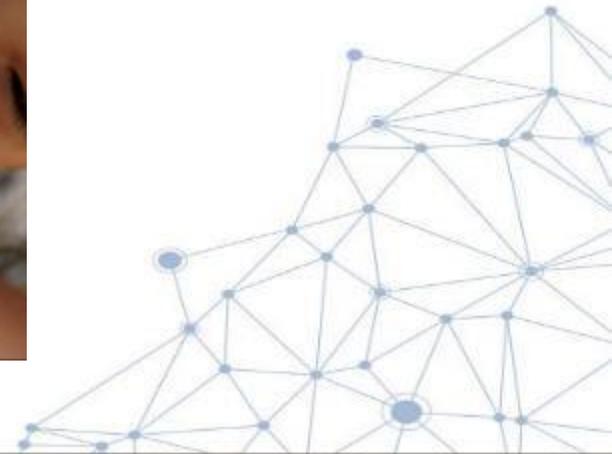
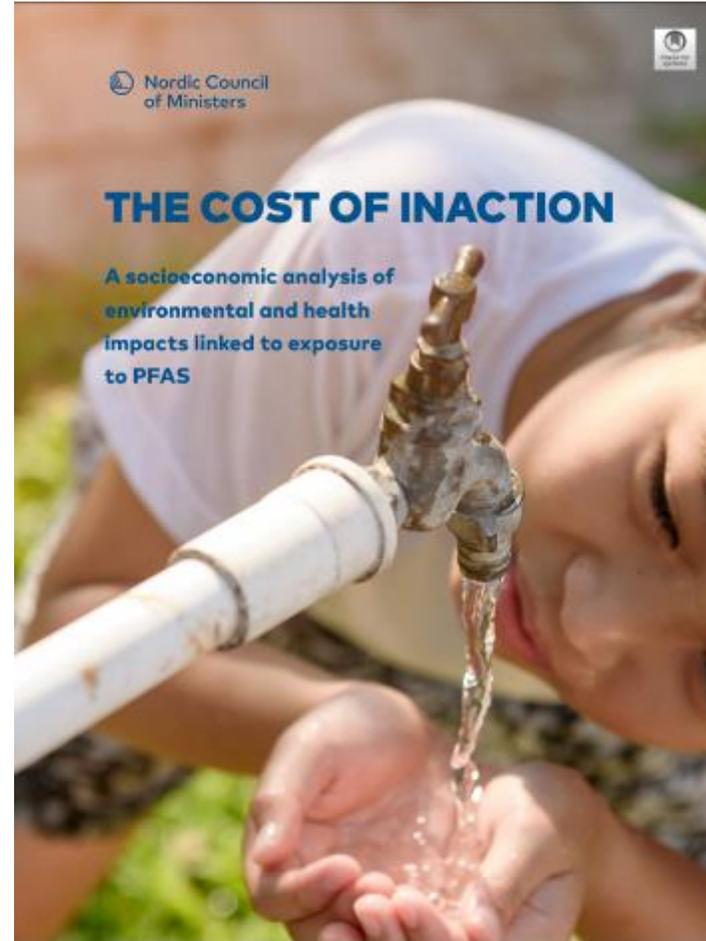


The main challenges for PFAS – their management and regulation – within the UK context.

- What are PFAS
- How to measure PFAS
- Replacement of one PFAS with another
- Regulatory frameworks
- PFAS point sources
- UK waters
- PFAS destruction
- Green Chemistry Solutions
- Summary



Poly- and Perfluoroalkyl Substances (PFASs)

(~4,730 manufactured compounds)

More Commonly Regulated

Polyfluorinated
“Precursors” -Proprietary
PFASs

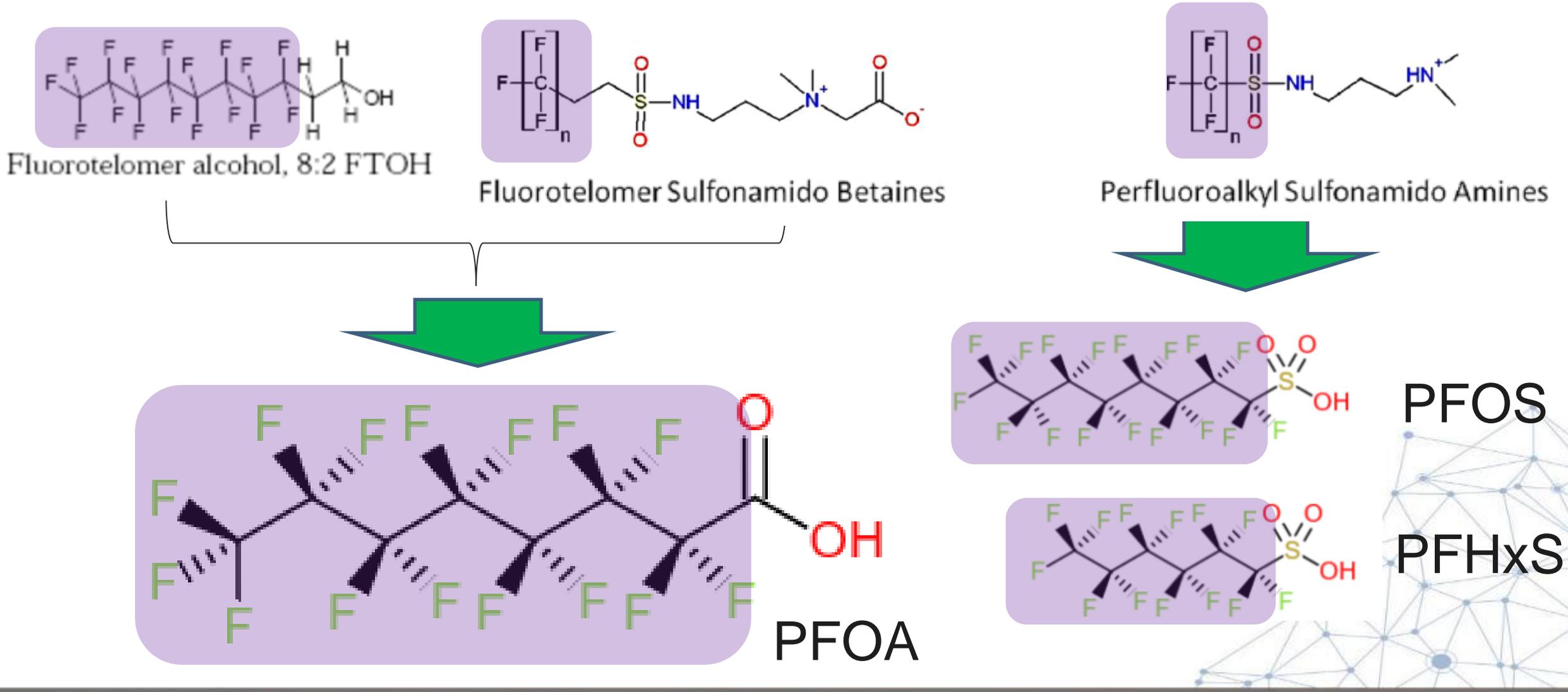
Thousands of individual parent
compounds, sharing common
daughters e.g. 6:2 FTS, 5:3 acid

Perfluorinated Compounds (PFCs)
or Perfluoroalkyl Acids (PFAAs)

~25 common individual compounds, terminal
daughters i.e. “forever chemicals”
e.g. PFOS, PFOA, PFHxS, PFBA, PFHxA

Environmental / Higher Organism Biotransformation

Perfluoroalkyl group – confers extreme persistence



PFASs in Landfill Leachate



Our Work

Get Involved

About

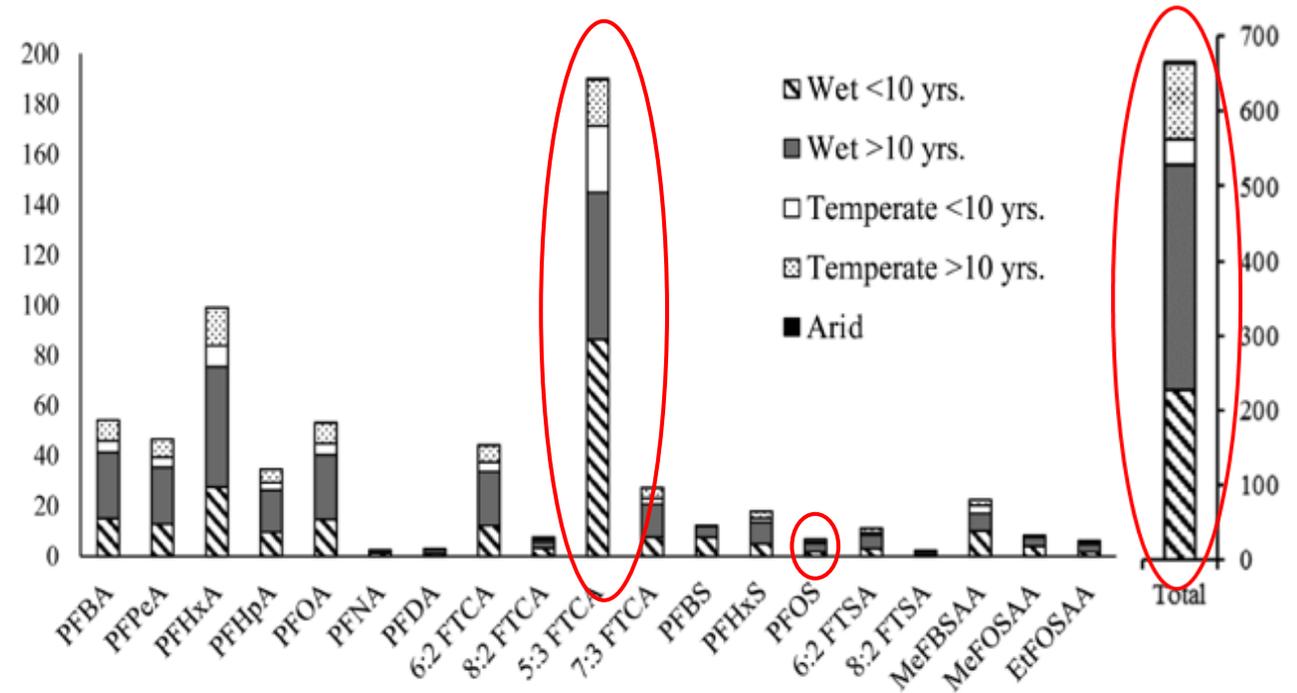
Donate

Home > Blogs > EDF Health > The elephant in the room: potential biopersistence...

