x0002_quantifying PFAA precursors by oxidizing and converting precursors to measurable PFAAs. uPLC-QToF/MS Analysis.	na

na	HPLC-TOF MS	internal standard
the target compounds in the cartridge were eluted with 4mL of MeOH and 4mL of 0.1% ammonia solution	LC/MS/MS with negative electrospray ionizationinterface	internal standard

na	LC/MS/MS	Internal & external standard (at a minimum, five calibration levels are required when using a linear calibration curve and six calibration levels are required when using a quadratic calibration curve.)
Clean-up of methanol extracts was conducted using active carbon (EnviCarb, Sigma_x0002_Aldrich Co., PA, USA)	The quantitative determination of PFAS was done with high-performance liquid chromatography (HPLC) using an Agilent 1200 series HPLC (Agilent Technologies, Waldbronn, Germany) and an Agilent 6460 (Agilent Technologies, Santa Clara, CA, USA) triple quadrupole mass spectrometer equipped with a jet stream electrospray ion source	internal standard calibration curves with eight concentration points

na	LC/ESI-MS/MS)	na
na	na	na
na	LC–ESI–MS/MS.	internal standards
na	na	na

na	gas chromatography-mass spectrometry (GC–MS) analysis.	
ENVI-Carb	UPLC/MS/MS	PFC standards
6 mL of Milli-Q water were used for rinsing	LC-HRMS/MS	internal standard
na	according to standard EN 12457-4	na

na	HPLC-MS/MS	using 20 internal standards
Extraction cells were filled inserting two cellulose filters at the bottom of the cell, 1 g of anhydrous sodium sulphate and the sample were added and the cell was completely filled with anhydrous sodium sulphate. Finally, a cellulose filter was placed on top. Methanol was used as extraction solvent, and the PLE conditions were those reported by Llorca et al. [11]: a temperature of 70C at 100 bar and two extraction cycles of ° 1 min. After the extraction step, PLE extracts (ca. 15 mL) were evaporated to 0.5 mL under a nitrogen stream using a Turbo Vap II concentrator (Zymark, Hopkinton, MA, USA). The residue was reconstituted up to 2 mL of LC–MS grade methanol. Extracts were filtered through a 0.2 mm nylon filter before the UPLC–MS/MS analysis.	UPLC–MS/MS	Quantification was performed by multiple reaction monitoring (MRM) and ion extraction

SPE	HPLC-MS-MS	na
Methanol	LC-MS/MS	internal standard
na	UHPLC–MS–MS	internal standard
na	liquid chromatography (LC)–high-resolution tandem mass spectrometry (HRMS/MS)	through 25 labeled standards (13C or 2 H labeled)

Two post-extraction cleanup strategies (ENVI-Carb and ion-pair).	UPLC-MS/MS.	internal standard
na	Acetonitrile/water extracts were analyzed on a Waters Acquity ultraperformance liquid chromatograph (UPLC) interfaced with a Waters Quattro Premier XE tandem mass spectrometer operated in negative electrospray-ionization mode.	ba
na	na	total oxidizable precursor (TOP) assay LC-QTOF

na	LC-HRMS on orbitrap (targeted and untargeted) HPLC-MS non-targeted	na
na	GC analysis with a classical thermal conductivity detector and a flame ionization detector (GC/TCD/FI	na
na	HPLC-MS-MS	isotop dilution/ external calibration curve
na	GC-MS	na
na	GC-MS	mass spectra

Concentrated extracts were filtered using a syringe filter (nylon membrane, 13 mm diameter and 0.45 mm pore size). The filtrate was concentrated using a stream of nitrogen in a TurboVap II (Caliper LifeSciences, USA) concentrator unit to 500 mL and transferred to a minivial. samples were diluted using a solution of ammonium ace- tate in water (concentration 5 mM) up to a final volume (50/50, ammonium acetate in water/ammonium acetate in methanol, v/v). Prior to final analysis, syringe standards (13C4 PFOA, 13C4 PFOS) were added to all samples.	HPLC-ESI-MS/MS	Internal standard
na	LC–MS/MS	internal standard

na	LC-MS/MS	Internal standard
5 L of water was added to rinse cartridge	LC–MS/MS	internal standard
na	High-performance liquid chromatography–mass spectrometry	PFOA-13C8 were used as internal standards
washed using 5 ml of reagent water followed by 5 ml of a solution containing 50% methanol and 50% 0.1 M formic acid in water. The cartridges were eluted with 4 ml of methanolic ammonium hydroxide (0.3%)	(LC/MS/MS)	standard solution containing 13C4-PFBA, 13C2-PFHxA, 13C2-PFOA, 13C5-PFNA, 13C2-PFDA, 13C2-PFDoA and 13C4-PFOS

na	UPLC-MS/MS	analytical standards of PFASs and their stable-isotope surrogates
na	dansylation UPLC- ESI-MS/MS method	internal standard

the cartridges were washed with 4 mL buffer solution 25 mmol L-1 acetic acid/ammonium acetate (pH=4) and centrifuged at 3000 r min-1 for 3 min to remove residual water	UPLC-MS/MS.	internal standard
na	UPLC-MS/MS using electrospray ionization operated in negative ion mode according to a method published in detail earlier (Vestergren et al. 2012)	Quantification of the PFAAs was achieved using the internal standard method and a six-point external calibration curve covering a concentration range from the individual method detection limits (MDLs) to 2.5 pg /µL

na	Fp-SPE-HPLC-MS/MS	na
na	HPLC/MS system	na

na	ACQUITY™ ultra-performance liquid chromatography system (Waters, USA) coupled with a Quattro Micro™ API triple quadrupole mass spectrometer (MS/MS, Waters, USA) in negative ionization mode	na
na	LC-MS/MS	internal standard

PFASs were eluted from the cartridges by the successive use of 1 mL of metha-nol (MeOH), 4 mL of ammonium hydroxid	UPLC-QTRAP/MS	internal standard

na	LC-MS/MS	internal standard
washing with 400 mL of bidistilled water/methanol (90:10; v:v)	liquid chromatographyehigh resolution mass spectrometry (LCeHRMS)	Target com_x0002_pounds were quantified by standard addition, pentobarbital and the suspect seco_x0002_barbital by isotope dilution
transfered to tubes with graphitized carbon and acetic acid, samples were again mixed and centrifuged.	UPLC/MS/MS	Acquity ultra-performance liquid chromatography system coupled to a Xevo TQ-S tandem mass spectrometer (UPLC/MS/MS; Waters Corp., Milford, MA) operated in negative electrospray ionization mode

SPE cartridges were eluted using 2 mL MeOH that was used to rinse the sample bottle, followed by4mLof0.1%(v/v) ammonium hydroxide in methanol.	LC–MS/MS	Internal standard
na	Ultra-high performance liquid chromatographic (UHPLC)	
na	UHPLC-MS/MS	Non-isotopically labelled and labelled PFAS standard solutions were used.

na	HPLC-MS-MS	internal standard

prepared 1.7 mL Eppendorf centrifuge tube with 25 mg ENVI-Carb and 50 µL glacial acetic, the supernatant was then filtered through a 25 mm syringe filter (Ø = 0.45 µm) with a polypropylene membrane	HPLC-EIS-MS/MS	internal standard
na	LC-ESI-MS/MS (Weremiuk et al. 2006)	For calibration, a stock solution of 98 mg/L 13C-PFOA was prepared by dissolving 10 mg of 13C-PFOA (98%) in 100 mL acetonitrile, a 13C-PFOS (free acid) stock solution of 1.9 mg/L was prepared by diluting 1 mL of a 50-mg/L_x0002_solution 13C-PFOS sodium salt in a 25-mL PP-volumetric flask (Supelco, Bellefonte, USA).

na	All five PFASs were analysed with a 1200 Infinity series liquid chromatograph equipment coupled to a 6410 B triple-quadrupole mass analyser (MS/MS) with an electrospray ionization (ESI) source (Agilent Technologies).	na
na	high performance liquid chromatography (HPLC) System coupled to an Agilent 6460 Triple Quadrupole LC/MS System (Agilent Technology, Palo Alto, CA, USA) with the negative electrospray ionization (ESI) mode	na

na	LC-TOFMS	na
SPE	HPLC-Orbitrap-MS	na
cleaned with 3 mL H2O–MeOH	HPLC–MS/MS-a (for analytes with acidic characteristics) HPLC–MS/MS-n (for analytes with neutral characteristics)	internal standards
SPE WAX (optional) Elution with MeOH 0.1% NH3	LC-QTOF, LC-MS/MS	na

Working range (ng/mL) As	Matrices	Reported levels (ng/mL)	info - validation of the method
Details in the Supplementary Information	biosolids	Sum of the 9 PFAS: 99-231 µg/kg in biosolids	Details in the Supplementary Information
na	na	Urban Runoff: prio to oxidative treatment: PFOS (2.6–26 ng/L), PFOA (2.1–16 ng/L), and PFHxA (0.9–9.7 ng/L) after oxidative treatment: PFCAs with 5–12 membered perfluoroalkyl chains increased by a median of 69%, or between 2.8 and 56 ng/L.	The PFAA precursor oxidation method was validated with experiments using representative C8 and C6 PFAA precursors: FOSA, N-EtFOSAA, NMeFOSAA, 8:2 FtS, 8:2 diPAP, 6:2 FtS, and 6:2 diPAP. The concentrations of precursors used in control experiments ranged from 25 ng/L to 25 µg/L .
na	na	na	na

na	na	na	blank samples
na	na	97 to 1004 pg m—3 (neutral PFCs)	na

na	na	∑PFASs in the two landfills were up to 9.5 ng/m3 in the air, 4.1 µg/g in dry deposition, and 48 µg/g lipid in leaves with trifluoroacetic acid and perfluoropropionic acid being dominant (71% −94%)	na
0.5 - 200 ng/l	air, leachate	0.20 - 1.6 pg/m3 for air samples and n.d. - 6.2 ng/L for leachate	During the sample pretreatment, one procedural blank was per-formed and analyzed along with each batch of ten samples. On sampleinjections, instrumental blanks were run for every ten samples to mon-itor carryover effects
na	na	na	na

na	biosolids	From these analyzed compounds, the highest mean concentrations observed over the study period were 25.1 ng/g dw, 23.5 ng/g dw, and 22.5 ng/g dw for perfluorononanoic acid (PFNA), perfluorooctanoic acid (PFOA), and perfluorooctanesulfonic acid (PFOS), respectively, and these compounds were detected at concentrations 2.5e5 times higher than the remaining, detectable PFASs	Instrument detection limits (IDLs) were determined as outlined by the USEPA (USEPA, 1984) and the limit of quantitation (LOQ) was established as three times the IDL.
na	na	gas contained different fluorocarbons: 27 micro g/ L . other results found on Table 1	na
na	na	na	na

na	Sewage sludge samples from 45 WWTPs in Switzerland near potential industrial emitters.	PFAAs (C4–C8) ranging from 4 to 2480 micro g/ kg; PFOS (predominant PFAA) 4 - 2440 mg/ kg (median 75 micro g/ kg); PFOS median concentration of 82 micro g /kg- 2290 mg/kg. PFCAs: up to 233micro g/ kg.	Accuracy was determined by spike and recovery experiments. The precision of the entire method, as indicated by the relative standard deviation was determined by extracting 3 replicates of the spiked sewage sludge. Relative recoveries ranged in general between 80% and 120%, with the exception of PFBS (65–95%). Recoveries of PFNA and PFDA varied strongly and thus these compounds were only included in the analysis if recoveries ranged from 80% to 120%. Procedural blanks were tested with quartz sand that went through the whole procedure, including drying. A blind value of 0.04 lg kg_x0003_1 could be determined for only one compound, PFHxS.
na	waste water (effluent and influent)	43–78 and 65–112 µg/L for the effluent and influent, respectively	average recovery was 100.1% with relative standard deviation of <10%

na	na	hindered determination due to elevated blank values.	na
na	na	na	na
na	na	The sum of detected PFAS (14PFAS): 26 ng/L - 5,200 ng/L. PFHxS : 2.6 - 280 ng/L . PFOS : 1.3 - 4,800 ng/L. PFHxA: <LOQ - 46 ng/L. PFOA: 1.7 - 74 ng/L.	field reagent blank (FRB), method blank (MB), laboratory control sample (LCS) and two sites were selected by random number generator to be sampled and analysed in triplicate. Statistical Analysis (ANOVA) was used to analyse significance.
na	dust	values in dust: Legacy PFASs: 1,8 - 132 ng/g PFAS precursors: 0.6 - 7 ng/g All values highest from industrial aera	Quantification was performed by a 10-point calibra-tion curve with a concentration range of 0.10 - 100 ng/mL.

na	na	1 - 7.9E+6	na
na	na	PFAS total concentration in ranes from 29.8-77 ng/L	Calibration curves consisting of at least five points were prepared for the targeted compounds. Procedure blanks treated in the same way as the samples were included in each batch of 8–10 samples. The method limit of detection (LOD) was determined as three times the signal in the procedural blanks, and in absence of the analyte in the blank, the lowest point in the calibration curve. Triplicates of three sludge samples from the WWTPs were used to assess the accuracy, precision, matrix effects, and recoveries of the method

na	water, sludge	PFOA was the predominant PFCs in water phase, and its concentrations were in the range between 20 and 170 ng/L in influents and between 30 and 145 ng/L in effluents. PFOS and PFOA were the predominant PFCs in sludge samples, and their concentrations were 42–169 and 12–68 µg/kg, respectively.	na
na	na	concentration per PFAS in table 2	Whole method precision was determined as the combination of inter and intraday variability and calculated using a one-way ANOVA . Estimated method detection limits (EMDLs) were defined as 3 times the S/N on either side of analyte peaks in leachate extract
na		Reported only presence of many different isomers in less time than other methods.	Method accuracy averaged 119% for target PFCs and 104% for ISs. Precision ranged from 4 to 19% RSD for targets and 2 to 7% RSD for ISs

na	na	PFOA levels ranging from 2.1 to 74 ng/L	Statistical analisis ANOVA and Shapiro Wilk test to analyse significant differences.
na	landfil biosolids, leacheates	PFHxA: 12–5700 ng/L PFHpA: 2.2–3500 ng/L PFOA :19–2100 ng/ L PFOS: (37–1100 ng/L	To assess the reproducibility/precision of the extraction and analysis methods over time, an aliquot of a bulk biosolid or leachate sample was extracted and analysed with each batch of samples, as a QAQC sample. Replicate and procedural blank samples were also extracted.
na	na	Perfluoroalkyl carboxylates were the most abundant (67 ± 4% on a nanomolar (nM) basis), up to 2,800 ng /L. Perfluoroalkyl sulfonates (22 ± 2%) on a nM basis. Perfluorobutane sulfonate concentrations were as high as 2,300 ng/L. Sulfonamide derivatives composed 8 ± 2.1% (nM basis) Fluorotelomer sulfonates (6:2 and 8:2) composed 2.4 ± 1.3% (nM basis)	The precision of the method, as indicated by relative standard deviation (RSD) was determined by replicate extractions (n=3) of a single leachate sample. RSDs ranged from 2 to 26%

na	soil	The sum 15 PFAS concentrations in soil from 0.175 to 11.7 ng/g. Soil from industrial complexes (0.346e11.7 ng/g), Landfills (0.504e10.4 ng/g: Soil samples from industrial areas, 15 PFAS concentrations from 3.11 to 11.7 ng/g, from the textile industries, 3.26e8.74 ng/g, from the metal industries, 1.53e5.71 ng/g	The PFAS concentrations quantitated by internal standard methodwere within the calibration range (0.05e50 ng/mL), and the cor-relation coefficients of the calibration curves were higher than 0.99for all curves. The relative standard deviations of the relativeresponse factors of each compound in the calibration solutionswere all below±15%
na	water and sediment	PFAS leachate concentrations ranged from 68 to 6800 ng/L Sediment_ 8.5-2120 ug/l	na
na	Water (leachate and precipation runoff from the plant)	mean total concentration of the 34 PFAS was 211±31 ng/L The highest S34PFAS concentrations were (262 ng/L), and the lowest (172 ng/L) we found that 34PFAS only accounted for 12% ±4% of EOF detected in the leachate	PFASs were quantified by internal calibration using corre-sponding mass-labelled standards.
		PFOA: 180–2500 ng /L in all samples; PFOS: (<5–92 ng/ L in 2 samples.	Five quality assurance and quality control (QA/QC) samples were included for analysis. They included a 1L ultrapure water blank, a laboratory control sample (LCS) using ultrapure water spiked with 300 ng L_x0003_1 of analytes and three matrix spike (MS) samples (Site A, Site B and Site D Tank) each spiked with 300 ng L_x0003_1 of analyte

na	Leachate, fly ash, bottom ash	Sum of PFAS Leachate: 21.4-682 ng/mL Fly ash: 1.46-87 ng/g Bottom ash: 3.12-77.4 ng/g	Procedural blanks were prepared at an interval of every six to eight samples to determine if contamination had occurred during sample extraction. Solvent blanks containing methanol and calibration check standards were prepared to run after every eight samples to monitor the background contamination. Calibration curves were constructed using a series of PFAS concentrations
na	water	The maximum individual PFAS concentration was for PFECHS (per-fluoroethylcyclohexanesulfonate), at 9.5mg/L, while PFOS and PFOAreached 2.7 and 0.85mg/L, respectively. The three landfills withmarkedly higher concentrations of PFAS, specifically PFSA, than theother sampling areas (i.e., DC-A, DC-B, DC-C; maximumS17PFAS of2.4e12.7mg/L;Fig. 1B) were all within the same city, with disposallimited to the early 1960s	All analytes were quantified using a 16-level calibration curve ranging from 0.01 to 15 ng/ml, R2>0.99. Quantitation was based on relative response to the corresponding isotopically labeled standard to correct for recovery and matrix effects
na	na	na	na

na	investigation-derived waste	na	na
na	na	na	na
na	na	PFOS was detected in every sample in levels up to 38.9 ng L−1, while PFOSA was found once at a concentration of 26.4 ng L−1. PFHxS and PFOA were frequently detected up to concentrations of 13.1 and 23.5 ng L−1, respectively. (Antwerp).	Besides the validation procedure of the accredited lab of the Flemish Environment Agency (FEA), the SANCO/2007/3131 document [22] was also used as guideline for the validation of this new analytical method.

The lower limit of application is 0,01 µg/l, or 0,025 µg/l for treated waste water.	Water	na	The recovery rates of the internal standards are a measure of the analyte recovery over the whole analytical process, for each individual sample. They shall be determined in accordance with and shall lie in a range between 50 % and 150 %.
calibration from 10 µg/kg to 500 µg/kg	Soil Sediment Sludge	na	recovery of internal standards have to be

na	landfill leachates	ΣPFAS concentrations in flow-through leachate (landfill A) ranged from 3.8 to 36 µg/L and on a molar basis were made up of 31−71% PFAAs (15−56% PFCAs, 12−21% PFSAs) and 29−69% PFAA-precursors (19−48% FOSAMs, 9− 24% FTAs). Recirculated leachate (landfill B) generally contained lower ΣPFAS concentrations (2.5 µg/L), made up almost entirely of PFAAs (∼83% PFCAs and ∼17% PFSAs on a molar basis). PFPeA and PFHxA were the major PFASs detected.	assessment of method accuracy and precision using triplicate spike/recovery experiments (10 ng of individual PFASs spiked into 50 mL of recirculated leachate and extracted along with samples) can be found elsewhere
na	water	PFOA and PFNA were quantified in all samples (range: 0.19–0.72 and 0.07–0.21 ng L-1, respectively) and PFDA in all samples but one (range:<0.02–0.25 ng L-1), while long-chain PFASs were not detected.	conducted on a filtered fresh influent wastewater matrix

na	na	1.5 - 67 pg/mL	na
na	na	Regarding raw leachate samples, the total concentration of 11 PFAAs (∑PFAAs) ranged from 7280 ng L−1 (CZ) to 292,000 ng L−1 (SH), with a mean value of 82,100 ng L−1.	recovery of internal standards have to be 50 % bis 150 %
na	leachate	Total PFASs (PFASs) in raw leachates reached 1378.9 ng/L, while in treated samples PFASs was approximately two-fold (3162.3 ng/L). PFCAs accounted for the majority of the detected PFASs and perfluorooctanoic acid (PFOA) was the dominant compound in raw leachates (42.6%), followed by shorter chain PFHxA (30.1%), PFPeA and PFBA	na

na	leachate	Five PFASs were detected ubiquitously, with perfluorohexanoate (PFHxA) the predominant PFAS (mean 1700 ng/L; range 73–25,000 ng/L).	na
0.1, 0.5, 1 ng/L, 0.5ppb	influent and effluent	na (only mentioned in %)	blank samples ; sensitivity of instrument analysis for four different levels of known PFAS standard solutions were used for verification; spiking of procedural recovery with 0.5 ng fg known PFAS standards to check recovery method. .

na	na	Ultra-short-chain PFAAs were detected in all samples at concentrations up to 84 000 ng/L (∑C1−C3), representing up to 69% of the concentration of 29 per- and polyfluoroalkyl substances (PFASs). Trifluoroacetic acid (TFA), perfluoropropanoic acid (PFPrA), trifluoromethane sulfonic acid (TFMS), perfluoroethane sulfonic acid (PFEtS), and perfluoropropane sulfonic acid (PFPrS) were detected at concentrations up to 14 000, 53 000, 940, 1700, and 15 000 ng/L, respectively.	blank samples
na	compost material	PFAA loads ranged from 28.7 to 75.9 μg/kg for OFMSW composts that included food packaging and from 2.38 to 7.60 μg/kg for composts that did not include food packaging	na

na	leachate	respect to PFASs, the predominant compounds were: PFBS (arithmetic mean = 1100 ng L−1) PFOA (790 ng L−1) PFOS (270 ng L−1) PFHxS (200 ng L−1) PFNA (30 ng L−1)	MilliQ sample spiked with target compounds was also analysed with each batch of samples (n = 4).
na	na	metal-plating factories: 0.73–18.91 textile-dyeing factories: PFOA and/or PFHxA, which were present in all effluent wastewater samples,varied from 0.37 to 15.96 ng/L and 1.07 to 43.58 ng/L, respectively surface water samples of craft villages: 0.83 to 58.2	Six-pointcalibration curves were developed for each target analyte bydiluting calibration stock in methanol at concentrationsranging from 0.5 to 20ng/mL.

10 – 400 ng/L, 50 – 2000 ng/L for PFPeA, PFBA, 200 – 8000 ng/L for FDEA, 300 – 8000 ng/L for FOEA, FHEA	Water Sludge Influent Effluent Wastewater	This test method was tested by CRL on reagent water.	The recovery limits for the RLCS are 35 to 150 %, if any analytes are outside of these limits the QC failure is explained in a narrative accompanying the data.
na	Water, sediment and biota	was 643 ± 84 ng L−1, while it was 365 ± 8.0 ng L−1 in a freshwater pond and 57 ± 4.0 ng L−1 in a creek in the vicinity of the FFTS. These levels were an order of magnitude higher than in coastal seawater of the nearby fjord (maximum level PFAS = 10.1 ±1.2 ng L−1, at the FFTS impacted site). PFOS was the most predominant compound in all seawater samples and in freshly fallen snow (63–93% of PFAS). In freshwater samples from the Longyear river and the reference site, PFCA ≤ C9 were the predominant PFAS (37–59%), indicating that both local point sources and diffuse sources contributed to the exposure of the marine food web in the fjord. PFAS concentrations increased from zooplankton (1.1 ± 0.32 µg kg−1 ww) to polychaete (2.8 ± 0.80 µg kg−1 ww), crab (2.9 ± 0.70 µg kg−1 ww whole-body), fish liver (5.4 ± 0.87 µg kg−1 ww), and gull liver (62.2 ± 11.2 µg kg−1).	full validation carried out

na	na	not reported, only reported presence.	na
na	na	na	na
na	na	(PFOS): 53.0 - 121.1 microg/kg. Oder PFCs: 0.3 and 30.3 micro g/kg	validated using an “in-house” procedure according to ISO 11843 using spiked materials bec
na	na	na	na

na	na	mechanical removal of the backsheet from the PV panel allows to eliminate the formation of HF, COF2 and fluorinated organic compounds	na
na	na	Waste water PFOS: 19.0 to 49.9 ng/L in sludge and sediments: PFOS: less than 100 ng/g PFDS: not detected	instrument detection limit (IDL) was set at three times the standard deviation of the background levels detected in the blanks, and the method detection limit (MDL) was calculated based on the IDL according to U.S. EPA guidance (Gomez-Taylor et al., 2003)
na	water	Raw leachate: LOD - 14,7 µg/l Treated leachate: LOD - 15 µg/l	The quantification of the detected contaminants was based on thestandard addition method, while a Screening Detection Limit (SDL) isprovided for the non-detected analytes. The SDL is not compound-specific, but a generic reporting value derived after method validation.
na	na	na	na

treated and untreated leachates in different WWT processes.	na	In untreated leachate: sum of PFC concentrations ranged from 31 to 12,819 ng/L. The dominating compounds were PFBA (mean contribution 27%), PFBS (24%), PFHxA (15%), PFOA (12%), PFPA (6.0%), PFHpA (4.0%), 6:2 FTS (3.7%), PFOS (2.7%), and PFHxS (2.3%). in treated leachate: sum of PFC concentrations ranged from 4–8060 ng/L . Almost all target compounds were detected (39 of 43 PFCs)	Quality control and assurance included the using of 20 internal standards, recovery rates, method blanks, mass detection limits (MDL), mass quantification limits (MQL), control standards, reproducibility and the calculation of the matrix effect
na	na	<3.03 ng/g	na

na	na	The concentration of the 15 PFAA and 3 PFAA precursors before oxidation in the river water samples were 3.8-38 ng L—1 .	na
na	Sludge (freeze-dryed)	PFAS contamination of sewage sludge, reaching values from 5.6 to 963.2 ng /g . PFOS was the most abundant among the targeted PFAS, reaching 932.9 ng g1	na
na	na	quantified perfluoroalkyl carboxylates and perfluoroalkyl sulfonates concentrations ranged from 10 to 597 and 14 to 540 pg/g, respectively	na
na	na	comments: 19 of 27 PFAS were significantly higher in the foam compared to the unadultered leachate	na

na	soil	na (can be found in the can be found in the supplementary	na
na	na	highest concentrations were perfluorodecanoic acid (≤990 ng/g), perfluorododecanoic acid (≤530 ng/g), perfluorooctanoic acid (≤320 ng/g), and perfluorooctane sulfonate (≤410 ng/g)	na
isotopes	biosolids	biosolid-based products (9.0 – 199 µg/kg) > food and yard waste (18.5 µg/kg) > other 27 organic products (0.1 – 1.1 µg/kg).	

na	waste water	PFBS was quantified at the highest concentration among the samples (8040 ng L−1) The sum concentrations of the target PFASs in the diluted discharge samples from each fab were 623, 394, and 376 ng L−1 sum concentrations of target and nontarget PFASs in the diluted discharge samples from each fab were 1490, 78 700, and 2170 ng L−1	na
na	na	proposed treatment lies in the total elimination of the emissions of hydrofluoric acid and fluorinated organic compounds deriving from the Tedlar degradation	na
na	na	0.20 to 14.6	na
na	na	na	na
na	flue gas	3.32-6.21 ppmv of C4H8	mass spectrum and GC retention times were used to idenify C4H8

na	wastes of electrical & electronic equipment (WEEE) collected at a sorting plant	WEEE materials contained PFOS in the range of 0.07 - 0.43 mg kg—1 and also other PFASs and PFCAs at detectable levels.	Blank samples were prepared with every extraction batch.
na	water	na (only mentioned in %)	na

	water	PFAS concentrations from 0.60 to 193 ng/L All results in article	The method accuracy was assessed using the meansurrogate-corrected value from those same seven spikedreplicates and compared with the expected concentration.
a 11-point calibration curve (from 0.05 to 500 µg L−1 was generated , and thelinear correlation coefficient (r) was used for the qualification of linearity	na	na	Method performance was evaluated through the recovery , linearity , precision and method detection and quantification limits studies
na	Surface water and effluent water	ranges from 0.010 to 0.096 µg /L PFBuA: not detected	Precision of the method (expressed in terms of relative standard deviation (RSD)) was evaluated from surface and wastewater samples spiked in triplicate at a concentration level of 1 µg /L for each pollutant. Method detection limits (MDL) and method quantitation limits (MQL) were calculated in surface water and in effluent wastewater as the concentrations of each compound corresponding to a signal-to-noise ratio of 3:1 and 10:1, respectively.
na	facultative and aerated lagoons, chemically assisted primary treatment, secondary aerobic biological treatment, and advanced biological nutrient removal treatment	(PFOA): 2.2 - 150 ng/L (influent) and 1.9 to 140 ng/L (effluent). (PFOS): in primary sludge: 6.4 to 2900 ng/g dry weight (dw) in waste biological sludge, and treated biosolids: , 9.7 to 8200 ng/g dw, and 2.1 to 17,000 ng/g dw, respectively	na

na	na	Effluent from Municipal treatment plants: highest median concentrations of PFHxA (24 ng/L), followed by PFOA (23 ng/L), PFBA (19 ng/L), and PFOS (15 ng/L). PFPeA (9.7 ng/L), PFNA (9.0 ng/L), PFHxS (4.9 ng/L), and PFBS (2.8 ng/L). Low levels of the C6 and C8 PFPAs, PFHxPA (1.3 ng/L, median) and PFOPA (0.9 ng/L, median) were also detected.	na
na	sludge and water	8:2 FTOH was the predominant congener, with concentrations of 2.10−11.0 ng/L, 3.05−12.4 ng/L, and 0.36− 1.91 ng/g dry weight in the influent, secondary effluent, and sludge, respectively	methods not been validated in wastewater or sludge samples

na	River water and WTTP water	na	na
na	domestic, hospotal and industrial WWTP	Perfluorooctanoic acid (PFOA): in wastewater 1.3–28 ng/L and in sludge samples 117–673 pg/g Perfluorooctane sulfonate (PFOS): in wastewater: 0.9–9.8 ng /L and in sludge samples 98–683 pg/g *specific values pero PFAA are found in Table 3.	The calibration curves bracketed all quantified concentrations in sample extracts and displayed r2 values >0.99

na	water	0.33 - 82.4	na
na	na	up to 6231 ng/L.	na

na	na	na	na
	sludge		Samples were extracted in batches of 12 with each batch con-taining a method blank and a laboratory control sample (

na	water	Effluent from WWTP: 3.6×106 to 1.3×107 ng/L PFAS Wastewater drained from fire-fighting areas: 5.3 × 106 to 1.2 × 108 ng/L PFAS Runof water: 2.9 × 107 to 1.0 × 103 ng/L Lagoon: 2.3×105 to 5.0×105 ng/L	na

na	waster and biosolids	Σ9PFASs ranged from 0.98 – 440 ng/L (influent), 21 – 560 ng/L (effluent) and 5.2 – 150 ng/g (biosolids)	na
na	na	Concentrations were below the limit of quantification	na
na	tap watter, influent, effluent, sludge	PFAAs In tap water: up to 3890pg/L In influent: up to 6690 pg/L in Effluent: up to 13000pg/L in Sludge: up to 8820 pg/g	Analytical quality control included procedural blank extractions, determination of compound-specific method detection limits (MDLs), calculation of IS recoveries and precision testing through duplicate sample analysis.

ranging from 0.05 to 1 ng/mL	water	Method accuracy ranged from 70 to127% for 49 of the 53 extracted PFAS, with the remaining four between 66 and 138%. Method precision ranged from 2 to 28%RSD, with 49 out of the 53 PFAS being below < 20%.	Linear calibration curves were constructed for six to ninelevels by gravimetric dilution of 100 ng/mL native compoundmixture in MeOH
	drinking waters, ground waters , surface waters , influents, effluents ofnwastewater treatment plants	up to 100 micro g /L	leave-one-out cross-validation
na	na	The mean of the sum concentration of the 22 other PFAS (ΣPFAS22) in the biosolids samples ranged from 4.93 to 92.6 ng/g d.w	regression coefficients (r2) higher than 0.99 were accepted.

na	na	na	na

na	waster and sludge	∑PFAS concentrations in effluent from Bugolobi wastewater treatment plant (WWTP) were higher (5.6–9.1 ng L−1) than in the corresponding in_x0002_fluent (3.4–5.1 ng L−1), indicating poor removal of PFASs within theWWTP.∑PFAS concentrations decreased by a factor of approximately five between Nakivubo channel (8.5–12 ng L−1) and Lake Victoria (1.0–2.5 ng L−1), due to dilution, sorption to sediment and uptake by plants in the wetland. ∑PFAS concentrations were within the range 1700–7900 pg g−1 dry weight (dw) in soil and 160 pg g−1 dw (maize cobs) to 380 pg g−1 dw (sugarcane stems) in plants.	na
na	river upstream, river downstream, WWTP effluent	Waste water: PFOA in concentrations of 20- 73 ng/L PFOS up to 390 ng/L River water downstream: PFOA: 11 +/-4 ng /L PFOS: up to 32 ng/L river upstream: PFOA: 0-2 ng/L PFOS: 0-1.5 ng/L	Calibration curves had regression coefficients of more than 0.995.

na	na	na	na
na	na	main PFAS reported: inffluents: PFBA: 23.8 ng/L PFOA: 6.15 ng/L Effluents: PFBA: 20.2 ng/L PFOA: 6.07 ng/L sludge: PFOS: 2.13 ng/ g PFOA: 0.85 ng/ g other values found in Fig 2.	blank samples, LOD and LOQ were defined.

na	na	na	na
na	na	na	na
na	inffluent, effluent, industrial and municipal	municipal WWTP effluents: sodium perfluoro-1-hexanesulfonate (4.7 ng/L), 8:2-FTS (1 ng/L), PFOA (3 ng/L), and 6:2-FTS (4.7 ng/L). industrial WWTP inffluent: PFASs up to 700 µg/L	na
na	na	na	na

Limitations	LoD (ng/mL)	subgroup	Measurement - generic name
na	Details in the Supplementary Information	na	
na	Total method detection limits ranged between 0.1 and 0.5 ng/L	na	
na	0.23 - 0.51	na	

future work is needed to identify FTCA precursors in landfills and to estimate the attenuation of FTCAs during wastewater treatment	na	na
na	na	na

na	0.02-0.45	na
na	Not in article	na
A large number of biosolids samples were combined to form five composites in this study in order to reduce the number of samples to be analyzed and still provide with a defensible mean baseline concentration for the analytes	0.03 and 0.14 ng/g dry weight (dw) of biosolids	na

na	IDL: PFBA -4.8, PFPeA - 0.15, PFHxA - 0.18, PFHpA - 0.10, PFOA - 0.66, PFNA - 0.30, PFDA - 0.17, PFUnA - 6.41, PFBS - 0.19, PFHxS - 0.18, PFOS - 0.80, and PFDS - 0.21 ; LOD stated as three times the IDL	na
na	na	na
na		na

na	Therefore, the limit of quantification (LOQ) was defined as the concentration in which sewage sludge samples yielded a reliable chromatographic peak. This was the case usually for peaks with a signal intensity > 5E3.	na
na	Instrumental LOQs for F-53B and PFOS in this study were 0.14 and 0.15 ng/L, respectively, and instrumental LODs were 0.04 ng/L for both	na

A challenge in very comprehensive screening methods are elevated blank values which have to be considered to avoid false positive findings. In this study this hindered the determination of the following ten compounds: the insect repellents diethyltoluamide (DEET) and icaridine, the plasticizers dibutyl adipate, N-butylbenzenesulfonamide (NBBSA), triethyl phosphate (TEP), tris(2-butoxyethyl) phosphate (TBEP) and triphenyl phosphate (TPP), the UV filter octocrylene, the lubricant oleamide and the perfluorinated compound perfluorooctanoic acid (PFOA).	mna	na
na	na	na
na	0.2 ng/L	na
na	values ranged from 0.02 (6:2Cl-PFESA) ng/mL to 0.50 (PFBA) ng/mL. Many LOQ values in the article	na

na	LOQ: 0.5 ng/L for water samples and 0.1 µg/kg d.w. for sludge samples	na
na	was determined as three times the signal in the procedural blanks	na

na	0.12 - 0.75	na	
na	na	na	LC-MS/MS
Dilusion may reduce matrix effects	na	na	LC-MS/MS

na	na	na	GC-MS
na	na	na	LC-MS/MS
na	for each analyte varied from 0.5 to 5.4 ng/L	na	LC-MS/MS

na	MDLs for each compound ranging from 0.030 to0.200 ng/g dry weight	na	LC-MS/MS
na	na	na	LC-MS/MS
na	The MDLs ranged between 0.06 and 2 ng/L.	na	LC-MS/MS
na	na	na	LC-MS/MS

na	na	na	LC-MS/MS
na	Minimum detection limit: 1.4 ng/L	na	LC-MS/MS
na	na	na	LC-MS/MS

na	na	na	
na	na	na	LC-HRMS
na	Surface water: 7.5 - 100 Seawater: 1-100 Sewage water: 5-100	na	LC-HRMS

na	na	na	LC-MS/MS
na	LoQ: 10 µg/kg	na	LC-MS/MS

na	na	na	LC-MS/MS
na	na	na	LC-HRMS

na	0.1-1	na	GC-MS
na	na	na	LC-MS/MS
na	na	na	LC-MS/MS

na	na	na	LC-MS/MS
Because of the low intensity and/or the limit fragments in MS/MS spectra, there was no identified PFAS with a level 3 or above in ESI positive mode. Also, the extract of samples has been kept in −20 °C for 6 years, and the identified PFASs could be the potential transformation products.	na	na	LC-HRMS

na	ranging from 0.01-5; TFA: 34	na	SFC-MS/MS, LC-MS/MS
na	na	na	TOPassay, LC-HRMS

na	na	na	LC-HRMS
na	MQL varied from 0.19ng/L to 0.49ng/L.	na	LC-MS/MS

	MDL (ng/L) = 0.7 (PFTriA) - 4.6 (PFBA, PFPeA), 47.2 (FDEA), 92.9 (FHEA), 106.8 (FOEA)	na	LC-MS/MS	
	in ng/g Water: 0.03 - 1.08 for different coumpounds Fish: 0.0.1 - 0.0.9 Sediment: 0.01 - 2 Crab: 0.01 - 1.11 Plankton: 0.002 - 8.82			
na	Worms: 0.01 - 5.3	na	LC-HRMS	

na	na	na	LC-MS/MS
na	na	na	
na	The method limits of detection were ranging in general from 15 to 79 ng/kg.	na	LC-MS/MS
na	na	na	

na	na	na	GC-MS
na	na	na	LC-MS/MS
na	can be found in the Supplementary data	na	LC-HRMS
na	na	na	

For four compounds, PFPS, PFNS, PFPeDA and PFHpA no standards were available. These compounds were quantified by parameters of the corresponding shorter and longer-chain PFCs and are therefore only estimations	The MQL ranged between 0.05 ng/L for PFHxSi and 22.8 ng/L for PFDPA	na	LC-MS/MS
na	<0.2 ng g1 (dry sewage sludge)	na	LC–MS/MS

na	na	na	
na	The ILOD for all of the targeted PFAS ranged between 0.01 and 0.25 ng mL1 , and the ILOQ values were in the range of 0.05e0.7 ng mL1	na	LC-MS/MS
na	9.5 pg/g	na	LC-MS/MS
na	na	na	LC-HRMS

na	na	na	LC-MS/MS
na	na	na	LC-MS/MS
from 0.1 to 15 µg/L recovery: 78% to 126 %	na	na	TOPassay

na	na	na	LC-HRMS
na	na	na	GC-MS
na	0.2 - 0.4	na	LC-MS/MS
na	na	na	GC-MS
na	na	na	GC-MS

na	not in report	na	LC-MS/MS
na	~10	na	LC-MS/MS

na	The MDLs ranged from 0.28 to 18 ng/L and methodquantitation limits (MQLs) from 0.35 to 26 ng/L (all details in article)	na	LC-MS/MS
na	method quantification limits < 1ng/L	na	LC-MS/MS
na	(LOD) were 0.01 µg L−1 for PFOA and PFOS; 0.50 µg L−1 for NP, PrP, PFBu, PFPeA, PFHxA, and PFHpA;	na	LC-MS/MS
na	na	na	LC-MS/MS

na	na	na	LC-MS/MS
na	Influent: 0.05- 0.12 Secondary influent: 0.03-0.11 Sludge: 0.01 - 0.07	na	LC-MS/MS

na	MQL: 0.39-1.00 ng L-1	na	LC-MS/MS
na	limit of quanti_x0002_tation (LOQ) was 4 pg (absolute amount) for the HPLC-MS/MS method.	na	LC-MS/MS

na		0.04–0.05	na	LC-MS/MS
na			na	LC-MS/MS

na	na	na	LC-MS/MS
na	na	na	LC-MS/MS

na	4–25	na	LC-MS/MS

na	na	na	LC-MS/MS
Concentrations were below the limit of quantification (three times the LDC) for perfluorinated acids			LC-HRMS
PFBA and PFPeA: not result due to interferences.	na	na	LC-MS/MS

na	not in paper	na	LC-MS/MS
na	method detection limits (0.014–0.44 ng/L))	na	LC-MS/MS
na	na	na	LC-MS/MS

na	na	na	LC-MS/MS

na	water: 0.05 to 1.79 solid: 20 to 2700 pg g−1 dry weight (dw)	na	LC-MS/MS	
na	The limits of quantification (LOQ, signal to noise ratio 7) for river and waste water were 0.06 and 0.12 ng/L PFOA and 0.12 and 0.24 ng/L PFOS, respectively.	na	LC-MS/MS	

na	0.6 (PFHxA), 0.3 (PFOA), 0.3 (PFDoDA), 0.8 (PFHxS), and 0.2 ng/L (PFOS)	na	LC-MS/MS
na	provided in Tables S1–S3	na	LC-MS/MS

na	2.8 - 185.8	na	LC-HRMS
na	0.35 pg for PFOA and 0.05 pg for PFOS	na	LC-HRMS
The inclusion of all analytes in only one HPLC–MS/MS experiment was impossible because of the different HPLC parameters needed, such as the flow rate and solvent composition of the injected samples.	m 0.3 to 199 ng/L depending on the analyte and matrix	na	LC-MS/MS
na	na	na	LC-HRMS, LC-MS/MS

Title

A simple and sensitive gas chromatography-electron capture detection method for analyzing perfluorocarbon tracers in soil gas samples for storage of carbon dioxide

Ultra trace detection of perfluorocarbon tracers in reservoir gases by adsorption/thermal desorption in combination with NICI-GC/MS

Simultaneous determination of trace amounts of sulphur hexafluoride and cyclic perfluorocarbons in reservoir samples by gas chromatography

Solid phase microextraction (SPME) sampling under turbulent conditions and for the simultaneous collecting of tracer gases

Authors	Journal	year
Nazzari et al.	International Journal of Greenhouse Gas Control 2013 Vol. 14 Pages 60-64	2013
Galdiga et al.	Fresenius Journal of Analytical Chemistry 2000 Vol. 367 Issue 1 Pages 43-50	2000
Galdiga et al.	Chromatographia 1997 Vol. 46 Issue 7-8 Pages 440-443	1997
Susanne et al.	International Journal of Mining Science and Technology 2015 Vol. 25 Issue 4 Pages 559-563	2015

comments (t, nt, o)	DOI link
targeted	10.1016/j.ijggc.2012.12.029
targeted, see also construction products	10.1007/s002160051596
targeted	10.1007/bf02490884
targeted	10.1016/j.ijmst.2015.05.007

Name

perfluoromethylcyclohexane PMCH, perfluoro-1,2-dimethylcyclohexane PDCH, perfluoromethylcyclopentane PMCP

PMCP, PDMCB, PMCH, 1,2-PDMCH, 1,3-PDMCH

perfluorodimethyl cyclobutane, perfluoromethyl cyclopentane, perfluoromethyl cyclohexane and the 1,2- and 1,3-
isomers of perfluordimethyl cyclohexane

SF6 and PMCH

CAS (if available in source)
na
na
na
na

Sampling	sample amount used
Samples are collected using a hollow steel probe driven into the ground to a depth of 0.6–0.8 m. through CarbotrapTM 100 graphitized carbon black	na
e tracer compounds were trapped in tubes filled with a carbon molecular sieve and in a two_x0002_step procedure thermally desorbed	na
pressurised gas from a North Sea reservoir	na
SPME under dynamic conditions	na

Pre- treatment	Extraction
na	na
na	na
na	na
na	na

Clean up	Measurement
na	thermal desorption autosampler, coupled to a gas chromatograph fitted with an electron capture detector (GC–ECD)
na	adsorp_x0002_tion/thermal desorption in combination with NICI-GC/MS All measurements were carried out with a NCI-ion source. The separations were carried out on an Al2O3 PLOT column (50 m × 0.32 mm × 0.8 µm)
na	GC-ECD, Carbopack C column and a 5A Molecular Sieve column
na	GC-ECD

Quantification method	Working range (ng/mL) As	Matrices
external calibration procedure	na	Soil gas
na	na	petroleum reservoirs
na	na	gas
na	na	na

reported levels (ng/mL)	info - validation of the method	Limitations
na	linear up to 500 pg, with R2 ranging between 0.989 and 0.993. within-day precision was between 5 and 11% between-day precision ranged from 6 to 15%	na
42 femtoliter/liter	na	na
na	na	na
na	1-2 % RSD	na

LoD (ng/mL)	subgroup	Measurement - generic name
1.3 to 5.8 fL/L	na	GC-ECD
na	na	GC-MS
10 EXP-15 [liter/liter]	na	GC-ECD
ppb levels	na	GC-ECD

Title	Authors
Monitoring hydrofluorocarbon refrigerant leakage from air-conditioning systems in buildings	Cheong et al.
Determination of fluorochemical surfactants in acid etch baths by ion chromatography with on-line matrix elimination	Laikhtman et al.
Ultra trace detection of perfluorocarbon tracers in reservoir gases by adsorption/thermal desorption in combination with NICI-GC/MS	Galdiga et al.
Development and Validation of a Wipe Test Method Using Liquid Chromatography with Tandem Mass Spectrometry for the Determination of Perfluorooctanoate (PFO) on Various Surfaces	Botelho et al.

