PFAS in Our Environment: Exploring Effects, Widespread Contamination, and Detection Methods

Expert Insights

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Contents

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Introduction

This Expert Insight delves into the multifaceted realm of per- and polyfluoroalkyl substances (PFAS), a class of synthetic chemicals extensively employed in industrial processes and manufacturing for nearly a century. PFAS exhibit remarkable resistance to degradation, which has led to their pervasive environmental distribution and consequent human exposure. The repercussions of such exposure are far-reaching, encompassing adverse effects on fertility, developmental anomalies, cholesterol levels, immune function, and an elevated risk of certain cancers. In addition to their toxicological effects, PFAS has become a global concern, with regulatory agencies and researchers striving to understand the extent of their impact and develop effective methods for detection and mitigation. This article collection brings together research on the contamination and effects of PFAS in the air, soil, and water, shedding light on the complex challenges posed by these persistent substances in our environment.

This Expert Insight begins with a study on occupational exposures to airborne PFAS, emphasizing the importance of assessing PFAS levels in both air and dust within specific occupational settings [1].

Next, Atoufi, H.D. and Lampert, D.J [2] present an investigation into the behavior of PFAS in sediments, utilizing passive sampling devices to assess the bioaccumulation of these substances.

Finally, Ojha, S. et al. [3] introduce a geospatial and binomial logistic regression model aimed at prioritizing sampling for PFAS in public water systems, a crucial step in managing and mitigating PFAS contamination in drinking water sources.

Overall, this collection of articles endeavors to enhance researchers’ knowledge regarding the dynamics, impacts, and detection of PFAS. We encourage further exploration of these topics on Sartorius’ website to foster a deeper understanding of available options for improving research on PFAS-related issues.

Dr. Cecilia Kruszynski
Editor at *Wiley Analytical Science*

References

[1] Paris-Davila, T. et al. (2023). Occupational exposures to airborne per- and polyfluoroalkyl substances (PFAS)—A review. *American Journal of Industrial Medicine.* DOI: 10.1002/AJIM.23461.

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Occupational exposures to airborne per- and polyfluoroalkyl substances (PFAS) – A review

Adapted from Paris-Davila, T. et al. 2023

Per- and polyfluoroalkyl substances (PFAS) are synthetically produced chemicals, used in industrial processes and manufacturing since the first half of the 20th century. Their resistance to degradation and widespread use facilitates environmental contamination and subsequent human exposure. They are known to decrease fertility, cause developmental effects such as accelerated puberty, affect cholesterol and the immune response, and increase the incidence of certain cancers. Exposure to PFAS can occur through aerosolization and/or volatilization during the application or use of products already contaminated with PFAS [1]. it is important to determine PFAS levels in aerosolized and/or volatilized substances (referred to as "air" exposure) as well as dust-containing PFAS (referred to as "dust" exposure) within certain occupational settings.

Table 1: Literature search strings and the number of articles obtained for review of occupational PFAS exposures.

Search string	Number of articles returned and reviewed
(perfluor* OR polyfluor*) AND "occupational" NOT "review"	32
(perfluor* OR polyfluor*) AND (wax OR waxing) NOT "review"	2
(perfluor* OR polyfluor*) AND ("worker") NOT "review"	2
(perfluor* OR polyfluor*) AND "occupation" NOT "review"	2
(perfluor* OR polyfluor*) AND firefight*	4
(perfluor* OR polyfluor*) AND ("textile" OR "textiles")	4
(perfluor* OR polyfluor*) AND "nanocoating"	0
(perfluor* OR polyfluor*) AND "dust"	0
(perfluor* OR polyfluor*) AND "inhalation"	0
(perfluor* OR polyfluor*) AND "chrome plating"	0
(perfluor* OR polyfluor*) AND "metal plating"	0
(perfluor* OR polyfluor*) AND (ski OR skiing) NOT "review"	0
(perfluor* OR polyfluor*) AND "fluorinated repellant"	0
(perfluor* OR polyfluor*) AND "worker" NOT "plant"	0
(perfluor* OR polyfluor*) AND firefight*	0
(perfluor* OR polyfluor*) AND "employment"	0

Methods

A review of the literature was performed using different academic search engines to identify studies investigating PFAS and occupational exposure (Table 1), and 13 published scientific articles were identified. The following industries/occupational settings were identified: ski waxing, firefighting, education/office buildings, textile manufacturing plants, and retail textile stores. Methodology to detect PFAS included dust sampling with a photometric direct reading respicon, vacuum cleaners, and manual brushes, while air sampling was performed with solid phase cartridges with aerosol membrane filters, polyurethane foam (PUF) disk passive samplers, glass fiber filters, and PM2.0 samplers with quartz fiber filters and glass tubes fitted with GFF and PUF.