The elephant in the room: potential biopersistence of short-chain PFAS



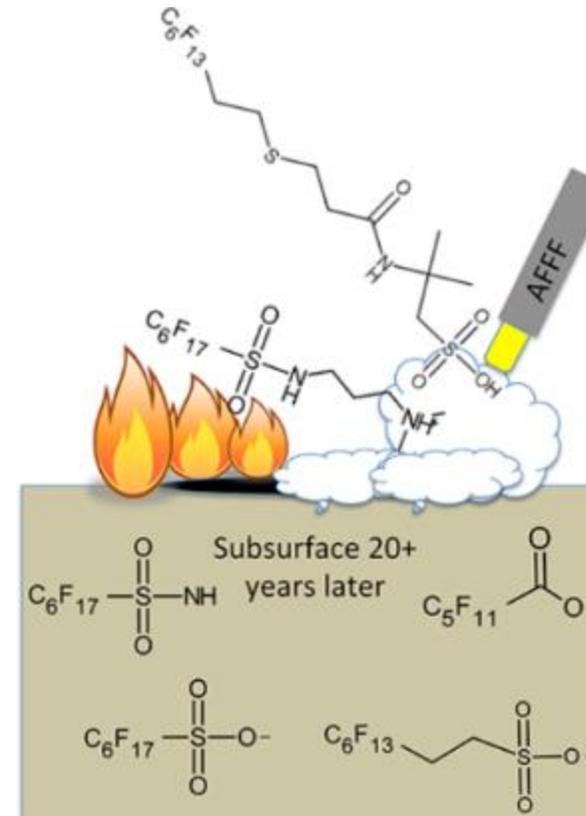
Estimated PFAS Mass Flows in U.S. Landfill Leachate in 2013 (kg/yr)



Environ. Sci. Technol., 2017, 51 (4), pp 2197–2205

Digest AFFF precursors and measure the hidden mass: TOP Assay

- Microbes slowly make simpler PFAA's (e.g. PFOS / PFOA) from PFAS (PFAA precursors) over 20+ years
- Need to determine precursor concentrations as they will form PFAAs
- Too many PFAS compounds and precursors –so very expensive analysis
- Oxidative digest **stoichiometrically** converts PFAA precursors to PFAA's
- TOP assay indirectly measures total precursors as a result of increased PFAAs formed after oxidation vs before.



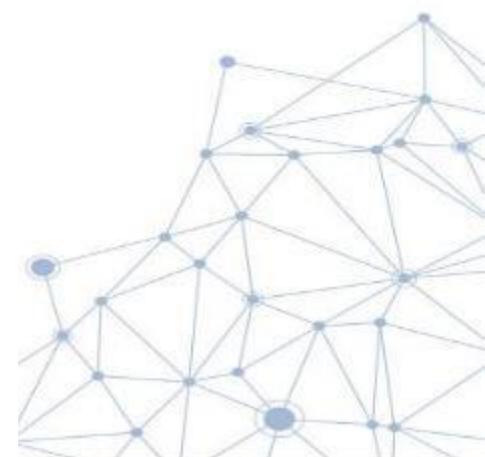
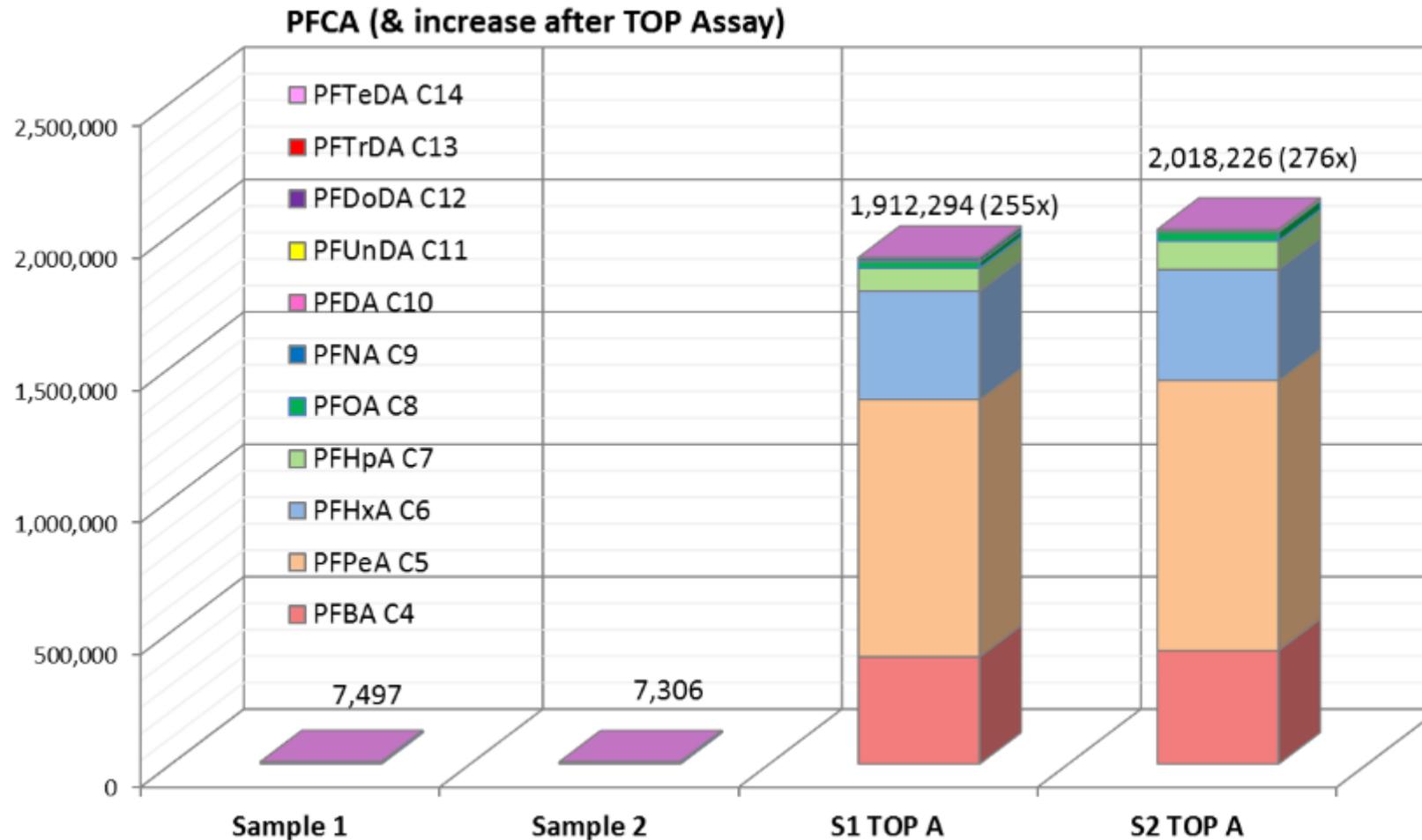
Persistence of Perfluoroalkyl Acid Precursors in AFFF-Impacted Groundwater and Soil

Erika F. Houtz,[†] Christopher P. Higgins,[‡] Jennifer A. Field,[§] and David L. Sedlak^{†,*}



Analytical tools fail to measure the hidden PFAS precursor mass, the TOP assay solves this

TOP Assay Applied to Surface Water from Recent C6 Fluorotelomer Foam Loss



Data Courtesy of Nigel Holmes Queensland DEHP

Chemical “Whack a Mole”

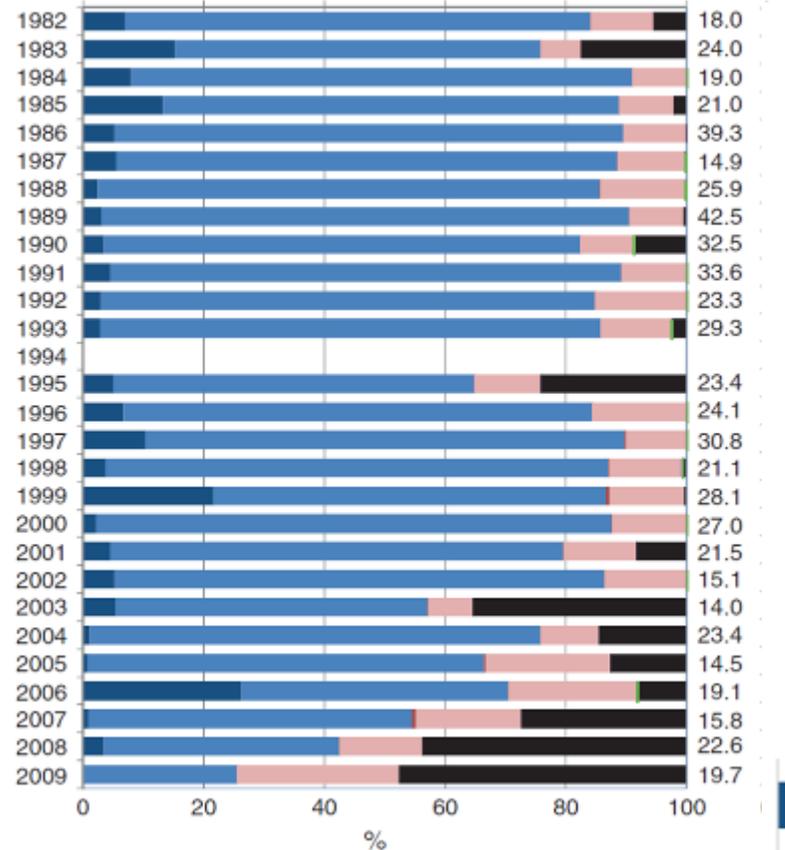
CSIRO PUBLISHING

Environ. Chem., 2016, 13, 102–110
<http://dx.doi.org/10.1039/C5EN00150A>

Are humans exposed to increasing amounts of unidentified organofluorine?

Leo W. Y. Yeung^A and Scott A. Mabury^{A,B}

ng F mL⁻¹



Science News

from research organizations

Novel PFAS comprise 24% of those measured in blood of Wilmington, N.C. residents

Date: July 22, 2020

Source: North Carolina State University

Summary: Researchers detected novel per- and polyfluoroalkyl substances (PFAS) called “fluoroethers” in blood from residents of Wilmington, North Carolina. The fluoroethers represented 24% of the total PFAS detected in the blood of Wilmington residents and appear to leave the body faster than legacy PFAS.