An optimized method for the determination of perfluorooctanoic acid, perfluorooctane sulfonate and other perfluorochemicals in different matrices using liquid chromatography/ion-trap mass spectrometry	Dolman et al.
Stability of Per- and Polyfluoroalkyl Substances in Solvents Relevant to Environmental and Toxicological Analysis	Zhang et al.
Structural isomers of polyfluorinated di- and tri-alkylated phosphate ester surfactants present in industrial blends and in microwave popcorn bags	Trier et al.

Determination of Perfluorooctane Sulfonates (PFOS) in Four Chemical Materials by HPLC/MS/MS	Cheng et al.
Previously unidentified sources of perfluoroalkyland polyfluoroalkyl substances from building materials and industrial fabrics	Janousek et al.
Screening for perfluoroalkyl acids in consumer products, building materials and wastes	Becanova et al.

Journal	year
Applied Energy 1996 Vol. 53 Issue 4 Pages 341-347	1996
Journal of Chromatography A 1998 Vol. 822 Issue 2 Pages 321-325	1998
Fresenius Journal of Analytical Chemistry 2000 Vol. 367 Issue 1 Pages 43-50	2000
Journal of Occupational and Environmental Hygiene 2009 Vol. 6 Issue 7 Pages 390-395	2009

Journal of Chromatography B-Analytical Technologies in the Biomedical and Life Sciences
2011 Vol. 879 Issue 22 Pages 2043-2050 2011

Environ. Sci. Technol. 2021

Environmental Science and Pollution Research
2011 Vol. 18 Issue 8 Pages 1422-1432 2011

In: Advances in Chemistry Research Ii, Pts 1-3, edited by S. Chen, Z. T. Liu and Q. Z. Zeng	2012
Environmental Science Processes & Impact	2019
Chemosphere	2016

Comment	DOI link
bad - method is about emission rate of HFC's in buildings	10.1016/0306-2619(95)00027-5
bad - method is about surfactants	10.1016/s0021-9673(98)00631-1
bad - reservoir samples - no construction products	10.1007/s002160051596
bad - applicable only to nonporeus surfaces! Caution for the porous surfaces!	10.1080/15459620902911212

bad - only application of 1 sample (PTFE sealant)	10.1016/j.jchromb.2011.05.032
stability measurements	10.1021/acs.est.1c03979
bad - industrial bland is a standard mixture, only 1 sample is measured	10.1007/s11356-011-0488-2

bad - limited sample (only 1)	10.4028/www.scientific.net/AMR.554-556.1872
very good	10.1039/c9em00091g
good	https://doi.org/10.1016/j.chemosphere.2016.08.1

PFAS	CAS (if available in publication)
na	na
fluorochemical surfactant FC-93	na
PMCP, PDMCB, PMCH, 1,2-PDMCH, 1,3-PDMCH	na
PFO	na

PFOA, PFOS	na
Twenty-one PFASs in four classes (i.e., 1 PFCA, 1 PFSA, 18 PFEAs, and 1 fluorotelomer sulfonate)	na
diPAPS . S-diPAPS . triPAPS	na

PFOS	na
per-uoro carboxylicacids (C4–C14), per-uoro sulfonic acids (C4–C8,C10and C12),n:2-uorotelomer sulfonates (n: 2 FTS,n=4, 6 and 8),n:2FTOHs (n=6, 8 and 10), 2H,2H-per-uorodecanoic acid (8 : 2FTCA), 2H,2H,3H,3Hper-uoroundecanoic acid (8 : 3 FTCA),7H-per-uoroheptanoic acid (7HPFHpA), per-uoro-3,7-dimethyloctanoic acid (PF37DMOA) and per-uorooctanesulfonamide (PFOSA).	na
per-uoro carboxylicacids (C4–C14), per-uoro sulfonic acids (C4–C8,C10and C12),n:2-uorotelomer sulfonates (n: 2 FTS,n=4, 6 and 8),n:2FTOHs (n=6, 8 and 10), 2H,2H-per-uorodecanoic acid (8 : 2FTCA), 2H,2H,3H,3Hper-uoroundecanoic acid (8 : 3 FTCA),7H-per-uoroheptanoic acid (7HPFHpA), per-uoro-3,7-dimethyloctanoic acid (PF37DMOA) and per-uorooctanesulfonamide (PFOSA).	na

Sampling	sample amount used
na	na
etch bath composed of HF–ammonium fluoride (1:6) and the fluorochemical surfactant FC-95 in an etch bath containing concentrated HF, HCl and HNO	na
e tracer compounds were trapped in tubes filled with a carbon molecular sieve and in a two_x0002_step procedure thermally desorbed	na
Wiping of surfaces	na

microwave popcorn bag brands A and B, non-stick baking paper brands A and B, a French fry box, sandwich wrapper, a hamburger box and PTFE sealant tape, one piece of 50 mg	na
PFAS standard solutions	starting concentration of ~50 µg/L, Samples (100 µL)
A microwave popcorn bag extract 0.5 dm2 was taken from each of two bags	na

a total area of 50 cm2 was cut into small sections	na
23 samples of building materials. 28 samples of industrial textiles. Mostly purchased directly but in some cases the manufacture's supplied the articles	1 gram
23 samples of building materials. 28 samples of industrial textiles. Mostly purchased directly but in some cases the manufacture's supplied the articles	1 gram

Pre- treatment	Extraction
na	na
na	na
na	na
The wipe samples were extracted	na

off-line SPE	na
PFAS stability: The PFAS was subsequently dissolved in 10 mL of solvent [i.e., deionized water, methanol, acetonitrile (ACN), acetone, DMSO, or isopropyl alcohol (IPA)]. For experiments involving various water-to-organic solvent ratios, solvents of different compositions (100% organic solvent, 90:10% (v/v) or 80:20% (v/v) organic solvent/water) were added.	no extraction
The strips were therefore fully Environ Sci Pollut Res (2011) 18:1422–1432 1423 immersed in 40 mL of 95% aqueous ethanol	na

accelerated solvent extraction (ASE) or solid phase extraction (SPE)	na
samples were cut and dried.	Liquied-solid extraction was done with methanol and water.
samples were cut and dried.	Liquied-solid extraction was done with methanol and water.

Clean up	Measurement
na	The concentration-decay technique was used to determine the air exchange rate in a room. The method is based on an initial injection of tracer gas to simulate refrigerant leakage, R134a was injected into the chamber with all the dampers closed and fans off. SF 6 was also released in the chamber in order to compare the accuracy of R 134a measurement of air exchange rates. A desk fan was used to assist the mixing of tracer gases and air in the chamber over a period of 10 min. Once a uniform concentration of tracer gases was achieved, dampers at the supply and extract ducts were opened and the fans were switched on. Monitoring of the concentrations of R 134a and SF 6 tracer gas then commenced simulta_x0002_neously at the centre of the chamber, using a multigas analyser,
na	On-line matrix elimination 3 was accomplished on a polymeric reversed-phase column followed by separation on a multiphase HPLC column, and detection by suppressed conductivity
na	adsorp_x0002_tion/thermal desorption in combination with NICI-GC/MS All measurements were carried out with a NCI-ion source. The separations were carried out on an Al2O3 PLOT column (50 m × 0.32 mm × 0.8 µm)
na	Column temperature: 30◦C Flow rate: 0.3 mL/min Injection volume: 5µL Run time: 14 min Retention time: 6.7 min Mobile phase: Gradient Time (min) %A %B 0 90 10 5 10 90 9 10 90 10 90 10 14 90 10 A = 2mM ammonium acetate in water B = methanol

		reversed_x0002_phase liquid chromatography on a Phenyl–Hexyl column coupled with ion-trap (IT) mass spectrometric detection acetonitrile gradientin water from 20% to 50% in 6 min. As a cleaning step, the column was washed with 95% acetonitrile for 2 min and equilibrated for 7 min at 20%
na		acetonitrile
Samples were taken at different times and diluted into 10 mL of deionized water in PP tubes and stored at room temperature until analysis. Measured at several temperatures.		LC–MS analysis was performed using an Agilent 1290 Infinity II HPLC coupled to an Agilent 6545 quadrupole time-of-flight (QTOF) mass spectrometer. After 5 d, samples of degration products of HFPO–DA, HFPO–TA, and HFPO–TeA were taken and analyzed using a headspace gas chromatography–mass spectrometry (GC–MS) method.
na		Waters Acquity BEH C18 column (150×2.1 mm i.d., 1.7 µm particle size) operated at 45°C. The binary solvent system consisted of methanol/ distilled water 5:95 (v/v) (mobile phase A) and methanol (mobile phase B) A 35 min gradient elution programme was used with an initial composition of 95% A: 0–3 min linear to 40% A, 3–24 min linear to 5% A, 24–31 min linear to 2% A, 31–33 min curved to initial composition and isocratic from 33–35 min. The flow rate was 0.28 mL min−1 , and the column heater was at 45°C The accurate mass measurements and MS2 analysis for structure elucidation were performed with a Micromass quadrupole time-of-flight (QTOF)

na	HPLC measurement was performed using Atlantis T3 C18 column with 2.1 mm × 150 mm i.d. 5.0 µm. The mobile phase was acetonitrile and 10 mmol/L ammonium acetate solution with a volume ratio of 4:1. The flow rate was 0.2 mL/min and the injection volume was 10 µL
na	HPLC-MS/MS
na	HPLC-MS/MS

Quantification method	Working range (ng/mL) As
na	na
na	na
na	na
internal standard	on a 10-cm × 10-cm surface. The analytical method was evaluated over a range of 1 to 23 ng/cm2,

When possible, quantification was conducted with an isotope dilution approach, in which the analyte response was normalized to that of an isotopically labeled analogue. For other PFASs, the analyte response was normalized to that of an isotopically labeled PFAS with an LC retention time similar to that of the analyte	na
na	na

na	na
Internal standard	na
Internal standard	na

Matrices	Reported levels (ng/mL)	info - validation of the metho	Limitations
na	emis_x0002_sion rate for R134a was found to be in the range 270.2-870.7 mg/h,	na	na
na	5 mg/l of the surfactant FC-93 in 100 ml of the etch bath	the area R.S.D. was 0.6%, linear between 10 and 50 mg/l	na
petroleum reservoirs	42 femtoliter/liter		na
six surfaces: stainless steel, polycarbonate, Formica, butyl acid suit material, laminated disposable suit material, and a painted surface	na	all recoveries are within acceptance limit criteria of 80% to 120% %RSD95 ranged from 1.9 to 6.6%	na

food packaging, polytetrafluoroethylene (PTFE) sealant tape and drinking water	low ug/kg	PFOA recover_x0002_ies between 75 and 78% and PFOS recoveries between 81 and 88 (RSD) of 1.9 and 2.8%	na
na	na	na	na
oil- and water-repellent coatings on paper and board	na	na	na

coatings of nonstick pot, food packaging materials, waterborne coatings containing fluoride and fire-fighting foams		linear calibration curve was obtained in the range of 0.002 - 0.1 µg/mL recovery for PFOS was in the range of 93.4 - 103% with relative standard deviation of 0.48 - 3.59%. T	na
textiles, paint, foan, glue, foil, coatings	awning: 260 µg/kg Seat Cover (car): 2-50 µg/kg Coatings: 20-70 µg/kg Foul (for facedes): 2-30 µg/kg	Blank samples were prepared with every extraction batch.	na
textiles, paint, foan, glue, foil, coatings	awning: 260 µg/kg Seat Cover (car): 2-50 µg/kg Coatings: 20-70 µg/kg Foul (for facedes): 2-30 µg/kg	Blank samples were prepared with every extraction batch.	na

LoD (ng/mL)	subgroup	Measurement - generic name
na	na	
na	na	LC-MS/MS
na	na	GC-MS
100 ng/wipe.	na	LC-MS/MS

25 pg/mL	na	LC-MS/MS
na	na	LC-MS/MS
na	na	LC-MS/MS

0.4 µg/m2	na	LC-MS/MS
not in report	na	LC-MS/MS
not in report	na	LC-MS/MS

Title

Occurrence and characteristics of perfluoroalkyl substances (PFASs) in electroplating industrial wastewater

First Report of a Chinese PFOS Alternative Overlooked for 30 Years: Its Toxicity, Persistence, and Presence in the Environment

Targeted and Nontargeted Analysis of PFAS in Fume Suppressant Products at Chrome Plating Facilities

Multianalyte profiling of per- and polyfluoroalkyl substances (PFASs) in liquid commercial products

Authors	Journal	year
Jiawei et al.	Water Sci Technol 2019 Vol. 79 Issue 4 Pages 731-740	2019
Wang et al.	Environmental Science & Technology	2013
Michigan Department of Environment, Great Lakes, and Energy (EGLE)	na	2020
Favreau et al.	Chemosphere	2017

comments (t, nt, o)	DOI link
na	10.2166/wst.2019.092
na	10.1021/es401525n
na	https://www.michigan.gov/document
Also applied to AFFF	10.1016/j.chemosphere.2016.11.127

PFAS

perfluorobutyric acid (PFBA), perfluorovalerate (PFPeA), perfluoroheptanoic acid (PFHpA), perfluoroproxic acid (PFOA), perfluoro NONYLIC acid (PFNA), perfluorodecanoic acid (PFDA), perfluoro twelve acid (PFDoDA) and perfluorooctyl sulfonic acid (PFOS), perfluorohexanic acid (PFHxA), perfluorohexanoic acid (PFUnDA), and perfluoro ten. Tri acid (PFTrDA), perfluoro butyl sulfonic acid (PFBS) and perfluorohexyl sulfonic acid (PFHxS), perfluorooctyl sulfonamide (FOSA), quantitative mixed standard PFAC-MXB, internal standard 13C4-PFOS, internal standard 13C4-PFOA, internal standard 13C4-PFBA, and internal standard 13C2-PFDoDA

chlorinated polyfluorinated ether sulfonate (locally called F-53B, C8ClF16O4SK), PFOS

Targeted analysis of 25 PFAS (4:2 FTS, 6:2 FTS, 8:2 FTS, GenX, N-EtFOSAA, N-MeFOSAA, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFOSA), non-targeted analysis

41 targeted PFAs including PFCAs (C4-C16), PFSAs (C4, C6, C8, C10), ipPFNS, PFPAs (C6, C8, C10), FOSA, N-Me FOSA, N-Et FOSA, FASAAs: FOSAA, N-MeFOSAA, N-EtFOSAA, N-MeFOSE, N-EtFOSE, FTSAs (4:2, 6:2, 8:2 FTS), FTOHs (4:2, 6:2, 7:2s, 8:2, 10:2), 8:2 FTI, 8:2 FTAC, 8:2 FTMAC

CAS (if available in source)
na
na
757124-72-4 (4:2 FTS), 27619-97-2 (6:2 FTS), 39108-34-4 (8:2 FTS), 13252-13-6 (GenX), 2991-50-6 (N-EtFOSAA), 2355-31-9 (N-MeFOSAA), 375-22-4 (PFBA), 2706-90-3 (PFPeA), 307-24-4 (PFHxA), 375-85-9 (PFHpA), 335-67-1 (PFOA), 375-95-1 (PFNA), 335-76-2 (PFDA), 2058-94-8 (PFUnDA), 307-55-1 (PFDoDA), 72629-94-8 (PFTrDA), 376-06-7 (PFTeDA), 375-73-5 (PFBS), 2706-91-4 (PFPeS), 355-46-4 (PFHxS), 375-92-8 (PFHpS), 1763-23-1 (PFOS), 68259-12-1 (PFNS), 335-77-3 (PFDS), 754-91-6 (PFOSA)
na

Sampling

water sampling

surface water samples (5 L for each sampling point) were taken from the Oujiang River, at Wenzhou city, China the vicinity of where the discharge from a municipal WWTP enters the river. This WWTP is known to receive wastewater from the electroplating industry, where both F-53B and PFOS are assumed to be in use. Wastewater samples were also collected “upstream”, at a small WWTP which treats the raw effluents of electroplating plants before they enter the municipal sewer system.

25 samples collected from fume suppressant products and effluents at 11 chrome plating facilities in Michigan

Household products included impregnation agents (n = 60), cleansers (n = 24), polishes (n = 18), lubricants (n = 7). A miscellaneous category of products (n = 23) was defined by various applications that included foamsuppressing agents for the chromium industry, paints, ski wax, inks and tanning substances.

sample amount used
na
5 mL
water samples (500 mL)
500 mg for LC-MS, 200 mg for GC-MS

Pre- treatment	Extraction
purify by WAX columella	na
filtered through glass microfiber filters	solid phase extraction (SPE)
filtered	extracted using a WAX solid phase, PFAS was removed from the cartridge in methanol extraction cartridge
LC-MS: dissolved in 10 mL water, adding methanol/water, ammonium acetate (pH 4), GC-MS: dissolved in 10 mL methanol, filtration	LC-MS: SPE with methanol/ ammonium acetate (50:50)

Clean up	Measurement
na	LC-MSMS, Acclaim 120 C18 (4.6 ×150 mm, 5 m), mobile phase A was methanol, mobile phase B was 50 mM ammonium acetate solution, the sample volume was 10 uL with 1 mL/min of flow rate
extracts were reduced using a gentle stream of nitrogen, diluted to 1 mL with ultrapure water and filtered	LC–MS/MS, ZORBAX Eclipse XDB C18 column (5 µm × 2.1 mm × 150 mm, Agilent, CA) using an UltiMate 3000 HPLC (Dionex by Thermo Fisher Scientific Inc., MA), API 3200 triple quadrupole mass spectrometer (AB SCIEX, ON, Canada)
volume reduced	UPLC-MS using targeted workflow methods described within laboratory Quality Assurance Project Plan
LC-MS: adding ammonium hydroxide in methanol (0.5 %), neutralized with acetic acid	LC- MS/MS, GC-MS/MS for FTOHs, FTI, FTAC, FTMAC

Quantification method	Working range (ng/mL) As
na	na
Potassium L-PFOS and 13C4- and 13C8-labeled L-PFOS, as recovery and injection standards	na
calibration curves derived from authentic standards, matched stable isotope labeled internal standard (when available) or a closely eluting labeled standard (when an exact match was not available)	10 to 150 ng/L
internal standardisation using mass-labeled standards	na

Matrices	reported levels (ng/mL)
electroplating waste water	drainage system: 229.5 to 5 410.6 ng/ L effluents is about 538 ng/L
waste water (effluent and influent)	43–78 and 65–112 µg/L for the effluent and influent, respectively
fume suppressant sampling, effluent sampling	The only PFAS compound observed in the fume suppressant products with targeted analysis was 6:2 FTS, which was present in very high concentrations in all products except product 3 where it was not detected
household products (impregnation agents, cleanser, polishes), lubricants, foamsuppressing agents for the chromium industry, paints, ski waxes, inks, tanning substances,	55% of all samples contained at least one PFAS between 0.1 and 25'000 mg/kg of product, with the majority of products falling within the 100e1000 mg/kg range

info - validation of the method	Limitations	LoD (ng/mL)
recovery (90-127%) and reproducibility (1-15%)	na	na
average recovery was 100.1% with relative standard deviation of <10%	na	Instrumental LOQs for F-53B and PFOS in this study were 0.14 and 0.15 ng/L, respectively, and instrumental LODs were 0.04 ng/L for both
relative percent difference (RPD), averaged 15% and no sample/analyte comparison exceeded the project goal of <30% RPD	na	LOQ 10 ng/L
na	na	LOQ: 0.5-2 ng/mL (LC-MS), 2-10 ng/mL (GC-MS)

subgroup	Measurement - generic name
na	LC-MS/MS
na	LC-MS/MS
na	LC-MS/MS
na	LC-MS/MS, GC-MS

Title
Analysis of Perfluoro-carboxylic Acid Fluorides by Gas Chromatography/Mass Spectrometry
Electrospray ionization time of flight mass spectrometry analysis of perfluoroalkyl acrylic oligomers synthesized using atom transfer radical polymerization
Efficient "total" extraction of perfluorooctanoate from polytetrafluoroethylene fluoropolymer
Adsorption of perfluorooctane sulfonate (PFOS) on mesoporous carbon nitride
Adsorption of perfluorinated compounds on aminated rice husk prepared by atom transfer radical polymerization
Distribution characteristics of trifluoroacetic acid in the environments surrounding fluorochemical production plants in Jinan, China
Perfluoroalkyl acids (PFAAs) with isomer analysis in the commercial PFOS and PFOA products in China

Characterizing direct emissions of perfluoroalkyl substances from ongoing fluoropolymer production sources: A spatial trend study of Xiaoqing River, China

Occurrence and source apportionment of novel and legacy poly/perfluoroalkyl substances in Hai River basin in China using receptor models and isomeric fingerprints

Isomer Profiles of Perfluoroalkyl Substances in Water and Soil Surrounding a Chinese Fluorochemical Manufacturing Park

Authors	Journal	year
Lou et al.	Chinese Journal of Analytical Chemistry 2013 Vol. 41 Issue 7 Pages 1086-1090	2013
Romack et al.	Abstracts of Papers of the American Chemical Society 2007 Vol. 233	2007
Larsen et al.	Analyst 2006 Vol. 131 Issue 10 Pages 1105-1108	2006
Yan et al.	Rsc Advances 2013 Vol. 3 Issue 44 Pages 22480-22489	2013
Deng et al.	Chemosphere 2013 Vol. 91 Issue 2 Pages 124-130	2013
Xie et al.	Environ Sci Pollut Res Int 2020 Vol. 27 Issue 1 Pages 983-991	2020
Jiang et al.	Chemosphere 2015 Vol. 127 Pages 180-187	2015

Shi et al.	Environmental Pollution 2015 Vol. 206 Pages 104-112	2015
Li et al.	Water Research 2020 Vol. 168	2020
Jin et al.	Environmental Science & Technology 2015 Vol. 49 Issue 8 Pages 4946-4954	2015

comments (t, nt, o)	DOI link
no access	10.3724/sp.J.1096.2013.21000
na	no link
na	10.1039/b606801d
na	10.1039/c3ra43312a
na	10.1016/j.chemosphere.2012.11.015
na	10.1007/s11356-019-06689-4
na	10.1016/j.chemosphere.2015.01.049

na	10.1016/j.envpol.2015.06.035
na	10.1016/j.watres.2019.115145
na	10.1021/acs.est.5b00212

Name
na
na
PFOA and APFO
PFOS
perfluorooctanoate (PFOA), perfluorobutanoic acid (PFBA) and perfluorooctane sulfonate (PFOS)
TFA
PFOS, PFOA

per_x0002_fluorobutanoic acid (PFBA), perfluoropentanoic acid (PFPeA), per_x0002_fluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), PFOA, PFNA, perfluorodecanoic acid (PFDA), perfuoroundecanoic acid (PFUnDA), perfluorododecanoic acid (PFDoDA), per_x0002_fluorotridecanoic acid (PFTrDA), perfluorotetradecanoic acid (PFTeDA), perfluorohexadecanoic acid (PFHxDA), per_x0002_fluorooctetradecanoic acid (PFODA), perfluorobutane sulfonic acid (PFBS), perfluorohexane sulfonic acid (PFHxS) and PFOS. In addi_x0002_tion, structural isomers of PFOA including L-PFOA and four br_x0002_PFOAs (iso-, 5m-, 4m- and 3m-PFOA)

PFCAs (C4eC14), perfluoroalkyl sulfonic acids (PFSAs, C4eC10, even), PFOSA, Cl-PFESAs (6:2 and 8:2), FTS (4:2, 6:2 and 8:2), ammonium 4, 8-dioxa-3H-perfluorononanoate (ADONA), 6:2 diPAP, HFPO-DA, hexafluoropropylene oxide trimer acid (HFPO-TA), PFECHS

na

CAS (if available in source)
na
na
na
na
na
na
na

na

na

na

Sampling	sample amount used
na	na
na	na
na	na
na	na
aminated rice husk (RH) adsorbent	na
Samples from flowing water bodies were collected from five sites air sampling was conducted at S1 using an annular glass denuder with a quartz fiber filter system d 1-kg soil samples from a depth of 0–10 cm were collected using undisturbed soil samplers	All water samples were collected in pre-rinsed 500-mL polypropylene bottles
na	na

na	na
na	na
sampling was conducted around a major fluorochemical manufacturing park in China in 2012, including soil and water collection inside the park, including from a wastewater treatment plant (WWTP), as well as in surrounding rivers and soil (~15 km radius).	na

Pre- treatment	Extraction
na	na
na	na
pressurized solvent extraction (PSE)	na
na	na
na	na
After shaking, the filtrate was extracted by solid_x0002_phase extraction (SPE) using Oasis WAX SPE cartrid gas-phase sample, the two denuders were extracted with three consecutive additions of double-distilled water (10, 10, and then 5 mL) by transferring each addition from the first denuder to the second after shaking each denuder, and a com_x0002_bined extract (25 mL) was obtained. 10 g of each soil sample was placed into a 50-mL Erlenmeyer flask along with 30 mL of methanol	na
na	na

na	na
na	na
e extraction by Oasis WAX cartridges	na

Clean up	Measurement
na	na
na	na
na	liquid chromatography with tandem mass spectrometry
na	Kinetics studies reveal that the adsorption of perfluorooctane sulfonate (PFOS) HPLC with conductivity detector
na	HPLC with a conductivity detector
na	The method for detecting TFA was developed by Taniyasu et al. (2008)
na	PFAAs and the isomers of PFOS and PFOA were analyzed on high performance liquid chromatography couple with tandem mass spectrometry (HPLC-MS/MS) using the method developed by Benskin et al. (2007) FluoroSep RP Octyl column (ES Industries, West Berlin, NJ) at 38 _x0003_C. The mobile phase started from 60% A (HPLC grade water adjusted to pH 4.0 with ammonium formate) and 40% B (methanol) at a flow rate of 150 lL min_x0003_1 . The initial condition was held for 0.3 min and then ramped to 64% B by 1.9 min; increased to 66% B by 5.9 min, 70% B by 7.9 min, 74% B by 26 min, 80% B by 30 min, and finally to 100% B by 37 min

na	All samples were treated according to previously developed methods (Zhou et al., 2013)
na	LC-MSMS
na	high-performance liquid chromatography tandem mass spectrometry (HPLC-MS/MS) also paired with an ultrahigh resolution orbitrap mass spectrometer

Quantification method	Working range (ng/mL) As	Matrices
na	na	na
na	na	na
external calibration	na	Polytetrafluoroethylene fluoropolymer resin
na	na	
na	na	
na	na	water
PFOS isomers (n-, iso-, 5m-, 4m-, 3m-, 1m-, m2-) and those of PFOA (n-, iso-, 5m-, 4m- and 3m-) were quantified using a characterized technical standard and isomer-specific product ions Riverine discharges of PFOA (23e67 t/yr) were in agreement with theoretical emission calculations from FP production (68 t/yr)	na	na

na	na	water and sediment
na	na	na
na	na	na

reported levels (ng/mL)
na
na
adsorption capacities of MCN-1 calcined at 673, 773 and 873 K are 625.0, 555.5 and 433.7 mg g_x0001_1
adsorption capacities of PFOA, PFBA and PFOS on the aminated RH at pH 5.0 were 2.49, 1.70 and 2.65 mmol g_x0002_1 ,
250-3000 ng/L water <0,1-2,6 ng/g in soil 1000-7000 pg/m3 air
The purity of the three PFOS products was 76.7–80.6%. The major impurity in the PFOS products is PFOA, which contributes more than 10%. Other impurities include perfluorohexane_x0002_sulfonate (PFHxS), perfluorohexanoate (PFHxA) and perfluoroheptanoate acids (PFHpA). The percentage of linear PFOS (n-PFOS) in the three products was 66.2–71.9%, similar to that in the product manufactured by 3M (70.3%). The purity of the five PFOA products was relatively high (94.0–95.8%), and the major impurity was PFOS (2.06–3.09%). The percentage of n-PFOA in the five PFOA products was 76.4–77.9%, which was similar to that in the 3M PFOA (78%)

Substantially elevated PPFAS concentrations downstream of tributary 4 demonstrated that the emissions from this FP manufacturer dominated total riverine discharges. Isomer profiles of per_x0002_fluorooctanoic acid (PFOA) in water displayed a stepwise increase in percentage branched PFOA down_x0002_stream of tributary 3 (14.0%) and 4 (22.7%) reflecting the importance of FP sources PPFAS concentrations ranging from 36.5 to 496 000 ng/L. PPFASs in sediment ranged from 0.333 to 4100 mg/kg dw and PFOA was the main homologue (18.1e95% of PPFASs).

The total concentrations of PFASs (PPFASs) ranged from 1.74 to 172 ng/L, with perfluorooctanonate (PFOA) as the dominant compound (15.2% Unmix, was introduced to identify the sources of PFASs in the surface water, and the results indicated that fire-fighting foam/fluoropolymer processing aids (36.6%) trace the manufacturing sources of PFOA. Electrochemical fluo_x0002_rination (ECF) was the major PFOA manufacturing source with considerable contribution by telomeri_x0002_zation.

Perfluoroalkyl sulfonates (PFSAs) were lower than perfluoroalkyl carboxylates (PFCAs) in all samples, and short-chain (C4−C6) PFCAs were predominant. Perfluoroalkyl phosphonates and phosphate diesters were occasionally detected, but at low detection frequency. Branched isomers of perfluorobutanesulfonate (PFBS) are reported for the first time, accounting for 15−27% of total PFBS in water. An enrichment of isopropyl_x0002_PFOA (28%) was found in WWTP influent, suggesting its manufacturing primarily by isopropyl telomerization. PFOA was still a major chemical in use at this site, primarily from isopropyl telomerization.

info - validation of the method	Limitations	LoD (ng/mL)
na	na	na
na	na	na
acceptable recovery range of 70 to 130%	na	0.5 ppb,
	na	na
	na	na
instrument blank, solvent blank, and sam_x0002_pling site blank The detection limit and the limit of quantitation were calculated as 3 and 10 times the signal-to-noise ratio (S/N), respectively. The recoveries for the soil samples ranged from 91.3 to 95.8%. The recoveries for the water samples ranged from 93.1 to 94.8%, and the RSDs ranged from 2.1 to 6.2%. The recoveries of the atmospheric samples ranged from 91.4 to 93.7%, and the RSDs ranged from 1.5 to 2.1%.	na	na
na	na	na

recoveries ranged from 70.4 ± 8.7% to 109.2 ± 4.1% in water and from 81.5 ± 2.1% to 103.3 ± 4.0% in sediment	na	na
The recoveries of all the target PFASs were in the range of 65.7e129%, 73.5e119% and 59.8e137%	na	na
The recoveries of all target compounds were in the range of 47–124% and 52–109%	na	na

subgroup	Measurement - generic name
na	
na	
na	LC-MS/MS
na	LC-ECD
na	
na	
na	LC-MS/MS

na	
na	LC-MS/MS
na	LC-MS/MS

Title

Elucidation of contamination sources for poly- and perfluoroalkyl substances (PFASs) on Svalbard (Norwegian Arctic)

Simultaneous measurement of ventilation using tracer gas techniques and VOC concentrations in homes, garages and vehicles

A pilot study of per- and polyfluoroalkyl substances in automotive lubricant oils from the United States

Side-chain fluorotelomer-based polymers in children car seats

Authors	Journal	year
Skaar et al.	Environ Sci Pollut Res Int 2019 Vol. 26 Issue 8 Pages 7356-7363	2019
Batterman et al.	Journal of Environmental Monitoring 2006 Vol. 8 Issue 2 Pages 249-256	2006
H. K. Zhu and K. Kannan	Environmental Technology & Innovation 2020 Vol. 19 Pages 8	2020
Wu et al.	Environmental Pollution 268 (2021) 115477	2021

comments (t, nt, o)	DOI link
targeted	10.1007/s11356-018-2162-4
targeted	10.1039/b514899e 10.1016/j.eti.2020.100943
PIGE, XPS, LC-MS, GC-MS, TOPassay	https://www.sciencedirect.com/scien

PFAS

C4–C13 PFCAs (i.e. PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTriDA); C4, C6, and C8 PFSAs (i.e. PFBS, PFHxS, PFOS) and 6:2 fluorotelomer sulfonate (6:2 FTSA)

hexafluorobenzene [392-56-3], octa_x0002_fluorotoluene [434-64-0], perfluoro (1,2-dimethylcyclobutane) [28677-00-1], perfluoro(methylcyclohexane) [355-02-2], and perfluoro(methylcyclopentane) [1805-22-7].

na

PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFHxDA, PFPrS, PFBS, PFPeS, PFHpS, PFOS, PFNS, PFDS, Cl-PFOS, 4:2-FTSA, 8:2-FTSA, 8:2-FTCA, FOSA, MeFOSA, EtFOSA, 6:2-FTOH, 8:2-FTOH, 8:2-FTOH, 10:2-FTOH, EtFOSE, 6:2-FTAc, 8:2-FTAc, 10:2-FTAc, 6:2-FTMAc,, 8:2-FTMAc

CAS (if available in source)
na
[392-56-3], [434-64-0], [28677-00-1], [355-02-2], and [1805-22-7].
na
na

Sampling	sample amount used
Soil, freshwater (lake, draining rivers), seawater, meltwater run-off, surface snow and coastal sediment	2.5 g of soil and 1000–2300 mL of aqueous samples
active or passive samplers	na
na	na
Eighteen children’s car seats, representing twelve brands, were purchased new by the Ecology Center as part of a project analyzing chemical additives in car seats	Samples were cut into small pieces using scissors pre-cleaned with dichloromethane and methanol

Pre- treatment

water samples (Jahnke et al. 2007; Möller et al. 2010) and soil samples (Powley et al. 2005)

na

na

No additional treatment was performed for samples prepared for PIGE and XPS analyses.

Extraction

na

na

Briefly, 50-100 mg of material was spiked with 20 ng each of the surrogate standards, and extracted with 4:1 hexane/isopropanol twice followed by 1:1 methanol/acetonitrile. For each extraction step, the sample was sonicated for 30 min and then centrifuged at 3000 rpm for 5 min. The supernatants were combined, reduced in volume to ~5 mL.

Clean up

na

na

cleaned-up with ~100 mg Envi-Carb graphite by vortexing for 1 min and centrifuging for 5 min.