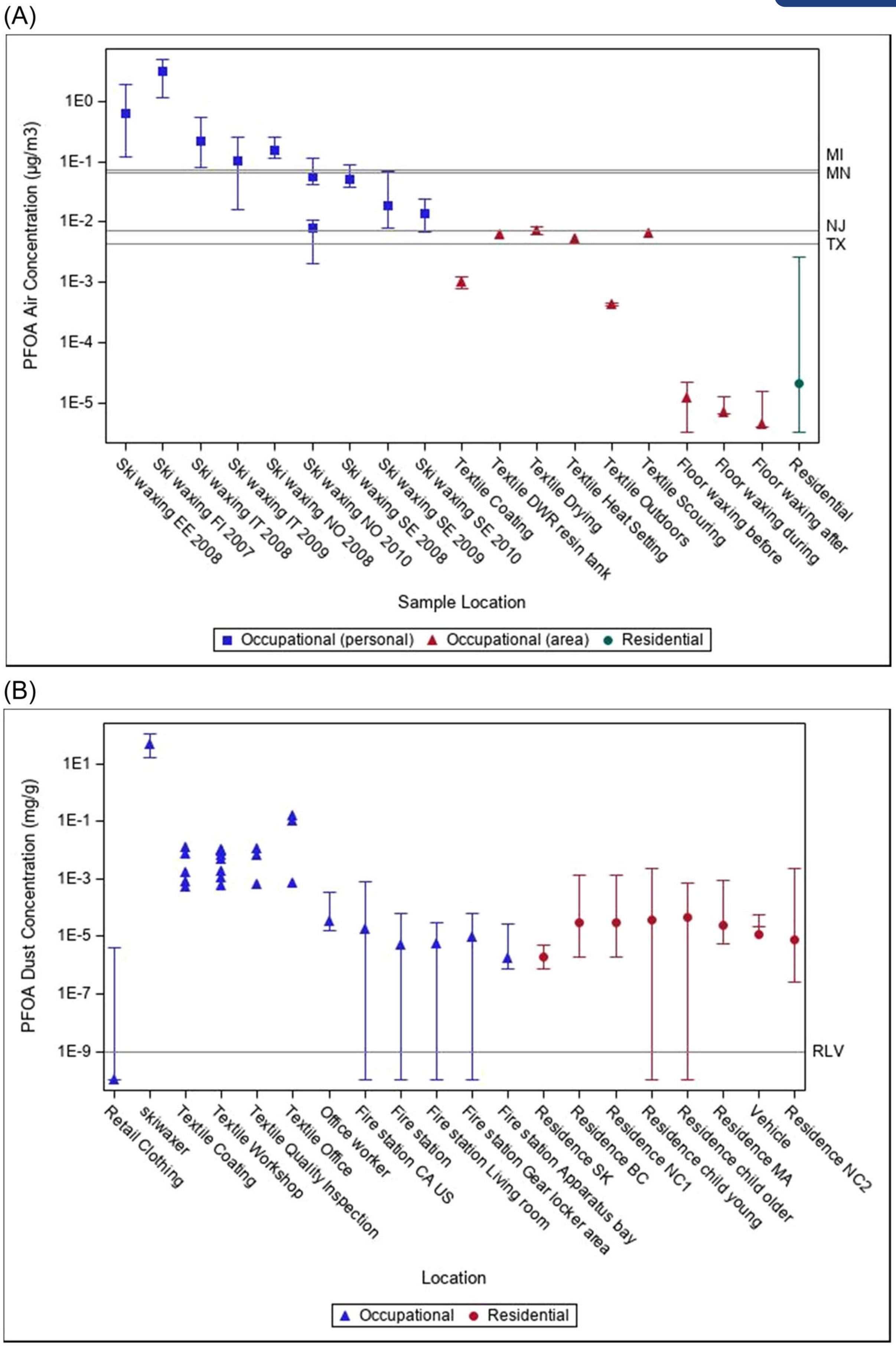

Figure 1: (A) Perfluorooctanoic acid (PFOA) air concentrations in different occupations and residences. The TX, NJ, MN, and MI lines are screening levels of 1.80E−2, 3.07E−2, 2.76E−1, and 3.07E−1 µg/m^3, based on toxicity values from the states of Texas, New Jersey, Minnesota, and Michigan, respectively. (B) PFOA dust concentrations in different occupations and residences. The RLV line represents the reported limit value.

Data analysis

We compared only the PFAS types that were consistently measured in all the included studies. This included: perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorooctanesulfonic acid (PFOS), perfluorohexanoic acid (PFHxA), perfluorotetradecanoic acid (PFTet-DA), perfluorododecanoic acid (PFDoDA), and perfluorodecanoic acid (PFDA). When available, the median, minimum, and maximum air and/or dust concentrations were used from the different data sets.

Results

Workers experience varying levels of PFAS exposure contingent upon the workplace/industry and the performed work tasks within the workplace. A total of 41 PFAS air and/or dust concentrations were reported in the nine occupational and four residential studies included in this review. The number of PFAS monitored for air levels varied from six to 14 and for dust levels from five to 27 in occupational studies, while 21 PFAS were monitored in residential studies (15 and 21 for air and dust, respectively). Out of all occupations, ski waxing exhibited the highest total PFAS air concentrations when compared to all other reported occupational and residential exposures (Figs. 1A, B).