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In a new paper detailing findings from North Carolina State University's GenX Exposure Study, researchers detected novel per- and polyfluoroalkyl substances (PFAS) called “fluoroethers” in blood from residents of Wilmington, North Carolina. The fluoroethers -- Nafion byproduct 2, PFO4DA and PFO5DoA -- represented 24% of the total PFAS detected in the blood of Wilmington residents and appear to leave the body faster than legacy PFAS. These are the first measurements of these chemicals in humans.



Exposure from one PFAS replaced by another

Next Generation PFASs

Science Inventory

You are here: [EPA Home](#) » [Science Inventory](#) » [Assessing Generated In Vitro Toxicokinetic Data of Per- and Polyfluoroalkyl Substances \(PFAS\) with In Vitro-In Vivo Extrapolation \(IVIVE\)](#)

Assessing Generated In Vitro Toxicokinetic Data of Per- and Polyfluoroalkyl Substances (PFAS) with In Vitro-In Vivo Extrapolation (IVIVE)

Citation:

Smeltz, M., D. Crizer, Larry - RTP McMillan, G. Patlewicz, M. Devito, AND B. Wetmore. Assessing Generated In Vitro Toxicokinetic Data of Per- and Polyfluoroalkyl Substances (PFAS) with In Vitro-In Vivo Extrapolation (IVIVE). North Carolina Society of Toxicology Annual Fall Meeting, RTP, NC, September 21 - 23, 2020. <https://doi.org/10.23645/epacomptox.13203011>

Contact

CCTE@epa.gov

email: CCTE@epa.gov

Impact/Purpose:

This presentation will be given at the annual Fall meeting for the North Carolina chapter of the Society of Toxicology and is focused on utilizing in vitro toxicokinetic assays with PFAS. This meeting is being held virtually over three separate days in September 2020. Plasma protein binding for more than 50 PFAS was determined by ultracentrifugation. Hepatic clearance data from collaborators at NTP was also included to then perform IVIVE to predict systemic concentrations. Future work will examine toxicokinetic differences based on functional group and may help inform risk-based chemical safety assessment.

Fluorinated alternatives to long-chain perfluoroalkyl carboxylic acids (PFCAs), perfluoroalkane sulfonic acids (PFSA) and their potential precursors

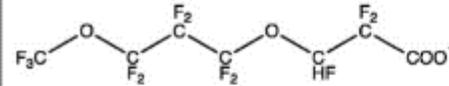
Zhanyun Wang^a, Ian T. Cousins^b, Martin Scheringer^{a,*}, Konrad Hungerbühler^a

^a Institute for Chemical and Bioengineering, ETH Zurich, Wolfgang-Pauli-Strasse 10, CH-8093 Zurich, Switzerland

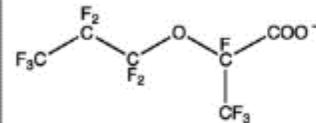
^b Department of Applied Environmental Science (ITM), Stockholm University, SE-10691 Stockholm, Sweden

Fluoropolymer manufacture

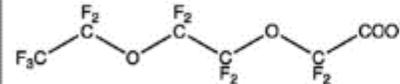
ADONA (CAS No. 958445-44-8)



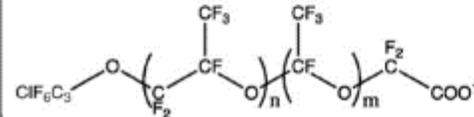
GenX (CAS No. 62037-80-3)



Asahi's product (CAS No. 908020-52-0)

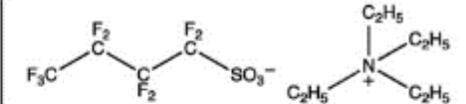


Solvay's product (CAS No. 329238-24-6)

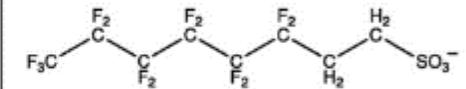


Metal plating

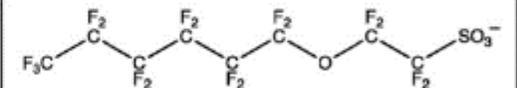
N(Et)₄-PFBS (CAS No. 25628-08-4)



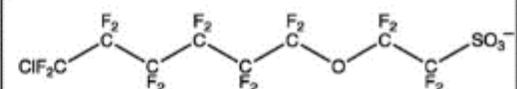
6:2 FTSA (CAS No. 27619-97-2)



F-53 (CAS No. 754925-54-7)



F-53B (CAS No. 73606-19-6)



PBT Applicability?

- For drinking water quality, PBT-based regulations are only marginally effective
- PBT aimed to protect food chain, not drinking water?
- In contrast, persistent and mobile organic compounds (PMOCs) are more of a concern for water quality because, like PCBs, they can persist in the environment, but they are not removed from water by sorption processes due to their high polarity and thus excellent water solubility
- Therefore, they may end up in drinking water, posing a potential risk to human health
- Umweltbundesamt (UBA) suggesting alternative assessment frameworks:
 - PMT **P**ersistent **M**obile **T**oxic
 - vPvM very **P**ersistent and very **M**obile as potential Substances of Very High Concern

ENVIRONMENTAL
Science & Technology

Mind the Gap: Persistent and Mobile Organic Compounds—Water Contaminants That Slip Through

Theoosten Reemtsma,^{1*} Urs Berger,¹ Hans Peter H. Arp,¹ Hervé Gallard,² Thomas P. Knepper,¹ Michael Neumann,³ José Benito Quintana,⁴ and Pin de Voogt^{5,6}



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German environment agency updates criteria for 'mobile' chemicals in water

Now includes vPvM category

13 October 2017 / Cosmotoxicology, Europe, PBT/vPvD

Germany's federal environment agency (UBA) has updated its proposal for implementing criteria to identify persistent, mobile and toxic (PMT) substances, following comments from EU member states and industry. The revised document now includes a very persistent, very mobile (vPvM) category.



The agency first published its proposal to introduce a PMT classification for substances in drinking and ground water in May. The aim is for such compounds to qualify for inclusion on the REACH candidate list. The agency also hopes that chemical manufacturers and downstream users will adopt its proposed criteria and assessment procedure, to identify PM/PMT substances during product development.

Short chain replacement PFAS more mobile so more potential to impact drinking water

Concerns over short chain PFAS - Overview

Persistent

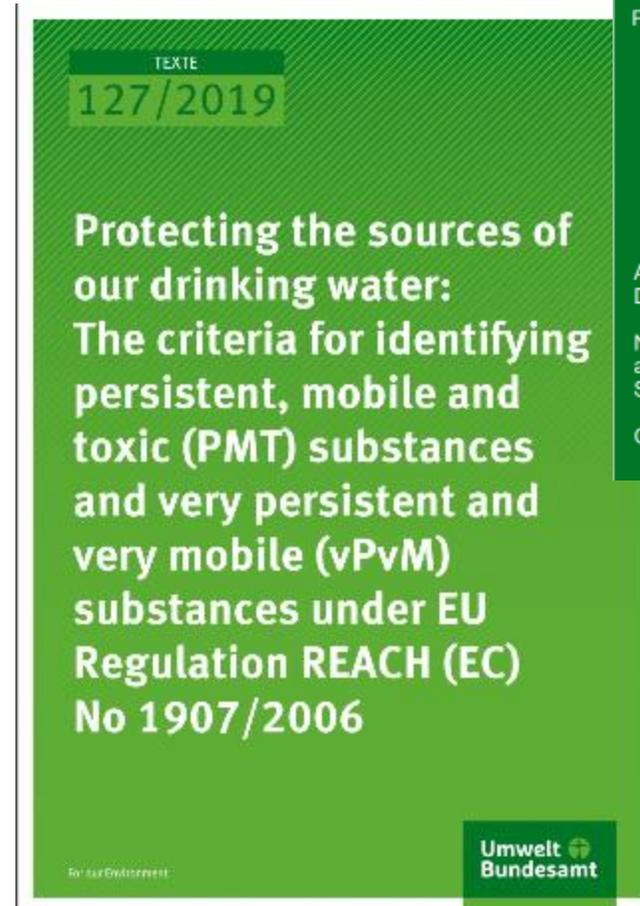
- Based on read-across from long chain PFAS
- Long-range transport and findings in remote areas

Mobility and Exposure of Organisms

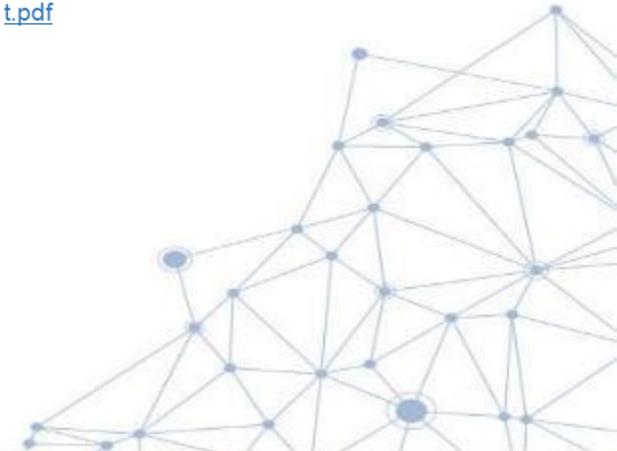
- Potential to contaminate drinking water resources
- Difficult to be removed from water
- Binding to proteins
- Non-negligible half-lives in organisms
- Enrichment in plants

Toxic

- No indications of ecotoxicity
- Toxicity in humans to be assessed
- Potential endocrine disruptor



https://www.umweltbundesamt.de/sites/default/files/medien/421/dokumente/01_uba_eisentrager_pmt.pdf



Regulation of PFHxA

- EU proposal to limit the use of PFHxA related substances (precursors) – December 2019;
- Rationale:
 - *“Fulfils the P-criterion and vP-criterion”*
 - *“Mobility and long range transport potential”* and *“unpredictable and irreversible adverse effects on the environment or human health over time”*
- Exemptions (5 years) are in place for certain uses:
 - Hard chrome plating;
 - Photographic coatings;
 - Firefighting foams – **Emergency use only**
 - There is **no exemption** for testing (unless all releases contained) or training with fire fighting foams.
- Exemptions (12 year) are in place for Class B firefighting foams used to protect storage tanks with a surface area **above** 500m²
- Military users exempted – Requirement that during training foam contained and disposed of safely
- The EU considers the restriction practical as it is affordable, implementable, and manageable