Measurement	Quantification method
validated quantification methods for the trace analytical determination of PFASs	na
GC-MS	na
article-included gamma ray emission spectroscopy (PIGE), Xray photoelectron spectroscopy (XPS), as well liquid and gas chromatography mass spectrometry (LC/MS and GC/MS) and TOP assay	na

Working range (ng/mL) As	Matrices	reported levels (ng/mL)
na	water	m 0.4 to 4 ng/L in surface lake water FFTS meltwater run-off (118 ng/L) run-off water (113–119 ng/L) and soil (211–800 ng/g)
na	gas	na
na	car seats	FAS were detected in 97% of the car seat samples analyzed with MS, with total concentrations of 43 PFAS (PPFAS) up to 268 ng/g

info - validation of the method	Limitations	LoD (ng/mL)
detection limits (LOD), quantifica_x0002_tion limits (LOQ) and recoveries	na	na
na	na	na
The recoveries of surrogate standards were generally in the range of 60 -130% with some exceptions. Matrix spike recoveries of each individual compound were all within the range 75-125% for all the treatments.	na	PIGE measures total fluorine (organic and inorganic) with a sensitivity at the mg/g levels while XPS can distinguish organic and inorganic fluorine was only reliable for samples with fluorine content greater than 500 - 1000 mg/g.

subgroup	Measurement - generic name
na	LC-MS/MS
na	GC-MS
na	PIGE, XPS, LC-MS/MS, GC-MS, TOP assay

Title	Authors	Journal
Perfluorinated compounds and total and extractable organic fluorine in human blood samples from China	Yeung et al.	Environmental Science and Technology 42(21): 8140-8145
Combustion ion chromatography for extractable organofluorine analysis	Aro et al.	iScience, 24(9)
Enantioseparation of chiral perfluorooctane sulfonate (PFOS) by supercritical fluid chromatography (SFC): Effects of the chromatographic conditions and separation mechanism	Zhao et al.	Chirality 2019 Vol. 31 Issue 10 Pages 870-878

Selective extraction of perfluorooctane sulfonate in real samples by superparamagnetic nanospheres coated with a polydopamine-based molecularly imprinted polymer	Lin et al.	J Sep Sci 2021 Vol. 44 Issue 5 Pages 1015-1025
Enantiomer Fractions of Chiral Perfluorooctanesulfonate (PFOS) in Human Sera	Wang et al.	Environ. Sci. Technol. 2011, 45, 8907–8914

Are humans exposed to increasing amounts of unidentified organofluorine	Yeung et al.	Environ. Chem. 2016, 13, 102–110
Assessing exposure to legacy and emerging per- and polyfluoroalkyl substances via hair - The first nationwide survey in India	Ruan et al.	Chemosphere 2019 Vol. 229 Pages 366-373
Exposure assessment to parabens, bisphenol A and perfluoroalkyl compounds in children, women and men by hair analysis	Martin et al.	Science of the Total Environment 2019 Vol. 695
Hand Wipes: A Useful Tool for Assessing Human Exposure to Poly- and Perfluoroalkyl Substances (PFASs) through Hand-to-Mouth and Dermal Contacts	Poothong et al.	Environ Sci Technol 2019 Vol. 53 Issue 4 Pages 1985-1993

Screening of Poly- and Perfluoroalkyl Substances (PFASs) and Extractable Organic Fluorine (EOF) in the Blood of Highly Exposed People	Aro et al.	na
Determination of 21 perfluoroalkyl substances and organophosphorus compounds in breast milk by liquid chromatography coupled to orbitrap high-resolution mass spectrometry	Beser et al.	Anal Chim Acta 2019 Vol. 1049 Pages 123-132
Perfluorinated substances in the Flemish population (Belgium): Levels and determinants of variability in exposure	Colles et al.	Chemosphere 2020 Vol. 242

Levels of Perfuoroalkyl Acids (PFAAs) in Human Serum, Hair and Nails in Guangdong Province, China: Implications for Exploring the Ideal Bio-Indicator	Liu et al.	Archives of Environmental Contamination and Toxicology
A liquid chromatography-high resolution mass spectrometry method for the determination of thirty-three per- and polyfluoroalkyl substances in animal liver	Barola et al.	Journal of Chromatography A 2020 Vol. 1628 Pages 11
Comparison of extraction methods for per- and polyfluoroalkyl substances (PFAS) in human serum and placenta samples-insights into extractable organic fluorine (EOF)	Kaiser et al.	Analytical and Bioanalytical Chemistry 2021 Vol. 413 Issue 3 Pages 865-876

Determination of perfluoroalkyl substances (PFAS) in human hair by liquid chromatography-high accurate mass spectrometry (LC-QTOF)	Piva et al.	Journal of Chromatography B-Analytical Technologies in the Biomedical and Life Sciences 2021 Vol. 1172
Extractable Organofluorine Analysis in Pooled Human Serum and Placental Tissue Samples from an Austrian Subpopulation —A Mass Balance Analysis Approach	Kaiser et al.	Environ. Sci. Technol. 2021, 55, 13, 9033–9042

A Comparative Analysis of Per- and Polyfluoroalkyl Substances (PFAS) and Extractable Organofluorine (EOF) Using Solid Phase Extraction-Weak Anion Exchange and Ion Pair Extraction in Serum	Marichal Salameh	Bachelor thesis
Extractable organofluorine analysis: A way to screen for elevated per- and polyfluoroalkyl substance contamination in humans?	Aro et al.	Environment International

Per- and Polyfluoroalkyl Substances (PFAS) in Facemasks: Potential Source of Human Exposure to PFAS with Implications for Disposal to Landfills	Muensterman et al.	Environ. Sci. Technol. Lett. 2022, 9, 320−326
Biomarkers, matrices and analytical methods targeting human exposure to chemicals selected for a European human biomonitoring initiative.	Vorkamp et al	Environment International, 2021, 146, 106082.
PFASs: What can we learn from the European Human Biomonitoring Initiative HBM4EU.	Uhl M, Schoeters G, Govarts E, Bi	Int J Hyg Environ Health.

year	Comments	DOI link
2008	na	10.1021/es800631n
2021	na	10.1016/j.isci.2021.102968
2019	targeted	10.1002/chir.23120

2021	targeted	10.1002/jssc.202000824
2011	na	10.1021/es2023434

2016	na	10.1071/EN15041
2019	na	10.1016/j.chemosphere.2019.04.195
2019	na	10.1016/j.scitotenv.2019.133864
2019	targetted	10.1021/acs.est.8b05303

2019	na	na
2019	na	10.1016/j.aca.2018.10.033
2020	na	10.1016/j.chemosphere.2019.125250

2020 na 10.1007/s00244-020-00743-w

2020 na 10.1016/j.chroma.2020.461442

2021 na 10.1007/s00216-020-03041-5

2021	na	10.1016/j.jchromb.2021.122651
2021	na	10.1021/acs.est.1c00883

2021	na		na
2022	Suggested workflow for rapid screening of samples for elevated PFAS contamination is proposed (based on Koch et al. 2020)		https://www.sciencedirect.com/s

2022	These preliminary findings indicate that wearing masks treated with high levels of PFAS for extended periods of time can be a notable source of exposure and have the potential to pose a health risk. 3 new PFAS were found with the suspect screening	https://pubs.acs.org/doi/10.1021/
2021	Recommended standard method for target analyses of PFAS in human samples	10.1016/j.envint.2020.106082
2023		10.1016/j.ijheh.2023.114168.

PFAS	CAS (if available in publication)
PFOS, PFHxS, PFOSA, PFDoDA, PFUnDA, PFDA, PFNA, PFOA, PFHpA, and PFHxA	na
Fluoride standard solution Anion multi-element standard Perfluorooctanoic acid Perfluoro-n-butanoic acid Perfluoro-n-[1,2-13C2]octanoic acid Perfluoro-n-[1,2-13C2]undecanoic acid Potassium perfluoro-1-butanesulfonate Sodium perfluoro-1-[13C8]-octanesulfonate Sodium perfluoro-1-dodecanesulfonate Sodium 1H,1H,2H,2H-perfluorooctane sulfonate (6:2) N-methylperfluoro-1-octanesulfonamide 2-Perfluorooctyl ethanol (8:2) Sodium bis(1H,1H,2H,2H_x0002_perfluorodecyl)phosphate Perfluorooctylphosphonic acid Potassium 9-chlorohexadecafluoro-3-oxanonane-1-sulfonate 2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)propanoic acid	na
perfluoro-1-methylheptane sulfonate (1 m-PFOS) 1 m-, 3 m-, 4 m-, 5 m-, and 4,5m2-PFOS	na

PFOS	na
racemic -1m PFOS	na

PFCAs (C5-C14), PFSAs (C4-C8, C10), FOSAs (H, Me, Et), FOSAAs (H, Me, Et), di-SAmPAP, FTCAs (3 : 3, 5 : 3, 7 : 3), FTUCAs (6 : 2, 8 : 2, 10 : 2), monoPAPs (6 : 2, 8 : 2), diPAPs (4 : 2, 4 : 2/6 : 2, 6 : 2, 6 : 2/8 : 2, 8 : 2, 8 : 2/10 : 2, 10 : 2), PFPAs (C6, C8, C10), PFPiAs (C6/C6, C6/C8, C6/C10, C6/C12, C8/C8, C8/C10, C8/C12), FTSAs (4 : 2, 6 : 2, 8 : 2) and FTSASs (6 : 2, 8 : 2)	na
na	na
perfluorobutanoic acid (PFBuA), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), PFOA, PFOS	na
na	na

na	na
na	na
perfluorohexane sulfonic acid (PFHxS), PFOA, perfluorononanoic acid (PFNA) and perfluorobutane sulfonate (PFBS)	na

na	na
na	na
perfluorocarboxylic acids (PFCAs: C4–C14), perfluo rosulfonic acids (PFSAs: C4–C10), perfluorooctane sulfon_x0002_amides (perfluoro-n-octane sulfonamide (FOSA), N-ethyl_x0002_perfluoro-n-octane sulfonamide (EtFOSA)), N-ethyl_x0002_perfluoro-n-octane sulfonamido acetic acid (EtFOSAA), N-ethyl-perfluoro-n-octane sulfonamido ethanol (EtFOSE), fluorotelomer sulfonates (FTSAs: 4:2, 6:2, and 8:2), polyfluoroalkyl phosphate diesters (diPAPs: 6:2/6:2, 6:2/8:2, 8:2/8:2), polyfluorinated ether acids (ADONA and GenX), and 6:2 Cl-PFESA (F-53B))	na

11-chloroeicosafluoro-3-oxaunde_x0002_cane-1-sulfonic acid (11Cl-PF3OUdS); 9-chlorohexadecafluoro-3-oxano_x0002_nane-1-sulfonic acid (9Cl-PF3ONS); Perfluoro-n-butanoic acid (PFBA); perfluoro-1-butanesulfonic acid (PFBS); Perfluoro-n-decanoic acid (PFDA); Perfluoro-n-dodecanoic acid (PFDoA); perfluoro(2-ethoxyethane)sulfonic acid (PFEESA); perfluoro-1-heptanesulfonic acid (PFHpS); Perfluoro-n-heptanoic acid (PFHpA); perfluoro-1-hexanesulfonic acid (PFHxS); Perfluoro-n-hexanoic acid (PFHxA); perfluoro-3-methoxypropanoic acid (PFMPA); perfluoro-4-methoxybutanoic acid (PFMBA); Perfluoro-n-nonanoic acid (PFNA); perfluoro-1-octanesulfonic acid (PFOS); Perfluoro-n-octanoic acid (PFOA); Perfluoro-n-pentanoic acid (PFPeA); perfluoro-1-pentanesulfonic acid (PFPeS); perfluoroundecanoic acid (PFUnA); dodecafluoro-3H-4,8-dioxanonanoic acid (ADONA)	na
	na

PFCAs (C4 - C12), PFSAs (C4, C6, C8) and 6:2 FTSA	na
63 different PFAS; TFA, PFPrA, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTDA, PFHxDA, PFOcDA, PFEtS, PFPrS, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFDoDS, 3:3 FTCA, 5:3 FTCA, 6:2 FTUCA, 7:3 FTCA, 8:2 FTUCA, 10:2 FTUCA, FBSA, MeFBSA, PFHxSA, MeFHxSA, FOSA, FOSAA, MeFOSAA, EtFOSAA, 4:2 FTSA, 6:2 FTSA, 8:2 FTSA, 10:2 FTSA, 6:2 Cl-PFESA, 8:2 Cl-PFESA, PFECHS, 6:2 mPAP, 8:2 mPAP, 10:2 mPAP, 6:2 diPAP, 6:2/8:2 diPAP, 8:2 diPAP, 10:2 diPAP, SAmPAP, diSAmPAP, PFHxPA, PFOPA, PFDPA, C6/C6 PFPiA	
C6/C8 PFPiA, C8/C8 PFPiA, HFPO-DA (GenX), ADONA	na

nonvolatile PFAS: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, PFHxDA, PFPrS, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFDoS, Cl-PFOS, PFEtCHxS, FBSA, FHxSA, FOSA, MeFOSA, EtFOSA, FOSAA, MeFOSAA, EtFOSAA, 4:2-FTS, 6:2-FTS, 8:2-FTS, 10:2-FTS, 6:2-FTCA, 8:2-FTCA, 10:2-FTCA, 3:3-FTCA, 5:3-FTCA, 7:3-FTCA, 6:2-UFTCA, 8:2-UFTCA, ADONA, 9Cl-PF3ONS, 11-PF3OUdS, HFPO-DA, 6:2-diPAP, 8:2-diPAP, diSAmPAP volatile PFAS: 4:2-FTOH, 6:2-FTOH, 8:2-FTOH, 10:2-FTOH, 12:2-FTOH, MeFOSA, EtFOSA, MeFOSE, EtFOSE, 4:2-FTAc, 6:2-FTAc, 8:2-FTAc, 10:2-FTAc, 6:2-FTMAc, 8:2-FTMAc suspect volatile PFAS: 14:2-FTOH, MeFPrSE, MeFBSE, MeFPeSE, MeFHxSE, MeFHpSE, EtFEtSE, EtFPrSE, EtFBSE, EtFPeSE, EtFHxSE, EtFHpSE, 4:2-FTI, 6:2-FTI, 8:2-FTI, 10:2-FTI, PFBI, PFHxO, PFOI, PFDI, 6:2-FTO, 8:2-FTO, 10:2-FTO, 12:2-FTO	na
nonvolatile PFAS: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, PFHxDA, PFPrS, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFDoS, Cl-PFOS, PFEtCHxS, FBSA, FHxSA, FOSA, MeFOSA, EtFOSA, FOSAA, MeFOSAA, EtFOSAA, 4:2-FTS, 6:2-FTS, 8:2-FTS, 10:2-FTS, 6:2-FTCA, 8:2-FTCA, 10:2-FTCA, 3:3-FTCA, 5:3-FTCA, 7:3-FTCA, 6:2-UFTCA, 8:2-UFTCA, ADONA, HFPO-DA, 6:2-diPAP, 8:2-diPAP, diSAmPAP	
nonvolatile PFAS: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, PFHxDA, PFPrS, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFDoS, Cl-PFOS, PFEtCHxS, FBSA, FHxSA, FOSA, MeFOSA, EtFOSA, FOSAA, MeFOSAA, EtFOSAA, 4:2-FTS, 6:2-FTS, 8:2-FTS, 10:2-FTS, 6:2-FTCA, 8:2-FTCA, 10:2-FTCA, 3:3-FTCA, 5:3-FTCA, 7:3-FTCA, 6:2-UFTCA, 8:2-UFTCA, ADONA, HFPO-DA, 6:2-diPAP, 8:2-diPAP, diSAmPAP	

Sampling	sample amount used
na	na
na	na
na	na

na	na
Pregnant Women, “High-Exposure” Family	na

na	na
A total of 39 samples were collected from 14 different 73 cities of 11 states	na
Hair samples were collected from 42 volunteers Hair samples were washed first with ultrapure water, then with SDS (0.1%, w/v), and finally twice again with ultrapure water	na
n hand wipe samples collected as a composite sample from 23 both hands of 60 adults	na

na	na
They were collected by mothers, in different stages after birth, in a glass container using a breast pump	na
na	na

human serum (n=60), hair (n=49) and nails (n=39)	na
wild boar liver samples	Aliquots of 30 g mashed liver
The solid-phase extraction of serum using hydrophilic-lipophilic bal_x0002_ance sorbent (SPE-HLB) was adapted from the work of Kuklenyik and co-workers The preparation of placental tissue was adapted based on the method developed by Martin and co-workers	na

All hair samples for analysis were collected from the vertex posterior region	na
36 human maternal blood, 136 placental tissue, and 136 cord blood samples	For the serum pool samples, 600 µL from two to four individuals were pooled. For placental tissue pools, individual samples were pooled using 1.5–3 g per sample

na	na
We obtained 20 whole blood samples (1–2 mL) from 20 randomly selected participants in a longitudinal study with a wide range of PFAS levels due to longstanding exposure to drinking water contaminated by AFFF firefighting foams. Additionally, 9 randomly selected samples from a nearby municipality with uncontaminated drinking water was obtained, thus representing background PFAS exposure.	0.5 - 1.6 mL blood

Facemasks were purchased from local stores in Notre Dame, IN

0,1-1 ml blood, plasma or serum

0,1-1 ml blood, plasma or serum

Pre- treatment	Extraction
improved extraction (ion pairing) and cleanup (ENVI-carb and solid phase extraction)	na
extraction and SPE-WAX	na
na	na

Extraction experiments for the spiked samples with different PFOS concentrations (5–200 ng/L−1) were con_x0002_ducted under the optimized conditions. Briefly, 100 mL of water sample or 50 mL pretreated human serum sample was added into a polypropylene flask (pH = 3), 100 mg of MIPDA@Fe3O4 was added to the solution, and the mixture was sonicated for 2 min. Then the solution was transferred to a thermostatic bath and agitated at 150 rpm (298 K) for 30 min, to facilitate mass transfer and adsorption of the PFOS onto MIPDA@Fe3O4. The MIPDA@Fe3O4 was isolated using an external magnetic field and the supernatant was discarded. Then the col_x0002_lected magnetic adsorbents were transferred to a 50 mL polypropylene flask, with 10 mL methanol added as a des_x0002_orption solvent. The mixture was shaken in a thermostatic bath (150 rpm, 298 K) for 10 min and the eluent was then dried under a gentle nitrogen	na
na	na

modified ion-pair extraction method at pH 4 and pH 10	na
hair samples were washed stepwise Extraction method was adopted after reviewing the previous methods based on organic solvent extraction followed by clean up (Li et al., 2013; Kim and Oh, 2017; Alves et al., 2015) extract were applied to Envi-Carb cartridge (100 mg, 1 mL, 100–400 mesh, Supelco, USA) for cleanup to achieve quick analysis	na
Target compounds were extracted and analysed by a previously re_x0002_ported method (Martín et al., 2016).	na
sonicated	na

na	na
extraction and clean-uThe analytical method described below has been developed and modified on the basis of a previous study for PFAS analysis carried out by Lankova et al. procedure based on the QuEChERs methodology f	na
na	na

The serum samples without any pre-treatment were used to analyze TF. The separate pre-treatment of extracting EOF and PFAAs from serum samples, which was described in detail by Yeung et al. (2013), The pre-treatment of extracting PFAAs and EOF from nails and hair samples was depicted by Wang et al. (2018).	na
extracting liver with acetonitrile followed by two clean-up steps The extraction and purification protocol was performed according to Kärrman et al.	na
n (ion-pair liquid-liquid extraction, solid-phase extraction (SPE), using hydrophilic_x0002_lipophilic (HLB) or weak anion exchange (WAX) sorbents)	na

100 mg of hair were weighted in a polypropylene vial and 10 µl of mass labelled I.S. were added. Two ml of acetonitrile were added up carefully to soak all the material before extraction in ultrasound bath at 45 ◦C for 45 min. The extract was collected in a separated polypropylene vial and the extrac_x0002_tion procedure was repeated another time. Finally, extracts were collected in the same vial (4 ml total volume). Sample clean-up was by solid phase extraction (SPE) by using Bond elut-ENV cartridges.	na	
The serum samples were prepared using solid phase extraction with a weak anion exchange sorbent (SPE-WAX), modified from Kuklenyik et al. (2004)		
The placental tissue samples were extracted with a method adapted from Martín et al. (2016) (16) with an EnviCarb clean-up step		
61 investigated PFAS, sample preparation, and the extraction procedure are shown in the study by Kaiser et al. (2020)	na	

na	ion-pair extraction (IPE) and solid phase extraction with weak anion exchange (SPE-WAX).	First, 2 mL of 0.5 M TBA solution in water and 5 mL of MTBE were added to the sample (0.5–0.7 mL of blood for Replicate 1 and 0.5–1.6 mL for Replicate 2). Then the mixture was shaken horizontally at 250 rpm for 15 min and after that centrifuged for 10 min at 8500 rpm (8000 g). The extraction was repeated twice with 3 mL of MTBE, after collecting the organic solvent layer. The organic solvent extracts from all three cycles were combined and evaporated to 0.2 mL under a stream of nitrogen, then reconstituted to 1.0 mL with MeOH and evaporated to a final volume of 0.5 mL.

TF-analysis: Facemasks were cut to 2 × 2 cm2 pieces with methanol rinsed scissors and were mounted to a stainless steel target frame with 1 cm diameter LC-qTOF: Methanol-rinsed scissor was used to cut 2 × 2 cm2 pieces of facemasks GC-MS: Methanol-rinsed scissor was used to cut 1.5 × 1.5 cm2 pieces of material	LC-qTOF: 3 times extraction with hot methanol (60-65°C) GC-MS: and methanol was added to a final volume of 1500 µL. Samples were sonicated for 30 min at 25 °C

see references in paper

see references in paper

Clean up	Measurement
na	Thirteen individual PFCs were analyzed using the ion-pairing method. HPLC-MSMS Total fluorine (TF) and extractable organic fluorine (EOF) also were measured in the blood samples using combustion ion chromatography
na	Combustion ion chromatography (CIC), The prevailing assumption has been that all PFASs are incinerated in CIC and matrix components have no impact on this process
na	The optimal separation was obtained using a Chiralpak QN-AX column with CO2/2-propanol (70/30, v/v) as the mobile phase with a flow rate of 1 mL/min, column temper_x0002_ature was 32°C, and BPR pressure was 1800 psi. The resolution (Rs) and reten_x0002_tion time were 0.88 and 130 minutes, respectively The Acquity UPC2 (Waters, Prague, Czech Republic) SFC system used in this study consisted of an Acquity UPC2 binary solvent manager, Acquity UPC2 -FL sample manager, Acquity UPC2 convergence manager, Acquity column manager, isocratic solvent manager, and Xevo TQ-S detector

na	na
na	chiral HPLC-MS/MS method was developed for alpha-perfluoromethyl branched PFOS Two Chiralpak QN-AX HPLC columns (2.1 mm I.D. _x0003_ 150 mm each, 5 µm particles, Chiral technologies Inc. PA) in tandem with a C18 guard column (4.0 mm I.D. _x0003_ 3 mm, 5 µm particles, Phenomenex, Torrance, CA) were used for enantioseparation of 1m-PFOS. Chromatographic conditions were optimized in re_x0002_versed-phase mode on an HPLC-MSMS Isocratic elution was applied and the mobile phase consisted of tetrahydrofuran, 0.2 M formic acid, triethylamine, and water in the ratio 70:20:0.05:10, by volume. Flow rate was 0.12 mL/min and column temperature was kept at 15 _x0001_C. Injection volume was 2 to 20 µL

na	LC-MSMS EOF
na	Ten microliter (10 µL) of sample was injected to HPLC–MS/MS for analysis. Details about instrumental analysis has been described in the SI. The most recent international standard method (ISO DIS21675, 2019) was applied to this study.
na	Target compounds were extracted and analysed by a previously re_x0002_ported method (Martín et al., 2016). Analytical determination was performed on a 1200 Series LC system (Agilent, USA) coupled to a 6410 Agilent triple quadrupole (QqQ) mass spectrometer (MS). Chromatographic separation was carried out on an Agilent Zorbax Eclipse XDB–C18 Rapid Resolution HT (50 mm × 4.6 mm i.d.; 1.8 µm particle size) column. An electrospray ionization source op_x0002_erating in negative-ion mode was used Separation was performed by gradient elution with methanol (solvent A) and 5 mM ammonium acetate aqueous solution (solvent B) at a flow rate of 0.6 mL min−1 with the column thermostated at 25 °C. The elution program was as follows: 0–20 min, linear gradient from 28 to 95% of solvent A, held for 2 min
na	online-SPE UHPLC-MS/MS established analytical method for analysis of PFASs in serum, plasma, and whole blood as described by Poothong et al

	the same as used in the report “Screening of Poly- and Perfluoroalkyl Substances (PFASs) and Extractable Organic Fluorine (EOF) in Swedish Blood Samples” UPLC-MSMS The mobile phases were methanol (MeOH) and 30:70 MeOH:MilliQ water mixture, both with 2 mmol/L ammonium acetate and 5 mmol/L 1-methylpiperidine as additives [31]. Ultra-short chain compounds (C2-C3) were separated by a supercritical fluid chromatographic system
na	EOF: combustion ion chromatography (CIC) system
	ultra-high performance liquid chro_x0002_matography coupled to high-resolution mass spectrometry (UHPLC-HRMS) determination. The full-scan mass data were acquired with a resolution of 50000 FWHM and a mass accuracy better than 5 ppm Chromatographic separation was carried out with a Hypersil Gold column (100 _x0005_ 2.1 mm, 1.9 mm) from Thermo Fisher Scientific (Bremen, Germany). The flow rate used was 300 mL min_x0003_1 and the injection volume was 10 mL. The mobile phase consisted of (A) an 0.1% acetic_x0002_acid aqueous solution and (B) methanol:acetoniltrile (80:20, v/containing 0.1% acetic acid. The gradient was as follows: 0 min (40% B) and held for 2 min. After that, solvent B increased linearly to 80% in 4 min, and to 100% in another 4 min and was kept for 3 min. Finally, solvent B changed to the initial percentage (40%) in 0.5 min and was maintained for 3.5 min to equilibrate the column before
na	the next injection. The total run time was 17 min
	were determined in serum and cord plasma using procedures as described by (Kato
na	et al., 2011).

na	total fuorine (TF), extractable organic fuorine (EOF), identifed organic fuorine (IOF, total concentration of identifed PFAAs quantifed as fuorine) and 11 target PFAAs TF and EOF in serum, nails and hair were determined by cyclic neutron activation analysis (CNAA) (Zhang et al. 2017).
na	LC-HRMS full MS/dd-MS2, t-SIM/dd-MS2 and SIM experiments Kinetex XB C18 column Mobile phases were water (A) and methanol (B) both containing 2 mM of ammonium acetate. The gradient was initiated with 100% eluent A at 0.05 mL min−1. In 1 min the flow increased to 0.3 mL min−1 and the eluent B increased to 20% maintaining this condition for 2 min. The gradi_x0002_ent continued with linear increase to 70% B in 8 min. This con_x0002_dition was maintained for 4 min following by another linear in_x0002_crease of mobile phase B up to 100% in 6 min. After 5 min, the system returned to 100% A and the flow at 0.05 mL/min in 2 min
na	(HPLC-MS/MS The analytical column was a Luna 5 µm C18(2), 100 × 2 mm (Phenomenex, CA, USA). The eluents were methanol (mobile phase B) and LC-MS grade water, contain_x0002_ing 10 mM ammonium acetate (mobile phase A) The stationary phase was an ACQUITY UPLC® BEH C18 1.7 µm, 2.1 × 100 mm column (Waters Corporation, Milford, MA, USA), and the eluents for the mobile phases were a 70:30 mixture of Milli-Q water and methanol (mobile phase A) and methanol (mobile phase B), both containing 2 mmol/L ammo_x0002_nium acetate and 5 mmol/L n-methylpiperidine

na	The LC MS system consisted of an Agilent 1290 Infinity II high pressure liquid-chromatography (HPLC) system coupled to an Agilent 6546 quadrupole- time-of-flight mass spectrometer (Q-TOF, Agilent Technologies, Santa Clara, CA). Separations were carried out in an EC_x0002_C18 column (2.1 × 100 mm, 1.9 µm), (Agilent Technologies, Santa Clara, CA), while a second LC C18 column (EclipsePlus-C18, 3.0 × 50 mm 1.8 µm) was placed after pump exit to delay any perfluorinated interferents originating from fluidic system. The mobile phases consisted of water added with 20 mM ammonium acetate (A) and acetonitrile added of 0.1% formic acid (B) with a flow rate of 0.3 ml/min. The gradient was as follows: 3% B at time 0, 25% B at 1 min, 25–85% B from 1 to 9 min, 85–97% from 9 to 10, isocratic 97% B for 2 min, equilibration at 3% B up to 15 min. The volume of injection was optimized and the final result was 20 µl. The Q-TOF instrument was operated in negative ion mode
na	measuring the extractable organofluorine (EOF) in pooled maternal serum, placental tissue, and cord serum samples The EOF was analyzed using combustion ion chromatography, and the concentrations of known PFAS were determined using ultraperformance liquid chromatography coupled with a tandem mass spectrometer

na	LC-MS/MS extractable organofluorine (EOF) with CIC	
Several Replicate 1 samples (used for target PFAS analysis) required an additional clean-up step with solid phase extraction (SPE), weak anion exchange cartridges	The EOF content was measured with a CIC system. Target analysis: ultra performance liquid chromatograph (UPLC) with a mass spectrometer (MS/MS). For ultra-short chain compounds an SFC system was coupled to a MS/MS.	

	Total Fluorine Analysis by Particle-Induced Gamma Ray Emission
	Nonvolatile PFAS Analysis by Liquid Chromatography Quadrupole Time-of-Flight Mass Spectrometry (LC-qTOF)
GC-MS: strong anion exchange (SAX) solid phase extraction (SPE)	Nonvolatile PFAS Suspect Screening
	Volatile PFAS Analysis by Gas Chromatography-Mass Spectrometry

Quantification method	Working range (ng/mL) As	Matrices
na	na	whole blood
na	na	surface water and whole-blood sample extracts
na	na	serum

na	na	water and human serum samples
na	na	serum

na	na	plasma and whole blood
na	na	hair
na	na	hair
internal standard	na	wipes

internal standard	na	na
na	na	breast milk
na	na	serum and plasma

na	na	na
isotope	na	liver
na	na	serum and placental tissue

na	na	hair
na	na	pooled maternal serum, placental tissue, and cord serum samples

na	na	na
isotope dilution method, except for TFA and PFPrA analysis (qualitative) due to the lack of suitable internal standards	na	whole blood

TF-analysis: standard response of the external calibration curve (PFOA) LC-qTOF and GC-MS: isotope dilution method	na		Face masks

Reported levels (ng/mL)
five cities (Jintan, Nanjing, Guiyang, Beijing, and Shenyang). PFOS was found to be the dominant PFC ranging from 0.446-83.1 ng/ mL. known PFCs could account for >70% of EOF in samples from Beijing, Shenyang, and Guiyang, whereas known PFCs could only account for ∼30% of EOF in samples from Jintan
na
The frequency of occurrence of 1m-PFOS in 10 human sam_x0002_ples were 80% (S/N ≥ 10). 1m-PFOS EF ranges from 0.395 to 0.474 in human sera (n = 8), and the average 1m-PFOS EF was 0.443 ± 0.025

na

1m-PFOS was racemic (EF =
0.485_x0001_0.511)
nonracemic, with a mean EF ((standard
deviation) of
0.432 (0.009

quantifiable PFASs accounted
for 31–86 % of EOF
0-0,07 ng/mL, 0-45 ng F/mL

concentrations of total
11 PFAS in hair varied from below matrix-
specific limit of quantification (<0.02 ng/g) to
12 3.78 ng/g. Among 9 PFAS quantified,
perfluorohexanesulfonic acid (PFHxS),
13 perfluorooctanesulfonic acid (PFOS), and
perfluorooctanoic acid (PFOA) were the
14 predominant compounds.

PFCs were detected at concentrations in the
range from 0.6 to 15.5 ng/g, being PFHpA and
PFOS the ones most
frequently detected (86% and 76%,
respectively)

Polyfluoroalkyl phosphate esters (PAPs) were
the predominant PFASs
in the hand wipe samples (medians between
0.21 and 0.54 ng per sample)
The median of estimated daily intakes via
hand-to-mouth and dermal
contacts (for hands only) for PFOA were 0.83
and 0.50 pg·kg bw−1·day−1,

average sum PFAS concentrations was 346 ng/g (from 74.1 ng/g to 715 ng/g). The average EOF concentration was 186 ng F/g and 79% of the EOF was explained by the target analytes.

In all samples, perfluoro-n-pentanoic acid (PFPeA), perfluoro-n-octanoic acid (PFOA) and sodium perfluoro-1-octanesulfonate (PFOS) were the most frequently detected analytes 0.0021 mg kg_x0003_1 b.w.- day and 0.0029 mg kg_x0003_1 b.w.- day, respectively, for PFOA; and for PFOS the daily intake resulted in 0.0092 mg kg_x0003_1 b.w.- day and 0.01254 mg kg_x0003_1 b.w.- day, respectively. Considering TDI values of 1.5 mg kg_x0003_1 b.w.- day for PFOA and 0.15 mg kg_x0003_1 b.w.- day for PFOS

na

EOF was the major form of fuorine in serum, accounting for 70–80% of TF. The levels of IOF contributed less than 10% of EOF. Perfuorooctane sulfonic acid (PFOS) was found to be the dominant PFAA with mean concentration of 23 ng·mL−1 in serum, 35 ng·g−1 in hair and 33 ng·g−1 in nail

range 0.2–150 ng g − 1

Results showed that performance, in terms of recovery, differed between the extraction methods for different PFAS; different extraction methods resulted in different EOF concentrations indicating that the choice of extraction method is important for target PFAS and EOF analysis. Results of maternal serum samples, analyzed in two different laboratories using two different extraction methods, showed an accordance of 107.6% (± 21.3); the detected perfluoroalkyl acids (PFAAs) in maternal and cord serum samples were in the range of 0.076 to 2.9 ng/mL.

The detected PFAS were PFBA (range 0.24–14.6 ng/g), PFBS (0.496 ng/g), PFOA (range 0.08–0.178 ng/g) and PFOS (<LOQ-0.239 ng/g)

he amount of unknown PFAS was estimated between the levels of known PFAS and EOF. The EOF levels ranged from 2.85 to 7.17 ng F/mL (21 PFAS were quantified) in the maternal serum, from 1.02 to 1.85 ng F/g (23 PFAS were quantified) in the placental tissue, and from 1.2 to 2.10 ng F/mL (18 PFAS were quantified) in the cord serum. An average of 24, 51, and 9% of EOF is unidentified

IPE had an average ionization enhancement of 9%, while SPE-WAX showed an average ionization suppression of -1%. SPEWAX showed higher average recoveries for procedural blanks (78%), horse serum (96%) and human serum (95%) in comparison to IPE (69%, 36%, 88%, respectively). The CIC analysis for EOF content was observed to be below MDL (<50 ng/mL F) with some contaminations observed in the procedural blanks.

The average EOF concentration in the Ronneby group was 234 ng/mL F (<107–592 ng/mL F) vs 24.8 ng/mL F (17.6–37.8 ng/mL F) in the control group. This was confirmed by target analysis, which found an average ∑PFAS concentration of 346 ng/mL in the exposed group and 7.9 ng/mL in the control group.

Summed PFAS concentrations ranged from 15 to 2900 µg/m2

info - validation of the method	Limitations
Analysis of PFOS standard 10 and 100 ng/mL in MeOH showed 95% (SD: 5%) and 98% (SD: 3%) recovery, respectively. In-house reference material (pig's blood) was analyzed before and after every 10 CIC injections (TF mean: 173 ng F/mL and SD: 13 ng/mL, n) 10) t	na
combustion efficiencies of 66–110% RSD was 5%	na
between-run less than or equal to 2.97, precision (Relative Standard Deviation, RSD, %) within-run less than or equal to 1.83 and between-run less than or equal to 1.41, the Rs precision (RSD, %) of enantiospearation within-run less than or equal to 5.50 and between-run less than or equal to 6.12.	na

recoveries of ~70–101.5% RSDs of 1.22–6.86%	na
na	na

Matrix recoveries ranged from 61 to 115 % standard deviations for all batches were between 9 and 15 % recoveries ranging from 89 to 92 % (80 to 90 %) and combustion 500 ng (or 50 ng) of PFOA resulted in 85 to 90 % (83 to 89 %) recoveries. Inter-day performance and reproducibility were monitored by repeated combustions of SRM1957 samples. The relative standard deviations for SRM1957 analysed on different days were less than 18 % (19.4_x0004_ 3.2 ng F mL_x0002_1); the quantifiable PFASs represented ,83 % of the EOF	na
procedural blanks, procedural recoveries and internal standards recoveries 121 DIS21675, 2019) was applied to this study. For quality assurance and quality control, procedural blanks, procedural recoveries and internal standards recoveries for each sample were analyzed. Procedural blanks and recoveries were assessed following the same procedure used for hair sample extraction. Detail values for matrix-specific limits of quantification (MLQ), blank and recovery results has been summarized in the SI (Tables S2–S4). Mean procedural recovery ranged from 79%–91% among PFAS	na
For each batch of 20 samples analysed (within one day), procedural blank, blank samples spiked	na
Method recoveries in spiked blank gauze pads were 60–90% while in spiked gauze pads with a commercial hand cream the recovery of internal standards ranged between 50–75% average method accuracy ((the obtained concentration in the spiked sample / the nominal concentration) *100) of 98±12% repeatability was calculated to be 12% intermediate precision was 11±6%	na

Recovery: 20-92%, RSD: 9-40%	na
recovery, repeatability, linearity and limit of quantifi_x0002_cation. The obtained recoveries varied between 70 and 120% with a precision (RSD) lower than 25%. The limit of quantification (LOQ) ranged between 1.9 and 19.0 ng g_x0003_1 lipid weight for OPs, and between 0.066 ng mL_x0003_1 and 0.666 ng mL_x0003_1 for PFASs. A breast milk reference material was used in order to check the validated method.	na
Quality controls included reagent methods blanks comprised of bovine serum as well as calibration standards and quality control samples in bovine serum (ACILA AG, Weiterstadt, Germany). Reproducibility was checked by analysing spiked bovine serum and a native human plasma sample. Recovery rates were 102% for PFOS, 99% for PFOA, 104% for PFHxS, 95% for PFNA and 91% for PFBS. Detection limits (LOD) were calculated as three times the signal/noise ratio of the analytical background noise in the temporal vicinity of the analyte signal. The limit of quantification (LOQ) was determined as twice the LOD and was 0.3 mg/L for PFOS and PFOA in FLEHS II (2007e2011) and in FLEHS III (2012e2015) LOQ was 0.2 mg/L for PFOS, PFOA, PFHxS and PFBS, and 0.1 mg/L for PFNA	na

The limits of detection (LODs) for TF in serum, hair and nails were 0.058 μg·mL−1, 0.61 μg·g−1 and 0.60 μg·g−1, respectively, while the LODs for EOF in serum, hair and nails were 0.02 μg·mL−1, 0.21 μg·g−1 and 0.20 μg·g−1, respectively. Hair standard sample (GBW07601) was used to assess the accuracy for the TF and EOF measurements. The recoveries of TF and EOF at 2.0 μg·g−1 and 0.50 μg·g−1 were 99±1% and 95±2%, respectively. The LODs of 11 PFAAs ranged from 0.09 to 0.41 ng·mL−1. The recoveries of 11 PFAAs ranged from 83 to 116% in bovine serum, 76% to 137% in hair and 68% to 130% in nails.	na
Trueness was from 94 to 126% with intra-laboratory reproducibility lower than 20%.	na
Recovery SPE-WAX: 75%, ion-pair method: 51%, SPE-HLB 59%	na

The obtained sensitivities (LOQ), linearity and RSD accuracies were respectively in the range of 0.07–0.5 ng/g, 0.1 (or 0.2 or 0.5)-10 ng/g, 1–16% sensitivity, linearity, accuracy, matrix effect and stability The calculated matrix-related effect was comprised from 52% to 119%; stability of processed samples, tested while main_x0002_taining the samples in the autosampler at room temperature for 48 h, were in the range of 45–100%	na
comparing the PFAS concentrations in the pooled samples with the PFAS concentrations measured in the individual samples additional quality control procedures are described elsewhere	na

(recovery, matrix effect (ME) in terms of intra-/inter-day repeatability		na
Every extraction batch included a procedural blank and a quality control (QC) sample. The relative standard deviation (RSD) was below 20% for L-PFOS and L-PFOA for the QC samples (n = 19). The acceptable recovery range for target PFAS was set to 20–150% and it was measured separately for each sample with the use of isotopically labelled standards (recovery standards). Compounds, whose recoveries fell outside of this range, were marked as not quantified (n.q.). The performance and condition of the CIC were monitored with repeated injections of an anion standard solution and blank injections. The repeatability of the CIC system was tested by triplicate analysis of the anion standard solution, resulting in an RSD below 10%. The performance of EOF analysis was verified by participating in an interlaboratory comparison study.		na

TF analysis: Method accuracy was calculated to be between 96 and 106% and precision was calculated to be ±5.4%.2,3 Based on the standard response of the external calibration curve.			
LC-qTOF: Whole method precision : 1.2-35%, Whole method accuracy: 41-310%			
GC-MS: Whole method precision : 0.62-11%, Whole method accuracy: 62-140%	na		

LoD (ng/mL)	subgro	Measurement - generic name
na	na	LC-MS/MS, CIC
50 ng/mL	na	CIC
	na	LC-MS/MS

). The detection limit (LOD) calculated from 3δ/K to be ∼0.1 ng L−1	na		
na	na	LC-MS/MS	

10 and 50 pg mL_x0002_1	na	LC-MS/MS, CIC
na	na	LC-MS/MS
na	na	LC-MS/MS
0.0045–0.09 ng	na	LC-MS/MS

na	na	LC-MS/MS
na	na	LC-MS/MS
na	na	LC-MS/MS

na	na	CIC
2–100 pg g−1	na	LC-HRMS
na	na	LC-MS/MS

na	na	LC-MS/MS
na	na	CIC

na	na	LC-MS/MS, CIC
The LOQ of the EOF analysis ranged from 7.1 to 107 ng/mL F in whole blood LOQ ranged from 6 - 4917 pg/mL for the target analysis	na	CIC, LC-MS/MS

0.5 - 2.5 µg/m2		na	PIGE, LC-HRMS, GC-MS

Title

Target and Nontarget Analysis of Per- and Polyfluoralkyl Substances in Wastewater from Electronics Fabrication Facilities

Screening for perfluoroalkyl acids
in consumer products, building materials and wastes

Perfluoroalkyl and polyfluoroalkyl substances (PFASs) in consumer products in Norway – A pilot study

Authors	Journal	year
Jacob et al.	Environ Sci Technol 2021 Vol. 55 Issue 4 Pages 2346-2356	2021
Becanova et al.	Chemosphere	2016
Herzke et el.	Chemosphere	2012

comments (t, nt, o)	DOI link
targeted and untargeted	10.1021/acs.est.0c06690
na	10.1016/ j.chemosphere.2016.08.1120045-6535/
na	10.1016/j.chemosphere.2012.03.035

PFAS

The 25 target PFASs included 11 perfluorocarboxylic acids (PFCAs), seven perfluorosulfonic acids (PFSAs), three fluorotelomer sulfonic acids (FTSs), one perfluoroalkylsulfonamide (FOSA), two polyfluorosulfonamido acetic acid derivatives (N-MeFOSAA and N-EtFOSAA), and perfluoro-2-methyl-3-oxahexanoic acid (GenX).