In contrast, floor waxing had the lowest area air concentrations; concentrations associated with ski waxing were similar to other occupations, and median PFOS dust concentrations at ski waxing facilities were similar to the median of 1E–4 µg/m^3 for the textile office and textile coating workshop.

Discussion

Ski waxing

Ski waxing consistently had the highest values for both air and dust concentrations. This suggests that ski waxers experience the highest PFAS exposures of the occupations examined in this study. Ski waxers were observed to have PFAS serum levels similar to populations exposed to PFAS through contaminated water [2,3]. Our analysis shows that air concentrations of PFDA, PFOA, PFNA, and PFDoDA in ski waxing facilities can exceed occupational indoor air screening levels calculated for this review. During ski waxing, no or limited ventilation system may be used, which may be insufficient to protect from these high levels of PFAS exposure. The published studies did not state whether ski waxers used respiratory protection, but given that ski waxers' exposures were among the highest in the reviewed literature, using full-face respirators with organic vapor cartridges and proper cartridge changeout is recommended while performing tasks where PFAS is present in the products used.

Firefighting

As for the firefighter data, the dust samples provide a perspective of what PFAS firefighters may be exposed to during day-to-day operations in the fire station but do not account for exposures associated with firefighting activities. Because the levels measured in air and dust at fire stations are