ANNEX XV RESTRICTION REPORT

PROPOSAL FOR A RESTRICTION



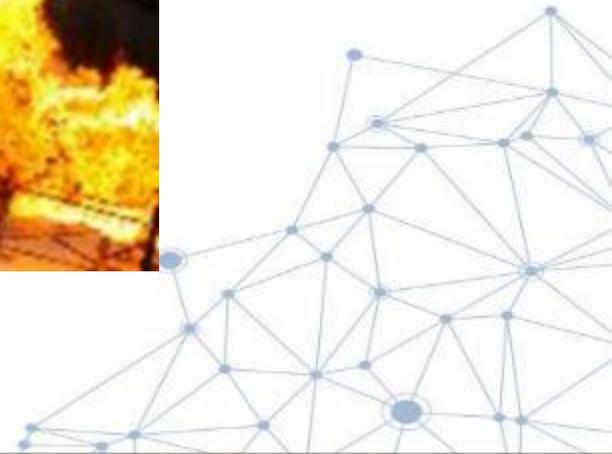
SUBSTANCE NAMES:

Undecafluorohexanoic acid (PFHxA), its salts and related substances



Potential Locations of PFAS Point Source Contamination

- Primary Manufacturing (e.g. for PTFE)
- Product manufacturing: carpets, paints, paper coating, leather tanneries, metal plating, textiles
- Fire Training Sites: Airports, Civil, Defence, Petrochemical, Rail Yards
- Sites of hydrocarbon fires, since late 1960's e.g. Buncefield
- Car wash/wax, dry cleaners, ash pits
- Sprinkler systems -warehouses, aircraft hangars, car workshops, pharmaceutical plants
- Wastewater treatment plants – biosolid waste
- Landfills



Soils / Concrete are Long Lasting Sources of PFASs

- The unsaturated zones continue to be a source of PFASs to the groundwater after **18 years** (FTA-1) and **20 years** (infiltration beds) of inactivity.
- Some precursors are mobile at this field site
- Results indicate that shorter chain length PFAAs are more mobile than PFOS both vertically and horizontally.
- Significant long PFOS retained at the surface (top 0.5 cm) of 12 cm concrete core
- Long term leaching of PFOS from concrete surfaces is an ongoing issue with potential for impacted run off and surface water impacts for >80 years

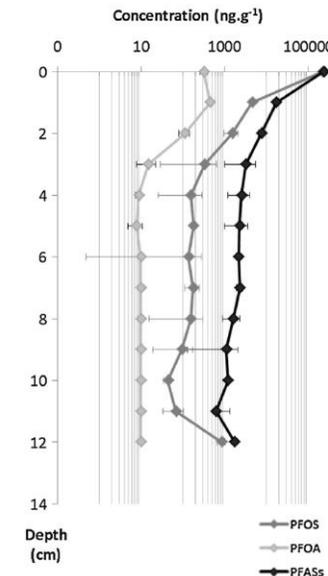
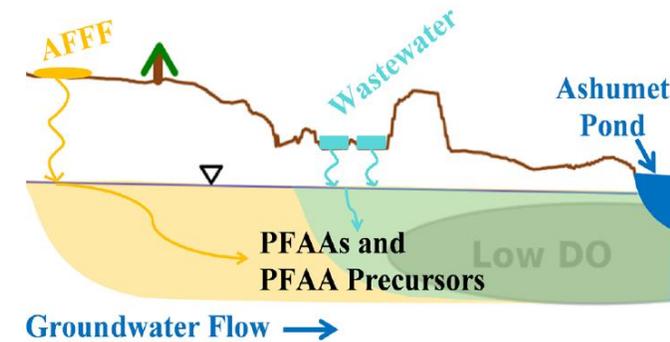


Fig. 3. Vertical profile contamination (ng.g⁻¹) of PFOS, PFOA and Σ PFASs in the concrete at site #14 close to the out flow pipe. The concentration is an average of the two core profiles and the error bars represent the standard variation between these two values. More compounds are presented in Supplementary material S3(b).

Geochemical and Hydrologic Factors Controlling Subsurface Transport of Poly- and Perfluoroalkyl Substances, Cape Cod, Massachusetts

Andrea K. Weber,¹ Larry B. Barber,² Denis R. LeBlanc,³ Elsie M. Sunderland,^{1,2} and Chad D. Vecitis^{4,5}



Worldwide Distribution of Novel Perfluoroether Carboxylic and Sulfonic Acids in Surface Water

Yitao Pan,^{†,‡,⊥} Hongxia Zhang,^{†,⊥} Qianqian Cui,[‡] Nan Sheng,[‡] Leo W. Y. Yeung,[§] Yan Sun,^{||} Yong Guo,^{||} and Jiayin Dai^{*,†,⊥}

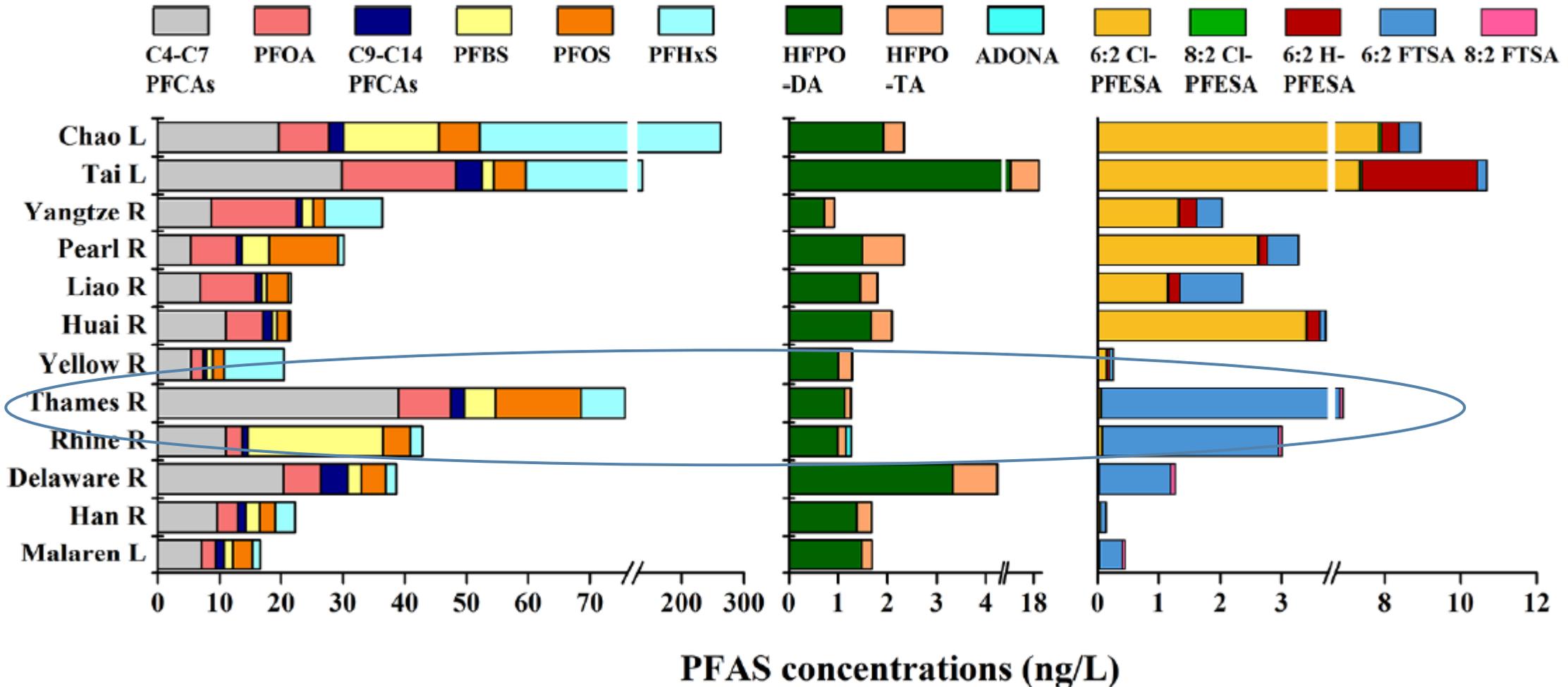
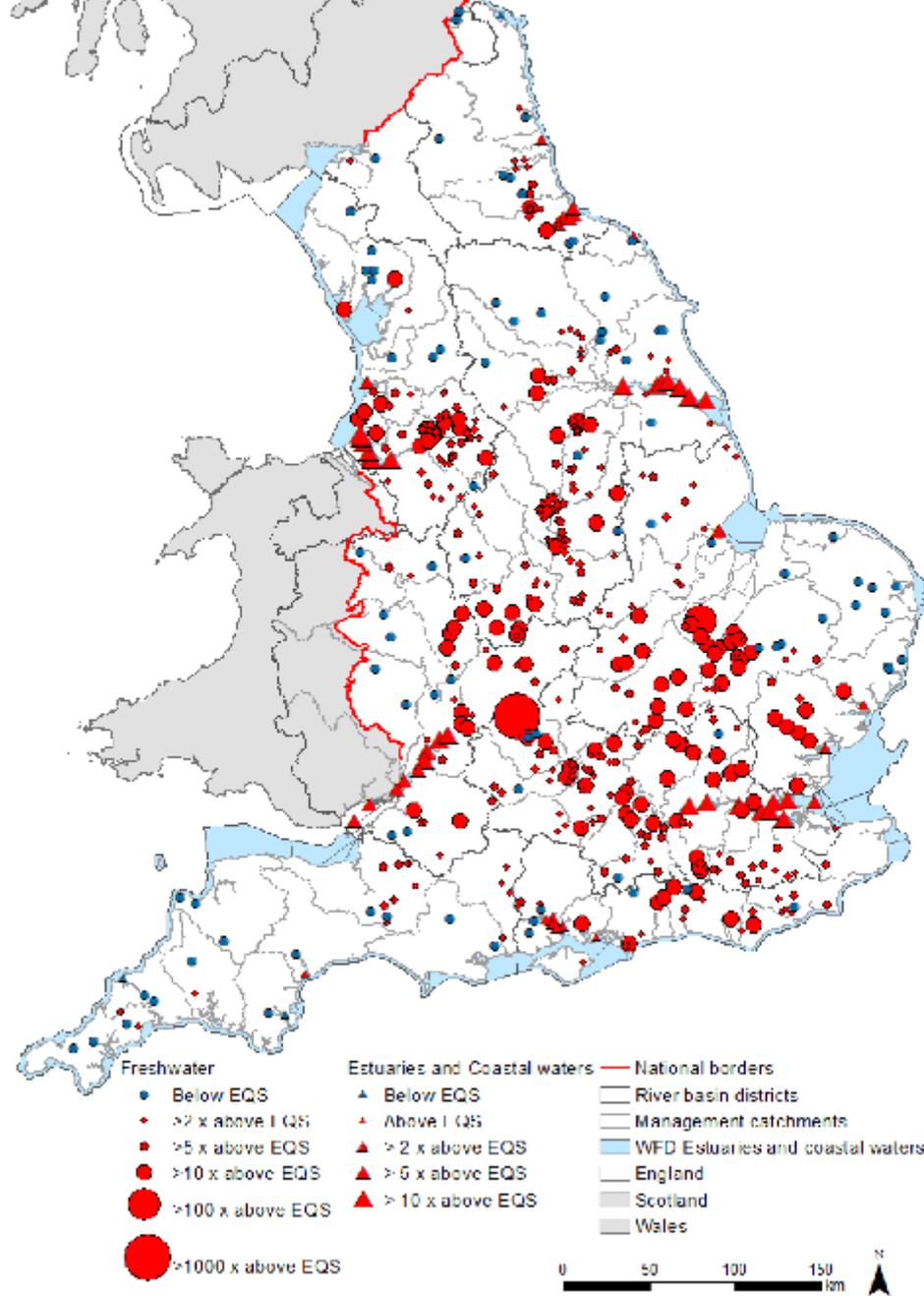