PFPA, PFHxA, PFHpA, PFOA, PFNa, PFDA, PFUnDA, PFDoDa, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS and PFDS

PFAS (i.e. C4–C14 PFCAs, C4,C6,C8,C10 PFSAs, 6:2 and 8:2 fluorotelomersulfonates (FTSs), PFOSA, 4:2, 6:2, 8:2, 10:2 FTOH

CAS (if available in source)
na
na
na

Sampling	sample amount used
waste waters at 3 positions	na
126 samples in four categories: Textiles, Floor coverings, Electrical & Electronic equipment and plastics. All bought in Czech Republic	5 g
30 products in 6 different product groups: waterproofing agents, paint, coated fabrics, non-stick ware, electronics and fire fighting agents. They were purchased from retailers in Norway and Sweden.	1 g

Pre- treatment	Extraction
na	na
Materials were crushed, chopped or cut into small pieces	Methanol with the addition of ammonium acetate
Liquid and solid samples were homogenized	methanol for ionic compounds and ethylacetate forFTOH

Clean up	Measurement
na	LC-HRMS on orbitrap (targeted and untargeted) HPLC-MS non-targeted
Following extraction, samples were cleaned up according to the procedures for PFAAs analysis described indetail elsewhere (Karaskova et al., 2016).	HPLC-ESI-MS/MS
Centrifugation and solvent evaporation, clean up with ENVI-Carb and glacial acetic acid (for ionic PFAS)	GC-MS

Quantification method	Working range (ng/mL) As	Matrices
na	na	waste water
internal standards	na	Textiles, matierials of wood and composite wood, plastics, foam, air conditioner components. electronic components
internal standard	na	food contact paper, textile, fire fighting foam, water proofing agents and lubricants, paint, leather, carpets, non-stick ware, printed circuit boards

reported levels (ng/mL)	info - validation of the method
PFBS was quantified at the highest concentration among the samples (8040 ng L−1) The sum concentrations of the target PFASs in the diluted discharge samples from each fab were 623, 394, and 376 ng L−1 sum concentrations of target and nontarget PFASs in the diluted discharge samples from each fab were 1490, 78 700, and 2170 ng L−1	na
Textiles: up to 77,6 µg/kg Plastics: up to 0,384 µg/kg OSB and wood: up to 18,3 µg/kg (PFAS found in 14 out of 14 samples) Car interior materials: up to 3535 µg/kg	The accuracy of method was evaluated using a set of spiked solidblank materials (polyurethane foam (n = 6) and sand matrix blank (n = 10))
na	As standard procedure, laboratory blanks, method detection limits (MDLs) and recoveries were examined. For each sample, a high resolution full scan spectra was used to control positive detections (typical mass tolerance 50 ppm). No laboratory contamination for any of the analyzed compound was detected

Limitations	LoD (ng/mL)	subgroup	Measurement - generic name
na	na	na	LC-HRMS
na	MQL = 0.02 - 0.28 µg kg-1	na	LC-MS/MS
na	MDLs not reported	na	GC-MS

Title	Authors	Journal
US EPA 537.1 - Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)		
ISO 25101:2009 - Water quality — Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry.	na	na

US EPA 8327 - Per-and Polyfluoroalkyl Substances (PFAS) Using External Standard Calibration and Multiple Reaction Monitoring (MRM) Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)	na	na
ASTM D7968-17a - Standard Test Method for Determination of Polyfluorinated Compounds in Soil by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS)		

ASTM D7979-20 - Standard Test Method for Determination of Per- and Polyfluoroalkyl Substances in Water, Sludge, Influent, Effluent, and Wastewater by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS)		
DIN 38414-14 - German standard methods for the examination of water, waste water and sludge – Sludge and sediments (group S) – Part 14: Determination of selected polyfluorinated compounds (PFC) in sludge, compost and soil – Method using high performance liquid chromatography and mass spectrometric detection (HPLC-MS/MS) (S 14)	na	na

EPA Draft Method 1633 - Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS

US EPA OTM45 - Other Test Method 45 (OTM-45) Measurement of Selected Per- and Polyfluorinated Alkyl Substances from Stationary Sources		
DIN 38407-42:2011 - Standard methods for the examination of water, waste water and sludge	na	na

ISO 21675:2019 - Water quality — Determination of perfluoroalkyl and polyfluoroalkyl substances (PFAS) in water — Method using solid phase extraction and liquid chromatography-tandem mass spectrometry (LC-MS/MS)	na	na
US EPA 537.1 - Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)		

US EPA 533 - Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Isotope Dilution Anion Exchange Solid Phase Extraction and Liquid Chromatography/ Tandem Mass Spectrometry	na	na
Isolating the AFFF Signature in Coastal Watersheds Using Oxidizable PFAS Precursors and Unexplained Organofluorine	Ruyle et al.	Environ. Sci. Technol. 2021, 55, 6, 3686–3695

Point source characterization of per- and polyfluoroalkyl substances (PFASs) and extractable organofluorine (EOF) in freshwater and aquatic invertebrates	Koch et al.	Environ. Sci.: Processes Impacts, 2019, 21, 1887
Per- and polyfluoroalkyl substances in Chinese and German river water e Point source- and country-specific fingerprints including unknown precursors	Joerss et al.	Environmental Pollution 267.
Fluorine Mass Balance and Suspect Screening in Marine Mammals from the Northern Hemisphere	Spaan et al.	Environmental Science & Technology
The use of high resolution graphite furnace molecular absorption spectrometry (HR - MAS) for total fluorine determination in extractable organofluorines (EOF)	Akhdhar et al.	Talanta 209: 120466.

"Simultaneous targeted and non-targeted analysis of per- and polyfluoroalkyl substances in environmental samples by liquid chromatography-ion mobility-quadrupole time of flight-mass spectrometry and mass defect analysis"	de Vega et al.	Journal of Chromatography A 2021 Vol. 1653 Pages 8
A new method to search for per- and polyfluoroalkyl substances (PFASs) by linking fragmentation flags with their molecular ions by drift time using ion mobility spectrometry	Yukioka et al.	Chemosphere 2020 Vol. 239 Pages 10
Analysis of Fluorotelomer Alcohols in Ambient Air by Dansyl Chrolide Derivatization LC/MS/MS	Takemine et al.	Bunseki Kagaku 2018 Vol. 67 Issue 6 Pages 341-348
Occurrence and fate of legacy and novel per- and polyfluoroalkyl substances (PFASs) in freshwater after an industrial fire of unknown chemical stockpiles	Marchiandi et al.	Environmental Pollution 278.

Poly- and perfluoroalkyl substances in a drinking water treatment plant in the Yangtze River Delta of China: Temporal trend, removal and human health risk	Qu et al.	Science of the Total Environment 696.
Data-independent acquisition with ion mobility mass spectrometry for suspect screening of per- and polyfluoroalkyl substances in environmental water samples	Yukioka et al.	Journal of Chromatography A 2021 Vol. 1638 Pages 8
Per- and polyfluoroalkyl substances (PFASs) in precipitation from mainland China: Contributions of unknown precursors and short-chain (C2–C3) perfluoroalkyl carboxylic acids	Chen et al.	Water Research 153: 169-177.
Biomagnification of perfluoroalkyl acids (PFAAs) in the food web of an urban river: assessment of the trophic transfer of targeted and unknown precursors and implications	Simonnet-Laprade et al.	Environ Sci Process Impacts 21(11): 1864-1874.

Combustion ion chromatography for extractable organofluorine analysis	Aro et al.	iScience, 24(9)
Occurrence and spatial distribution of neutral perfluoroalkyl substances and cyclic volatile methylsiloxanes in the atmosphere of the Tibetan Plateau	Wang et al.	Atmospheric Chemistry and Physics 2018 Vol. 18 Issue 12 Pages 8745-8755
Ion exchange solid phase microextraction coupled to liquid chromatography/laminar flow tandem mass spectrometry for the determination of perfluoroalkyl substances in water samples	Olomukoro et al.	Journal of Chromatography A 2021 Vol. 1651 Pages 10

The PFOA substitute GenX detected in the environment near a fluoropolymer manufacturing plant in the Netherlands.	Brandsma et al.	Chemosphere
A targeted/non-targeted screening method for perfluoroalkyl carboxylic acids and sulfonates in whole fish using quadrupole time-of-flight mass spectrometry and Mse	Crimmins et al.	Anal Bioanal Chem (2014) 406:1471–1480
Per- and Polyfluoroalkyl Substances (PFAS) in Surface Water Near US Air Force Bases: Prioritizing Individual Chemicals and Mixtures for Toxicity Testing and Risk Assessment	East et al.	Environ Toxicol Chem 2021 Vol. 40 Issue 3 Pages 859-870
Screening method for extractable organically bound fluorine (EOF) in river water samples by means of high-resolution-continuum source graphite furnace molecular absorption spectrometry (HR-CS GF MAS)	Metzger et al.	Analytical and Bioanalytical Chemistry 2019 Vol. 411 Issue 19 Pages 4647-4660
Determination of organically bound fluorine sum parameters in river water samples—comparison of combustion ion chromatography (CIC) and high resolution-continuum source-graphite furnace molecular absorption spectrometry (HR-CS-GFMAS)	Gehrenkemper et al.	Analytical and Bioanalytical Chemistry 413(1): 103-115.

Analysis of GenX and Other Per- and Polyfluoroalkyl Substances in Environmental Water Samples	Tian et al.	Separation Science and Technology (New York). 11: 355-370
The structure of the fire fighting foam surfactant Forafac® 1157 and its biological and photolytic transformation	Moe et al.	Chemosphere
Historical trends of inorganic and organic fluorine in sediments of Lake Michigan	Codling et al.	Chemosphere 114: 203-209.
Fabrication of a near-infrared excitation surface molecular imprinting ratiometric fluorescent probe for sensitive and rapid detecting perfluorooctane sulfonate in complex matrix	Tian et al.	J Hazard Mater 2021 Vol. 413 Pages 125353
Micropollutants in drinking water from source to tap - Method development and application of a multiresidue screening method	Troger et al.	Science of the Total Environment 2018 Vol. 627 Pages 1404-1432

Determination of adsorbable organically bound fluorine (AOF) and adsorbable organically bound halogens as sum parameters in aqueous environmental samples using combustion ion chromatography (CIC)	von Abercron et al.	Sci Total Environ. 2019 Jul 10;673:384-391
Nontarget Discovery of Per- and Polyfluoroalkyl Substances in Atmospheric Particulate Matter and Gaseous Phase Using Cryogenic Air Sampler	Yu et al.	Environ Sci Technol 2020 Vol. 54 Issue 6 Pages 3103-3113
Suspect and Nontarget Screening for Contaminants of Emerging Concern in an Urban Estuary	Tian et al.	Environmental Science & Technology 2020 Vol. 54 Issue 2 Pages 889-901
Comprehensive Validation of the Adsorbable Organic Fluorine Analysis and Performance Comparison of Current Methods for Total Per- and Polyfluoroalkyl Substances in Water Samples	Han et al.	ACS ES&T Water, 1(6), 1474–1482.

Suspect, non-target and target screening of emerging pollutants using data independent acquisition: Assessment of a Mediterranean River basin	Ccanccapa-Cartagena et al.	Science of the Total Environment 2019 Vol. 687 Pages 355-368
Stir bar sorptive extraction and liquid chromatography-tandem mass spectrometry determination of polar and non-polar emerging and priority pollutants in environmental waters	Aparicio et al.	J Chromatogr A 1500: 43-52
PFASs in the Nordic environment: Screening of poly-and perfluoroalkyl substances (PFASs) and extractable organic fluorine (EOF) in the Nordic environment	Kärrman et al.	Nordic Council of Ministers.

A rapid method for the detection and quantification of legacy and emerging per- and polyfluoroalkyl substances (PFAS) in bird feathers using UPLC-MS/MS	Groffen et al.	Journal of Chromatography B-Analytical Technologies in the Biomedical and Life Sciences 2021 Vol. 1172 Pages 8
Markers of anthropogenic contamination: A validated method for quantification of pharmaceuticals, illicit drug metabolites, perfluorinated compounds, and plasticisers in sewage treatment effluent and rain runoff	Wilkinson et al.	Chemosphere 2016 Vol. 159 Pages 638-646
Micro solid-phase extraction for the analysis of per- and polyfluoroalkyl substances in environmental waters	Lockwood et al.	Journal of Chromatography A 2019 Vol. 1604 Pages 7
A liquid chromatography tandem mass spectrometry method for determining 18 per- and polyfluoroalkyl substances in source and treated drinking water	Borrull et al.	Journal of Chromatography A 2020 Vol. 1629 Pages 10

Per- and polyfluoroalkyl substances (PFAS) and total fluorine in fire station dust	Young et al.	Journal of Exposure Science & Environmental Epidemiology
Applicability of the direct injection liquid chromatographic tandem mass spectrometric analytical approach to the sub-ng L −1 determination of perfluoro-alkyl acids in waste, surface, ground and drinking water samples	Ciofi et al.	Talanta 2018 Vol. 176 Pages 412-421

Simultaneous determination of 21 trace perfluoroalkyl substances in fish by isotope dilution ultrahigh performance liquid chromatography tandem mass spectrometry	Gao et al.	Journal of Chromatography B-Analytical Technologies in the Biomedical and Life Sciences 2018 Vol. 1084 Pages 45-52
Automated online solid-phase extraction liquid chromatography tandem mass spectrometry investigation for simultaneous quantification of per- and polyfluoroalkyl substances, pharmaceuticals and personal care products, and organophosphorus flame retardants in environmental waters	Zhong et al.	Journal of Chromatography A 2019 Vol. 1602 Pages 350-358

Determination of 17 Perfluoroalkyl Substances in Sediments Using Automated Solid Phase Extraction and Ultrahigh-Performance Liquid Chromatography-Tandem Mass Spectrometry	Galezowska et al.	Chromatographia 2020 Vol. 83 Issue 8 Pages 975-983
Perfluoroalkyl substances in the urine and hair of preschool children, airborne particles in kindergartens, and drinking water in Hong Kong	Li et al.	Environ Pollut 2021 Vol. 270 Pages 116219
Combining passive sampling and tandem mass spectrometry for the determination of pharmaceuticals and other emerging pollutants in drinking water	Magi et al.	Microchemical Journal 2018 Vol. 136 Pages 56-60
Multi-residue method for the determination of over 400 priority and emerging pollutants in water and wastewater by solid-phase extraction and liquid chromatography-time-of-flight mass spectrometry	Robles-Molina et al.	Journal of Chromatography A 2014 Vol. 1350 Pages 30-43

Analysis of per- and polyfluorinated alkyl substances in sub-sampled water matrices with online solid phase extraction/isotope dilution tandem mass spectrometry	Sanan et al.	Journal of Chromatography A 2020 Vol. 1626 Pages 10
The fate of poly- and perfluoroalkyl substances in a marine food web influenced by land-based sources in the Norwegian Arctic	Aasim et al.	Environ. Sci.: Processes Impacts, 2021,23, 588
Analysis of emerging organic contaminants in water, fish and suspended particulate matter (SPM) in the Joint Danube Survey using solid-phase extraction followed by UHPLC-MS-MS and GC-MS analysis	Loos et al.	Science of the Total Environment 2017 Vol. 607 Pages 1201-1212
Robust trace analysis of polar (C-2-C-8) perfluorinated carboxylic acids by liquid chromatography-tandem mass spectrometry: method development and application to surface water, groundwater and drinking water	Janda et al.	na

Selective extraction of perfluorooctane sulfonate in real samples by superparamagnetic nanospheres coated with a polydopamine-based molecularly imprinted polymer	Lin et al.	J Sep Sci 2021 Vol. 44 Issue 5 Pages 1015-1025
Eco-friendly LC-MS/MS method for analysis of multi-class micropollutants in tap, fountain, and well water from northern Portugal	Barbosa et al.	Analytical and Bioanalytical Chemistry 2016 Vol. 408 Issue 29 Pages 8355-8367
Nitrogen-doped carbon dots as an effective fluorescence enhancing system for the determination of perfluorooctyl sulfonate	Lin et al.	Mikrochim Acta 2019 Vol. 186 Issue 6 Pages 380

Uptake and Translocation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) by Wetland Plants: Tissue- and Cell-Level Distribution Visualization with Desorption Electrospray Ionization Mass Spectrometry (DESI-MS) and Transmission Electron Microscopy Equipped with Energy-Dispersive Spectroscopy (TEM-EDS)	Wang et al.	Environmental Science & Technology 2020 Vol. 54 Issue 10 Pages 6009-6020
Contamination Profiles of Perfluorinated Chemicals in the Inland and Coastal Waters of Japan Following the Use of Fire-Fighting Foams	Taniyasu et al.	ACS Symposium SeriesVol. 1206
Total fluorine, extractable organic fluorine, perfluorooctane sulfonate and other related fluorochemicals in liver of Indo-Pacific humpback dolphins (Sousa chinensis) and finless porpoises (Neophocaena phocaenoides) from South China	Yeung et al.	Environmental Pollution 157(1): 17-23.
Retention performance of three widely used SPE sorbents for the extraction of perfluoroalkyl substances from seawater	Brumovsky et al.	Chemosphere 2018 Vol. 193 Pages 259-269
Development of multi-residue extraction procedures using QuEChERS and liquid chromatography tandem mass spectrometry for the determination of different types of organic pollutants in mussel	Alvarez-Ruiz et al.	Analytical and Bioanalytical Chemistry 2021 Vol. 413 Issue 15 Pages 4063-4076

Comparison of total fluorine, extractable organic fluorine and perfluorinated compounds in the blood of wild and pefluorooctanoate (PFOA)-exposed rats: Evidence for the presence of other organofluorine compounds	Yeung et al.	Analytica Chimica Acta 635 (2009) 108–114
Fluorine Mass Balance Analysis of Effluent and Sludge from Nordic Countries	Aro et al.	ACS EST Water 2021, 1, 9, 2087–2096
Legacy and emerging per- and polyfluoroalkyl substances (PFASs) in Dagang Oilfield: Multimedia distribution and contributions of unknown precursors	Meng et al.	Journal of Hazardous Materials 412.

Per- and Polyfluoroalkyl Substances in Outdoor and Indoor Dust from Mainland China: Contributions of Unknown Precursors and Implications for Human Exposure	Wang et al.	Environ Sci Technol.
A sensitive method for simultaneous determination of 12 classes of per- and polyfluoroalkyl substances (PFASs) in groundwater by ultrahigh performance liquid chromatography coupled with quadrupole orbitrap high resolution mass spectrometry	Siqi Liu, Muhammad Junaid, Wei Zhong, Youchang Zhu and Nan Xu	Chemosphere Volume 251, July 2020, 126327
Long-term trends of Per- and polyfluoroalkyl substances (PFAS) in suspended particular matter from German rivers using the direct total oxidizable precursor (dTOP) assay	Göckener et al.	Environmental science and technology
Digging deep—implementation, standardisation and interpretation of a total oxidisable precursor (TOP) assay within the regulatory context of perand polyfluoroalkyl substances (PFASs) in soil	Göckener et al.	Environmental Sciences Europe

Efficient workflow for suspect screening analysis to characterize novel and legacy per- and polyfluoroalkyl substances (PFAS) in biosolids	Dickman et al.	Analytical and Bioanalytical Chemistry
Nontarget Mass Spectrometry Reveals New Perfluoroalkyl Substances in Fish from the Yangtze River and Tangxun Lake, China	Liu et al.	Environmental science and technology
Per- and polyfluoroalkyl substances (PFAS) in commercial composts, garden soils, and potting mixes of Australia	Sivaram et al.	Environmental advances
Ultra-Short-Chain PFASs in the Sources of German Drinking Water: Prevalent, Overlooked, Difficult to Remove, and Unregulated	Neuwald et al.	Environmental science and technology

Levels and Temporal Trends of Trifluoroacetate (TFA) in Archived Plants: Evidence for Increasing Emissions of Gaseous TFA Precursors over the Last Decades	Freeling et al.	Environ. Sci. Technol. Lett. 2022, 9, 400−405
Extraction and Matrix Cleanup Method for Analyzing Novel Per- and Polyfluoroalkyl Ether Acids and Other Per- and Polyfluoroalkyl Substances in Fruits and Vegetables	Meng et al.	J. Agric. Food Chem. 2022, 70, 4792−4804
Quality assurance and quality control of solid phase extraction for PFAS in water and novel analytical techniques for PFAS analysis	Taniyasu et al.	Chemosphere

PFAS Analytical Methods Development and Sampling Research	EPA United States Environmental Protectin Agency	online
CWA Analytical Methods for Per- and Polyfluorinated Alkyl Substances (PFAS)	EPA United States Environmental Protectin Agency	online
PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024	EPA United States Environmental Protectin Agency	online
Nontargeted Discovery of Novel Contaminants in the Great Lakes Region: A Comparison of Fish Fillets and Fish Consumers	Baygi et al.	Environ. Sci. Technol. 2021, 55, 3765−3774
Identifying Unknown Fluorine-Containing Compounds in Environmental Samples Using 19F NMR and Spectral Database Matching	Gauthier, Jeremy R.; Mabury, Scott Andrew	Environmental Science & Technology

year	Comments
2018 (revised 2020)	https://www.restek.com/en/technical-literature-library/articles/method-guide-for-pfas-analysis/
2009	https://www.restek.com/en/technical-literature-library/articles/method-guide-for-pfas-analysis/

2019 https://www.restek.com/en/technical-literature-library/articles/method-guide-for-pfas-analysis/

2014 (2017 revised) https://www.restek.com/en/technical-literature-library/articles/method-guide-for-pfas-analysis/

2015 (2020 revised)

2011 na

2021

2021 https://www.restek.com/en/technical-literature-library/articles/method-guide-for-pfas-analysis/

2011 https://www.restek.com/en/technical-literature-library/articles/method-guide-for-pfas-analysis/

2019	https://www.restek.com/en/technical-literature-library/articles/method-guide-for-pfas-analysis/
2018 (revised 2020)	https://www.restek.com/en/technical-literature-library/articles/method-guide-for-pfas-analysis/

include the analysis of multiple short-chain per- and polyfluoroalkyl
2019 substances (PFAS) that cannot be measured by Method 537.1

2021 na

2019 na

2020

2020

2019 na

2021 targeted and non-targeted

2020 targeted

2018 na

2021 na

2019 na

2021 non-targeted

2019 na

2019 na

2021 na

2018 na

2021 targeted

2019 34 from Brase 2021

2014 na

2021 targeted

2019 non-targeted

2021 na

2019 review

2012 na

2014 na

2021 targeted

2018 na

2019 na

2020 non-targeted

2020 targeted and non-targeted

2021 na

2019 na

2017 na

2019 na

2021 targeted

2016 na

2019 targeted

2020

2021 na

2018 na

2018 targeted

2019 na

2020 targeted

2021 targeted

2018 na

2014 na

2020 targeted

2021 na

2017 na

2019 Reference taken from AlAmin-Review 2020

2021 targeted

2016 na

2019 na

2020

2015 na

2009 na

2018 targeted

2021 targeted

2009 na

2021 na

2021 na

2021 na

2020

2022 na

2022 For policy makers, the TOP assay may also allow monitoring of trends of unknown or unidentified PFASs, and thus observing shifts in production, e.g., from legacy to emerging PFASs. In addition, restrictions of precursors can be more extensively controlled by means of the TOP assay

2022 na

In total, the Nt-HRMS method revealed 10 homologous classes of 2018 PFASs in the 7 fish liver samples

2022 Targeted analysis and **TOP assay**

Liquid-chromatography (HILIC and RP) and Gas chromatography (derivatization of TFA, liquid-liquid extraction and headspace GC-MS) 2022 and **TOP assay** was applied

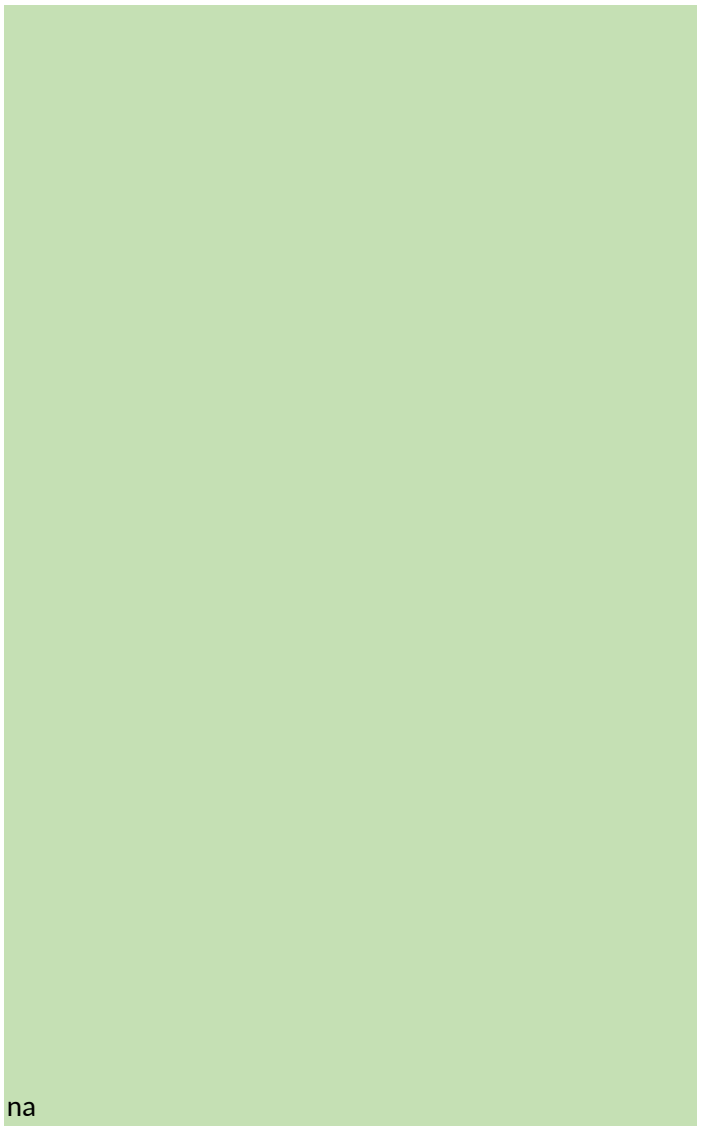
A statistically significant positive trend in the TFA concentration
2022 within the study period was found for most species/sites,

2022 na

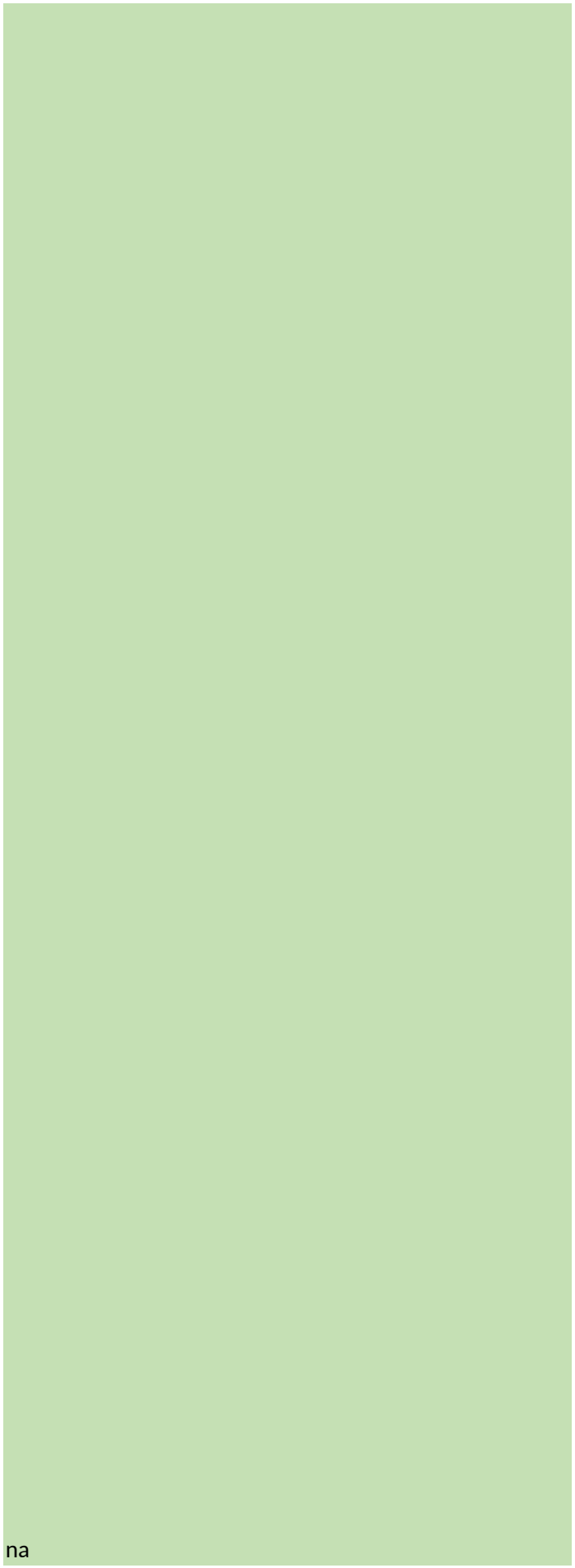
2022 interlaboratory ringtrial (ILT) according to ISO21675 (27 labs)

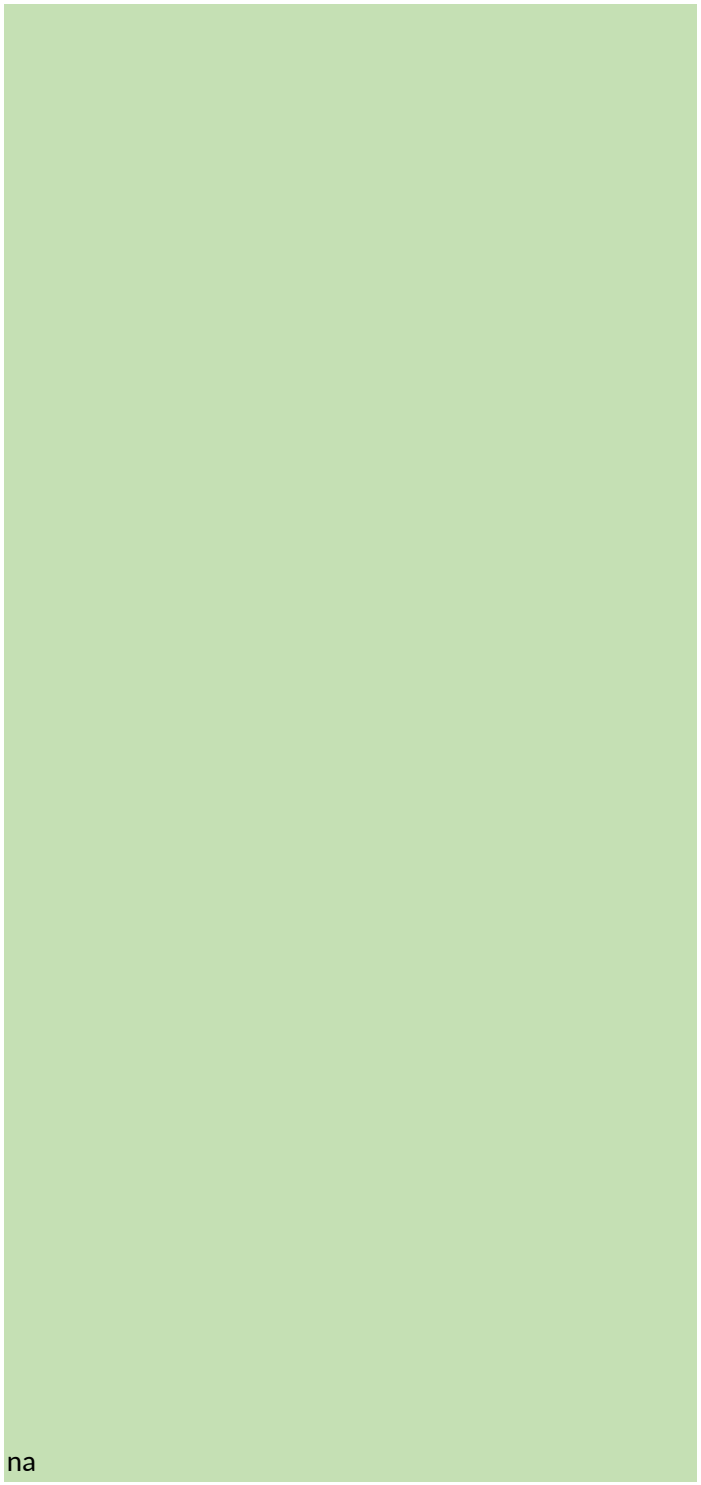
2022	
2022	
2022	commitments to action 2021 - 2024 -> no discussion about analytic methods
2021	isotopic profile deconvoluted chromatogram (IPDC) is developed for screening of novel contaminants
2023	Use of 19F NMR for the identifaction of PFAS in environmental samples

DOI link



na


na


na

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10.1016/j.envpol.2020.115567

10.1021/acs.est.9b06773

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10.1016/j.chroma.2021.462423

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10.2116/bunsekikagaku.67.341

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10.1016/j.chroma.2021.462335

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10.1007/s00216-020-03010-y

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10.1016/j.chemosphere.2012.05.012

10.1016/j.chemosphere.2014.03.080

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na

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PFAS	CAS (if available in publication)
HFPO-DA	13252-13-6
NEtFOSAA	2991-50-6
NMeFOSAA	2355-31-9
PFBS	375-73-5
PFDA	335-76-2
PFDoA	307-55-1
PFHpA	375-85-9
PFHxS	355-46-4
PFHxA	307-24-4
PFNA	375-95-1
PFOS	1763-23-1
PFOA	335-67-1
PFTA	376-06-7
PFTrDA	72629-94-8
PFUnA	2058-94-8
11Cl-PF3OUdS	763051-92-9
9Cl-PF3ONS	756426-58-1
ADONA	919005-14-4
PFOS	1763-23-1
PFOA	335-67-1

• PFOS	1763-23-1
• PFOA	335-67-1
• N-EtFOSAA	2991-50-6
• N-MeFOSAA	2355-31-9
• PFBS	375-73-5
• PFDA	335-76-2
• PFDoA	307-55-1
• PFHpA	375-85-9
• PFHxS	355-46-4
• PFHxA	307-24-4
• PFNA	375-95-1
• PFTeDA	376-06-7
• PFTrA	na
• PFUdA	na
• PFBA	375-22-4
• PFPeA	2706-90-3
• PFDS	335-77-3
• PFHpS	375-92-8
• PFPeS	2706-91-4
• FOSA	754-91-6
• 4:2 FTS	757124-72-4
• 6:2 FTS	27619-97-2
• 8:2 FTS	39108-34-4
• PFNS	68259-12-1
	29420-49-3
	3871-99-6
	1763-23-1
	375-22-4
	2706-90-3
	307-24-4
	375-85-9
	335-67-1
	375-95-1
	335-76-2
	2058-94-8
	307-55-1
	72629-94-8
	376-06-7
	67584-42-3
	812-70-4
C4-C14 PFCA, C4-C8 PFSA, PFECHS, FHpPrA, 6:2 FTCA, 8:2 FTCA, 10:2 FTCA, 2H-perfluoro-2- decenoic acid, 2H-perfluoro-2-octenoic acid	70887-84-2 27854-31-5 53826-12-3

PFTreA	
PFTriA	
PFDoA	29420-49-3
PFUnA	3871-99-6
PFDA	1763-23-1
PFOS	375-22-4
PFNA	2706-90-3
PFecHS	307-24-4
PFOA	375-85-9
PFHxS	335-67-1
PFHpA	375-95-1
PFHxA	335-76-2
PFBS	2058-94-8
PFPeA	307-55-1
PFBA	72629-94-8
FHEA	376-06-7
FOEA	67584-42-3
FDEA	812-70-4
FOUEA	70887-84-2
FHpPA	27854-31-5
FHUEA	53826-12-3)

	375-22-4
	2706-90-3
	307-24-4
	375-85-9
	335-67-1
	375-95-1
	335-76-2
	375-73-5
C4-C10 PFCA	355-46-4
C4-C8 PFSA	1763-23-1

PFHpA	375-85-9
PFOA	335-67-1
PFNA	375-95-1
PFDA	335-76-2
PFUnA	2058-94-8
PFDoA	307-55-1
PFTrDA	72629-94-8
PFTeDA	376-06-7
PFBS	375-73-5
PFPeS	2706-91-4
PFHxS	355-46-4
PFHpS	375-92-8
PFOS	1763-23-1
PFNS	68259-12-1
PFDS	335-77-3
PFDoS	79780-39-5
4:2FTS	757124-72-4
6:2FTS	27619-97-2
8:2FTS	39108-34-4
PFOSA	754-91-6
NMeFOSA	31506-32-8
NEtFOSA	4151-50-2
NMeFOSAA	2355-31-9
NEtFOSAA	2991-50-6
NMeFOSE	24448-09-7
NEtFOSE	1691-99-2
HFPO-DA	13252-13-6
ADONA	919005-14-4
PFMPA	377-73-1
PFMBA	863090-89-5
NFDHA	151772-58-6
9Cl-PF3ONS	756426-58-1
11Cl-PF3OUdS	763051-92-9
PFEESA	113507-82-7
3:3FTCA	356-02-5
5:3FTCA	914637-49-3
7:3FTCA	812-70-4

• HFPO-DA	375-73-5
• PFBA	2706-91-4
• PFPeA	355-46-4
• PFDS	375-92-8
• PFHpS	763-23-1
• PFPeS	68259-12-1
• FOSA	335-77-3
• 4:2 FTS	79780-39-5
• 6:2 FTS	754-91-6
• 8:2 FTS	31506-32-8
• 10:2 FTS	4151-50-2
• 8:2 FTUCA or FOUEA	24448-09-7
• MeFOSA	1691-99-2
• EtFOSA	2355-31-9
• PFHxDA	2991-50-6
• PFODA	757124-72-4
• 9Cl-PF3ONS	27619-97-2
• ADONA	39108-34-4
• PFNS	120226-60-0
• PFecHS	919005-14-4
• 3:3 FTCA	13252-13-6
• 5:3 FTCA	756426-58-1
• 6:2 FTCA or 6:2 FHEA	763051-92-9
• 7:3 FTCA or FHpPA	83329-89-9
• 6:2 FHUEA	151772-58-6
• PFEESA	113507-82-7
• NFDHA	1260224-54-1
• PFMPA	863090-89-5
• PFMBA	377-73-1
• 11Cl-PF3OUdS	67584-42-3
• N-MeFOSE	70887-84-2
• N-EtFOSE	53826-13-4
• Perfluorododecane	27854-31-5
sulfonate (PFDoS)4)	70887-88-6
• Sodium perfluoro-1-dodecanesulfonate (PFDoS)4)	356-02-5
• 8:2 FTA or FOEA	914637-49-3
• 10:2 FDEA	812-70-4