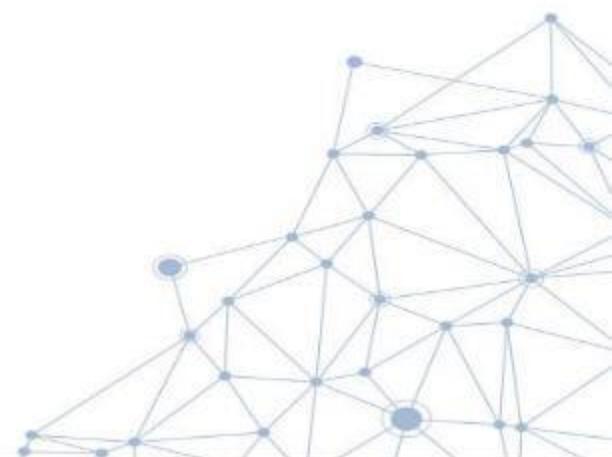
Figure 2. Mean concentrations (ng/L) of legacy PFASs (PFCAs and PFESAs) and fluorinated alternatives (PFECAs, PFESAs, and FTSA) in the studied rivers and lakes: Chao Lake ($n = 13$), Tai Lake ($n = 15$), Yangtze River ($n = 35$), Pearl River ($n = 13$), Liao River ($n = 6$), Huai River ($n = 9$), Yellow River ($n = 15$), Thames River ($n = 6$), Rhine River ($n = 20$), Delaware River ($n = 12$), Han River ($n = 6$), and Mälaren Lake ($n = 10$).

PFOS EQS Exceedances



Perfluorooctane sulfonate (PFOS) and related substances: sources, pathways and environmental data

October 2019



Principle Exposure Route – Drinking Water

2016



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Monitoring Unregulated Drinking Water Contaminants

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About the Unregulated Contaminant Monitoring Rule (UCMR)

Meetings & Materials

Laboratory Approval Program

Occurrence Data

Reporting Requirements

UCMR 5

Third Unregulated Contaminant Monitoring Rule

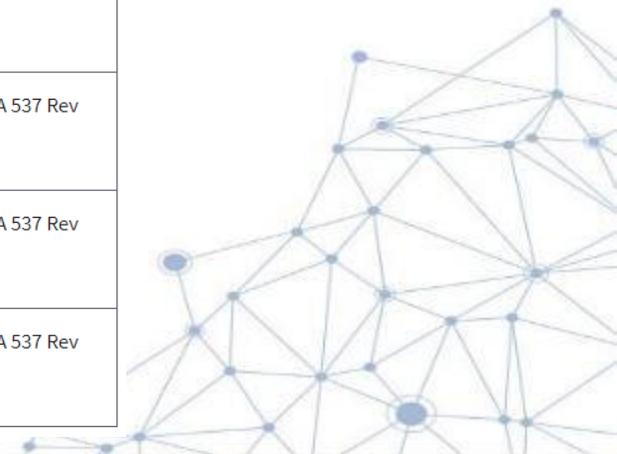
The 1996 Safe Drinking Water Act (SDWA) amendments require that once every five years EPA issue a new list of no more than 30 unregulated contaminants to be monitored by public water systems (PWSs).

The third Unregulated Contaminant Monitoring Rule (UCMR 3) was published on May 2, 2012. UCMR 3 required monitoring for 30 contaminants (28 chemicals and two viruses) between 2013 and 2015 using analytical methods developed by EPA, consensus organizations or both. This monitoring provides a basis for future regulatory actions to protect public health.

- [Federal Register Notice: Final Revisions to the UCMR 3 for Public Water Systems, May 2, 2012](#)
- [UCMR 3 Basic Information Fact Sheet](#)
- [EPA Approved Laboratories for UCMR 3](#)

Six Perfluorinated Compounds

Contaminant	CAS Registry Number ¹	Minimum Reporting Level	Sampling Points ²	Analytical Methods
perfluorooctanesulfonic acid (PFOS)	1763-23-1	0.04 µg/L	EPTDS	EPA 537 Rev 1.1
perfluorooctanoic acid (PFOA)	335-67-1	0.02 µg/L	EPTDS	EPA 537 Rev 1.1
perfluorononanoic acid (PFNA)	375-95-1	0.02 µg/L	EPTDS	EPA 537 Rev 1.1
perfluorohexanesulfonic acid (PFHxS)	355-46-4	0.03 µg/L	EPTDS	EPA 537 Rev 1.1
perfluoroheptanoic acid (PFHpA)	375-85-9	0.01 µg/L	EPTDS	EPA 537 Rev 1.1
perfluorobutanesulfonic acid (PFBS)	375-73-5	0.09 µg/L	EPTDS	EPA 537 Rev 1.1



EPA examines 29 PFAS

2021



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Monitoring Unregulated Drinking Water Contaminants

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Fifth Unregulated Contaminant Monitoring Rule

The Safe Drinking Water Act (SDWA) requires that once every five years EPA issue a new list of unregulated contaminants to be monitored by public water systems (PWSs).

The proposed fifth Unregulated Contaminant Monitoring Rule (UCMR 5) was published on March 11, 2021. UCMR 5, as proposed, would require sample collection for 30 chemical contaminants between 2023 and 2025 using analytical methods developed by EPA and consensus organizations. This proposed action would provide EPA, states, and communities with scientifically valid data on the national occurrence of these contaminants in drinking water. The proposed UCMR 5 would provide new data that is critically needed to improve EPA's understanding of the frequency that 29 PFAS are found in the nation's drinking water systems and at what levels. EPA will accept public comment on the proposed UCMR 5 for 60 days, following publication in the Federal Register. EPA will also hold a virtual stakeholder meeting twice during the public comment period.

- [40 CFR \(Code of Federal Regulations, Title 40\) Part 141: Proposal - Revisions to the Unregulated Contaminant Monitoring Rule \(UCMR 5\) for Public Water Systems and Announcement of a Public Meeting \(PDF\)](#) (27 pp, 440 K, About PDF)
- [Press Release: EPA Takes Action to Address PFAS in Drinking Water](#)
- [UCMR 5 Fact Sheet](#)
- [Public Stakeholder Meeting \(Webinar\): April 6 and 7, 2021](#)

Table 2. Contaminants, Minimum Reporting Levels, Sampling Locations, and Analytical Methods
Twenty-nine Per- and Polyfluoroalkyl Substances

Contaminant	Chemical Abstract Service Registry Number (CASRN)	Minimum Reporting Level	Sample Point Location ¹	Analytical Methods
11-difluoro-2,2,6,6-tetrafluoro-3-oxoheptanoic acid (LUC) (PFOS)	75292-82-9	0.025 µg/L	EP105	EPA Method 533
9-difluoro-2,2,6,6-tetrafluoro-3-oxooctanoic acid (LUC) (PFOS)	75292-82-9	0.025 µg/L	EP105	EPA Method 533
1,8-difluoro-2,4-perfluorooctanoic acid (PFDA)	81025-14-4	0.025 µg/L	EP105	EPA Method 533
hexafluoropyrene dicarboxylic acid (PFDA)	24252-12-9	0.025 µg/L	EP105	EPA Method 533
hexafluoro-2,5-dioxoheptanoic acid (PFHxH)	15172-58-6	0.025 µg/L	EP105	EPA Method 533
perfluorobutanoic acid (PFBA)	375-27-4	0.025 µg/L	EP105	EPA Method 533
perfluorobutanoic acid (PFBA)	275-72-9	0.025 µg/L	EP105	EPA Method 533
1,1,1,1-tetra(2,4,6-trifluorophenyl)ethane sulfonic acid (PFES)	33134-31-1	0.025 µg/L	EP105	EPA Method 533
perfluorodecanoic acid (PFDA)	335-75-7	0.025 µg/L	EP105	EPA Method 533
perfluorododecanoic acid (PFDA)	327-29-1	0.025 µg/L	EP105	EPA Method 533
perfluoro(2-ethylhexyl)sulfonic acid (PFES)	118537-82-7	0.025 µg/L	EP105	EPA Method 533
perfluorohexanoic acid (PFHx)	375-40-4	0.025 µg/L	EP105	EPA Method 533

perfluorheptanoic acid (PFHx)	375-51-0	0.025 µg/L	EP105	EPA Method 533
1,1,1,1-tetra(2,4,6-trifluorophenyl)ethane sulfonic acid (PFES)	33134-31-1	0.025 µg/L	EP105	EPA Method 533
perfluorundecanoic acid (PFDA)	335-45-4	0.025 µg/L	EP105	EPA Method 533
perfluorooctanoic acid (PFHx)	307-24-1	0.025 µg/L	EP105	EPA Method 533
perfluoro-3-methylpentanoic acid (PFHx)	377-73-1	0.025 µg/L	EP105	EPA Method 533
perfluoro-4-methylbutanoic acid (PFHx)	60390-99-6	0.025 µg/L	EP105	EPA Method 533
perfluorooctanoic acid (PFHx)	375-55-1	0.025 µg/L	EP105	EPA Method 533
1,1,1,1-tetra(2,4,6-trifluorophenyl)ethane sulfonic acid (PFES)	33134-31-1	0.025 µg/L	EP105	EPA Method 533
perfluorodecanoic acid (PFDA)	335-75-7	0.025 µg/L	EP105	EPA Method 533
perfluorododecanoic acid (PFDA)	327-29-1	0.025 µg/L	EP105	EPA Method 533
perfluoropentanoic acid (PFHx)	2706-30-3	0.025 µg/L	EP105	EPA Method 533
perfluoropentanoic acid (PFHx)	2704-31-4	0.025 µg/L	EP105	EPA Method 533
Perfluoroundecanoic acid (PFDA)	2058-34-8	0.025 µg/L	EP105	EPA Method 533
N-methyl perfluorooctanesulfonamide sulfonic acid (MFOSSA)	2061-52-4	0.025 µg/L	EP105	EPA Method 533.L
N-methyl perfluorodecane sulfonamide sulfonic acid (MFDSSA)	2255-31-9	0.025 µg/L	EP105	EPA Method 533.L
perfluorodecanoic acid (PFDA)	335-75-7	0.025 µg/L	EP105	EPA Method 533.L
perfluorododecanoic acid (PFDA)	327-29-1	0.025 µg/L	EP105	EPA Method 533.L



Groundwater Risks to Receptors

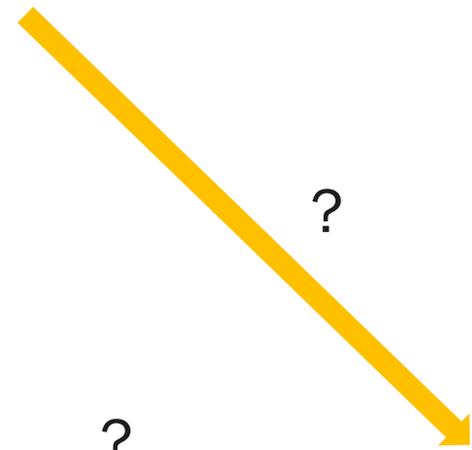
- Landfill Leachate
- Municipal / Domestic WWTP
- Industry & Manufacturing
- Agricultural Land
- Commercial / Domestic Products
- Metal Plating
- Car Wash/Wax
- ASTs – Fuel storage (FFFP / FP)

- AFFF / FFFP / FP
- Fire training
- Incident Response



?

Diffuse
Ground level impacts and ground/surface water



?

?

Source – Pathway – Receptor
High concentration, spill site, route via groundwater to receptor e.g. drinking water well



Grasshopper effect
via widening of source zones
e.g. concentrated plume intercepts crop spray irrigation to make secondary wider source area for more dilute plume



Incineration

- 1,000 to 1,200 °C required to completely degrade PFOS
- Lower temperature incineration of PFASs can produce toxic intermediates (e.g. perfluoroisobutylene)
- Not proven effective for liquid wastes, potential for steam expansion i.e. AFFF concentrates – U.S. litigation
- Incinerator ash pits source of PFAS to groundwater
- Potent greenhouse gases (CF₄, C₂F₆ etc.) require 1,400 °C for destruction – above incineration temperatures
- Comprehensive analysis of all gaseous emissions required for any thermal treatment
- Cement kilns one potential solution but several technologies potentially applicable – sonolysis, plasma, electrochemical oxidation, supercritical water etc.



Understanding and Managing the Potential By-Products of PFAS Destruction

by John Horst, Jeffrey McDonough, Ian Ross, and Erika Houtz

DISPOSAL OF AFFF, FFFP AND FP: CHALLENGES AND EMERGING SOLUTIONS

Ian Ross Ph.D., Arcadis, Leeds, West Yorkshire, UK.

Increasing attention to the environmental and human health effects of per- and polyfluorinated substances (PFAS) is leading to the development of increasingly conservative (and) regulatory limits for PFAS in drinking water, soil, groundwater, sediments and surface waters [1-5]. As an increasing number of PFASs, including both long chain (C8 and longer) and short chain (C4-C7) are regulated in drinking water, surface waters, soil and groundwater [4, 6] and the use of firefighting foams containing PFASs are being restricted in certain jurisdictions, with many foam users now or have transitioned to using fluorine free firefighting [7], foam [2, 8]. With their very different performance profiles, conventional and fluorine free foams (FFFP) have since 2012 [9]. As a result of the transition to FFP foams, increasing volumes of fluorinated firefighting foams require treatment, with traditional disposal options being challenged. A range of alternative technologies are being developed.

Fluorinated foams that contain PFASs include not just aqueous film forming foams (AFFF) but also fluorosurfactant based foams (FFFP) and fluoropolymer based foams (FP). The chemical structure of the water carrying PFAS is a derivative of the PFAS. The chemical stability that has enabled the use of PFAS for the regulated and controlled uses makes the class of compounds extremely difficult and expensive to destroy in liquid waste streams. There is often confusion regarding the many concepts used to describe different PFAS, so to provide some clarity regarding PFASs, the term PFAS or PFASs is often used. The term PFASs is often used to describe PFASs, including C8, C6 and fluorosurfactant based foams and will be the term used in this article, unless stated as perfluorinated (PF) [1]. To date, most PFAS in firefighting foam and other products that are available are perfluorinated (PF) [1].

Fluorinated foams, characterised by their stable polyfluorinated "precursors" in the regulated PFASs, are produced using a combination of different methods. This combination assesses the concentrations of perfluorinated PFASs in the regulated foams [5, 12].

Fluorinated foams that contain PFASs usually include high concentrations of glycols along with lower concentrations of hydrocarbon-based surfactants. Additives such as polyphosphate salts, organic nucleation inhibitors and stabilisers are also often included [13]. This combination of surfactants provides PFASs excellent stability, high concentrations of long-chain perfluorinated hydrocarbons (PFH) are used to biodegrade all PFAS in the environment [14].

Expanded fluorinated foams and foam concentrates cannot be treated using traditional wastewater treatment plants, meaning municipal sewage treatment or publicly operated wastewater works (POTW) cannot treat PFAS. The top volume of AFFF, FFP and FP concentrate or foam

should not be disposed to any full sewer, as biological treatment is not possible using conventional biological wastewater treatment plants [15]. Multiple foams in AFFF have been shown as a result of PFAS associated with toxicological impacts and soil [16]. Disposal of fluorine free foams via a sewer will be limited, since the foam surfactants contained there will not be biodegradable. This data can only be used to support disposal via the sewerage system in conventional biological treatment plants will be limited.

The foam foam is a recent preliminary report describing that an extremely slow growing microorganism may be degrading PFASs but these initial and limited reports require replication [16]. The organisms described only survived in high rich nutrient environments where it was not necessary to consume energy, which are extreme niche conditions. Aerobic wastewater treatment plants are available, although there have been concerns that the effluent for treatment of PFAS [14, 17].

PFAS have not been reported to be present in effluent from wastewater treatment plants with a very limited number of long-chain perfluorinated organics produced by plants [18]. To maintain these standards, designers to the infrastructure for wastewater treatment have not been advised to PFAS prior to the 1990s. It may take millions of years for them to arrive in the atmosphere via the flow, and many other compounds being metabolised in preference. Thus, PFAS are likely to be found in a variety of food to maintain food chain and surface areas [19].

https://earthjustice.org/sites/default/files/files/filed_complaint_-_pfas_incineration_suit.pdf

<https://joiff.com/wp-content/uploads/2020/11/Catalyst-Q4-FINAL.pdf>

https://www.epa.gov/sites/production/files/2019-09/documents/technical_brief_pfas_incineration_ioaa_approved_final_july_2019.pdf

<https://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+7708>

Biosolids as a PFAS Source to Groundwater / Milk

HEALTH DRINKING WATER INVESTIGATIONS TESTING FISH AND WILDLIFE PFAS FOAM MPART
 PFAS RESPONSE / INVESTIGATIONS / PFAS SITES

Kent County, Grand Rapids, Grand Rapids Water Resource Recovery Facility, Former Incinerator Ash Lagoon

Congress: Tell the Pentagon to halt incineration of toxic forever chemicals

BY JUSTIN DECK, OPINION CONTRIBUTOR — 06/06/20 09:30 AM EDT
 THE VIEWS EXPRESSED BY CONTRIBUTORS ARE THEIR OWN AND NOT THE VIEW OF THE HILL

164 SHARES



For 50 years, the Department of Defense (DoD) has known that military-grade firefighting foam, known as Aqueous Film Forming Foam, or AFFF, is toxic. Now in defiance of Congress, it is racing to burn it at incinerators across the country.

What makes AFFF so toxic is a class of manmade chemicals known as PFAS, which are often referred to as “forever chemicals” because of their incredibly strong chemical bond. Exposure to PFAS is associated with a variety of health risks, including cancer, thyroid disruption, reproductive and developmental harms and suppressed immune system function.

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https://www.michigan.gov/pfasresponse/0,9038,7-365-86511_95645-529272--,00.html

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...ound the former lagoon. gled all eight groundwater monitoring wells on-site for PFAS. lts to EGLE for review. This report indicated that two nards.

New Mexico 'This has poisoned everything' - pollution casts shadow over New Mexico's booming dairy industry

Pollution from Cannon air force base has gone unreported for decades. Now it's threatening the US food supply



▲ An Scharp looks over some of his 4,000 dairy cows at his farm in Clovis, New Mexico. Photograph: Dan...
 News/Searchlight New Mexico

Amy Linn, Searchlight New Mexico

Wed 20 Feb 2019 11:00 GMT



3,436

<https://www.theguardian.com/us-news/2019/feb/20/new-mexico-contamination-dairy-industry-pollution>

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Jul 30, 2020
 by Sharon Angin Treat

Just days before the Maine Legislature's Judiciary Committee was scheduled to hold a virtual hearing on LD 2150 — legislation to clarify when civil lawsuits may be filed for compensation for harm from Per- and Polyfluorinated Substances (PFAS) contamination — a second dairy and beef farm was found by Maine's Department of Agriculture, Conservation and Forestry to have “very startling” levels of PFOS, one of the PFAS family of chemicals.