PFBA	375-22-4
PFPeA	2706-90-3
PFHxA	307-24-4
PFHpA	375-85-9
PFOA	335-67-1
PFNA	375-95-1
PFDA	335-76-2
PFBS	375-73-5
PFHxS	355-46-4
PFOS	1763-23-1

• PFOS • PFOA • N-EtFOSAA • N-MeFOSAA • PFBS • PFDA • PFDoDA • PFHpA • PFHxS • PFHxA • PFNA • PFTeDA • PFTrDA • PFUnDA • HFPO-DA • PFBA • PFPeA • PFDS • PFHpS • FOSA • 6:2 FTSA • 8:2 FTSA • 8:2 FTUCA • 8:2 diPAP • N-MeFOSA • N-EtFOSA • PFHxDA • PFOcDA • 9Cl-PF3ONS • DONA	375-73-5 (PFBS), 355-46-4 (PFHxS), 375-92-8 (PFHpS), 1763-23-1 (PFOS), 335-77-3 (PFDS), 754-91-6 (FOSA), 31506-32-8 (N-MeFOSA), 4151-50-2 (N-EtFOSA), 2355-31-9 (N-MeFOSAA), 2991-50-6 (N-EtFOSAA), 27619-97-2 (6:2 FTSA), 39108-34-4 (8:2 FTSA), 73606-19-6 (9Cl-PF3ONS), 375-22-4 (PFBA), 2706-90-3 (PFPeA), 307-24-4 (PFHxA), 375-85-9 (PFHpA), 335-67-1 (PFOA), 375-95-1 (PFNA), 335-76-2 (PFDA), 2058-94-8 (PFUnDA), 307-55-1 (PFDoDA), 72629-94-8 (PFTrDA), 376-06-7 (PFTeDA), 67905-19-5 (PFHxDA), 16517-11-6 (PFOcDA), 70887-84-2 (8:2 FTUCA), 678-41-1 (8:2 diPAP), 13252-13-6 (HFPO-DA), 919005-14-4 (DONA)
NEtFOSAA	
NMeFOSAA	375-73-5
PFBS	335-76-2
PFDA	307-55-1
PFDoA	375-85-9
PFHpA	355-46-4
PFHxS	307-24-4
PFHxA	375-95-1
PFNA	1763-23-1
PFOS	335-67-1
PFOA	376-06-7
PFTA	72629-94-8
PFTrDA	763051-92-9
PFUnA	2058-94-8

• PFOS • PFOA • PFBS • PFDA • PFDoA • PFHpA • PFHxS • PFHxA • PFNA • PFUdA • HFPO-DA • PFBA • PFPeA • PFHpS • PFPeS • 4:2 FTS • 6:2 FTS • 8:2 FTS • 9Cl-PF3ONS • ADONA • PFEESA • NFDHA • PFMPA • PFMBA • 11Cl-PF3OUdS	763051-92-9 (11Cl-PF3OUdS), 756426-58-1 (9Cl-PF3ONS), 919005-14-4 (ADONA), 13252-13-6 (HFPO-DA), 151772-58-6 (NFDHA), 375-22-4 (PFBA), 375-73-5 (PFBS), 39108-34-4 (8:2FTS), 335-76-2 (PFDA), 307-55-1 (PFDoA), 113507-82-7 (PFEESA), 375-92-8 (PFHpS), 375-85-9 (PFHpA), 757124-72-4 (4:2FTS), 355-46-4 (PFHxS), 307-24-4 (PFHxA), 377-73-1 (PFMPA), 863090-89-5 (PFMBA), 375-95-1 (PFNA), 27619-97-2 (6:2FTS), 1763-23-1 (PFOS), 335-67-1 (PFOA), 2706-90-3 (PFPeA), 2706-91-4 (PFPeS), 2058-94-8 (PFUnA)
C3–C13 perfluoroalkyl carboxylates (PFCA), C4–C10 perfluoroalkyl sulfonates (PFSA), Cn (n = 4, 6, 8) perfluoroalkyl sulfonamides, C8 perfluoroalkyl sulfonamide acetates, Cn:2 (n = 4, 6, 8) fluorotelomer sulfonates, and a polyfluoroalkyl ether carboxylate (DONA) with 5 perfluorinated carbons	na

(PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFHxDA, PFOcDA); PFSAs with perﬂuorocarbon chain length of C4–C10 and C12 (PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFDoDS); and precursors, such as ﬂuorotelomer sulfonates (4 : 2 FTSA, 6 : 2 FTSA and 8 : 2 FTSA) and perﬂuorooctane sulfonamide (FOSA). The masslabeled internal standard (IS) included 13C-PFBA, 13C-PFPeA, 13C-PFHxA, 13C-PFOA, 13C-PFNA, 13C-PFDA, 13C-PFUnDA, 13CPFDoDA, 13C-PFTeDA, 13C-PFHxDA, 18O-PFHxS, 13C-PFOS, 13C4 : 2 FTSA, 13C-6 : 2 FTSA, 13C-8 : 2 FTSA, and 13C-FOSA. a reference branched PFOS isomer standard was used, containing 1m-PFOS, 6/2m-PFOS, 3/4/5m-PFOS, and 4.4/4.5/5.5-m2-PFOS (brPFOSK0113)	na
11 PFCAs (C4 to C14), five PFSAs (C4, C6, C7, C8, C10), the cyclic PFAS PFECHS, four PFECAs and PFESAs (HFPO-DA, ADONA; 6:2 and 8:2 Cl-PFESA), two PFPiAs (6:6 PFPiA, 6:8 PFPiA), three fluorotelomer sulfonic acids (4:2 FTSA, 6:2 FTSA, 8:2 FTSA), and three sulfonamide-containing precursors (FOSA, N-EtFOSE, N_x0002_EtFOSAA). A total of 15 internal standards were used, which included seven isotopically labelled PFCAs (13C4-PFBA, 13C2-PFHxA, 13C4-PFOA, 13C5-PFNA, 13C2-PFDA, 13C2-PFUnDA, 13C2-PFDoDA), three PFSAs (13C3-PFBS, 18O2-PFHxS, 13C4-PFOS), one PFECA (13C3eHFPO-DA), two FTSAs (13C2-4:2 FTSA, 13C2-8:2 FTSA), and two sulfonamide-containing precursors (13C8-FOSA, d9-N-EtFOSE). 13C8-PFOA was used as the injection standard	na
14 perfluoroalkyl carboxylic acids (PFCAs; C4-16, C18), 8 perfluoroalkyl sulfonic acids (PFSAs; C4-11), perfluorooctane sulfonamide (FOSA), 3 perfluoroalkane sulfonamidoacetic acids (FOSAA, MeFOSAA, EtFOSAA), 2 chlorinated polyfluorinated ether sulfonates (Cl-PFESAs; 9Cl-PF3ONS, 11Cl-PF3OUdS), ADONA, HFPO-DA (GenX), 3 fluorotelomer sulfonates (4:2, 6:2, and 8:2 FTSAs), and 3 fluorotelomer carboxylic acids (3:3, 5:3, and 7:3 FTCAs). Linear (L) and branched (br) isomers	na
1H,1H,2H,2H_x0002_162 perfluorohexanol (4:2 FTOH), 1H,1H,2H,2H-perfluorodecanol (8:2 FTOH) and 1H,1H,2H,2H-perfluorododecanol (10:2 FTOH) perfluorooctanoic acid (PFOA), perfluorodecanoic acid (PFDA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorohexanesulfonic acid (PFHxS) and potassium PFOS	na

24 PFAS with carbon chain lengths of C4-C13 perfluroalkylcarboxylic acids, C4-C10 perfluroalkylsulfonates, FOSA, N-MeFOSAA, N-EtFOSAA, perflurooctanesulfon- (amide & amidoacetic acids) as well as 4:2, 6:2 and 8:2 fluorinated telomer acids	na
34 PFASs The standard solution spiked with PFASs comprised 12 PFCAs, 3 PFSAs (per_x0002_fluoroalkane sulfonic acids), 3 PAPs (polyfluoroalkyl phosphate esters), 5 FTCAs (fluorotelomer carboxylic acids), 3 FTUCAs (fluo_x0002_rotelomer unsaturated carboxylic acids), 3 FTSs (fluorotelomer sulfonic acids), 3 FASAs (perfluoroalkyl sulfonamides), and 2 FASAAs (perfluoroalkyl sulfonamide acetic acids).	na
4 : 2 FTOH, 6 : 2 FTOH, 8 : 2 FTOH, and 10 : 2 FTOH	na
44 native target PFASs and 18 mass-labelled PFASs	na

7 perfluoroalkyl sulfonic acids (C4-C10), 11 PFCAs (C4–C14), 6 poly_x0002_and perfluoroether carboxylic and sulfonic acids (PFECAs/PFESAs) and 7 perfluoroalkyl acids	na
au_x0002_thentic standards (STD) of 20 PFASs	na
d C2eC12 PFCAs, C4, C6, C8 PFSAs, 8:2 fluorotelomer unsaturated carboxylic acid (8:2 FTUCA), 6:2 FTSA, 8:2 FTSA, dodecafluoro-3H-4,8-dioxanoate (DONA), 6:2 Cl_x0002_PFAES, 8:2 Cl-PFAES, 6:2 diPAP, and 8:2 diPAP. [13C4]-per_x0002_fluorobutanoic acid (PFBA), [13C4]ePFOA, [18O2]-perfluorohexane sulfonic acid (PFHxS), [13C4]ePFOS, [13C2]-8:2 FTUCA, [13C4]-6:2 diPAP, and [13C4]-8:2 diPAP	na
eleven PFCAs (C4–C14), ve PFSAs (C4, C6–C8 and C10), four FTSAs (4:2, 6:2, 8:2 and 10:2 FTSA), three (alkyl-)FASAs (FOSA, MeFOSA, EtFOSA), three (alkyl-)FASAAs (FOSAA, MeFOSAA, EtFOSAA), two diPAPs (6:2 and 8:2 diPAP) and two uoroalkyl ethers (PFPEs: ADONA and HFPO-DA)	na

Fluoride standard solution
Anion multi-element standard Perfluorooctanoic acid
Perfluoro-n-butanoic acid
Perfluoro-n-[1,2-13C2]octanoic acid
Perfluoro-n-[1,2-13C2]undecanoic acid
Potassium perfluoro-1-butanesulfonate
Sodium perfluoro-1-[13C8]-octanesulfonate
Sodium perfluoro-1-dodecanesulfonate
Sodium 1H,1H,2H,2H-perfluorooctane
sulfonate (6:2)
N-methylperfluoro-1-octanesulfonamide
2-Perfluorooctyl ethanol (8:2)
Sodium bis(1H,1H,2H,2H_x0002_perfluorodecyl)phosphate
Perfluorooctylphosphonic acid
Potassium 9-chlorohexadecafluoro-3-oxanonane-1-sulfonate
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-
heptafluoropropoxy)propanoic acid na

fluo_x0002_rotelomer olefin (8 : 2 FTO), fluorotelomer acrylates
(6 : 2,
8 : 2 FTA), fluorotelomer alcohols (4 : 2, 6 : 2, 8 : 2, 10 : 2,
and 12 : 2 FTOH), sulfonamides (NMeFBSA, NMeFOSA,
and NEtFOSA), and sulfonamidoethanols (NMeFBSE,
NMeFOSE, and NEtFOSE); na

hexafluoropropylene oxide dimer acid (GenX), perfluoro-1-
butanesulfonate
(PFBS), perfluoro-n-octanoic acid (PFOA) and perfluoro-1-
octanesulfonate (PFOS) na

HFPO-DA	na
MPFBA Perfluoro-n-[13C4]butanoic acid MPFDA Perfluoro-n-[1,2-13C2]decanoic acid MPFDoA Perfluoro-n-[1,2-13C2]dodecanoic acid MPFHxS Pefluoro-1-hexane[18O2]sulfonate MPFHxA Perfluoro-n-[1,2-13C2]hexanoic acid MPFNA Perfluoro-n-[1,2,3,4,5-13C5]nonanoic acid MPFOA Perfluoro-n-[1,2,3,4-13C4]octanoic acid MPFOS Perfluoro-1-[1,2,3,4-13C4]octane sulfonate MPFUnA Perfluoro-n-[1,2-13C2] undecanoic acid PFAS Perfluoroalkyl sulfonates PFBA Perfluoro-n-butanoic acid PFBS Perfluoro-n-butanesulfonate PFDA Perfluordecanoic acid PFDoA Perfluoro-n-dodecanoic acid PFDS Perfluoro-n-decane sulfonate PFHpA Perfluoro-n-heptanoic acid PFHpS Perfluoro-n-heptane sulfonate PFHxA Perfluoro-n-hexanoic acid PFHxS Perfluoro-n-hexane sulfonate PFNA Perfluoro-n-nonanoic acid PFOA Perfluoro-n-octanoic acid PFOS Perfluoro-n-octane sulfonate PFPeA Perfluoro-n-pentanoic acid	na
na	na
na	na
na	na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

nine native (i.e. unlabeled) linear PFCAs (C4–C12), five native PFSAs (C4–C8), three native fluorotelomer sulfonates (4:2, 6:2 and 8:2 FTS), sodium dodecafluoro-3H-4,8-dioxanonanoate (NaDONA), the major and minor components of F-53B (9Cl-PF3ONS and 11Cl-PF3OUdS), GenX (HFPO-DA), three perfluoroether/polyether-carboxylic acids (PF4OPeA, PF5OHxA and 3,6-OPFHpA) and a perfluoroethersulfonate (PFEESA)	na
perfluorinated compounds: PFOA, PFOS, PFNA, and PFBS, and deuterated internal standards:	na
perfluoro- butanoic (PFBA), pen_x0002_tanoic (PFPeA), hexanoic (PFHxA), heptanoic (PFHpA), octanoic (PFOA), nonanoic (PFNA), decanoic (PFDA), undecanoic (PFUnA), dodecanoic (PFDoA) and tetradecanoic (PFTeDA) acids as well as the perfluoro- butane (PFBS), hexane (PFHxS) and octane (PFOS) sulfonates	na
perfluoro-2-propoxipropanoic acid (PFPrOPrA), perfluorobutanoic acid (PFBA), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorohexane sulfonic acid (PFHxS), perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorononanoic acid (PFNA) and perfluorodecanoic acid (PFDA) nonafluoro-1-butanesulfonic acid (PFBSa), 2-(perfluorohexyl) ethane-1-sulfonic acid (6:2 FTSA), perfluorotridecanoic acid (PFTrDA) and perfluorododecanoic acid (PFDoA) perfluoroundecanoic acid (PFUnDA), perfluorodecane sulfonic acid (PFDS), pefluoropentane sulfonic acid (PFPS) and perfluorononane sulfonic acid (PFNS)	na

perfluoroalkyl carboxylates (PFCAs): per_x0002_fluorobutanoate (PFBA; C-4), perfluoropentanoate (PFPeA; C-5), perfluorohexanoate (PFHxA; C-6), perfluoroheptanoate (PFHpA; C-7), PFOA (C-8), perfluorononanoate (PFNA; C-9), PFDA (C-10), perfluoroundecanoate (PFUnDA; C-11), perfluorododecanoate (PFDoDA; C-12), perfluoro_x0002_tridecanoate (PFTrDA; C-13), and perfluorotetradecanoate (PFTeDA; C-14); perfluoroalkyl sulfonates (PFSAs): per_x0002_fluorobutane sulfonate (PFBS; C-4), perfluoropentane sulfo_x0002_nate (PFPeS; C-5), PFHxS (C-6), perfluoroheptane sulfonate (PFHpS; C-7), PFOS (C-8), perfluorononane sulfonate (PFNS: C-9), and perfluorodecane sulfonate (PFDS; C-10); precursors: 4:2 fluorotelomer sulfonate (4:2 FtS; C-6), 6:2 fluorotelomer sulfonate (6:2 FtS; C-8), 8:2 fluorotelomer sulfonate (8:2 FtS; C-10), perfluorooctane sulfonamide (FOSA; C-8), N-methyl perfluorooctane sulfonamidoacetic acid (N-MeFOSAA; C-8), and N-ethyl perfluorooctane sul_x0002_fonamidoacetic acid (N-EtFOSAA; C-8).	na
Perfluorobutanesulphonic acid (PFBuS, CAS number: 375-73-5), perfluoropentanoic acid (PFPeA, CAS number: 2706-90-3), perfluorohexanoic acid (PFHxA, CAS number: 307-24-4), perfluorohexanesulphonic acid (PFHxS, CAS number: 355-46-4), perfluoroheptanoic acid (PFHpA, CAS number: 375-85-9), perfluorooctanoic acid (PFOA, CAS number: 335-67-1), perfluoro-n-(1,2,3,4 13C4)octanoic acid (MPFOA), perfluoroactanesulphonic acid (PFOS, CAS number: 1763-23-1), and perfluoro-1-(1,2,3,4 13C4)octanesulphonate (MPFOS), perfluorononanoic acid (PFNA, CAS number: 375-95-1), perfluorodecanoic acid (PFDA, CAS number: 335-76-2)	na

perfluorobutanoic acid (PFBA), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), PFOA, perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnDA), perfluorododecanoic acid (PFDoDA), perfluorotridecanoic acid (PFTrDA), perfluorotetradecanoic acid (PFTeDA); 7 PFSAs including perfluorobutanesulfonate (PFBS), perfluoropentanesulfonate (PFPeS), PFHxS, perfluoroheptanesulfonate (PFHpS), PFOS, perfluorononanesulfonate (PFNS) and perfluorodecanesulfonate (PFDS); and 3 PFOS precursors including perfluorooctanesulfonamide (FOSA), N-methyl substituted perfluorooctanesulfonamido acetate (NMeFOSAA), N-ethyl substituted perfluorooctanesulfonamido acetate (N-EtFOSAA)	na
perfluorobutanoic acid (PFBA); perfluoropentanoic acid (PFPeA); perfluorohexanoic acid (PFHxA); perfluoroheptanoic acid (PFHpA); perfluorooctanoate (PFOA); perfluorononanoic acid (PFNA); perfluorodecanoic acid (PFDA); perfluoroundecanoic acid (PFUnDA); perfluorododecanoic acid (PFDoDA); perfluorotridecanoic acid (PFTrDA); perfluorobutanesulfonate (PFBS); perfluoropentanesulfonate (PFPeS); perfluorohexanesulfonate (PFHxS); perfluoroheptanesulfonate (PFHpS); perfluorooctanesulfonate (PFOS); perfluorodecanesulfonate (PFDS); 4:2 fluorotelomer sulfonic acid (4:2 FTS); 6:2 fluorotelomer sulfonic acid (6:2 FTS); 8:2 fluorotelomer sulfonic acid (8:2 FTS); Nethylperfluorooctanesulfonamide (EtFOSA); N-methylperfluorooctanesulfonamide (MeFOSA); chlorinated polyfluorinated ether sulfonate (6:2F-53B);	na

perfluoro-n-butanoic acid (PFBA), perfluoron-pentanoic acid (PFPeA), perfluoro-n-hexanoic acid (PFHxA), perfuoro-n-heptanoic acid (PFHpA), perfuoron-octanoic acid (PFOA), perfuoro-n-nonanoic acid (PFNA), perfuoro-n-decanoic acid (PFDA), perfuoro-n-undecanoic acid (PFUdA), perfluoro-n-dodecanoic acid (PFDoA), perfuoro-n-tridecanoic acid (PFTrDA), perfuoro-n-tetradecanoic acid (PFTeDA), perfuoro-n-hexadecanoic acid (PFHxDA), perfuoro-n-octadecanoic acid (PFODA), potassium perfuoro-1-butanesulfonate (PFBS), sodium perfuoro1-hexanesulfonate (PFHxS), sodium perfuoro-1-octanesulfonate (PFOS), sodium perfuoro-1-decanesulfonate (PFDS	na
perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluoroheptanoic acid (PFHpA), perfluorohexanoic acid (PFHxA), and perfluoro-1,10-decanedicarboxylic acid (PFDDA)	na
perfluorooctanoic acid (PFOA), perfluorooctanesulfonate (PFOS)	na
PFAA, PFHpA, PFOA, PFOS, PFNA, PFDA, PFBA	na

PFAS Mix	na
PFBA PFHxA PFHpA PFOA PFNA PFDA PFUnDA PFDoDA PFTrDA PFTeDA PFBS PFHxS PFOS 6:2 FTS FOSA N-MeFOSE N-MeFOSA N-EtFOSE N-EtFOSA	na
PFHxA, PFOA and PFOS, PFBS, PFHpA and PFNA	na
PFOA, TFA, PFPrA, PFBA, PFPeA, PFHxA, PFHpA	na

PFOS	na
PFOS	na
PFOS	na

PFOS PFOA	na
PFOS, perfluorohexanesulphonate (PFHxS), perfluorobutanesulphonate (PFBS), perfluorooctanesulfonamide (PFOSA), perfluorodecanoate (PFDA), perfluorononanoate (PFNA), PFOA, perfluoro-heptanoate (PFHpA), perfluoroundecanoate (PFUnDA), perfluoro-hexanoate (PFHxA) w	na
PFOS, PFHxS, PFOSA, N-EtFOSA, PFDoDA, PFUnDA, PFDA, PFNA, PFOA, and PFHpA)	na
PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFDoDA, PFTrDA, PFBS, PFHxS, PFOS, PFOSA,	na
PFPeA, PFBS, PFOA, PFDA, PFOS	na

Potassium salts of perfluorohexanesulfonate (PFHxS), perfluorobutanesulfonate (PFBS), and perfluorooctanesulfonamide (PFOSA) Perfluorononanoic acid (PFNA) was purchased from . PFOA Perfluorohexanoic acid (PFHxA) Perfluoroheptanoic acid (PFHpA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnDA), and perfluorododecanoic acid (PFDoDA) Saturated fluorotelomer carboxylate (8:2 FTCA) and unsaturated fluorotelomer carboxylate (8:2 FTUCA)	na
total, 73 different PFAS were monitored in this study: perfluoroalkyl acids (PFCAs), perfluoroalkyl sulfonic acids (PFSAs), PFCA precursors and intermediates [mono- and diPAPs, fluorotelomer carboxylic acids (FTCAs), fluorotelomer unsaturated carboxylic acids (FTUCAs), and fluorotelomer sulfonic acids (FTSAs)], PFSA precursors and intermediates [perfluoroalkyl sulfonamidoacetic acids (FOSAAs) and perfluoroalkyl sulfonamido phosphate esters (SAmPAPs)], perfluorinated phosphonic acids (PFPAs), perfluorinated phosphinic acids (PFPiAs), chlorinated polyfluorinated ether sulfonic acids (Cl-PFESAs), perfluoroethylcyclohexanesulfonic acid (PFECHS), 4,8-dioxa-3H-perfluorononanoic acid (ADONA), and HFPO-DA.	na
twenty-six per- and polyfluoroalkyl substances	na

	na
54 PFASs belonging to 12 classes in groundwater, including 24 perfluorocarbons and 30 precursors	
41 Targeted analytes; 13 PFCAs, 8 PFSAs, 3 fluorotelomer sulfonic acids, 6 FOSAs, 3 diPAP and 8 other substances before/after TOP asssay	na
na	na

targeted analysis: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, PFPrS, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, 4:2-FTS, 6:2-FTS, 8:2-FTS, FBSA, FOSA, N-EtFOSAA, N-MeFOSAA	na
na	na
38 per- and polyfluoroalkyl substances (PFAS); PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFDS, 4:2-FTS, 6:2-FTS, 8:2-FTS, FHuEA, FOuEA, FDUEA, FOEA, FDEA, FPRPA, FPePA, FHpPA, FOSA, N-MeFOSA, N-EtFOA, FOSAA, N-MeFOSAA, N-Et-FOSAA, F-Et-FOSE, 6:2-diPAP, 8:2-diPAP, 6:2/8:2-diPAP	na
43 PFASs were analyzed; TFMS, FAP, NTf2, PFEtS, PFPrA, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS, PFDS, 6:2-FTS, HFPO-DA, PFPrS, PFPeS, PFNS, PFDoS, Triflinate, DPOSA, TFA, 2,2,3,3,5,5,6,6-Octafluoro-4-(trifluoromethyl)-morpholine, Dichlorodifluoromethane, 1,1,2,2,3,3-Hexafluoro-1-tri-fluoromethoxy-3-trifluorovinyloxy-propane, 1,1,2,2,3,3,4-Heptafluoro-cycloentane, 2,2,3,3,3-Pentafluoropropanol, HFIP, 2,2,3,3,4,4,5,5-Octafluoropentyl methacrylate, 3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate, Trimethoxy(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)-silane, 3,3,4,4,5,5,,6,6,7,7,8,8,8-Tridecafluorooctyl methacrylate, Triethoxy(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)-silane, 1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-N-methyl-1-butane-sulfonamide, Trichloro(3,3,4,4,5,5,6,6,7,7,8,8,8-trideca-fluorooctyl)silane	na

TFA	76-05-1
PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoA, PFTrDA, PFTeDA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFMOAA, PMPA, PEPA, HFPO-DA, PFO2HxA, PFO3OA, PFO4DA, PFO5DoA, HydroEVE, ADONA (Na+ salt), Nafion by product 2, NVHOS, 9Cl-PF3ONS, Nafion by product 4, Ne-MeFOSAA, N-EtFOSAA, PFBSA, PFHxSA, PFOSA, 4:2-FTS, 6:2-FTS, 8:2-FTS, 5:3-FTCA, 7:3-FTCA, 6:2-FTCA, 8:2-FTCA, 6:2-FTUCA, 8:2-FTUCA	na
PFBS, PFHxS, PFHpS, PFOS, PFDS, FOSA, N-MeFOSA, N-EtFOSA, N-MeFOSAA, N-EtFOSAA, 6:2-FTSA, 8:2 FTSA, 6:2 Cl-PFESA, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFHxDA, PFOcDA, 8:2-FTUCA, 8:2-diPAP, HFPO-DA, DONA, 8:2-FTOH	na

na	na
na	na
na	na
na (screening)	na

Sampling	sample amount used
8.2.1. The sample handler must wash their hands before sampling and wear nitrile gloves while filling and sealing the sample bottles. PFAS contamination during sampling can occur from a number of common sources, such as food packaging and certain foods and beverages. Proper hand washing and wearing nitrile gloves will aid in minimizing this type of accidental contamination of the samples. 8.2.1. Open the tap and allow the system to flush until the water temperature has stabilized (approximately 3 to 5 min). Collect samples from the flowing system. 8.2.2. Fill sample bottles, taking care not to flush out the sample preservation reagent. Samples do not need to be collected headspace free. 8.2.3. After collecting the sample, cap the bottle and agitate by hand until preservative is dissolved. Keep the sample sealed from time of collection until extraction	250-mL
Take, preserve and handle samples as specified in ISO 5667-1. For sampling, use thoroughly cleaned bottles . Fill the bottle only to the shoulder with the water to be sampled (approximately 1 000 ml). In the presence of free chlorine, immediately add approximately 80 mg of sodium thiosulfate pentahydrate or another suitable dechlorinating agent (e.g. sodium sulfite).	nearest 1 g

Grab samples are collected in polypropylene containers. Other types of container materials, such as high-density polyethylene (HDPE), may be used if performance is acceptable for the project. PTFE containers and contact surfaces with PTFE should be avoided. Depending on the needs of the project, field blanks may be required and should be collected according to recommended PFAS sampling practices, where available. The samplers should acquire pre-verified reagent water and containers from the analytical laboratory for preparing field blanks, where practical. Aqueous field samples and associated QC samples must be collected in separate containers, including field blanks, MS/MSDs, and duplicates. Volumes collected for water samples should match volumes consumed in the laboratory's preparation procedure. Conventional laboratory practices involving chain of custody, field sampling, laboratory custody beginning with receipt and transfer custody, and sampling protocols should be followed.	na
Grab samples are collected in glass or polypropylene containers. Sample containers and contact surfaces with PTFE shall be avoided.	2 g

Grab samples are collected in polypropylene containers. Sample containers and contact surfaces with PTFE shall be avoided.	5-mL sample size per analysis
According to DIN 38402-24, DIN 38414-11, DIN EN ISO 5667-13	1 ± 0,01 g

received by the laboratory within 48 hours of collection. The laboratory must confirm that the sample temperature is 0 - 6 °C upon receipt. Once received by the laboratory, the samples must be stored at ≤ -20 °C until sample preparation. 8.3 Solid (soil, sediment, biosolid), excluding tissue 8.3.1 Collect samples as grab samples using wide-mouth jars and fill no more than ¾ full (see Section 6.1.1.2 for container size and type). 8.3.2 Maintain solid samples protected from light (in HDPE containers) at 0 - 6 °C from the time of collection until receipt at the laboratory. The laboratory must confirm that the sample temperature is 0 - 6 °C upon receipt. Once received by the laboratory, the samples must be stored at ≤ -20 °C until sample preparation. 8.4 Fish and other tissue samples The nature of the tissues of interest may vary by project. Field sampling plans and protocols should explicitly state the samples to be collected and if any processing will be conducted in the field (e.g., filleting of whole fish or removal of organs). All field procedures must involve materials and equipment that have been shown to be free of PFAS. 8.4.1 Fish may be cleaned, filleted, or processed in other ways in the field, such that the laboratory may expect to receive whole fish, fish fillets, or other tissues for analysis 8.4.2 If whole fish are collected, wrap the fish in aluminum foil or food-grade polyethylene tubing, and maintain at 0 - 6 °C from the time of collection until receipt at the laboratory, to a maximum time of 24 hours. If a longer transport time is necessary, freeze the samplebefore shipping. Ideally, fish should be frozen upon collection and shipped to the laboratory on dry ice. 8.4.3 Once received by the laboratory, the samples must be maintained protected from light at ≤ -20 °C until prepared. Store unused samples in HDPE containers or wrapped in aluminum foil at ≤ -20 °C	Aqueos samples: Typical sample size is 500 mL; however, sample size may be up to 1000 mL, Solid samples: The maximum sample weight for sediment or soil is 5 g dry weight. The maximum sample weight for biosolids is 0.5 g dry weight. The default sample weight for tissue is 2 g wet weight; however, a 1-g sample may be used.

This method involves collection and recovery of trace concentrations of semivolatile organic compounds. Therefore, field sampling and recovery staff must be trained in the best practices for handling and using organic solvents in field environments to recover and protect samples from contamination.	3.0 dry standard cubic meters of source gas
Take samples as specified in DIN 38402-11, DIN 38402-12, DIN 38402-13, DIN 38402-15 and DIN ISO 5667-5 Use only cleaned vessels for sampling and fill them completely with the water sample	na

Take, preserve and handle samples as specified in ISO 5667-1 and ISO 5667-3. Weigh the sample bottle with its original cap and water sample, to the nearest 1 g or mark the line on the sample bottle with the sample volume. 1 g

8.2.1. The sample handler must wash their hands before sampling and wear nitrile
gloves while filling and sealing the sample bottles. PFAS contamination during
sampling can occur from a number of common sources, such as food packaging
and certain foods and beverages. Proper hand washing and wearing nitrile gloves
will aid in minimizing this type of accidental contamination of the samples.
8.2.1. Open the tap and allow the system to flush until the water temperature has
stabilized (approximately 3 to 5 min). Collect samples from the flowing system.
8.2.2. Fill sample bottles, taking care not to flush out the sample preservation reagent.
Samples do not need to be collected headspace free.
8.2.3. After collecting the sample, cap the bottle and agitate by hand until preservative is
dissolved. Keep the sample sealed from time of collection until extraction 250-mL

Open the tap and allow the system to flush until the water temperature has stabilized. Collect samples from the flowing system. Samples do not need to be collected headspace free. After collecting the sample, cap the bottle and agitate by hand until the preservative is dissolved. Keep the sample sealed from time of collection until extraction.		100–250 mL
na		na

surface water and aquatic invertebrates	na
River water in China and Germany	na
Marine mammal liver samples	na
river, sea, waste and effluent waters	10 g

river water	na
na	na
	na
water from firefighting run into a creek	na

water from DWTP	na
pump stations around a firefighting training area	na
na	na
water, sediments and biota (including biofilm, invertebrates and fish	na

na	na
Sorbent-impregnated polyurethane foam (SIP) disc passive air samplers were therefore deployed for 3 months	na
Tap water, lake water, bottled water and river water sam_x0002_ples were evaluated in this study. According to EPA guidelines in Method 533	1.5 mL

na	na
na	na
na	na
2 L river water samples	na
river water	500 mL

na	na
na	na
dated cores of sediment	na
per_x0002_fluorooctanoic acid (PFOA), perfluorohexyl sulfonate potassium (PFHSK), perfluorinated butyl sulfonic acid potassium (PFBSK), perfluoro-1-octanesulfonyl fluoride (PFSF), nonafluorobutane-1-sulfonic acid (OSA)	na
In total, 16 Water samples (12 L) were collected from the Uppsala– Stockholm region in Sweden in March to April 2015 flocculation with Al2(SO4)3, sand filtration, GAC fil_x0002_tration (Norit 830W, five years since last regeneration), and disinfection with UV and chloramine (NH2Cl). Two tap water samples Three samples were also collected from a pilot-scale treatment plant that takes water from after sand filtration in the full_x0002_scale DW Triplicate samples were collected downstream from the major waste_x0002_water treatment plant (WWTP)	na

na	na
sampling process lasted for 48 h with a flow rate of 20 L•min−1	na
Eighteen sampling sites were selected based on land use, proximity to primary contaminant	
74 sources	na
na	na

na	na
na	na
bird eggs, fish, marine mammals, terrestrial mammals, surface water, WWTP effluents and sludge, and air	na

free ranging chickens feathers small pieces of approximately 1 mm	na
Effluent samples (n ¼ 12) were collected in duplicate from six STWs along three rivers in the south east of England Runoff samples were collected from grass field drainage (n ¼ 3) and street runoff (n ¼ 2) during periods of rainfall Grab samples were collected (200 mL) in amber glass bottles.	na
na	na
influent and effluent water from a drinking water treatment plant	na

Dust from fire stations	na
drinking waters (DW), 12 ground waters (GW), 13 surface waters (SW), 8 influents and 11 effluents of wastewater treatment plants	100 µl

fish muscle tissue	1g
24-h composite flow-proportional samples were collected from different places within an advanced drinking water treatment plant (DWTP) The raw water was subjected to primary treatment by coagulation, flocculation, and sedimentation and secondary treatment by granular activated carbon (GAC) filtration. In addition, three grab samples were collected from Changzhou wastewater treatment plant effluent, SW, and tap water system to investigate the occurrence of the EOCs within the complete water/wastewater environment. Within 72 h of collection, samples were passed through a 0.7-µm glass fiber filter. The filtrate pH was adjusted to 10 with ammonium hydroxide, and then a mixture of the isotopically-labeled surrogates (IS) were spiked at a final concentration of 25 ng L-1 . Prior to preparation and analysis, all samples were kept at 4 °C in the dark	na

lyophilized	na
na	na
Commercial POCIS with HLB (hydrophilic-lipophilic balance) phase were supplied by Environmental Sampling Technologies. Home-made POCIS were assembled using HLB sorbent phase (60 µm particle size), and 0.1 µm pore size polyethersulfone (PES) membranes. PES membranes were washed before assembling in a H2O/CH3OH solution (80:20 v/v) for 24 h and then with CH3OH for 24 h Four samplers were exposed in the influent and four in the effluent of Site 1; two of these were re_x0002_trieved after for 14 days, while the other two after 28 days	na
Surface waters and effluent wastewater samples, collected from different sampling points	na

na	na
Water, sediment and biota (polychaetes, pelagic zooplankton, crabs, fish, glaucous gulls) samples were collected from locations impacted by a firefighting training site (FFTS) and a landfill as well as from a reference site;	Polychaetes were depurated overnight in seawater in order to separate sediment-bound PFAS from accumulated PFAS.
water in 1L aluminum bottles (methanol cleaned), frozen	1 L
na	na

na	na
Grab DW samples from different sources, namely tap water (n = 13), fountain water (n = 5), and well water (n = 5), were collected at the end of May 2015 Before SPE, samples were acidified with sulfuric acid (pH 3), and sodium thiosulfate was added to each sample (30 mg L−1) to reduce any residual chlorine that might be added as a disinfectant	na
The surface water samples were first centrifuged at 4500 g to separate solid particles and then filtered off with 0.45 μm pore size membrane to remove suspended particles. The samples were heated in oil bath at 105 °C for 30 min then stored at 4 °C for further use	na

plants were cultured with PFOS and PFOA spiked solution Longitudinal and cross sections of fresh plant roots at the root hair zone and stem sections 10 cm above the root collar or crown were made	na
surface water	na
liver samples of Indo-Pacific humpback dolphins	
na	na
mussels	na

na	na
The effluent and sludge samples were collected in low-density polyethylene (LDPE) containers	na
na	na

outdoor and indoor dust	na
The German ESB collects SPM in the rivers Rhine, Elbe, Danube, Saar, Saale and Mulde	na
na	na

grab samples of PS (n = 3) and WAS (n = 3) from a wastewater treatment plant (WWTP) were collected in polypropylene (PP) bottles (250 mL)	na
A total of three fish species were obtained at the Yangtze River site, including common carp (Cyprinus carpio), silver carp (Hypophthaimichthys molitrix), and bighead carp (Aristichthys nobilis). The same three species were obtained at Tangxun Lake as well as a fourth species, white Amur bream (Parabramis pekinensis)	na
A total of 19 commercially available garden products comprising four composts, two garden soils, and thirteen potting-mixes were purchased in 2020 in Newcastle, Australia	2 gram
46 grab water samples were obtained from 13 water suppliers all over Germany, all representing direct or indirect source waters for drinking water production. These comprised 16 surface water samples, 16 bank filtrate samples, 7 raw water samples, and 7 groundwater samples, covering the river basins Danube, Elbe, Ems, Havel, Main, Neckar, Rhine, and Sieg, among others, and their surroundings	200 g for LC and 19 mL for GC

Freeze-dried, homogenized, and finely ground plant material	0.25 gram	
total of 10 types of fruits and vegetables were purchased from Whole Foods Market (Raleigh, NC, U.S.A.) in January 2019		
Samples were stored at 5 ± 3 ◦C in the dark until analysis		na

1) EPA Technical brief on PFAS methods and Guidance for sampling and analyzing water and other Environmental media 2) EPA methods 533 and 537.1 3) iTRC sampling and analylitical methods 4) Michigan Department of Environmental quality General PFAS sampling Guidance 5) New Jesey Department of environmental protection PFNA/ PFAS sampling information for Water systems 6) New York department of Environmental conservation guidelines for sampling and analysis of PFAS 7) North East Biosolids and Residuals Association (NEBRA) sampling and analysis of PFAS in biosolids and associated media	na
na	na
na	na
Fish fillet and sera cohort collection and storage were described by Renaguli et al.	0.5 gram

Pre- treatment

na

without pretreatment, homogenize the sample by shaking

Samples are prepared using an appropriate sample preparation method (e.g., solvent dilution or extraction).

na

Standards and samples shall be in a 50:50 methanol:water solution containing 0.1 % acetic acid.
When preparing the sample, observe the specifications of the Sewage Sludge Ordinance (AbfKlärV) and the Federal Soil Protection Ordinance (BBodSchV). A sufficiently homogeneous laboratory sample must be available for taking a partial sample (test sample). Observe the specifications according to DIN 19747 for taking partial samples. The sample must not be dehydrated before homogenization, e.g. by centrifugation, as the soluble fraction of some PFCs cannot be neglected.
 Homogenize water sediments and thin-bodied sewage sludges by stirring and take a subsample, if necessary with continued stirring.
 For soil, compost, pressed sludge and animal feed, reduce laboratory sample according to DIN 19747, e.g. by means of cross-rugation divider (8.6).
 Sort out foreign materials and record gravimetrically; if necessary, examine these materials separately.
 Take a partial sample and dry it; measure the partial sample in such a way that, if possible, at least a dry mass of 5 g can be expected.
The subsample must be representative of the laboratory sample and, for soil samples, should be at least 1/4 of the mass of the laboratory sample. In the case of homogeneous, fine-grained and free-flowing materials, the subsample may be less.
 Preferably freeze-dry sewage sludge according to DIN 38414-22 (8.5), other samples if necessary at 40 °C in a drying oven, depending on the water content.