In fact, the amount of PFOS in milk from the dairy herd at the Toule farm in Somerset County was worse than “startling” — it may be the highest milk contamination levels ever recorded in North America. Measurements in late June and early July ranged from 12,700 to 82,200 parts per billion (ppb). The highest reading is 153 times Maine's standard for determining that milk is “acceptable” and unfit for sale (80 ng/l). As a result, the farm has been forced to stop selling its milk and beef.

<https://www.iatp.org/blog/202007/second-farm-shuttered-due-to-massive-pfas-contamination-maine-legislators-weigh-easing>

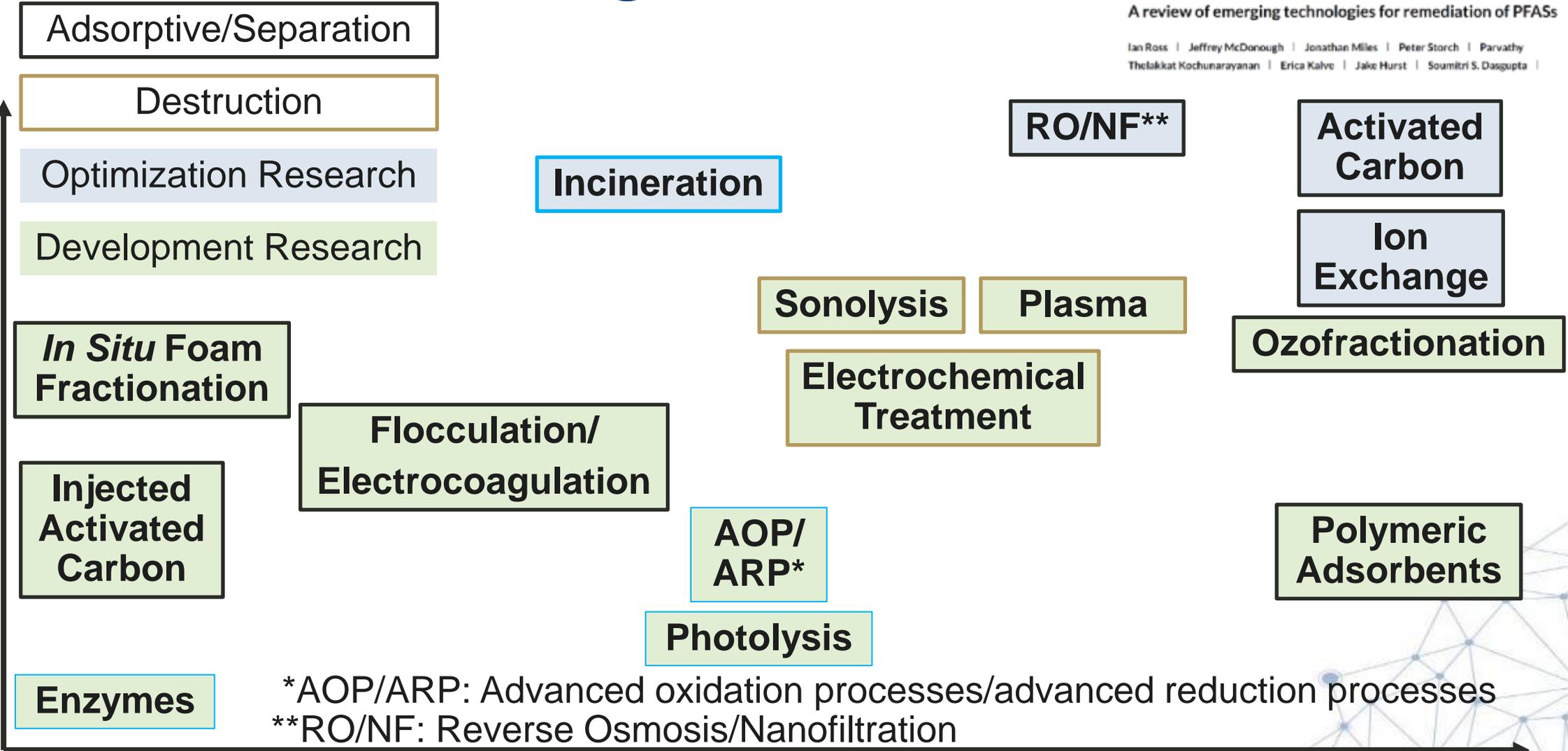


PFAS Treatment Technologies for Water

Stage of Development

Mature

Experimental



*AOP/ARP: Advanced oxidation processes/advanced reduction processes
 **RO/NF: Reverse Osmosis/Nanofiltration

Not Viable

Practicability

Feasible

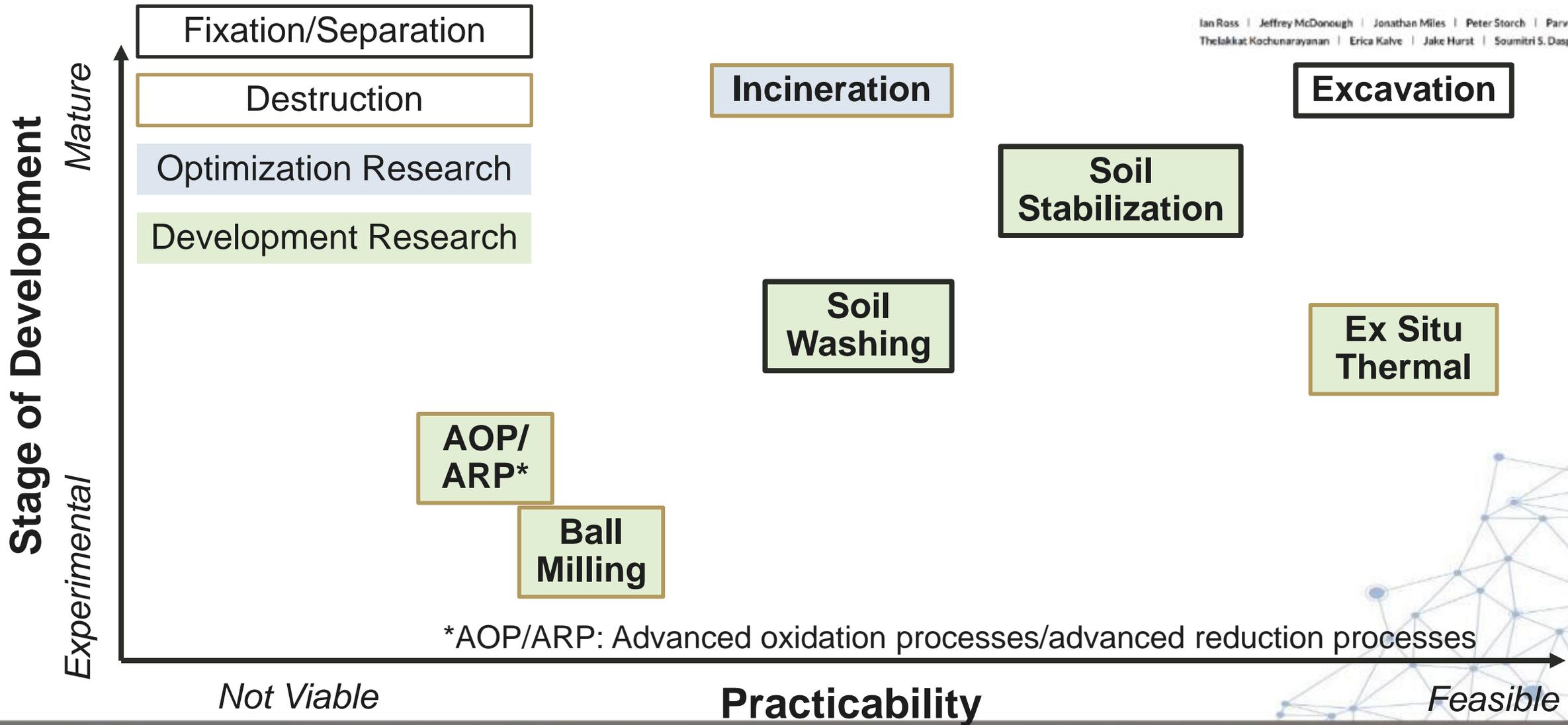
PFAS Treatment Technologies for Soil/Sediment

RESEARCH ARTICLE

WILEY

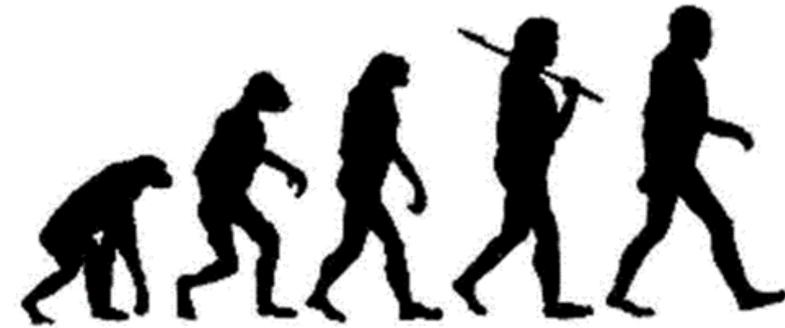
A review of emerging technologies for remediation of PFASs

Ian Ross | Jeffrey McDonough | Jonathan Miles | Peter Storch | Parvathy Thelakkat Kochunarayanan | Erica Kalve | Jake Hurst | Soumitri S. Dasgupta |



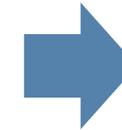
PFAS Foams being Replaced

- C8 (PFOS) generally phased-out, replaced with foams containing C6 and C8 (20% PFOA precursors)
- C6-pure foams with shorter (C6) perfluorinated chains, still contain PFOA and precursors
- C4, C6 PFAS are less bioaccumulative, but extremely persistent and more mobile in aquifer systems vs C8 - more difficult and expensive to treat in water.
- Regulations addressing multiple chain length PFAS (long and short) are evolving globally – **PFHxA restrictions coming**
- Fluorine free (F3) foams contain no persistent pollutants
- F3 foams pass ICAO tests with highest ratings for extinguishment times and burn-back resistance and are widely available as replacements to AFFF
- Lastfire Independent Large Scale Storage Tank Test Program Results 2018: *“It is not possible to state, for example, that all C6 foams demonstrate better performance than all FF foams and vice versa”*



C8

C6



F3 Foams

AFFF

FFFP

FP

AR-AFFF

AR-FFF



Research Work – Rational Progression - more than 200 tests



Small scale
Simulated tank fire
Critical application rates



Phases have included
Different foams
Different nozzles
Different application methods
Different rates
Different fuels (including crud)
Different preburns
Fresh/Salt water

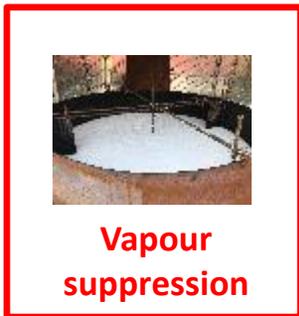


Spill fire
Critical application rates

Larger scale
“Real life” Application
NFPA rates



Longer flow
“Real life” Application
NFPA rates



Transition to Green Chemistry

Denmark just became the first country to ban a toxic lining common in food containers



The group of members also included national parliament members, who were able to pass the ban on Monday (Sept. 2) after a long debate.