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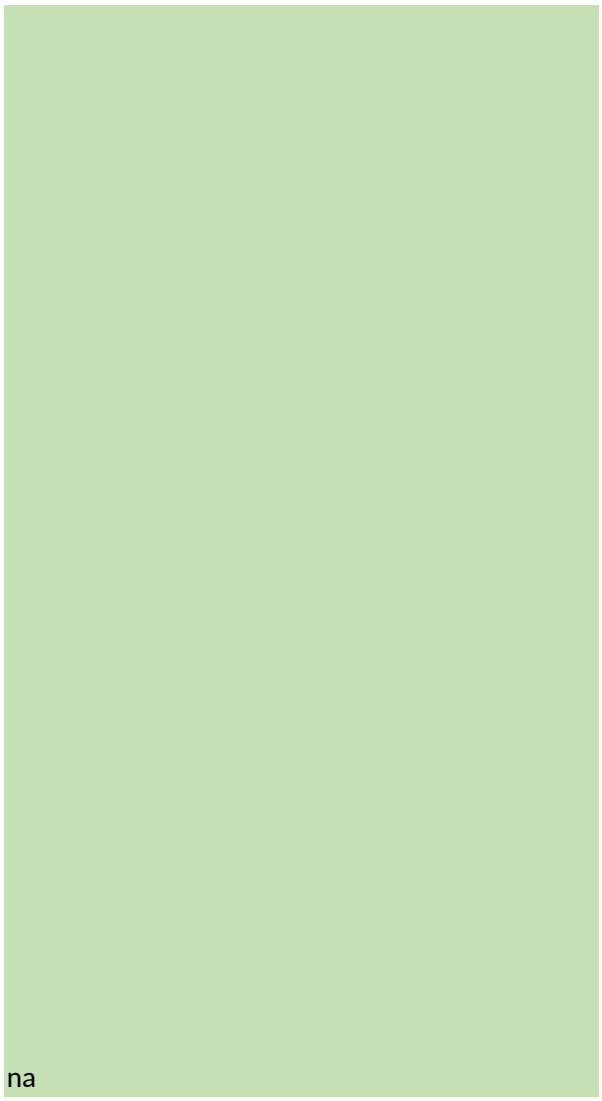
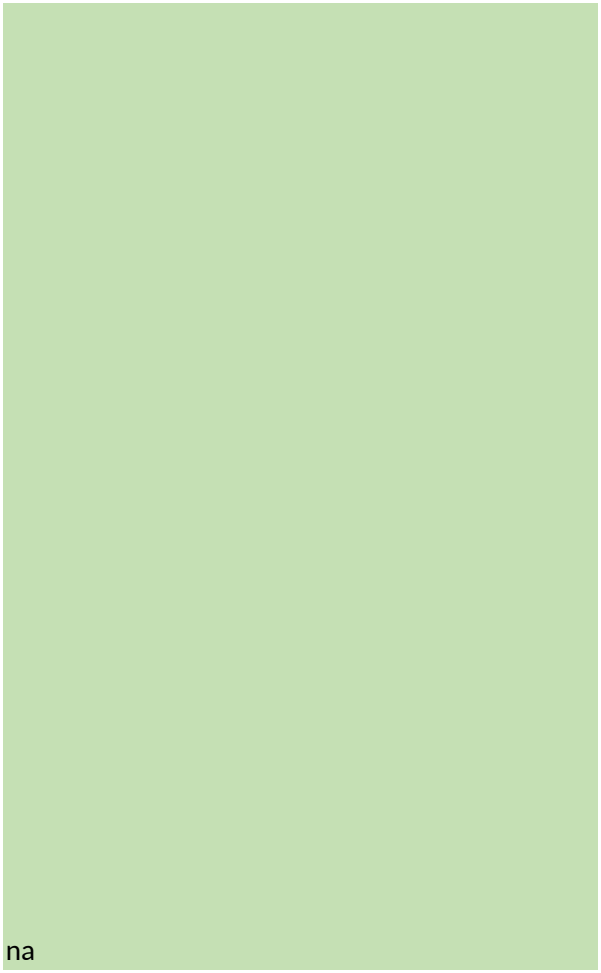

na

Particular matter filter

The samples are analysed in the unfiltered state. The pH value of the sample should lie in the range between pH 6 and pH 8 and shall be adjusted with sodium hydroxide solution or sulfuric acid, if necessary

samples are analysed without pre-treatment

na



were extracted following the methods described in prior work

SPE according to the ISO/
DIS 25101:2009 method using Oasis weak anion
exchange
(WAX)

Glass microfiber filters, Solid phase extraction
(SPE) was performed as described
previously (Joerss et al., 2019).

extraction using the
129 procedure described by Powley et a

sonication, Oasis weak anion exchange cartridges

µSPE following the pro_x0002_tocol previously described by Lockwood et al.

Fresh plant samples (roots, stems and leaves) in both the blank
140 and treatment groups were freeze-dried with a freeze dryer (Biocool FD-2A, Beijing, China) and
141 homogenized with a micro plant grinding machine

solid-phase extraction (SPE)

n (SPE)
based on earlier literature (Coggan et al., 2019a).

were pre-treated according
to previously reported methodology (Boone et
al., 2019; Eschauzier
et al., 2012; Post et al., 2013).

PresepC-Agri (C18) cartridges
(Wako, Japan) and Oasis HLB cartridges

unfiltered
precipitation samples were oxidized using a
previously developed
TOP assay method
solid-phase extraction (SPE) using Oasis WAX
cartridges

Biota samples were freeze-dried, ground and
homogenized
prior to analysis. Sediments were also freeze-
dried, sieved at
2 mm and homogenized. Biota samples were
processed using a previously published
method

extraction and SPE-WAX

sequential
cold-column extraction

solid phase microextraction (SPME), hydrophilic-lipophilic
balance-weak anion-exchange/polyacrylonitrile (HLB-WAX/PAN) as a SPME coating

na

extraction and Envi-Carb

na

SPE

filtered and TF, SPE

na

na

lyophilized, and
homogenized, fortified with surrogate standard
extracted by repli_x0002_cates of MTBE.
Samples were cleaned using Envi Carb

300 µL of analytical identification
material solution (0.015 mg/mL) and 100 µL of
reference material so_x0002_lution (0.06
mg/mL) were mixed

The water was then extracted using the HLB and
ENV car_x0002_tridges. The 12-L samples
collected during field sampling were filtered
using
glass fiber filters One subsample was
ex_x0002_tracted using the 1 g Oasis HLB
cartridge and the other using the 1 g
Bond-Elut ENV cartridge

AutoAD SPE

ultrasonically extracted extraction with Oasis MAX, Oasis MCX and Oasis HLB cartridges

0.5 g pre-cleaned micro glass beads (Filter Aid 400, 3M, MN) were added to solid phase extraction
85 (SPE) cartridges (200 mg, 6 mL Oasis HLB, Waters, MA)

sorbent cartridge was made with a 1 mL polypropylene syringe packed with 80 mg sorbent and quartz
wool plugged in the end

Analyte isolation and pre-concentration from water samples is car_x0002_ried out by off-line Solid Phase Extraction (SPE) as described previously
(Masiá et al., 2013).

na

detailed description per sample type in publication

na

Solid Phase Extraction (SPE) of 200 mL sample water was carried
out using Phenomenex Strata-X cartridges preconditioned with
3 mL 50:50 acetonitrile/acetone (v/v), washed with 3 mL HPLC_x0002_grade H2O and loaded at a rate of 5 mL/min. Loaded cartridges
were dried under vacuum for 15 min and eluted with 2 _x0003_ 7 mL
aliquots of 50:50 acetonitrile/acetone (v/v) at a rate of 1 mL/min.
Extracts were evaporated to dryness using rotary evaporation and
reconstituted with 1 mL of (80:20 HPLC H2O/acetonitrile, v/v)
spiked with internal standards to 25 ng/mL

micro-SPE the optimal phase consisting of a 50:50 mixture of C18 and aminopropyl silica

samples were filtered with regenerated cellu_x0002_lose (RC) syringe filters 0.45 µm

na

NO

Solid phase extraction (SPE) by WAX cartridges and then freezing at −30 °C

An automated Agilent 1260 Infinity Flexible Cube was employed to achieve online preconcentration of all analytes. The system consisted of a quaternary pump with four solvent
lines used to transfer samples to SPE columns via two 10-port switching valves. Two SPE columns were alternatively used during the analytical cycle.
In addition, a delay column (Agilent Eclipse Plus C18, 4.6 × 50 mm, 3.5 □m) was installed after the mixing valve of the quaternary pump and before the autosampler to minimize potential PFAS interferences from the solvent system

automated solid
phase extraction using a commercially available
weakly basic secondary and tertiary ammonium
polymeric anion exchange
sorbent

na

na

200 mL of surface or wastewater sample (pH 7) were passed through an Oasis HLB SPE cartridge (200 mg) previously conditioned with 4 mL of methanol and 8 mL of Milli-Q water. After loading the sample, the elution was performed with two aliquots of 4 mL of MeOH. The extract collected was evaporated under a gentle nitrogen stream using a Turbo Vap LV from Zymark (Hopkinton, MA), with a water bath temperature of 37 °C and a N2 pressure of 15 psi. Finally, the residue was re-dissolved in 1 mL of MeOH/water (20:80), achieving a final preconcentration factor of 200:1

The LC-MS/MS system was equipped with an on_x0002_line solid phase extraction system (Thermo Scientific EQUAN MAX) allowing for injection volumes from 0.5 to 5.0 mL. After injection, the sample was loaded onto the solid phase extraction trap car_x0002_tridge (SPETC). The sample was then rinsed with deionized water to remove preservatives and buffer salts, before engaging a switch_x0002_ing valve to reverse the direction of mobile phase flow to enable elution of the SPETC onto the analytical column. Elution of the an_x0002_alytes from the SPETC was performed using a basic mobile phase of deionized water and methanol modified with ammonium hy_x0002_droxide (0.1 to 1% in both eluents) and a flow rate of 250 to 300 µL/minute.

add IS, SPE Oasis HLB, evaporate to dry and reconsitute in mobile phase A

na

Extraction experiments for the spiked samples with
different PFOS concentrations (5−200 ng/L−1
) were con_x0002_ducted under the optimized conditions. Briefly, 100 mL of
water sample or 50 mL pretreated human serum sample
was added into a polypropylene flask (pH = 3), 100 mg
of MIPDA@Fe3O4 was added to the solution, and the
mixture was sonicated for 2 min. Then the solution was
transferred to a thermostatic bath and agitated at 150 rpm
(298 K) for 30 min, to facilitate mass transfer and adsorption of the PFOS onto MIPDA@Fe3O4. The
MIPDA@Fe3O4 was isolated using an external magnetic
field and the supernatant was discarded. Then the col_x0002_lected magnetic adsorbents were transferred to a 50 mL
polypropylene flask, with 10 mL methanol added as a des_x0002_orption solvent. The mixture was shaken in a thermostatic
bath (150 rpm, 298 K) for 10 min and the eluent was then
dried under a gentle nitrogen

The vacuum extraction and drying devices LiChrolut® used for SPE procedure SPE optimization was performed by
com_x0002_paring Oasis® HLB, MCX, and MAX cartridge

na

Extraction of the target compounds PFOA and PFOS was based on
147 previous methods with small modifications.

solid
phase extraction by Oasis® WAX cartridges and Oasis® HLB cartridges

e ion-pairing method, the
details of which are described elsewhere (Hansen et al., 2001),

the best overall extraction conditions were found to be at pH 8 and 50%/100% matrix seawater content using Oasis® HLB/Strata™-X as SPE sorbents and methanol as eluent

(i) SQ and EMR_x0002_Lipid, (ii) AQ and Z-sep+ bulk-based dSPE and (iii) AQ and graphitized carbon black (GCB)-based dSPE

PFCs were extracted using the ion-pair method and two-step clean-up procedure using Envi-carb and WAX SPE, as described elsewhere

SPE

na

ultrasonic extraction described in our previous study

Groundwater samples were treated according to a previously
validated methodology for PFASs (Boone et al., 2014)

SPM is collected every month by sedimentation traps installed in about 1 m depth in the water stream of the river or in a partial stream that runs through a measuring station

na

samples were lyophilized, pulverized

The whole liver was collected from each individual fish, weighed (wet liver weight), and placed into a clean polyethylene bag.
All liver samples and 10 g of potassium chloride granules were freezedried, weighed

homogenized, freeze-dried,
ground and sieved (2 mm) composts, potting mixes, and garden soils

na

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Samples were taken out of the original packages and stored
in zip bags (polyethylene, Ziploc) at −20 °C before analysis.

NA

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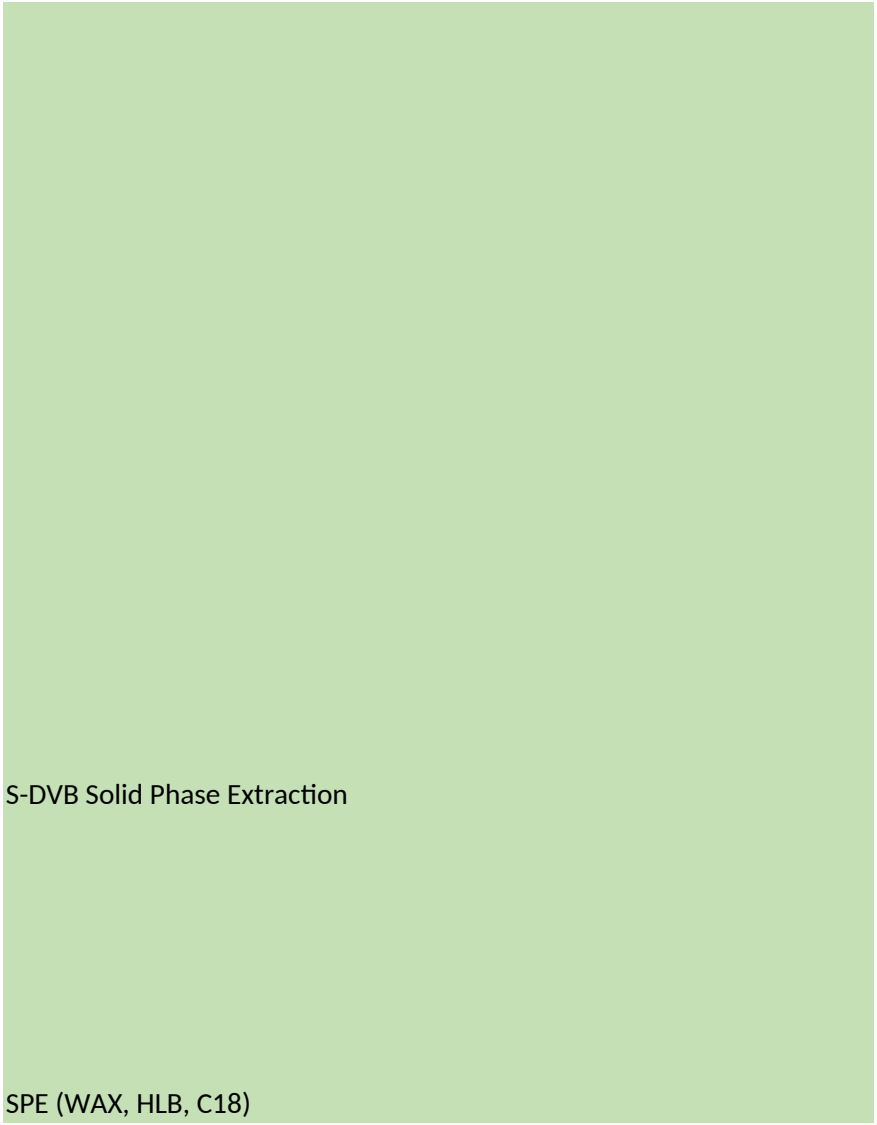
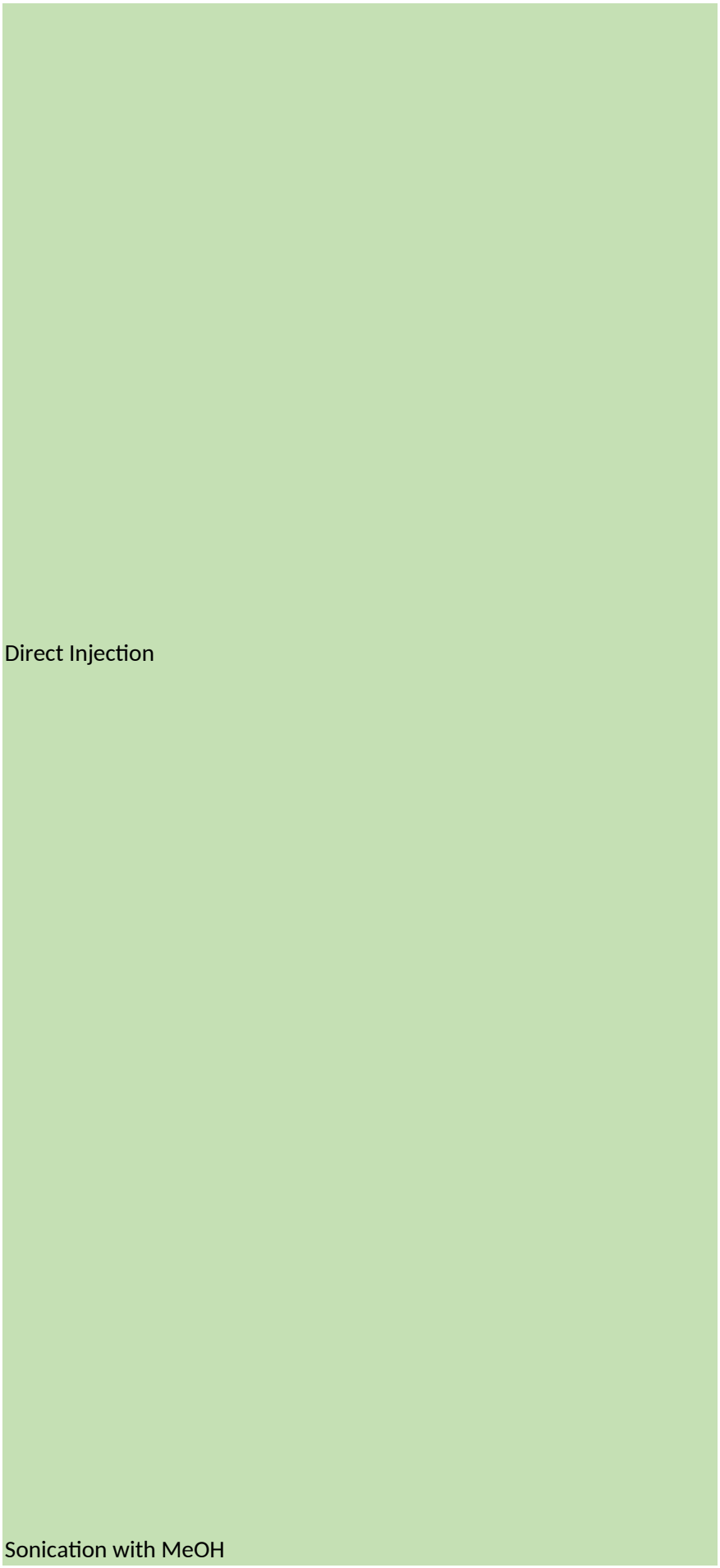
homogenization of fish fillet or serum

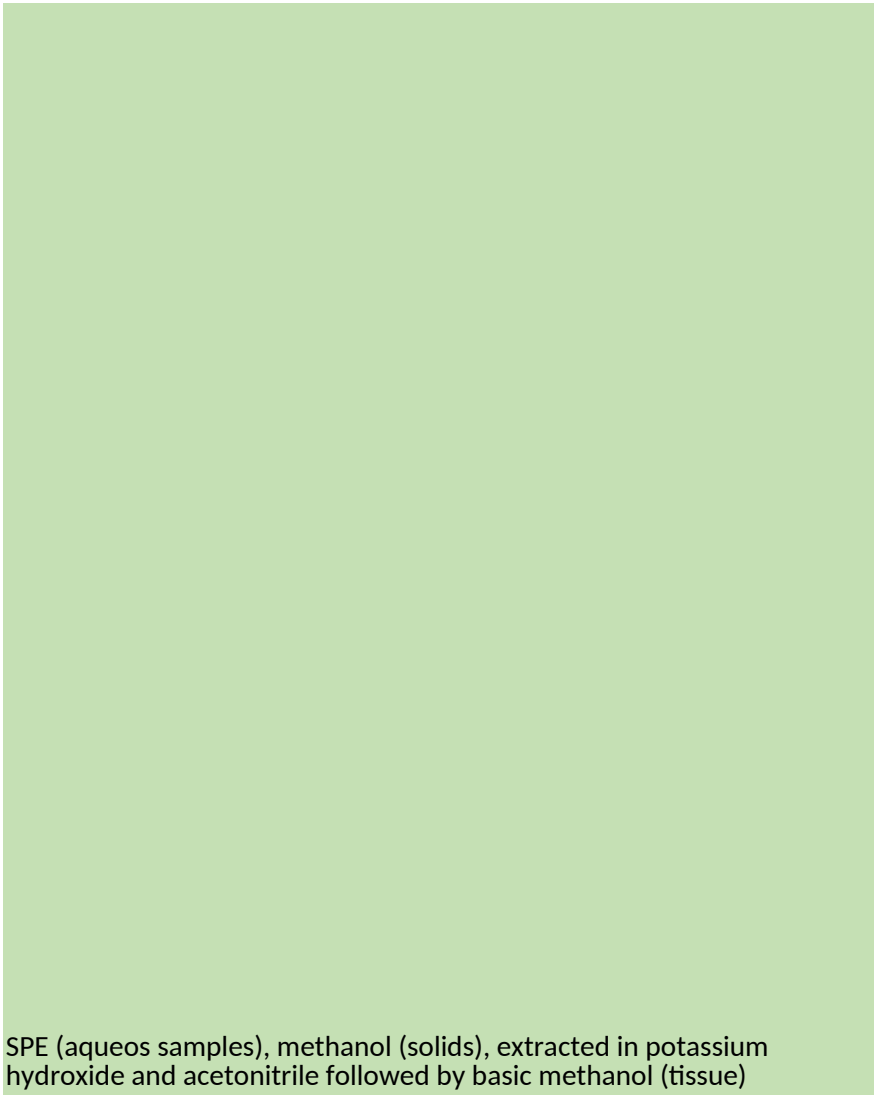
Extraction



Direct Injection

Vortexing and shaking with 50:50 MeOH/water and 50:50 MeOH/water/ NH3 (pH 9-10)


Direct Injection
Sonication with MeOH



SPE (aqueos samples), methanol (solids), extracted in potassium hydroxide and acetonitrile followed by basic methanol (tissue)

Sampling Train with XAD resin and impingers

WAX (weak anion exchange)
Solid Phase Extraction (Use at least 60 mg of the solid phase material (7.3) for a sample volume of e.g. 50 ml)

WAX (weak anion exchange) Solid Phase Extraction

S-DVB Solid Phase Extraction

WAX (weak anion exchange) Solid Phase Extraction

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methanol 100% 24 h at room t

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Sediment and biota samples were extracted with methanol. Water and melted snow samples were extracted on Oasis® Waters (Mildford, MA, USA) weak-anion exchange (WAX) SPE cartridges (6 mL volume, 0.5 g).

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SPE

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Sample extraction with methyl tertbutyl ether and tetrabutylammonium hydrogensulfate

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Two extraction solvents were used, (A) aqueous acetic acid (1% v/v) and (B) 90:10 (v/v) ethanol:aqueous acetic acid (1% v/v). A series of ultrasonication solvent extractions were used

All of the fish samples with the procedural blank salts were extracted with
acidified acetonitrile

The samples were extracted with methanol/ 200 mM
ammonium acetate mixture by shaking and vortexed for 5 min. The PP tubes were then placed in an ultrasonic water bath for 20 min at 30◦C and then centrifuged for 20 min at 4000 g. The supernatant was transferred to another PP tube, and the samples were extracted three times. The extracts were evaporated to dryness under N2 gas and reconstituted with 1.5 mL of a 99:1 (v/v) methanol/glacial acetic acid mixture.

for GC: headspace extraction or liquid-liquid extraction

Plant material was spiked with a defined amount of IS and mixed with 0.8 mL of MeOH and 0.8 mL of ultrapure water (+1% (v/v) formic acid). The obtained suspension was agitated for 15 min using a reciprocating shaker and sonicated for another 15 min. After centrifugation (15 min, 4695g), the supernatant was transferred to another 15 mL PP centrifuge tube. This procedure was repeated twice with fresh extractant to optimize the extraction yield

After spiked standards were allowed to equilibrate with individual food matrices for 12 h, 4 mL of basic methanol was added for extraction, followed by vortexing for 30 s,
sonicating for 30 min, and centrifuging at 4000 rpm for 10 min. The 12 h equilibrium time was selected on the basis of previous studies. The supernatant was decanted into clean 15 mL polypropylene tubes. After 3 extraction cycles, ∼13 mL of supernatant (first supernatant) was collected for each sample. The extracts were stored at −20 °C for 12 h to precipitate any starch present and then centrifuged at 4000 rpm for 10 min to separate solids.

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	A set of 11 isotope-labeled PFAS (listed in Table S.1) was added as surrogate recovery standards to ~0.5 g of homogenized matrix (fish fillet or serum) prior to extraction with 3 mL of methanol followed by ENVI-Carb activated carbon powder cleanup.

Clean up

Concentrate the extract to dryness under a gentle stream of nitrogen in a heated water bath (60-65 °C) to remove all the water/methanol mix. Add the appropriate amount of 96:4% (vol/vol) methanol:water solution and the IS PDS to the collection vial to bring the volume to 1 mL and vortex.

Add 4 ml of acetate buffer solution to the dried cartridge and discard the eluate. Then elute the target analytes with 4 ml of methanol, followed by 4 ml of 0,1 % ammonia/methanol (5.9)
at a rate of one drop per second. Evaporate the eluate with a gentle stream of nitrogen gas (5.11) to a final
volume of 500 µl.

Sample cleanup – Cleanup procedures should not be necessary for relatively clean sample matrices. Extracts from highly contaminated environmental, waste or biota samples may require additional cleanup steps prior to analysis to meet acceptance criteria for all QC categories. The specific cleanup procedure used will depend upon the analytes of interest, the nature of the interferences, and the DQOs for the project. At the time of publication, no cleanup methods have been validated in conjunction with this determinative method.

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SPE WAX (optional)
Elution with MeOH
0.1% NH3

Carbon (aqueos samples), SPE (solids), carbon and SPE (tissue), Carbon cleanup may remove analytes if the sample has a very low organic carbon content (this is unusual for non-drinking water environmental samples). If the laboratory can demonstrate that the carbon cleanup is detrimental to the sample analysis (by comparing results when skipping the carbon cleanup during reanalysis), then the carbon cleanup may be skipped for that specific sample

Concentrate the eluate to dryness, e.g. in a nitrogen stream. Dissolve the residue in e.g. 1 ml using a mixture of solvent and water in accordance with the composition of the reference solutions. If necessary, filter the extract through a syringe filter and use a partial volume for the analysis.

Add water/ acetate buffer, centrifuge, evaporate

Concentrate the extract to dryness under a gentle stream of nitrogen in a heated water bath (60-65 °C) to remove all the water/methanol mix. Add the appropriate amount of 96:4% (vol/vol) methanol:water solution and the IS PDS to the collection vial to bring the volume to 1 mL and vortex.

The extract is concentrated to dryness with nitrogen in a heated water bath. The extract volume is adjusted to 1.0 mL with 20% water in methanol (v/v), and three isotopically labeled isotope performance standards are added.

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Clean-up of methanol extracts was conducted using active carbon (EnviCarb, Sigma_x0002_Aldrich Co., PA, USA)

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SPE (solid phase extraction) combined with GCB (Graphitized carbon black)

purified with weak anion exchange cartridges (SPE solid phase extraction)

The mixture was then transferred into 2 mL microcentrifuge tubes prefilled with 25 - 40 mg Envi-carb carbon. The extracts were then vortexed for 30 sec, centrifuged for 20 min at 14,000 g, and 500 µL of supernatant was transferred into a 1.25 mL PP LC-MS vials.

for LC: multilayer
solid-phase extraction (mlSPE) or weak anion-exchange SPE (solid phase extraction)

na

To clean up food extracts, the secondary supernatant was diluted with 140 mL of deionized water and then loaded onto Oasis WAX SPE cartridges

SPE
in-situ SPE
purge and trap extraction

na

na

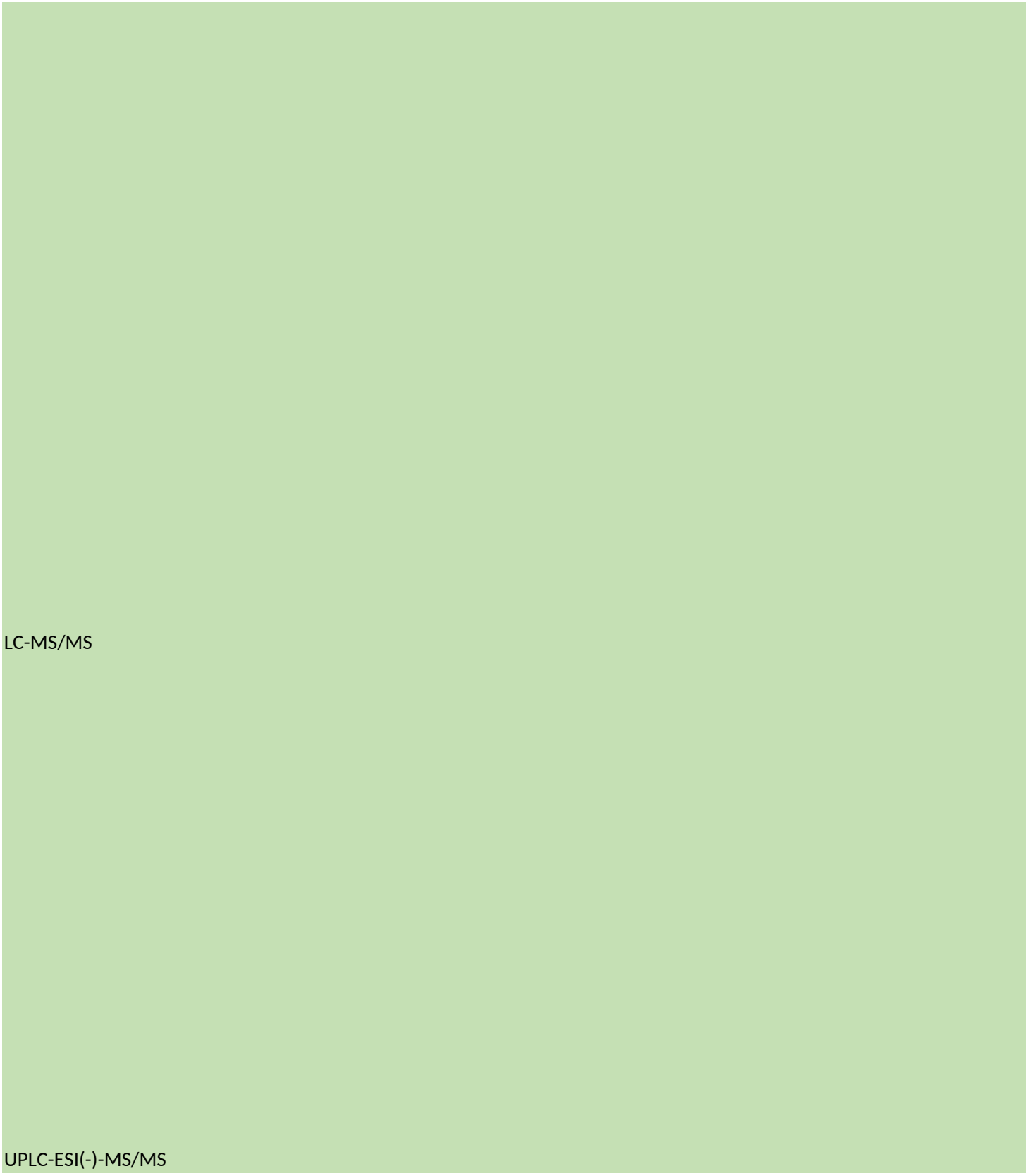
na

na

Measurement

LC-MS/MS (capable of negative ion electrospray ionization (ESI))

HPLC-MS/MS


LC-MS/MS
UPLC-ESI(-)-MS/MS

LC/MS/MS

HPLC-ESI(-)-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS n the electrospray ionization (ESI) negative mode

LC-MS/MS (capable of negative ion electrospray ionization (ESI))

(LC–MS/MS
multivariate clustering techniques
EOF

homologue, isomer and extractable organofluorine (EOF) profiling
LC-MSMS

source-specific fingerprints of per- and polyfluoroalkyl substances
(PFASs) in river water from China and Germany
The TOP assay was performed according to Houtz and Sedlak
(2012)
LC-MSMS

f targeted PFAS analysis, EOF and total fluorine determination, and suspect screening
UPLC MS/MS (targeted analysis) and UPLC-Orbitrap-MS (suspect screening)
EOF by combustion ion chromatography (CIC)
combusted directly on the CIC for determination of total
120 fluorine (TF)
Suspect screening by LC-orbitrap and feature extraction

high-resolution graphite furnace continuum source molecular absorption spectrometry (HR- MAS)
400 µg of W was used as a permanent modifier together with an optimised temperature program

UPLC-IMS-QTOF-MS, combination of mass defect analysis with common fragment and neutral loss filtering

AC_x0002_QUITY UPLC I-Class system coupled to Waters VionTM IMS-QTOF_x0002_MS with high definition MSE data acquisition using the Wa_x0002_ters UNIFI software (Waters Corporation, Milford, MA, USA). An AccucoreTM VanquishTM C18+UHPLC (100 x 2.1 mm; 1.5 µm parti_x0002_cle size) column (Thermo Fisher Scientific, Waltham, MA, USA) was used for chromatographic separation. Mobile phase A consisted of ultrapure water and B of methanol, each containing 2 mM ammo_x0002_nium acetate. The initial conditions of 20% B were held for 0.5 min, followed by a linear increase to 60% B at 4.5 min and to 90% B at 11 min. This was maintained for 4 min before returning to the starting conditions and equilibrating for 3 min. The flow rate was set at 0.3 mL min-1, the column temperature at 50 ℃, and the injection volume was 5 µL

Classification of fragment ions and selection of fragmentation flags. We analyzed the 34 PFAS standards mixture solution by MS/MS mode using an Agilent 1200 SL with Agilent 6560 IM-QTOF. Milli-Q water containing ammonium acetate (5 mM) and acetonitrile was used as the mobile phase for LC. The PFASs were separated with a Zorbax Eclipse Plus C18 column (2.1 mm _x0004_ 100 mm, 1.8 mm, Agilent Technologies) and examined by Dual Agilent Jet Stream negative electrospray ionization (ESI) mode We selected the abundant fragment ions as fragmentation flags for non-target analysis. To select a wide range of fluoroalkyl chain lengths up to carbon number ¼ 16, the fragmentation flags of PFASs homolog were inputted by considering mass differences of 49.9968 Da (eCF2e) and 99.9936 Da (eCF2CF2e) The samples were analyzed by LC/IM-QTOF-MS in all ions MS/MS mode We used ion mobility spectrometry to search for molecular ions of fragmentation flags.

dansyl chloride (DNS-Cl) derivatization LC/MS/MS was investigated

na

total oxidizable precursor assay
EPA Method 537.1 was applied to quantify PFASs (Shoemaker and
Tettenhorst, 2018).

Data independent IMS-MS-MS acquisition with support of ion mobility mass spectrometry (IMS) to distinguish the relevan
ions from
co-eluting ions

HPLC-MSMS
The extracts
were analyzed using different LC-MS/MS methods for specific
classes of analytes. Separation of short-chain PFCAs (C2eC4) was
achieved using an ion-exchange RSpak JJ-50 2D column (2.0 mm
i.d. _x0001_ 150 mm length, 5 mm; Shodex, Japan) (Taniyasu et al., 2008).
For PFCAs (C4eC12), PFSAs, and diPAPs, an X-terra MS C18 column
(2.1 mm i.d. _x0001_ 150 mm, 5 mm

LC-MSMS
TOPA
The isotopic composition of biota samples (C and N) was eval_x0002_uated on defatted samples

Combustion ion chromatography (CIC), The prevailing assumption has been that all PFASs are incinerated in CIC and matri
components have no impact on this process

GC-MS equipped
with a SUPELCOWAX column (60 m, 0.25 mm inner diam_x0002_eter, 0.25 µm film;

ultra-high pressure liquid chromatography-laminar flow tandem mass spectrometry (UHPLC-MS/MS)

UHPLC-HRMS

(UPLC-QToF continuous precursor/product ion mon_x0002_itoring mode
identify unknown PFCs using
experimental fragmentation patterns, mass defect filtering and
Kendrick plots
2.1 mm x 100 mm Acquity HSS
T3 1.8 µm column held at 40 °C with a 100 µL injection loop

Data processing of available datasets

quantitative determination of extractable organically bound fluorine (EOF)
solid-phase extraction (SPE) for extraction of fluorinated compounds as
well as separation of interfering inorganic fluoride in combination with high-resolution–continuum source graphite furnace
molecular absorption spectrometry

combustion ion chromatography (CIC) and high resolution-continuum source-graphite furnace molecular absorption spectrometry (HR-CS-GFMAS)
Extractable (EOF) and adsorbable (AOF) organically bound fluorine as well as total fluorine (TF) were measured

na

LC/(-)ESI-MS/MS

Total fluorine (TF), extractable organic fluorine (EOF) by combustion ion chromatography (CIC) and poly- and per-fluorinated compounds (PFCs) by LC-MSMS
were measured

a molecularly imprinted near-infrared excitation ratiometric fluorescent probe selectively recognition
of specific cavities in the probe surface with analyte, accompanied by fluorescence quenching due to the photoinduced electron transfer effect between upconversion materials and PFOS

UPLC system
(Acquity H-Class with FTN injector; Waters, Milford, MA, USA) coupled
to a Time-of-Flight mass spectrometer (QToF) (Xevo G2-S, Waters,
Micromass; Manchester, UK) The LC separation was performed using an
Acquity UPLC BEH-C18 column (Waters, 2.1 × 100 mm, 1.7 µm particle
size) for analyses in negative ionization mode and an Acquity UPLC
HSS T3-C18 column (Waters, 2.1*100 mm, 1.8 µm particle size) for anal_x0002_yses in positive ionization mode. The mobile phases used in positive
ionization mode were (A): ultrapure water with 5 mM ammonium for_x0002_mate and 0.01% formic acid, and (B): acetonitrile with 0.01% formic acid.
The mobile phases used in negative ionization mode were (A): ultra_x0002_pure water with 5 mM ammonium acetate with 0.01% ammonium hy_x0002_droxide and (B): acetonitrile with 0.01% ammonium hydroxide. The
same gradient was used in both ion modes, and the flow rate was 0.5
mL min−1
. The gradient, expressed as %B, was 0.0 min: 5%B, 0.5 min:
5%B, 16.0 min: 95%B, 16.1 min: 99%B, 19.0 min: 99%B, 19.1 min: 5%B,
and 21.0 min: 5%B. The injection volume was 5 µL for all injections

LC-MSMS
CIC
n automated, robust, cost-efficient and rapid CIC

cryogenic air sampler (CAS), which was used to collect all atmospheric components simultaneously. Then, non-target analysis was performed through PFASs homologue analysis. UPLC-orbitrap

Processed extracts were analyzed using an Agilent 1290 Infinity ultrahigh performance liquid chromatography (UHPLC) coupled to an Agilent 6530 Quadrupole Time-of-Flight HRMS (Santa Clara, CA, USA) with electrospray ionization in both positive and negative modes (ESI+/-), with full scan HRMS data acquired at the range of m/z 100-1700. For structure identification, MS/MS data was acquired (m/z 50-1700, collision-induced dissociation at 10, 20, and 40 eV) by data-dependent acquisition using lists of preferred precursors based on initial MS-only screening. UHPLC separation used a reversed-phase C18 analytical column (Agilent ZORBAX Eclipse Plus 2.1×100 mm, 1.8 µm) with a C18 guard column (2.1×5 mm, 1.8 µm). For ESI+, the mobile phase (0.4 mL/min) consisted of 5 mM ammonium acetate plus 0.1% acetic acid in each of water (A) and methanol (B) using a gradient of: 5% B at 0-1 min, 50% B at 4 min, 100% B at 17-20 min, 5% B at 20.1 min stop time 22.5 min; post-time 2 min. For ESI-, the mobile phase consisted of 1 mM ammonium fluoride in water (A) and methanol (B),31 using the same gradient. MassHunter Profinder (B.08.00) for non-target feature

the adsorbable organic fluorine
(AOF) method was improved and validated in this study
Combustion and IC Analysis.
Individual PFASs were
quantified using liquid chromatography with tandem mass
spectrometry (LC-MS/MS) and offline SPE

Identification of potential contaminants was based on mass accuracy, isotopic ratio pattern, theoretical fragmentation, and retention time using Waters UNIFI software.
The chromatography column and mobile phases were selected based on a pre-established screening method (Masiá et al., 2013). The chromatograph was a Waters Acquity UPLC system (Milford, MA, USA). Chromatographic separation was carried out using a column Luna C18 (15.0 cm × 0.21 cm) with a 3 µm particle size (Phenomenex, Torrance, USA). A binary mobile phase of A (10 mM formic acid in water) and B (10 mM formic acid in methanol) was applied with follow_x0002_ing program: 0–15 min, 10% B; 15–18.5 mi
95% B; 18.5–19 min, 95% B;
19–23 min, 10% B. The analytical column and the sample manager were kept at 35 °C and 7 °C, respectively. An aliquot of 10 µL was injected into UPLC-QTOF-MS with a flow rate of 0.4 mL min−1
. A Xevo G2-S Q-TOF mass spectrometer (Waters, Milford, MA USA) was used in positive ESI

na

ninety-nine (99) PFASs and analysis of extractable organic fluorine (EOF)
PFASs were analyzed using liquid-, supercritical fluid-, and gas chromatography coupled to mass spectrometry. EOF was analyzed using combustion ion chromatography.

LC-MSMS
ACQUITY BEH C18 column (2.1 × 50 mm; 1.7 µm, Waters, USA) The mobile phase solvent gradient started at 65% of 0.1% formic acid in water, changed to 100% of 0.1% formic acid in ACN in 3.4 min, and returned to 65% of 0.1% formic acid in water at 4.7 min. The flow rate was set at 450 µL/min with an injection volume of 6 µL

Extracts were analysed by HPLC-MS/MS using an Agilent Tech_x0002_nologies 1260 Infinity HPLC and an Agilent Technologies 6430 se_x0002_ries triple quadrupole mass spectrometer operated in multiple reaction monitoring (MRM) mode. Adequate separation was ob_x0002_tained at a flow rate of 0.2 mL/min with a solvent gradient starting at 80:20 H2O/acetonitrile (v/v) reducing to 35:65 H2O/acetonitrile (v/v) at 15 min which returned to 80:20 H2O/acetonitrile (v/v) at 15.1 min, where it remained until the end of the run at 19.5 min

LC-MSMS
Phenomonex Luna Omega 2.1 × 50 mm, 1.6 µm C18 column. Mobile phases consisted of ultra-pure water (A) and methanol (B), each with 2 mM ammo_x0002_nium acetate. Initial conditions of 20% B were held for 0.2 min be_x0002_fore being raised to 70% at 2.4 min, then 95% at 5 min. The gradient was then held at 95% for 2 min before returning to the initial con_x0002_ditions and equilibrated for 4 min. A flow rate of 0.6 mL min−1 and column temperature of 50 °C were used throughout the run. An injection volume of 5 µL was used.

directly injecting 900 µL of sample into a liquid chromatograph coupled to a triple quadrupole mass analyser, which involves minimal sample treatment as the sample only needs to be filtered
Poroshell 120 EC–C18 (3 × 100 mm × 2.7 µm) equipped with a Poroshell 120 EC–C18 (3 × 5 mm × 2.7 µm) guard cartridge kept at 40 °C. The mobile phase consisted of (A) water with 5 mM am_x0002_monium acetate and (B) MeOH. The elution gradient conditions were as follows: 2% B maintained for 4 min, increased to 40% over 2 min, increased to 90% over 9 min, after which 100% B was main_x0002_tained for 5 min and returned to initial conditions over 0.5 min and held for 3 min

LC–MS/MS
total fluorine (using particle-induced gamma ray emission)

The Shimadzu LC system was coupled to a 5500 QTrap mass spectrometer , a SIL-30AC autosampler equipped with a 100 µL loop, A delay column (C18, 100 x 4.6 mm) was installed between the mixer and the sample injector, in order to separate the impurity PFAAs originating from the LC system from the analyte PFAAs of the sample. ACQUITY UPLC BEH C18 column (100 x 2.1 mm, particle size 1.7 µm) equipped with a guard column (Waters, Milford, MA, USA), thermostatted at 50° C, employing a mixture of 95% water 5% methanol solution of 2 mM ammonium acetate (solvent A) and a methanol solution of 2 mM ammonium acetate (solvent B) at a flow rate of 0.5 mL min-1. The chromatographic gradient was the following: 25% B for 2 min, from 25% to 90% in 6 min, 90% for 5 min, from 100% to 25% in 0.5 min and final hold for 6.5 min for system re-equilibration. Total analysis time was 20 mins. The injection volume used was set to 100 µL

UHPLC-MS/MS
a Waters Acquity BEH
C18 column (1.7 µm, 2.1 mm × 100 mm). 2 mM ammonium acetate
aqueous solution (A) and acetonitrile (B) were used as mobile phases.
The flow rate was 0.2 mL/min. The dualistic gradient started at 10% B,
changed to 40% B in 3.5 min linearly, to 95% B in 5.5 min linearly;
remained constant for 2 min; returned to 10% B in 0.5 min and then
equilibrated for 3.5 min. The column oven was kept at 40 ℃ and the
auto-sampler was maintained at 10 ℃.

An Agilent 1260 series RPLC was used to perform chromatographic analyses. The
analytical separation was achieved using an Agilent Poroshell 120EC-C18 (3.0 × 50 mm, 2.7 µm) column maintained at 30 ℃. A delay column (Agilent Eclipse Plus C18, 4.6 × 50 mm, 5.0
µm) was installed after the mixing valve of the binary pump. The second valve was switched at
4 min. For chromatographic elution, the mobile phase was composed of acetonitrile (ACN) and
water with 0.05% formic acid, and the flow rate was 0.30 mL min-1
. The gradient elution profile
was programmed as follows: 0-4 min, 5% ACN; 4-9 min, 5-60% ACN; 9-16 min, 60-100%
ACN; and, 16-21 min, 100% ACN. A 9 min re-equilibration period was included before the
next analysis, resulting in an overall method run time of 30 min 300 ℃ drying gas temperature at 7 L min-1
; 350 ℃
sheath gas temperature at 7 L min-1
; 310 kPa nebulizer pressure; and, 3.5 kV capillary voltage

LC-MSMS Acquity UPLC BEH C18, 1.7 µm, 2.1 mm, 100 mm (Waters, USA) analytical column. The mobile phase con_x0002_sisted of the following 9-min sequence of linear gradients fows of solvent B (methanol) balanced with solvent A (0, 2.5 or 5 mM ammonium acetate in water) at a fow rate of 0.6 mL min−1: 40–65% B over 0.5 min, 65–95% B over 5 min, isocratic 95% B for 3.5 min and fnally 95–40% B over 0.1 min. The injection volume was 2 µL, and column temperature was 40 °C.

na

Agilent Liquid Chromatograph Se_x0002_ries 1200SL (consisting of a binary HPLC pump, an online vacuum degasser, an automatic sampler ALS and a thermostatted column com_x0002_partment and a DAD detector) coupled to a Agilent 6430 MSD triple_x0002_quadrupole mass spectrometer Hypersil Gold Aq column (3 × 30 mm, particle size 1.9 µm) 60 °C. An isocratic elution with 50% Milli-Q water containing 0.1% of acetic acid and 50% acetonitrile was performed with a flow rate of 0.2 mL min−1 and injection volume 10 µL, allowing the separation of compounds within 10 min.

Chromatographic analysis was carried out using an Agilent 1290 Infinity HPLC system consisting of a vacuum degasser, an autosampler and a binary pump (Agilent Technologies, Santa Clara, CA) equipped with a C-18 analytical column (Agilent ZORBAX Eclipse Plus C18, 50 mm × 4.6 mm, 1.8 µm particle size). 20 µL of the sample extract was injected in each run. Mobile phases A and B were mili-Q water and acetonitrile, both with 0.1% (v/v) formic acid. The chromatographic method held the initial mobile phase composition (10% B) constant for 3 min, followed by a linear gradient to 100% B up to 25 min and kept for 3 min at 100% B. After each run, a 10-min equilibration was performed with the initial mobile phase composition. The flow rate was 0.5 mL min−1 . The HPLC system was connected to an time-of flight mass spectrometer (Agilent 6220 accurate mass TOF, Agilent Technologies, Santa Clara, CA) equipped with an electrospray interface operated in positive or negative ionization mode

Online SPE-UPLC/LC/MS/MS was performed using a Thermo
Fisher Scientific TSQ-Quantiva triple quadrupole mass spectrome_x0002_ter (Waltham, MA) once the sampling loading onto the
SPETC was completed, the flow direction was reversed, and ana_x0002_lytes eluted onto the analytical column by a gradient of 20 mM
ammonium formate in deionized water containing 1% ammonium
hydroxide and methanol containing 0.4% ammonium hydroxide
ramped from 80:20 to 100% basic methanol over 6 min. The mo_x0002_bile phase composition was held at 100% basic methanol for an ad_x0002_ditional 3 min, after which the column was rinsed with 100% ace_x0002_tonitrile (for additional rinsing and conditioning with a neutral pH,
aprotic solvent), neutral deionized water, then returned to initial
conditions to equilibrate for the next run. After seven minutes of
runtime, the SPETC cartridge was removed from the sample path_x0002_way and rinsed with methanol for 11 min before equilibrating back
to initial conditions of 100% deionized water

The quantitative determination of PFAS was done with high-performance liquid chromatography (HPLC) using an Agilent 1200 series HPLC (Agilent Technologies, Waldbronn, Germany) and an Agilent 6460 (Agilent Technologies, Santa Clara, CA, USA) triple quadrupole mass spectrometer equipped with a jet stream electrospray ion source

na

na

na

A Kinetex™ 1.7 µm XB-C18 100 Å column (100 × 2.1 mm,i.d.) (Phenomenex, CA, USA) was used The optimized mobile phase was ethanol/water (70:30, v/v), pH 7.0, performed in
isocratic mode using a flow rate of 0.20 mL min−1 using an eco-friendly solvent
(ethanol) for both SPE procedure and UHPLC analysis,
. Column
oven and autosampler temperatures were set respectively at 35
and 4 °C, and the volume of injection was 5 µL

The nanoparticles respond selectively and sensitively to trace concentrations of
perfluorooctane sulfonate (PFOS) through electrostatic interactions between PFOS and NCDs
Different concentration of PFOS
and certain amount of NCDs was added into 10-mL cuvette,
then the solution was diluted into 10 mL using pH = 6.1 BR
buffer and mixed thoroughly. The final NCDs concentration
and PFOS concentration was 2.5 mg·mL−1 and 0, 3, 9, 10, 30,
50, 70, 90, 100, 140, and 160 × 10−10 mol·L−1 for a standard
plot preparation. After incubated in the room temperature for
10 min, the solutions were transferred into 1-mL quartz cu_x0002_vettes for fluorescence spectra recording at excitation wave_x0002_length of 370 nm

The tissue-level distribution of PFOS and PFOA in the roots and stems sections were identified with DESI-MS DESI 2D stage and analyzed using a Waters Xevo G2-XS mass spectrometer (Milford, MA, USA) in negative ion mode To help explain the results of DESI-MS, the cell-level distribution of PFOS and PFOA in the root cross sections was identified with TEM-EDS fluorine was carried out using an energy dispersive X-ray spectrometer

HPLC-MS/MS
CIC

CIC for TF and EOF
HPLC-MSMS

LC-MSMS The instrumental analysis was performed according to (Sharma et al., 2016)

LC-MSMS
ACQUITY
UPLC BEH C18 column (1.7 µm 130 Å, 50 × 2.1 mm,
Waters). When operated in negative ionization mode, the mo_x0002_bile phases employed were (A) H2O 2.5 mM NH4F and (B)
MeOH 2.5 mM NH4F

Combustion ion chromatographic technique for trace fluorine analysis was used to assess the concentrations of known PFCs (e.g., PFOS, PFOA) and total fluorine (TF) in the blood of wild rats
Concentrations of PFCs in the whole blood samples were ana_x0002_lyzed by using high-performance liquid chromatography with
tandem mass spectrometry (HPLC-MS/MS)

(UPLC-ESI-MS/MS)
C18 BEH column (2.1 mm × 100 mm,
1.7 µm) coupled to a XEVO TQ-S MS/MS instrument. The mobile phases were MeOH and a 30:70 MeOH/water mixture, both with 2 mmol/L ammonium acetate and 5 mmol/L 1-methylpiperidine as additives, and the column was kept at 50 °C. Ultra-short-chain
compounds (C2−C3) were separated by a supercritical fluid chromatography system
EOF: combustion ion chromatography (CIC); this method has been published by Yeung et al

LC-MSMS
TOP

Indoor dust samples were oxidized with TOP
assay optimized in our previous study
GC-MS
LC-MSMS

UHPLC-Q-Orbitrap HRMS
A full scan was firstly run and then a dd-MS/MS scan. All the target compounds were monitored within the 5 parts-per-million mass error range (±5 ppm).

ultrahigh performance liquid chromatography
coupled to a high-resolution mass spectrometer (UHPLCHRMS)

na

Ultra high performance liquid chromatography system coupled with a Thermo ScientificTM Q-ExactiveTM Focus Orbitrap high resolution mass spectrometer

nontarget high-performance liquid chromatography (HPLC)-Orbitrap

Liquid chromatography–negative ion electrospray tandem mass spectrometry (LC-MS/MS)

Liquid Chromatography–Mass Spectrometry Instrumentation
Gas Chromatography–Mass Spectrometry Instrumentation
TOP Assay Instrumentation: LC–MS
AOF Instrumentation: modified combustion ion chromatography (CIC) system

Ion exchange liquid chromatography coupled with negative-ion electrspray tandem mass spectrometry (IC-MS/MS)

Triple Quadrupole LC/MS or LC-MS/MS

according to ISO21675 (LC-MS/MS)

1) Method 537.1: Determination of Selected PFAS in Drinking Water by SPE and LC/MS/MS (2018/2020) ->Drinking (Potable) Water
2) Method 537: Determination of Selected PFAS in Drinking Water by SPE and LC/MS/MS (2009 - listed for historical purposes) ->Drinking (Potable) Water
3) Method 533: Determination of PFAS in Drinking Water by Isotope Dilution Anion Exchange SPE and LC/MS/MS (2019) -> Drinking (Potable) Water
4) Media Method Description -> Drinking (Potable) Water
5) Method 8327: PFAS Using External Standard Calibration and MRM LC/MS/MS (2019) -> Drinking (Potable) Water
6) Method 8327: PFAS Using External Standard Calibration and MRM LC/MS/MS (2019) -> Non-Potable Water and Other Environmental Media
7) Draft Method 1633 -> Non-Potable Water and Other Environmental Media
8) Other Test Method (OTM)-45 -> air emissions
9) SW-846 Test Method 0010: Modified Method 5 Sampling Train -> air emissions
10) Modified Method TO-15 -> air emissions
11) Ambient/Near-Source (coming soon) -> ambient air
12) Semivolatile PFAS (coming soon) -> ambient air
13) Volatile PFAS (coming soon) -> ambient air
14) Total Organic Fluorine (TOF) (coming soon) -> Total
15) Total Organic Precursors (TOP) (coming soon) -> Total

NON-EPA
1) CLG - PFAS 2.03 Screening, Determination and Confirmation of PFAS by UPLC-MS-MS
2) Bottle Selection and other Sampling Considerations When Sampling for Perand Poly-Fluoroalkyl Substances (PFAS)
3) CDC - Laboratory Procedure Manual - 6304.09 - Online Solid Phase Extraction-High Performance Liquid ChromatographyTurbo Ion Spray-Tandem Mass Spectrometry (online SPE-HPLC-TISMS/MS) in serum

1) Draft method 1633 for 40 PFAS compounds
2) Draft method 1621 for adsorbable organic fluorine

PFAS strategic roadmap
learn about EPA actions and accomplishments since January 2021

LC-HRMS

Quantification method	Working range (ng/mL) As	Matrices
*I*nternal and external standards. If commercially available, the method analytes must be purchased as technical grade (linear and branched isomers) standards or neat materials.	na	Drinking water
calibration uses a solution containing the analytes of interest and internal standards	2,0 ng/l to 10 000 ng/l for PFOS and 10 ng/l to 10 000 ng/l for PFOA	Water

external standard calibration	working range of the LC/MS/MS system	Non-potable water
Calculate the concentration in the sample using the linear or quadratic calibration curve generated.	25–1000 ng/kg, except for PFOS, PFHxA(50–1000 ng/kg), PFPeA, PFBA (125–5000), FHEA (600–20 000), FOEA (750–20 000), FDEH (500–20 000)	Soil

Internal & external standard (at a minimum, five calibration levels are required when using a linear calibration curve and six calibration levels are required when using a quadratic calibration curve.)	10 – 400 ng/L, 50 – 2000 ng/L for PFPeA, PFBA, 200 – 8000 ng/L for FDEA, 300 – 8000 ng/L for FOEA, FHEA	Water Sludge Influent Effluent Wastewater
External and internal standards	calibration from 10 µg/kg to 500 µg/kg	Soil Sediment Sludge

Internal standard quantitation, Isotope dilution (ID) quantitation	na	Water, Soil, Tissue

Calibration Curves	na	Air
Calibration using a external or internal standard	The lower limit of application is 0,01 µg/l, or 0,025 µg/l for treated waste water.	Water

Internal or external Calibration uses a solution containing the native analytes of interest and labelled internal standards. Internal standard calibration is preferred when the internal standards are available	PFAS were analysed in five samples which were spiked with analytes within a concentration range of 0,55 ng/l to 200 ng/l.	Water
*I*nternal and external standards. If commercially available, the method analytes must be purchased as technical grade (linear and branched isomers) standards or neat materials.	na	Drinking water

Isotope Dilution	The user may modify the concentrations of the individual analytes based on the confirmed MRLs and the desired monitoring range.	Drinking water
na	na	surface water

isotope	na	surface water and aquatic invertebrates
na	na	water
na	na	Marine mammal liver samples
na	na	river water

na	na	water
na	na	water
na	na	air
na	na	water

na	na	water
qualitative	na	water
na	na	precipitation samples
na	na	water, sediments and biota

na	na	surface water and whole-blood sample extracts
na	na	na
na	na	water

na	na	Deciduous leaves, Grass
na	na	fish
na	na	na
na	na	surface water
na	na	water

na	na	na
na	na	na
na	na	sediment
na	na	water, serum and egg
The target compounds were identified by UNIFI using accurate mass screening (maximum 10 ppm mass error) and retention time (1-min time window). UNIFI was also used to group all isotopes and adducts to_x0002_gether as one identified compound when processing the data,,	na	na

na	na	water
qualitative	na	air
na	na	na
na	na	water

The workflow (Fig. 1) and identification confidence criteria used on suspect and non-target screening were based on those described by Krauss et al. (2010), Schymanski et al. (2015) and Pedersen et al. (2013).	na	water
na	na	na
na	na	bird eggs, fish, marine mammals, terrestrial mammals, surface water, WWTP effluents and sludge, and air

na	na	feathers
Quantification was achieved using a 9-point blank-offset and internal standard-corrected calibration	na	na
isotope	na	
na	na	water

na	na	Dust and wipe
na	na	na

external standard and isotope dilution	na	fish
na	na	na

na	na	sediment
na	na	urine and hair, airborne particles, tap water and bottled water
The internal standard concentration (Ketoprofen-d3) was maintained constant at 25 ng mL−1 , while the analyte concentra_x0002_tions were 2, 5, 10, 15 and 30 ng mL−1 . Each point of the respective cal_x0002_ibration curves was the mean of three replicates. All analytes showed good linearity (R2 between 0.992 and 0.999).	na	na
accurate mass database	na	na

sotope dilution quantification	na	water
internal standard calibration curves with eight concentration points	na	Water, sediment and biota
na	na	na
LC/ (-)ESI-MS/MS		Surface, ground and drinking water

na	na	water and human serum samples
na	na	na
na	na	water

na	na	na
na	na	surface water
na	na	liver
isotope	na	water
na	na	mussel

na	na	blood
isotopically labeled IS	na	water
na	na	na

na	na	dust
Quantification was performed via UHPLC-HRMS	na	suspended particulate matter (SPM)
na	na	soil

isotope dilution	The linear ranges for target analytes were from 1 to 250 ng/g, with R2 values of 0.98 or higher, except for PFBS and 4:2 FTS, which were found to be linear from 5 to 250 ng/g with R2 values of 0.99	Waste-activated sludge (WAS) and limestabilized primary solids (PS)
Legacy PFASs were quantified using authentic standards, and nontarget PFASs were semiquantified against structurally similar authentic standards	na	Fish (liver)
Internal standard quantitation, Isotope dilution (ID) quantitation	calibration curve ranging in concentrations from 0.05 to 100 ng ml− 1	19 different commercially available composts, garden soils, and potting mixes
Internal standard quantitation, Isotope dilution (ID) quantitation	na	16 surface water samples, 16 bank filtrate samples, 7 raw water samples, and 7 groundwater samples

Internal standard quantitation, Isotope dilution (ID) quantitation	0.02 - 10 µg/L	leaf samples
internal standard method	na	biota *(fruits and vegetables: blackberries, blueberries, corn kernels (corn), grapes, okra, peaches, pecans, potatoes, squash, and tomatoes)*
na	na	drinking water, river water sea water, and effluent of wastewater from a sewage treatment plant from Japan

na	na	water, air, serum
na	na	na
na	na	na
na	na	fish and serum

Reported levels (ng/mL)	Limitations	LoD (ng/mL)	subgroup
na	na	Single laboratory LCMRLs (laboratory lowest concentration minimum reporting level) for analytes in this method range from 0.53-6.3 ng/L. Determining the Detection Limit (DL) for analytes in this method is optional.	
na	Considerable batch-to-batch differences in quality and selectivity of these materials are possible.		na

na	Matrix interferences can be caused by contaminants from the sample, sampling devices, or storage containers.		na
This test method was tested by CRL on Ottawa sand and ASTM reference soil.	na	LoQ: 0.01-0.25 µg/kg RL: 0.25 µg/kg	

This test method was tested by CRL on reagent water.	na	MDL (ng/L) = 0.7 (PFTriA) - 4.6 (PFBA, PFPeA), 47.2 (FDEA), 92.9 (FHEA), 106.8 (FOEA)	
na	na	LoQ: 10 µg/kg	na

na	matrix interferences for specific compounds	The LOQ shall be set at or above the concentration of the lowest initial calibration standard (the lowest calibration standard must fall within the linear range).

na	na	na	na
na	na	na	na

na		Substances with similar retention times that can produce ions with similar mass to charge ratios (m/z) to those produced by the analytes of interest may interfere with the determination. Matrix interferences may be caused by contaminants that are co-extracted from the samples.	≥0,2 ng/l as limit of quantification can be achieved	na
na		na	Single laboratory LCMRLs (laboratory lowest concentration minimum reporting level) for analytes in this method range from 0.53-6.3 ng/L. Determining the Detection Limit (DL) for analytes in this method is optional.	

na	Matrix interferences may be caused by contaminants that are co-extracted from the sample.	na	na
only 24%–63% of the EOF can be explained by targeted PFAS A distinct signature of AFFF contamination enriched in precursors with six perfluorinated carbons (C6) was identified in watersheds with an AFFF source, while others were enriched in C4 precursors. Principal component analysis of PFAS composition in impacted watersheds showed a decline in precursor composition relative to AFFF stocks and a corresponding increase in terminal perfluoroalkyl sulfonates with < C6 but not those with ≥ C6	na	.005 to 2.62 ng L−1	na

			0.004 and 0.81 ng L_x0001_1 for water samples and between 0.03 and 0.37 ng g_x0001_1 for aquatic invertebrate		
S25PFASs concentration in water was 1920 ng L_x0001_1 high amounts of EOF (e.g. 8.2 g F day_x0001_1 at site A) could be transported by water to recipient water bodies relative to S25PFASs (e.g. 0.15 g day_x0001_1 at site A).		na	16 ng F ranged from 257–782 ng F L_x0001_1 in the neutral fraction and 71–217 ng F L_x0001_1 in the anionic fraction		na
			0.017 ng/L (FOSA) to 0.33 ng/L (PFBA) MQLs were in the range of 0.50 ng/L (PFUnDA) to 2.5 ng/L (PFOS) for unoxidized samples and of 0.50 ng/ L (PFUnDA) to 7.9 ng/L (PFOA) for oxidized samples		
emerging PFASs, 24 were detected, with a sum ranging from 2.7 ng/L (Alz River) to 420,000 ng/L (Xiaoqing River). the increase of the short-chain compound PFBA was higher in German samples than in Chinese samples (88 ± 30% versus 12 ± 14%)		na			na
7:3 FTCA in polar bears (~1000 ng/g, ww) and cetaceans (<6-190 ng/g, ww) 30-75% of 15 the EOF was unidentified. Suspect screening revealed an additional 37 PFASs (not included in the targeted analysis) bringing the total to 63 detected PFASs from 12 different classes		na	na		na
na		na	0,1 mg/L SPE: 0,3 µg/L		na

f 3–7 compounds from the targeted list and the detection of a further 56–107 untargeted PFAS			
The measured concentrations ranged from 2.9 ± 1.5 to 257.3 ± 11.2 ng L-1	na	between 0.19 and 0.76 µg L-1	na
na	na	na	na
D (10 : 2 FTOH) to 300 pg m(-3)(6 : 2 FTOH)	na	1.5 pg m(-3) (6 : 2 FTOH) to 9.9 pg m(-3) (4 : 2 FTOH)	na
SPFAS concentration was observed at the point-source (mean 5500 ng/L; 95% CI: 4800, 6300) relative to upstream sites (mean 100 ng/L; 95% CI: 90, 110; p _x0002_ 0.001). The point-source SPFAS concentration decreased from 5500 ± 1200 ng/L to 960 ± 42 ng/L (_x0003_83%) after two months and to 430 ± 15 ng/L (_x0003_98%) two years later.	na	na	na

13 PFASs were detected in source and drinking water with total concentration of 25–38 ng/L mass flow in the wet season (i.e. summer) up to 83 kg/d.	na	na	na
suspect screening of PFASs with eternal database resulted in de_x0002_termining 32–96 PFAS suspects in firefighting foam impacted groundwater samples	na	na	na
TFA displayed the highest concentrations (8.8-1.8x 103 ng/L) 6:2 chlorinated polyfluorinated ether sulfonic acid, an alternative to PFOS, was detected for the first time in precipitation at a frequency of 43% (C4eC12; 2.0 _x0001_ 102 e3.4 _x0001_ 103 ng/m2 /d) with major PFAS manufacturing facilities were higher than those in the southwestern area (63e1.7 _x0001_ 103 ng/m2 /d pre-PFAAs at 3.1 _x0001_ 103 and 4.3 _x0001_ 103 ng/m2 /d	na	na	na
(2.0–147 ng g_x0001_1 wet weight), perfluorooctane sulfonate (PFOS) and C12–C14 perfluoroalkyl carboxylates (PFCAs) being predominant while Ppre-PFAAstargeted contributed to 1–18% of PPFASs Trophic magnification factors (TMFs) were >1	na	0.003–0.34 ng L_x0001_1 , 0.014–0.35 ng g_x0001_1 dw and 0.005–0.21 ng g_x0001_1 wet weight (ww)	na

na	na	50 ng/mL	na
65–223 pg m−3 for fluorotelomer alcohols (6FTOHs); 1.2–12.8 pg m−3 for fluorinated sulfonamides (6FOSA); and 0.29–1.02 pg m−3 for fluorinated sulfonamidoethanols (6FOSE)	na	na	na
na	na	d LOQs of 2.5 ng L− 1 (PFOS) and 1 ng L − 1 (GenX, PFBS and PFOA)	na

4.3–86 ng/g (n = 5), 1.0–27 ng/g (n = 5)			
linear perfluoroalkyl carboxylic acids (C4 to C14) and perfluoroalkyl sulfonates (C4, C6, C8 and C10) exhibited a linear range spanning over three orders of magnitude	na	less than 1 pg on column 0.01 – 0.11 ng/g	na
perfluorooctane sulfonate (PFOS) was often a dominant PFAS in a given surface water sample, frequently followed by perfluorohexane sulfonate (PFHxS). Second, that a four_x0002_chemical mixture generally accounted for > 80% of the sum of all routinely-reported PFAS in a sample and that the most representative four chemical mixture was comprised of PFOS, PFHxS, perfluorohexanoic acid (PFHxA) and perfluorooctanoic acid (PFOA)	na	na	na
50–300 ng/L	na	low nanogram per liter range	na
TF concentrations determined via HR-CS-GFMAS and CIC were comparable between 148 and 270 µg/L. AOF making up 0.14–0.81% of TF (determined using CIC) and EOF 0.04–0.28% of TF (determined using HR-CS-GFMAS)	na	na	na

na	na	na	na
na	na	na	na
total concentrations of PFCs (PPFCs) reached a maximum in the later 1990s and early 2000s	na	na	na
na	na	1 pmol/L	na
7,5 ng/L	na	na	na

surface water varied between 2.3 and 24.5 µg/L. The concentrations of AOF in 85% of the wastewater discharges were be_x0002_tween 2.0 and 8.5 µg/L, while 15% of the samples were below the limit of quantitation (LOQ = 2 µg/L AOF). In 56% of the ground water samples the values were below the LOQ. In 44% of the surface water samples (n = 41) the values were between 2.0 and 6.1 µg/L AOF 14 individual PFAS were determined by LC-MS/MS. AOF values up to 555 µg/L	na	na	na
A total of 117 PFAS homologues (38 classes) were discovered, 48 of which (13 classes) were identified with confidence level 4 or above	na	na	na
(PFOS) concentrations were as high as 72-140 ng/L	na	na	na
the TF concentration of FireAde (4.3 g/L) is about 1.6 times and 3.5 times higher than EOF and AOF concentrations, respectively. Similarly, T-Storm contains 4.4 g/L of TF, about 2.3 and 4.0 times higher than EOF and AOF concentrations, respectively. Meanwhile, in the Buckeye sample, EOF concentration (10 g/ L) is slightly higher than TF (9.1 g/L), and AOF (4.8 g/ L) after TOP assay treatment, 11 PFCAs (C4–C14) were detected at the levels of 8–399 mg/L	na	300 and 400 ng/L AOF analysis are conservatively defined based on 1 mg/L	na

na	na	na	na
na	na	na	na
The range of total PFAS concentrations in egg samples were 627 – 707 ng/g w.w. for Sweden, 44.9 – 99.9 ng/g w.w. for Iceland, and 56.9 – 81.4 ng/g w.w. for Faroe Islands. Among the marine mammals, polar bear liver samples (Ursus maritimus) from Greenland showed the highest sum of PFASs (1426 – 1890 ng/g) as well as highest EOF (1782 – 2056 ng fluoride/g). The total PFASs in other marine mammal samples ranged between 35.1 ng/g in grey seal (Halichoerus grypus) from Denmark to 123 ng/g in harbour porpoise (Phocoena phocoena), also from Denmark. The PFASs in surface water mainly ranged between 1 and 10 ng/L The target analysis of PFASs could explain between 2% and 102% of the measured EOF	na	30-126 ng F/L EOF	na

na	na	na	na
Levels of perfluorinated compounds (PFCs) perfluorooctanoic acid (PFOA) and perfluorononanoic acid (PFNA) maximum levels of 1160 ng/L, 647 ng/L and 2405 ng/L	na	0,23-1,52 ng/L	na
below the limit of quantification to 898 ± 15 ng L−1	na	na	na
The highest _x0002_PFASs level found in a sample was 32.0 ng·L−1 in influent The sum of the mean concentrations of the target PFASs determined in the influ_x0002_ent (8.6 ng·L−1) and the effluent (8.2 ng·L−1) are very close	na	between 0.1 and 2.0 ng·L−1	na

The Σ24 PFAS accounted for less than 2% of fluorine in dust (n = 39), suggesting the potential presence of unknown PFAS. The median total fluorine concentration in sampled fire station rooms was 157 µg/g PFAS: 60-189 ng/g	na	TF detection limit (MDL) was 25 µg/g	na
na	na	0.014-0.44 ng L-1	na

∑9PFASs con_x0002_centration range of 0.04 to 2.14 ng/g wet weight	na	2 pg/g to 10 pg/g	na
na	na	0.16 to 5.13 ng L-1	na

na	na	0.090 to 3.7 pg g−1 dry weight	na
All target PFASs were detected in at least 32% of urine samples, with geometric mean (GM) concentrations ranging from 0.18 to 2.97 ng/L, and in 100% of drinking water samples at GM concentrations of 0.18-21.1 ng/L. 48-70% of hair samples (GM concentrations: 2.40-233 pg/g) and 100% of air samples (GM concentrations: 14.8-536.7 pg/m(3)).	na	na	na
	Mar-13 na	limit of detection of 0.15 ng mL−1 and a limit of quan_x0002_titation of 0.50 ng mL−1 . Nonetheless, for practical reasons, the lowest point of the calibration curve (2 ng mL−1) was considered as the limit of quantitation for all of the compounds.	na
na	na	na	na

na	na	sub ng/L to single digit ng/L	na
Mean PFAS concentration in the landfill leachate was 643 ± 84 ng L−1, while it was 365 ± 8.0 ng L−1 in a freshwater pond and 57 ± 4.0 ng L−1 in a creek in the vicinity of the FFTS. These levels were an order of magnitude higher than in coastal seawater of the nearby fjord (maximum level PFAS = 10.1 ±1.2 ng L−1, at the FFTS impacted site). PFOS was the most predominant compound in all seawater samples and in freshly fallen snow (63–93% of PFAS). In freshwater samples from the Longyear river and the reference site, PFCA ≤ C9 were the predominant PFAS (37–59%), indicating that both local point sources and diffuse sources contributed to the exposure of the marine food web in the fjord. PFAS concentrations increased from zooplankton (1.1 ± 0.32 µg kg−1 ww) to polychaete (2.8 ± 0.80 µg kg−1 ww), crab (2.9 ± 0.70 µg kg−1 ww whole-body), fish liver (5.4 ± 0.87 µg kg−1 ww), and gull liver (62.2 ± 11.2 µg kg−1).	na	in ng/g Water: 0.03 - 1.08 for different coumpounds Fish: 0.0.1 - 0.0.9 Sediment: 0.01 - 2 Crab: 0.01 - 1.11 Plankton: 0.002 - 8.82 Worms: 0.01 - 5.3	na
1,4-5,9 ng/L	na	LOQ: 0,55-3,20 ng/L	na
na	na	0.1–3.3 ng/L	

		). The detection limit (LOD) calculated from 3δ/K	
na	na	to be ∼0.1 ng L−1	na
na	na		na
na	na	0.3 nM	na

na	na	na	na
targeted: 0.43 to 519 ng/L IF was the major contributor to TF in water samples	na	e 0.03 ng/L for seawater and lake water, 0.10 ng/L for snow, and 2 ng/L for runoff water	na
PFOS was the dominant PFC in the tissues at concentrations ranging at 26–693 ng/g ww in dolphins and 51.3–262 ng/g ww in porpoises a large proportion (w70%) of the organic fluorine in both species is of unknown origin	na	na	na
na	na	na	na
t organic pollutants were not detected in any sample	na	< 30 ng/g	na

PFCs (PFOS, PFOSA, PFUnDA, PFDA, PFNA, and PFOA) were detected in all of the wild rat blood samples. Con_x0002_centrations of extractable organic fluorine (EOF) in fraction 1 (Fr1; MTBE extraction) of wild rats ranged 60.9–134 ng F mL−1, while those in fraction 2 (Fr2; hexane) were below LOQ (32 ng F mL−1); TF concen_x0002_trations in the blood of wild rats ranged from 59.9–192 ng F mL−1. The contribution of known PFCs in EOF-Fr1 (MTBE) varied from 9% to 89% (56% on average), and known PFC concentrations in TF content were less than 25%. In contrast, TF concentrations in the blood of PFOA-exposed rats ranged from 46900 to 111000 ng F mL−1, with PFOA contributing over 90% of TF	na	na	na
on average 90% of the EOF could not be explained by the 73 PFAS monitored EOF. in effluent (324−1460 ng of F/L) and sludge (39−210 ng of F/g of dry weight)	na	EOF: 560 ng of F/g;	na
field log Kd of 1.3-2.2, With total oxidizable precursor assay, unknown precursors for C2-C3 perfluoroalkyl carboxylic acids (PFCAs) (57-99 mol%) contributed more than those for C4-C12 PFCAs in the three mediums	na	na	na

∑PFASs in outdoor dust tripled from 63 to 164 ng/g In 2017, the indoor dust levels of ∑PFASs were in the range 185–913 ng/g, which were generally higher than the outdoor dust levels (105–321 ng/g). Emerging PFASs were found at high median levels of 5.7–97 ng/g in both indoor and outdoor dust samples unknown perfluoroalkyl acid (PFAA)-precursors contributed 37–67 mol % daily perfluorooctanoic acid (PFOA) equivalent intakes of PFAAs (C4–C12) mixtures via indoor dust were first estimated at 1.3–1.5 ng/kg b.w./d for toddlers	na	na	na
Twenty PFASs were detected with the total concentration of 0.3–32.9 ng/L, indicating the contamination level similar to that in drinking water. The dominant PFASs were perfluorobutanesulfonate (PFBS), perfluorobutanoic acid (PFBA), perfluoropentanoic acid (PFPeA) and perfluorooctanoic acid (PFOA)		excellent method limits of quantification (MLOQs) (0.5–250 pg/L),	
Target analysis detected total PFAS concentrations (∑PFAStarget) in SPM in the range of 0.336–14.9 μg kg−1. ∑PFAS concentrations determined by dTOP assay (∑PFASdTOP) were considerably higher than those found by target analysis (i.e.,∑PFASdTOP: 5.55–331 μg kg−1	the different sorption properties of various PFAS may introduce a bias in the temporal evaluation and the results cannot be extrapolated to the water phase.	The LOQs were 0.05–0.5 μg kg−1 dw for target analysis and 1.0 μg kg−1 dw for the dTOP assay	
na	It is known that high levels of organic matter in biosolid samples interfere with the oxidation process and lead to an incomplete transformation of precursors	na	

concentrations of individual PFAS (27 targeted analytes) can range from 0.6 to 84.6 ng/g in WAS (average total PFAS = 241.4 ng/g) and from 1.6 to 33.8 ng/g in PS (average total PFAS = 72.1 ng/g)	na	LOD: 0.5 - 7.7 ng/g LOQ: 1.5 - 25.7 ng/g
PFCAs were generally present at very low levels in all fish (i.e., ∑PFCAs < 46 ng/g). The Tangxun lake fish generally had higher levels of PFSAs than the Yangtze River fish (i.e., ∑PFSAs: 50−950 versus 7−25 ng/g, respectively)	na	LOQ: 0.02 - 2.1 ng/g in wet liver
The total (Σ38) PFAS in the samples ranged between 1.26 to 11.84 μg kg− 1 (dry weight)	na	(instrumental LOD) 0.012 - 2.5 ng/mL
∑ DWD PFAS (18/20): 0.0003 - 0.0772 μg/L ∑ ultra-short-chain PFAS: 0.0005 - 12.41 μg/L	Ultrashort-chain PFASs, however, remain a blind spot even for these “PFAS total” parameters	0.0000625 - 0.1 ng/mL (method LOQ for GC and LC)

The highest concentrations (up to ∼1000 µg/kg dry weight) were found in Lombardy poplar (Populus nigra ‘Italica’) leave	na	18 - 30 µg/kg dw (LOQ)	
na	na	The MQLs (method quantification limits) of 45 PFAS (including 13 PFEAs) in 10 matrices ranged from 0.025 to 0.25 ng/g	na
The six water samples (drinking water, river water, seawater, and wastewater) showed concentration ranges of 0.55 ng/L to 200 ng/L for samples A through E, and 8000 ng/L for Sample F	several difficulties were noticed in measureing PFAS in seawater, greater amounts of adsorbent are necessary and removal of non-volatile salts. Novel techniques (in-situ SPE and purge and trap extraction) were evaluated and further development, optimization, and validation are needed.	na	na

na	na	na	na
na	na	na	na
na	na	na	na
na	na	na	na

Measurement
- generic name

LC-MS/MS

LC-HRMS

LC-MS/MS

HR-CS-GFMAS

CIC, HR-CS-GFMAS

LC-MS/MS

CIC, LC-MS/MS

LC-MS/MS

LC-MS/MS, CIC

LC-HRMS

LC-MS/MS

CIC, LC-MS/MS

LC-MS/MS

CIC

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

DESI-MS

LC-MS/MS

LC-MS/MS

CIC, LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS

LC-MS/MS, TOP assay

TOP assay, GC-MS, LC-MS/MS

LC-HRMS

LC-MS/MS

LC-HRMS

LC-HRMS

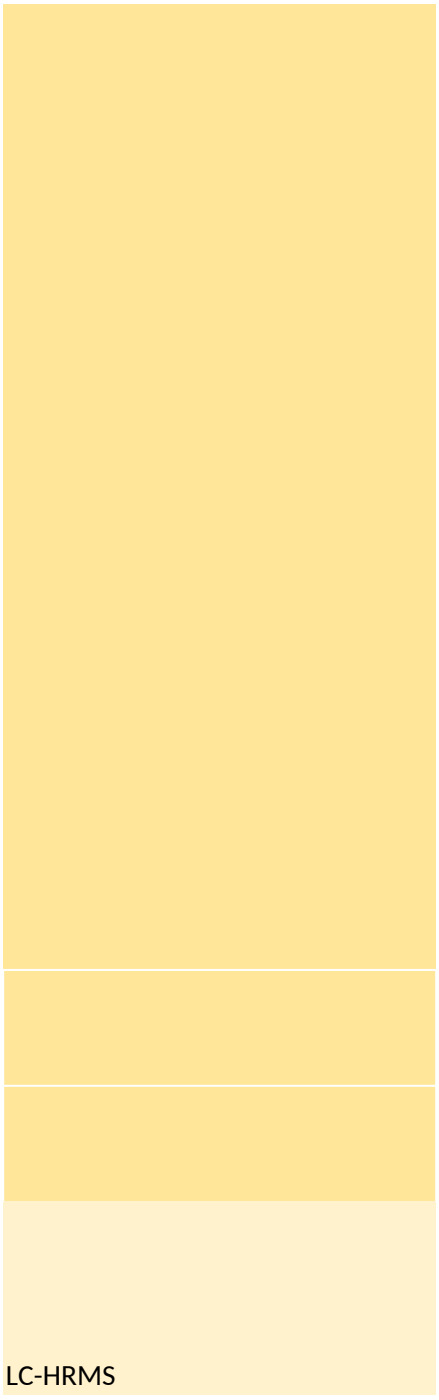
LC-MS/MS

TOP assay, LC-MS/MS, CIC

IC-MS/MS

LC-MS/MS

LC-MS/MS



LC-HRMS

Title	Authors
EPA method 533 for PFAS analysis in drinking water at low parts-per-trillion levels	Butt et al.
Analysis of Per/Polyfluoroalkyl Substances in Water Using an Agilent 6470 Triple Quadrupole LC/MS	Hunt et al.