Denmark on Monday (Sept. 2) has become the first country to ban PFAS from food packaging. It is the first time a country has banned PFAS from food packaging, including microwave popcorn bags, baking paper, and other food packaging.

By Zak Schlarger
Government Reporter
@zak_schlarger



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Fighting fire with fluorine-free foams



Fluororganic compounds are common in firefighting foams due to their performance boosting effects. Some per-fluorinated substances are recognised as having adverse effects on our health and the environment. As a result, the manufacturers of firefighting foams are investing in the development of new, improved fluorine-free foam concentrates. A serious challenge since high-risk areas such as the chemical and petrochemical industry require foams with the highest possible performance. Today, European manufacturers offer a new generation of high performing fluorine-free foams for various applications.

Two of these companies share their experience in replacing fluorine-based foams with safer substances.

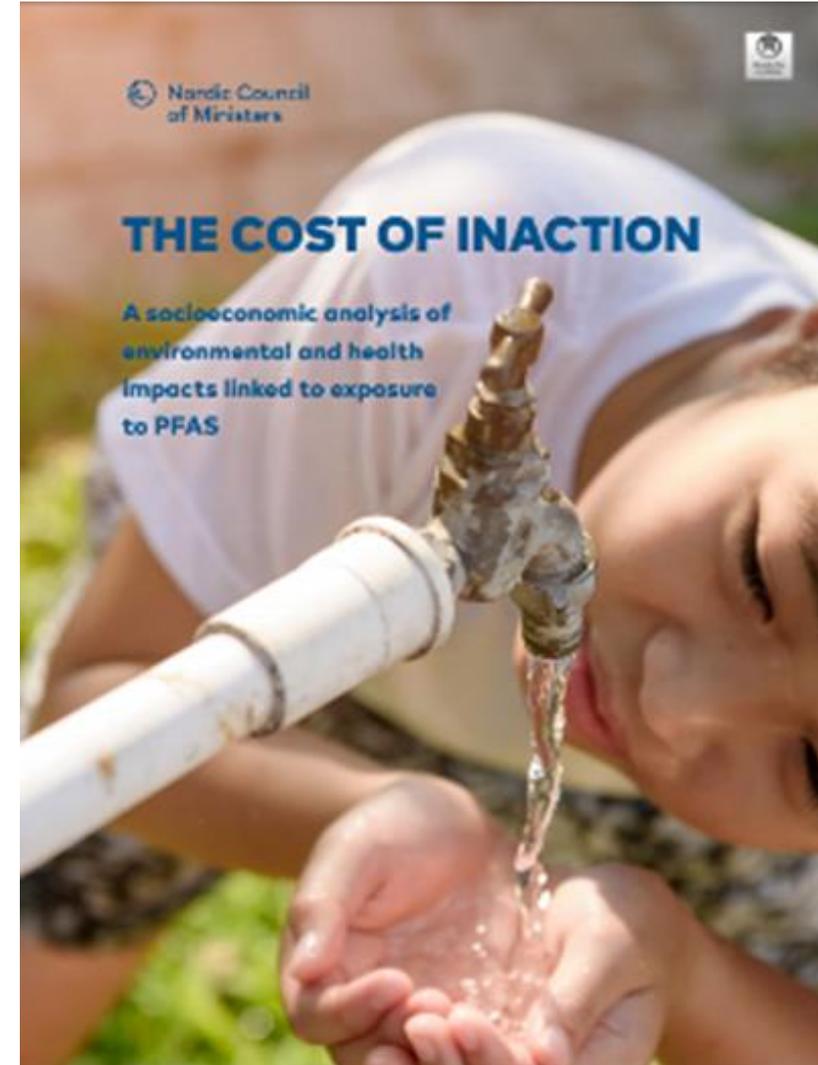
From the beginning of our existence, we were convinced of the negative impact of fluorine and focused our research into finding a good alternative without fluorinated derivatives," says Ms Audrey Rossard, Technical Manager, from the French company BIO-EX.

BIO-EX sold their first fluorine-free foam in 2002. Their environmental challenge has been to convince their customers to choose their new generation of green products, which are 100 % fluorine free, and have proven to be effective.

"We haven't just made a simple substitution of the fluorinated surfactant, but have worked with all the constituents of the formula to develop the best product," says Ms Rossard.

The Cost of Inaction

- Non-health costs, e.g., treatment of contaminated drinking water, are estimated to range between 16.9 and 170.8 billion EUR over the next 20 years. The estimates are based on actual costs of PFAS contamination incurred by communities and industries in the U.S. and Sweden.
- Health-related costs may be even higher. Epidemiological research on PFAS exposures of workers and communities with contaminated drinking water indicates that annual health-related costs range between 52 and 85 billion EUR each year.



Summary

Challenges

- PFAS diversity - short chains and ethers replacing long chains
- Proprietary precursors form PFAAs
- Uncertain toxicology of broader group of PFAS
- A significant mass of PFASs in source areas can bleed PFASs to form plumes for decades

Solutions

- Total PFAS can be detected –TOP assay
- Rapid In Vitro toxicological screening started
- Evaluation of exposure pathways and development of site specific CSMs essential for PFAS management
- Multiple remediation technologies evolving
- Effective and green substitutions for PFAS often available

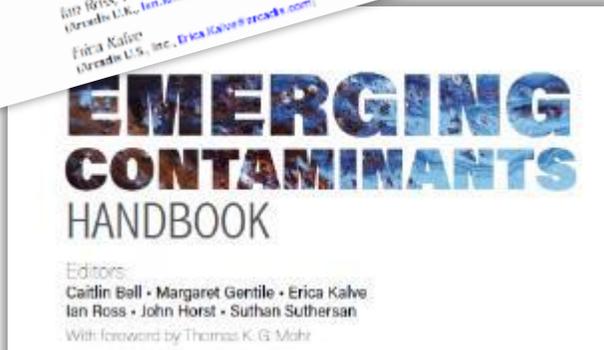


PFAS Publications

3 Per- and Polyfluoroalkyl Substances

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DOI: 10.1002/re

RESEARCH

A review

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Next
fire
Jeff

CLAIRE

CLAIRE technical sites in the UK approaches to manage

Managing and Pol

1. **SETTING 1**

Per- and polyfluoroalkyl (PFAS) substances are a diverse group of chemicals with a wide range of uses. They are found in many consumer products, including firefighting foams, and are persistent in the environment. This technical bulletin provides an overview of the current regulatory landscape for PFAS in the UK, including the new PFAS (S) Regulations 2020, and discusses the challenges of managing these substances in the context of the UK's environmental and public health objectives.

2. PFAS CHE

2.1. Types of P

PFASs are a very diverse group of chemicals, defined by the presence of a perfluorinated (PF) chain, known as the 'backbone'. The backbone can be fully fluorinated (PF) or partially fluorinated (PFAS). The backbone is typically composed of carbon and fluorine atoms, with the fluorine atoms providing the chemical stability and persistence of the molecule.

As the global (PFAS)s continue to grow, it is essential that we have a better understanding of the risks they pose to the environment and human health.

TH Q2

Understanding By-Products

By John Horst

Introduction

Over the past few years, there has been a significant increase in the number of PFAS (S) Regulations (S) in the UK. This is due to the growing concern over the potential health and environmental impacts of these substances. The new regulations require manufacturers and importers to provide information on the presence of PFAS in their products, and to take steps to reduce the use of these substances where possible.

Background

The current regulatory landscape for PFAS in the UK is complex, with a number of different regulations and standards in place. This includes the REACH regulation, the PFAS (S) Regulations 2020, and the PFAS (S) Regulations 2021. The new regulations are designed to provide a more consistent and comprehensive framework for the management of these substances.

DISPO CHALLENGE

Ultrasonic with sonoc

Richard James
Madeline J. J.

ABSTRACT

Sonocatalysis has been proposed as a means of breaking down PFASs into less harmful products. This process involves the use of ultrasound to generate reactive species that can attack the PFAS molecules, breaking them down into smaller, more easily manageable fragments.

1. Introduction

Perfluorinated compounds (PFAS) are a class of chemicals that are highly stable and resistant to degradation. They are used in a wide range of applications, including firefighting foams, and are found in many consumer products. The persistence of these substances in the environment has led to growing concerns over their potential health and environmental impacts.

Firefighting foams that contain PFAS are a major source of these substances in the environment. These foams are used to extinguish fires, but they can leave behind a residue that is difficult to clean up. This residue can contain PFAS, which can then be transported to other locations, such as water bodies, where they can persist for many years.

NAV PFAS

Introduction

Per- and polyfluoroalkyl substances (PFAS) are a diverse group of chemicals with a wide range of uses. They are found in many consumer products, including firefighting foams, and are persistent in the environment. This technical bulletin provides an overview of the current regulatory landscape for PFAS in the UK, including the new PFAS (S) Regulations 2020, and discusses the challenges of managing these substances in the context of the UK's environmental and public health objectives.

FOREVER CHEMICALS

Environmental, Economic, and Social Equity Concerns with PFAS in the Environment

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