Direct analysis of selected per- and polyfluorinated alkyl substances (PFAS) in ground, surface, and waste water by LC-MS/MS	Jacob et al.
Extraction and analysis of poly- and perfluoroalkyl substances (PFAS) from soil	MacLennan et al.

Direct Injection Analysis of Organofluorine Compounds (PFAS) by Triple-Quadrupole LC/MS/MS	na
Rapid LC-MS/MS method for monitoring bio-relevant levels of perand polyfluoroalkyl substances (PFAS) in serum	Negri et al.

Analysis of EPA Method 537 per- and polyfluoroalkyl substances (PFASs) using microflow liquid chromatography	Oetjen et al.
Analysis of legacy and emerging perfluorinated alkyl substances (PFAS) in environmental water samples using solid phase extraction (SPE) and LC-MS/MS	Organtini et al.
Large volume direct injection method for the anaysis of perfluorinated alkyl substances (PFAS) in environmetal water samples in accordance with ASTM 7979-17	Organtini et al.

A method for the extraction and analysis of PFAS from human serum utilizing weak anion exchange (WAX) chemistry and Xevo TQ-S micro	Organtini et al.
Analysis of Per/Polyfluoroalkyl Substances (PFAS) in Drinking Water by EPA 537.1 and EPA 533 Using the Agilent Ultivo Triple Quadrupole LC/MS	Pierri et al.
Analysis of PFAS in Drinking Water with EPA Method 537.1 and the SCIEX QTRAP® 4500 System	Roberts et al.

Analyses of PFOS and PFOA Precursors in Textile Products Using EI-MRM and PCI-SIM Method	Yeong et al.
Determination of per- and polyfluorinated alkyl substances (PFAS) in drinking water	Zhang et al.

Detection and treatment strategies of per- and polyfluoroalkyl substances (PFAS): Fate of PFAS through DPSIR framework analysis	John et al.

Journal	year
Sciex application note	2021
Agilent application notes	2017

Thermo application notes 2019

Thermo application notes 2021

Shimadzu application note 2020

Sciex application note 2020

Sciex application note 2020

Waters application notes 2020

Waters application notes 2020

Waters application notes	2021
Agilent application notes	2020
Sciex application note	2019

Shimadzu application note 2018

Thermo application notes 2020

Journal of Water process engineering 2021

comments	DOI link
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REVIEW - In this comprehensive review, a Driver-Pressure-State-Impact-Response (DPSIR) framework has been proposed to understand PFAS from the source of emission and their impacts on the environment. DPSIR framework is a conceptual model used to describe, analyze, and understand environmental problems.
Different treatment strategies for the removal of PFAS are discussed in this review.

https://www.sciencedirect.com/scien

Name
PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, 4:2 FTS, 6:2 FTS, 8:2 FTS, PFMPA, PFMBA, HFPO-DA, NFDHA, PFEESA, DONA, 9Cl-PF3ONS, 11Cl-PF3OUS
PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, FOSA, N-EtFOSAA, N-MetFOSAA, FHEA, FOEA, FDEA, PFHpPA, 4-2 FTS, 6-2 FTS, 8-2 FTS, 6-2 FTUA, 8-2 FTUA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS

TFA, PFPA, PFBA, PFPeA< PFHxA, PFHpA, PFOA, PFNA, PFDA,
TMSA, PFBS, PFHxS, PFOS, H4PFOS, Chiron AS, PFPS, PFPrS,
HFPO-DA, PBSF, POSF, 4-FBA

PFBS, PFHXS< PFOS, 4:2 FTS, 8:2 FTS, PFPeS, PFHpS, PFNS, PFDS, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, NEtFOSAA, NMeFOSAA, FOSA, M3PFHxS, M8PFOS, M4PFBA, M5PFPeA, M5PFHxA, M4PFHpA, M8PFOA, M9PFNA, M6PFDA, M7PFUnA, MPFDoA

PFBA, C4-PFBA, PFPeA, C6-PFPeA, PFBS, C3-PFBS, PFMBA, PFEESA, NFDHA, C6PFHxA, 4:2FTS, C2 4:2 FTS, PFHxA, C5-PFHxA, PFPeS, C3-PFHxS, HFPO-DA, C3-HFPO-DA, PFHpA, C4-PFHpA, PFHxS, ADONA, 6:2FTS, C2-6:2FTS, PFOA, C8-PFOA, PFHpS, PFNA, C9-PFNA, PFOS, C8-PFOS, 9Cl-PF3ONS, 8:2FTS, C2-8:2FTS, PFDA, C6-PFDA, PFUnA, C7-PFUnA, 11Cl-PF3OUdS, PFDoA, C2-PFDoA

PFOA, PFOS, 4:2 FTS, 6:2 FTS, 8:2 FTS, 10:2 FTS, N-EtFOSA, N-EtFOSAA, N-EtFOSE, FOSA, N-MeFOSAA, N-MeFOSE, N-MeFOSA, PFTrDA, PFBA, PFBS, PFDA, PFDoDA, PFHpA, PFHxA, PFHxS, PFPeS, PFNA, PFOA, PFDS, PFHpS, PFOS, PFPeA, PFTeDA, PFUnDA, PFHxDA

PFBS, PFPeA, PFHxA, PFPeS, PFHpA, PFHxS, PFOA, PFHpS, PFNA, FOSA, PFOS, PFDA, PFNS, PFUdA, PFDS, PFDoA, PFTrDA, PFTeDA. PFHxDA, PFODA, PFDoS

na

PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTriDA, PFTreDA, PFHxDA, PFODA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, N-MeFOSAA, N-EtFOSAA, FHUEA, FOUEA, 8_2 diPAP, 4_2 FTS, 6_2 FTS, 8_2 FTS, PFecHS, FHEA, FOEA, FDEA, FHpPA, ADONA, Cl-PF3ONS, 11Cl-PF3OUdS, GenX, PFMBA, NFDHA, PFEESA, 13C-PFBA, 13C5-PFPeA, 13C5-PFHxA, 13C4-PFHpA, 13C8-PFOA, 13C9-PFNA, 13C6-PFDA, 13C7-PFUnDA, 13C-PFDoDA, 13C-PFDoDA, 13C2-PFTreDA, 13C2-PFHxDA, 13C3-PFBS, 13C3-PFHxS, 13C8-PFOS, D5-N-EtFOSAA, D3-N-MeFOSAA, 13C-FOUEA, 13C4-8:2 diPAP, 13C2-4:2 FTS, 13C2-6:2 FTS, 13C2-8:2 FTS, 13C-FHEA, 13C-FOEA, 13C-FDEA, 13C3-GenX

PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTriDA, PFTreDA, PFHxDA, PFODA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, N-MeFOSAA, N-EtFOSAA, FHUEA, FOUEA, 8_2 diPAP, 4_2 FTS, 6_2 FTS, 8_2 FTS, PFecHS, FHEA, FOEA, FDEA, FHpPA, ADONA, Cl-PF3ONS, 11Cl-PF3OUdS, GenX, PFMBA, NFDHA, PFEESA, 13C-PFBA, 13C5-PFPeA, 13C5-PFHxA, 13C4-PFHpA, 13C8-PFOA, 13C9-PFNA, 13C6-PFDA, 13C7-PFUnDA, 13C-PFDoDA, 13C-PFDoDA, 13C2-PFTreDA, 13C2-PFHxDA, 13C3-PFBS, 13C3-PFHxS, 13C8-PFOS, D5-N-EtFOSAA, D3-N-MeFOSAA, 13C-FOUEA, 13C4-8:2 diPAP, 13C2-4:2 FTS, 13C2-6:2 FTS, 13C2-8:2 FTS, 13C-FHEA, 13C-FOEA, 13C-FDEA, 13C3-GenX

PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTriDA, PFTreDA, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, FBSA, FHxSA, FOSA, N-MeFOSAA, N-EtFOSAA, 4_2 FTS, 6_2 FTS, 8_2 FTS, ADONA, 9Cl-PF3ONS, 11Cl-PF3OUdS, GenX, 13C-PFBA, 13C5-PFPeA, 13C5-PFHxA, 13C4-PFHpA, 13C8-PFOA, 13C9-PFNA, 13C6-PFDA, 13C7-PFUnDA, 13C-PFDoDA, 13C-PFDoDA, 13C2-PFTreDA, 13C2-PFHxDA, 13C3-PFBS, 13C3-PFHxS, 13C8-PFOS, D5-N-EtFOSAA, D3-N-MeFOSAA, 13C-FOUEA, 13C4-8:2 diPAP, 13C2-4:2 FTS, 13C2-6:2 FTS, 13C2-8:2 FTS, 13C-FHEA, 13C-FOEA, 13C-FDEA, 13C3-GenX

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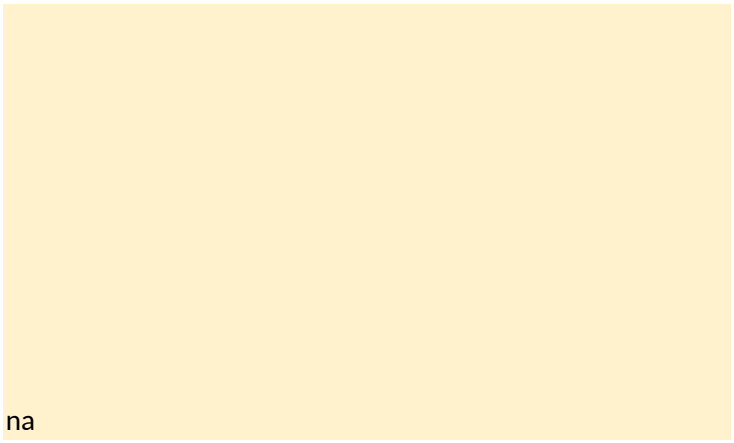
PFHxA, PFHpA, PFOA, PFDA, PFuDA, PFDoA, PFTrDA, PFTeDA, PFBS, PFHxS, PFOS, n-EtFOSAA, n-MeFOSAA

FTA 6:2, FTA 8:2, FTA 10:2, N-MeFOSA, N-EtFOSA, N-MeFOSE, N-EtFOSE

PFBA, C4-PFBA, PFMPA, PFPeA, C6-PFPeA, PFBS, C3-PFBS, PFMBA, PFEESA, NFDHA, C6PFHxA, 4:2FTS, C2 4:2 FTS, PFHxA, C5-PFHxA, PFPeS, C3-PFHxS, HFPO-DA, C3-HFPO-DA, PFHpA, C4-PFHpA, PFHxS, ADONA, 6:2FTS, C2-6:2FTS, PFOA, C8-PFOA, PFHpS, PFNA, C9-PFNA, PFOS, C8-PFOS, 9Cl-PF3ONS, 8:2FTS, C2-8:2FTS, PFDA, C6-PFDA, PFUnA, C7-PFUnA, 11Cl-PF3OUdS, PFDoA, C2-PFDoA



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CAS (if available in source)
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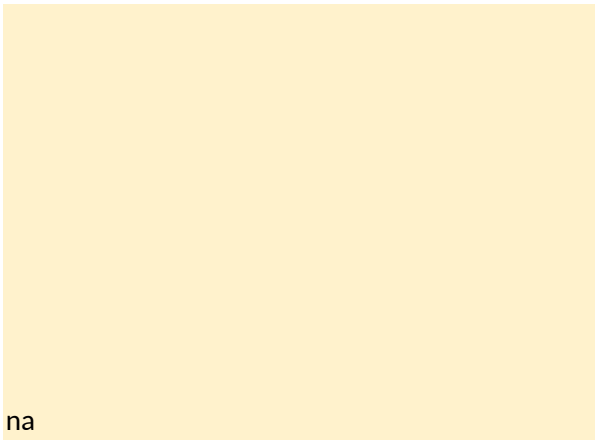
na



na

Sampling	sample amount used
na	na
na	na

Surface water, municipal wastewater, industrial wastewater, and groundwater samples	1000 mL

reagent water, surface water, ground water, and waste water	5 mL
A 10 g soil sample was in 250 mL polypropylene or polyethylene bottles	10 g

na	na
serum	na

na	na
surface water, ground water, influent waste water, effluent waste water	250 mL
surface water, ground water, influent waste water, effluent waste water	5 mL

na	na
water	250 mL
na	na

1 g of cut textiles was weighed into a 20 mL glass vial and 10 mL of tetrahydrofuran (THF) was added	na
water	250 mL

na	na

Pre- treatment
Similar to previous EPA methods, water samples are concentrated using solid-phase extraction (SPE) cartridges, but the choice of cartridge is flexible and the sample volume can vary from 100-250 mL Methods follow those outlined in the EPA Method 533 document
na

Sample preparation was performed according to
ISO 9562

na

Sample clean-up used a styrene-divinylbenzene (SDVB)
polymer SPE cartridge (500 mg, 6 mL), on a vacuumcontrolled manifold

na

: PFAS were extracted from 50 µL serum
samples by using a protein precipitation procedure

Sample preparation and data processing
were carried out according to EPA Method 537

prepared as mix in methanol

ASTM 7979-17 spiked with 160 ng/L isotopically labeled IS

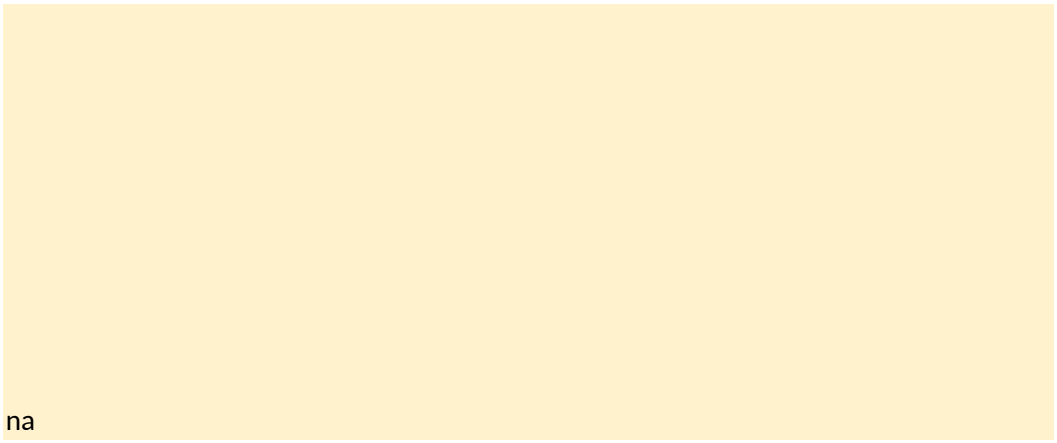
na

The
samples were then extracted using SPE
following the protocol described in the
respective EPA methods

Sample preservation and preparation
were performed according to the guidelines in EPA Method
537.1

na

na


na

Extraction

na

na

na

na

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na

ISO 25101 Oasis WAX 6 cc, 150mg SPE

na

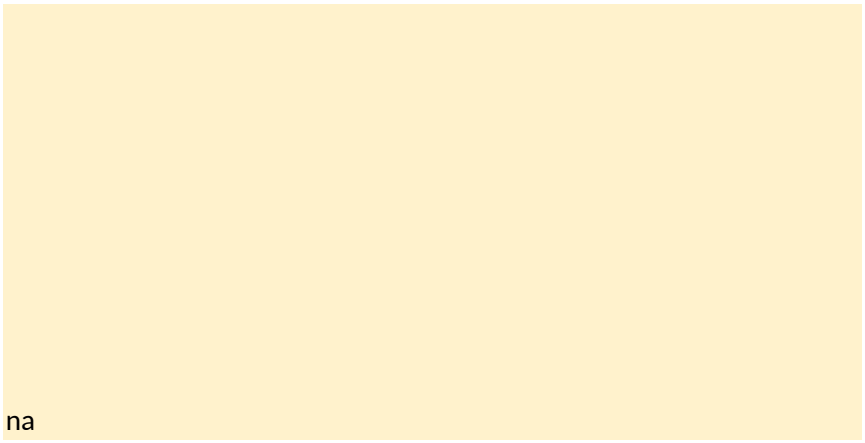
Oasis WAX

na

The water samples were extracted using the following procedure with Phenomenex Strata-XL solid phase extraction cartridges (6 mL, 500 mg):
1. Condition SPE tubes with 15 mL of water followed by 18 mL of methanol
2. Add sample to tubes at a flow rate of approximately 10-15 mL per minute.
3. Rinse tubes with 7.5 mL of water and repeat
4. Dry tubes under vacuum for 5 minutes
5. Rinse sample bottle with 4 mL of methanol and transfer methanol to SPE tube while collecting eluent and repeat
6. Evaporate sample to dryness under nitrogen at 40-60°C
7. Reconstitute sample in 1 mL of 96% methanol 4% water containing 1 ng/L of internal standards
8. Transfer a 0.25 mL aliquot to a polypropylene vial and archive the remaining volume

na

na



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Clean up

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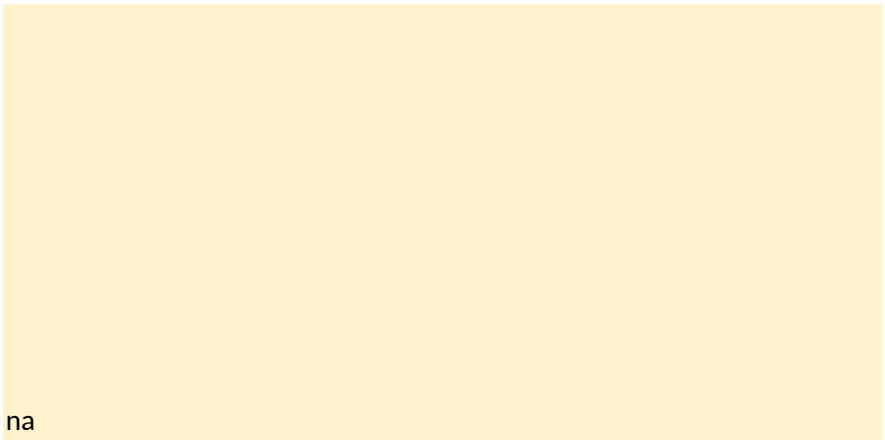

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Measurement

The SCIEX ExionLC™ system was used and chromatographic separation was achieved using gradient conditions with a Phenomenex Gemini C18 column (50 x 2 mm, 3 µm particle size). A delay column was used to separate the instrument PFAS contamination from the analyte peak. The mobile phases were water (A, modified with 20 mM ammonium acetate) and methanol (B) with a flow rate of 0.6 mL/min. The column oven was 40oC and the injection volume was 2 µL : Analysis was performed on the SCIEX
5500+ System with the Turbo V™ Ion Source using an electrospray ionization (ESI) probe in negative ion mode

Agilent 1260 series Infinity Agilent 6470 Triple Quadrupole MS/MS with
Agilent Jet Stream ESI source negative mode Analytical column Agilent ZORBAX Eclipse Plus C18,
3.0 × 50 mm; 1.8 µm (p/n 959757-302)
Delay column Agilent Eclipse Plus C18, 4.6 × 50 mm, 3.5 µm (p/n 959943-902)
Column temperature 50 °C
Injection volume 5 uL
Mobile phase A) 5 mM Ammonium acetate in water (LC grade)
B) 5 mM Ammonium acetate in 95 % MeOH
(LC grade)
Gradient flow rate 0.4 mL/min
Gradient Time (min) %B
0.0 10
0.5 10
2.0 30
14.0 95
14.5 100
Stop time 16.5 minutes
Post time 6 minutes

Thermo Scientific™ Dionex™ ICS-2100 Integrated
Reagent-Free™ Ion Chromatography (RFIC™) system • Mitsubishi
Chemical Analytech Automatic Combustion
Unit Model AQF–2100H system Thermo Scientific™ Dionex™ IonPac™
AS20 column,
2 × 250 mm Thermo Scientific™ Dionex™ IonPac™ AG20 guard
column,
2 × 50 mm
KOH gradient Inject (0 min)
2 mM (0–0.1 min)
2–3 mM (0.1–5 min)
3–12 mM (5–21 min)
12 mM (21–24 min)
12–35 mM (24–25 min)
35 mM (25–28 min)
35–100 mM (28–28.2 min)
100 mM (28.2–32.2 min)
2 mM (32.2–32.4 min)
0,25 mL/min
250 µl inj, temp: 30 °C (column temperature)
35 °C (detector cell temperature)
Dionex AERS 500 suppressor (2 mm),
timed constant current mode:
8 mA (0–28 min)
22 mA (28–33.2 min)
62 mA (33.2–37.4 min)
8 mA (37.4–44 min)

the LC-MS/MS system comprised a Thermo Scientific™ Vanquish™ Flex Binary UHPLC system fitted with a Thermo Scientific™ PFC-free kit (P/N 80100-62142) and interfaced with a Thermo Scientific™ TSQ Altis™ triple quadrupole mass spectrometer equipped with a HESI ionization probe. An isolator column was also installed after the LC pump and prior to the injection valve to offset background contaminants from the LC pump,
Analytical column: Thermo Scientific™ Accucore™ RP-MS, 2.6 µm, 2.1 × 100 mm
(P/N 17626-102130)
Isolator column: Thermo Scientific™ Hypersil™ BDS C18, 5 µm, 2.1 × 50 mm
(P/N 28105-052130)
Column temp.: 45 °C
Flow rate: 0.5 mL/min
Solvent A: Water containing 2 mM ammonium acetate, 2% methanol,
and 0.1% acetic acid
Solvent B: Methanol containing 2 mM ammonium acetate,
2% water, and 0.1% acetic acid
Injection volume: 25 µL
Gradient: Time (min) % Solvent B
0 0
1 30
6 45
13 80
14 95
17 95
18 0
21 0

A Thermo Scientific™ Vanquish™ LC, with all Teflon™ lines replaced by PEEK tubing, coupled to a Thermo Scientific™ TSQ Quantis™ triple quadrupole mass spectrometer, was used for sample analysis.
Solvent B
10 mM ammonium acetate in 19% v/v acetonitrile/81% methanol
Solvent A
10 mM ammonium acetate in 19% v/v acetonitrile in water
Column temperature 25 °C
Gradient
Solvent ramps from 40% Solvent B to 90% Solvent B over 15 min
LC flow rate 0.300 mL/min

Impurity Delay method.
[HPLC conditions] (NexeraTM Series)
Column : Shim-pack VeloxTM SP-C18
(150 mm L × 2.1 mm I.D., 2.7 µm, PN: 227-32003-04)
Delay column : Shim-pack™ XR-ODS Ⅱ
(75 mm L 2.0 mm I.D., 3 µm, PN: 228-41623-91)
Mobile phases : A) 20 mmol/L Ammonium Acetate in H2O
B) Methanol
Gradient program : B 60% (0.00 min) - B85% (25.00 - 30.00 min)
- 60% (30.01 - 34.00 min)
Flow rate : 0.25 mL/min
Column temp. : 40 ℃
Injection volume : 50 µL
[MS conditions] (LCMSTM-8060)
Ionization : ESI (Negative mode)

[HPLC conditions] (Nexera Series)
Column : Shim-pack ODS Ⅲ
(50 mm x 2.0 mm I.D., 1.6 µm, P/N: 228-59922-91)
Delay column : Shim-pack XR-ODS
(30 mm x 3.0 mm I.D., 2.2 µm, P/N: 228-41606-91)
Mobile phases
: A) 5mM Ammonium Acetate
/ 0.05% Acetic Acid in H2O
B) Methanol
Gradient program : B 50%(0.00 min) – B100%(4.60-5.50 min)
Flow rate : 0.4 mL/min
Column temp. : 40 ℃
Injection volume : 40 µL
[MS conditions] (LCMS-8050)
Ionization : ESI (Negative mode)

UHPLC separation was performed on
a Phenomenex Gemini® C18 column (50 x 2 mm, 3 µm, 00B4439-B0)
at 25°C on a SCIEX ExionLC™ AC System. A
Phenomenex Luna C18(2) column (30 x 2 mm, 5 µm, 00A-4252-
Y0) was installed between the pump mixing chamber and the
analytical column used for separation.
The LC flow rate was 0.6 mL/min and the total run time was 6.5
min. The injection volume was 10 µL
: Data were collected using a SCIEX
QTRAP 6500+ System with a IonDrive™Turbo V Ion Source,
operated with electrospray ionization (ESI) in negative mode.

The microflow analysis was performed using an M5 MicroLC System at a flowrate of 10 µL/min. A Gemini C18 3 µm, 100 x 0.3 mm column (Phenomenex) was used. This column uses the identical stationary phase, but smaller internal diameter as the high flow method.5 Mobile phases A and B were Milli-Q water with 10 mM ammonium acetate and J.T.Baker Ultra LC-MS grade methanol with 10 mM ammonium acetate, respectively

Time (Min)	% Mobile Phase A	% Mobile Phase B
0	98	2
1.2	45	55
7	1	99
8.5	0	100
8.6	98	2

The sample was injected into the SCIEX Triple Quad 6500+ System equipped with a OptiFlow Turbo V Ion Source that was designed specifically for lower flow rates.

Waters Xevo TQ-S micro with PFC Analysis Kit. ESI- Acquity UPLC-I-Class PLUS. Acquity UPLC BEH C18 2,1 x 100 mm, 1,7µm. T: 35 °C, sample T: 10 °C, injection vol: 10 µl, Mobile phase A: 95:5 Water: Methanol + 2 mM ammonium acetate; Mobile phase B: Methanol + 2mM ammonium acetate Gradient: 0 min: 0,3 ml/min 100% A, 1 min: 0,3 ml/min 800% A, 6 min: 0,3 ml/min 55% A, 13 min: 0,3 ml/min 20% A, 14 min: 0,4 ml/min 5% A, 17 min: 0,4 ml/min 5% A, 18 min: 0,3 ml/min 100% A, 22 min: 0,3 ml/min 100% A

Waters Xevo TQ-S micro with PFC Analysis Kit. ESI- Acquity UPLC-I-Class PLUS. Acquity UPLC CSH Phenyl Hexyl 2,1 x 100 mm, 1,7µm. T: 35 °C, sample T: 10 °C, injection vol: 30 µl, Mobile phase A: 95:5 Water: Methanol + 2 mM ammonium acetate; Mobile phase B: Methanol + 2mM ammonium acetate Gradient: 0 min: 0,3 ml/min 100% A, 1 min: 0,3 ml/min 800% A, 6 min: 0,3 ml/min 55% A, 13 min: 0,3 ml/min 20% A, 14 min: 0,4 ml/min 5% A, 17 min: 0,4 ml/min 5% A, 18 min: 0,3 ml/min 100% A, 22 min: 0,3 ml/min 100% A

Waters Xevo TQ-S micro with PFC Analysis Kit. ESI- Acquity UPLC-I-Class PLUS. Acquity UPLC HSS T3 2,1 x 100 mm, 1,8µm. T: 35 °C, sample T: 4 °C, injection vol: 5 µl, Mobile phase A: 95:5 Water: Methanol + 2 mM ammonium acetate; Mobile phase B: Methanol + 2mM ammonium acetate Gradient: 0 min: 0,3 ml/min 100% A, 1 min: 0,3 ml/min 800% A, 6 min: 0,3 ml/min 55% A, 13 min: 0,3 ml/min 20% A, 14 min: 0,4 ml/min 5% A, 17 min: 0,4 ml/min 5% A, 18 min: 0,3 ml/min 100% A, 22 min: 0,3 ml/min 100% A

Agilent 1290 Infinity II, Agilent Ultivo triple quadrupole LC/MS
Agilent Poroshell 120 EC-C18, 2.1 × 50 mm,
4 µm (p/n 699770-902T) gilent Poroshell 120 EC-C18, 2.1 × 50 mm,
1.9 µm (p/n 699675-902
55°C
A: 0,1% Acetic acid in H2O, B: Methanol injection 4 ul, flow rate 0,7 mL/min
A: 20mM Ammonium acetate in H2O, B: Methanol, injection 7ul, flow 0,7 mL/min

: An Agilent 1200 binary pump was modified
by replacing all clear fluoroethylene polymer (FEP) tubing with
1/8 in or 1/16 inch PEEK tubing. A delay column (Phenomenex
Luna C18(2), 5µm, 30x2mm) was inserted between the gradient
mixing chamber and the autosampler valve to retain
contaminants from the eluents or pumps for an extra 1-2 min
compared with target analytes eluting from the analytical column.
An Agilent 1200 autosampler injected 10 ul of each sample onto
the analytical column (Phenomenex Gemini C18, 3µm,
50x2mm), which was heated to 40°C. Gradient separation was
performed at a flow rate of 0.6 mL/min Mobile phase A - 20 mM
ammonium acetate
Mobile phase B – methanol
0 min: 95%A; 0,1 min, 45% A; 4,5 min: 1% A; 8 min: 1% A; 8,5 min: 95% A
: Samples were ionized using negative
mode electrospray

For the PCI-SIM method, a single quadrupole GC/MS, GCMS-QP™ 2020 NX was used. A triple quadrupole GC-MS/MS system, GCMS-TQ™8050 NX, was used for the EI-MRM method. The same GC conditions were applied to both methods
GC-MS : GCMS-QP2020 NX and GCMS-TQ8050 NX
Auto-Injector : AOC™-20i + 20s
Column : SH-Rtx™-200 (length 30 m, 0.32 mm I.D., _x001E_lm thickness 0.5 µm)
[GC]
Injection Temp. : 250 °C
Column Oven Temp. : 80 °C => (30 °C /min) => 260 °C (1 min)
Injection Mode : Splitless
Carrier Gas : He
Carrier Gas Control : 48.7 cm/sec (Constant Velocity)
High Pressure Injection : 150 kPa (1 min)
Injection Volume : 2 µL
[MS]
Ion Source Temp. : 200 °C
Interface Temp. : 250 °C
EI-MRM
Ionization Mode : EI
Acquisition Mode : MRM
Event Time : 0.3 sec
PCI-SIM
Ionization Mode : PCI
Acquisition Mode : SIM
Reagent Gas : Methane (200 kPa)
Event Time : 0.1 sec

Thermo Scientific™ Dionex™ AutoTrace™ 280 PFAS, Thermo Scientific™ Vanquish™ Flex UHPLC system, Thermo Scientific™ TSQ Fortis™ triple quadrupole mass
spectrometer Thermo Scientific™ Vanquish™ system fitted with Thermo
Scientific™ PFC-free kit Thermo Scientific™ Acclaim™ 120 C18 column, 2.1 × 150 mm, 2.2 µm Thermo Scientific™ Hypersil™ BDS C18 column, 2.1 × 50 mm, 5 µm
Column temperature 45 °C
Injection volume 5 uL
Mobile phase A) 20 mM ammonium acetate
B) Methanol
t:0 min, %B 5 flow 0,4 mL/min; t:0,5 min, %B 5 flow 0,4 mL/min; t:3 min, %B 40 flow 0,4 mL/min; t:14 min, %B 85 flow 0,4 mL/min; t:17 min, %B 85 flow 0,4 mL/min; t:18 min, %B 5 flow 0,4 mL/min t:21 min, %B 5 flow 0,4 mL/min

Sensors are used for detection of PFAS: nanoparticle based sensor, electrochemical sensor, fluorescence detector and smartphone based sensor
analytical methods for detecton of PFAS: TOP assay, total fluorine content - CIC (EOF and AOF), LC-MS and GC-MS

Quantification method	Working range (ng/mL) As
na	na
na	na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na

na	na

Matrices	reported levels (ng/mL)
na	na
na	na

		Surface water between 4.5 and 10.2 µg/L, Groundwater samples n 2 and 7 µg/L Municipal sewage treatment plants 2 and 8.5 µg/L Industrial wastewater values above 74 µg/L, with a highest value of more than 500 µg/L
na		

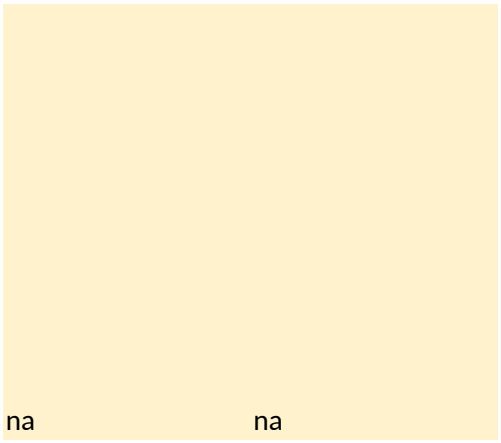
na	na
na	na

na	na
na	na

na	The concentrations of PFBS ranged from 0.5 to 44.8 ppt in the samples before extraction. PFOS was the second most detected compound, present in 8 of 20 samples, with concentrations ranging from 1.9 ppt to above the ULOQ
surface water, ground water, influent waste water, effluent waste water	0,1-50 (PFPeA) ng/L
surface water, ground water, influent waste water, effluent waste water	10-8000 ng/L

human serum	Total: 8,86-19 ng/L
na	na
na	na

Textile	The detected and quantitated concentrations of N-MeFOSE was 1.74 ng/g and that of N-EtFOSE was 2.91 ng/g FTA 8:2 and FTA 10:2 were quantitated to be 89.8 ng/g and 41.0 ng/g, respectively
na	na


na
na

info - validation of the method	Limitations
Calibration curve linearity was excellent with r2 values greater than 0.999 for most PFAS compounds over the 0.5-100 ng/mL standard range s the accuracy was very good, generally 100% +/- 5% (Figure 6). Precision was also very good, the CV% was ~5% for the 0.5 ng/mL standard and ~2% for the 25 ng/m	na
e linearity, accuracy 76 % to 120 %, precision 4-15%, and instrument detection limits 0.02 ng/L	na

e linearity of the calibration function within the range of 2 to 500 µg/L Recovery ranged from 16% to 121% The wastewater matrix showed recoveries from 85% to 102%		na

Excellent linearity and quantitative accuracy were achieved over the range of 5 to 200 ng/L All compounds analyzed in this method were within the range of 70% to 130%	na
Recovery: 71-110 %	na

e calibration curves for both PFOA and PFOS indicate good linearity with R2 > 0.999 The accuracy of the calibration curve was 91.4 to 101.5%, which is a good result. Figure 3 shows each chromatogram of the 1 ng/L standard sample for PFOA and PFOS, respectively. The repeatability (n = 3) of the standard sample at this concentration was 5.8% for PFOA and 4.9% for PFOS, indicating good reproducibility.	na
Method demonstrated excellent reproducibility and linearity for PFAS concentrations ranging from 0.5 to 100 ng/mL, with R2 values greater than 0.99, while maintaining accuracy and precision across the calibration range inter-day peak area variations of 5% or less	na

Using the outlined method, PFBS and PFHxA met all asymmetry requirements with values ranging from 1.0 to 1.2 (Table 3) at all the quality control concentration levels. Additionally, the ion ratios for both PFBS and PFHxA were within ±20% and the calculated concentration was within 5% of the expected value The mean ISTD area was calculated and all collected data points fell within ±20%, suggesting no major suppression was occurring. The surrogate concentrations were also plotted over the 3 day run and found to be within the acceptable ±30% outlined in EPA Method 537	na
Linearity, Recovery: 75-130%, Repeatability RSD: <15%, Robustness RSD: <10%	na
Linearity, Recovery: 70-130%, Repeatability RSD: <10%,	na

Linearity, residuals <15%, accuracy <20%	na
4. Recoveries were well within the 70 to 130% range required by the EPA methods. The RSDs were <20%	na
1. Linearity (r2>0.99) (as shown in Figure 2) 2. Accuracy (+/- 30% for each calibrator) 3. Precision (RSD <20% of 4 replicates of a fortified blank) 4. Asymmetry factor (>0.8 and <1.5 for the first 2 peaks in the chromatogram as shown in Figure 3) 5. Surrogate recovery +/- 30% of expected response 6. Laboratory reagent blanks (LFBs) and field reagent blanks (FRBs) quantitated at <1/3 of the MRL.	na

The four identification points were: (1) ±0.10 min deviation of absolute retention time (2) 1 quantitative or target MRM transition (3) ≥ 2 product ions (i.e. at least 1 qualitative or reference MRM transition) (4) The maximum tolerances for relative intensity% of reference MRM Linear IS	
calibration curves with average R2 ≥ 0.998 were obtained. Repeatability of the peak area ratios were evaluated at the lowest, mid	
and highest calibration levels from six replicates (Table 5). The %RSD at the lowest calibration levels of all targets ranged from 3.54 to 17.2%.	
the QC samples were quantitated to be in the range of approx. ±30% of the spiked concentrations	na
within 70–130% of their true value, calculated RSDs were all less than 20%	na

na	na

LoD (ng/mL)	subgroup	Measurement - generic name
2 ng/L	na	LC-MS/MS
0,02 ng/L	na	LC-MS/MS

1.3 µg/L	na	LC-MS/MS

1 ng/L	na	LC-MS/MS
0,01 ng/g	na	LC-MS/MS

1 ng/L	na	LC-MS/MS
0,1 ng/mL	na	LC-MS/MS

The lower limit of quantification (LLOQ) varied between 1 and 5 parts per trillion (ppt) in vial, equating to 0.04 and 0.2 ppt in the sample before extraction	na	LC-MS/MS
LOD: 2 (PFOA) - 2000 (PFOcDA), most 10 ng/L in vial and 0,01 - 8, most 0,04 ng/L in sample	na	LC-MS/MS
LOD: 0,82 (ADONA) - 7948 (FDEA) ng/L	na	LC-MS/MS

0,05 - 20 ng/mL	na	LC-MS/MS
0,13-0,92 ng/L	na	LC-MS/MS
0,2 ng/L	na	LC-MS/MS

0.5 - 4 ng/mL	na	GC-MS
2 to 10 ng/L	na	LC-MS/MS

nanoparticle based sensors (2.5 ng/L LOD) electrochemical sensor (30 µg/L LOD) fluorescence detector (124 µg/L PFOA LOD)	na	sensor, TOPassay, CIC, LC-MS/MS, GC-MS