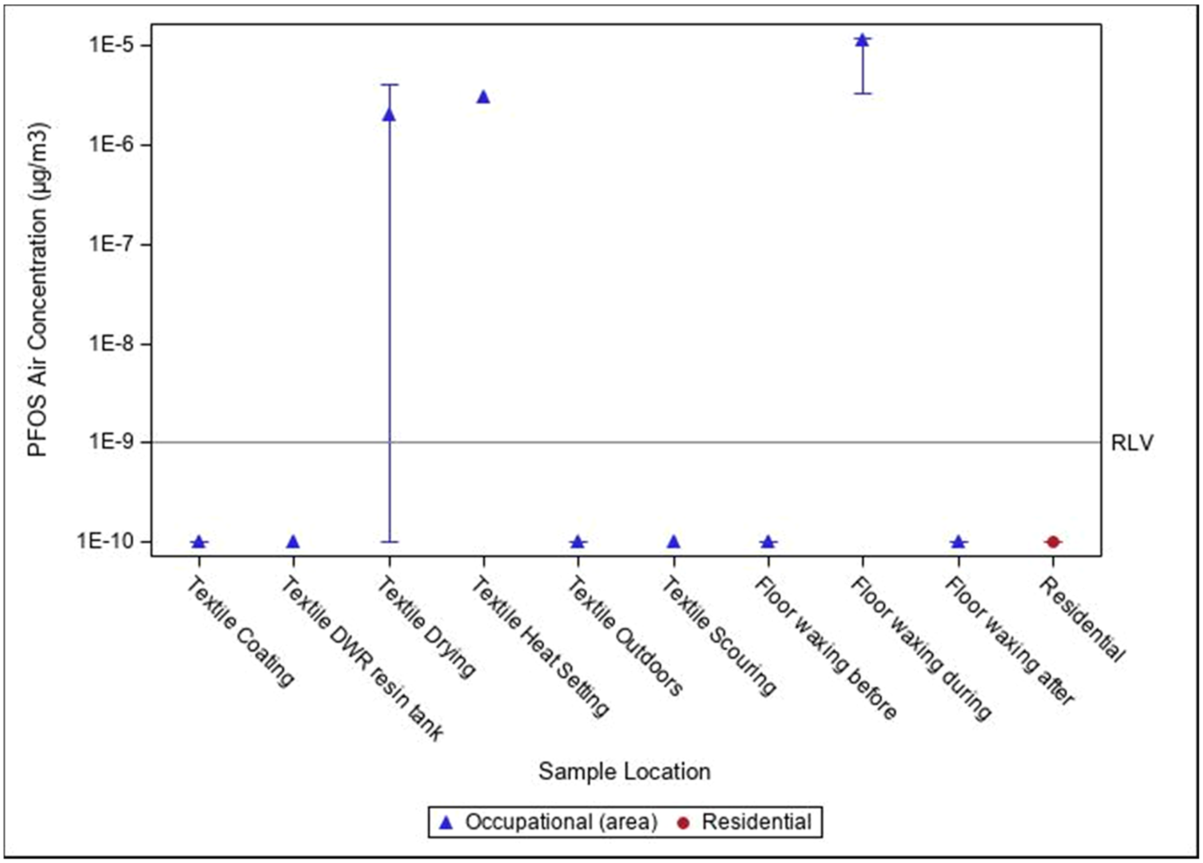

Figure 2: Perfluorooctanesulfonic acid (PFOS) air concentrations for occupations and residences. The RLV line represents the reported limit value.

comparable to those measured in residential settings, firefighters are likely to be exposed to PFAS during firefighting activities. Other studies have shown higher levels of PFAS in firefighters' serum compared to the general population [2,3]. Because firefighters use respiratory protection while firefighting, this could suggest that either the protection is insufficient or there are other exposure pathways that should be explored.

Textile manufacturing

Textile manufacturing processes resulted in consistently high levels of most PFAS, but the air concentrations of PFTetDA were especially high for textile scouring, drying, and heat setting compared to the other PFAS sampled during the textile manufacturing process.

Residential buildings

Although residences have lower PFAS levels than most occupational settings, elevated exposures may still occur depending on various factors, such as cleaning products used within homes, coated hard surfaces, textiles impregnated with PFAS, and many other consumer products that contain PFAS [4].

Overall, the results obtained in our analysis are comparable because in most studies similar sampling devices were used to collect aerosol/volatile or dust samples.

Limitation

An important limitation of the comparisons drawn in this review is the lack of available studies. It is unknown how comparable the measured air and dust levels are across time and countries. Much of the data is from 10 to 15 years ago, but some of the data is from just a few years ago. As the science of PFAS has evolved, product formulations have changed both voluntarily and due to government regulations. Thus, which PFAS would be found and what their concentrations would be if some of the studies were replicated today may not be identical.

Conclusion

Our review and analysis provide a foundational assessment of the current knowledge of occupational PFAS exposures. The results from this review emphasize the need for further research to increase our knowledge of occupational exposure scenarios and the levels of exposure to PFAS. Quantitative exposure assessment research as well as recognizing the occupations at risk, the products containing PFAS, and the causes for PFAS exposures will aid in the development of informed recommendations for safety measures including administrative and engineering controls as well as appropriate PPE use to protect workers from adverse health effects due to PFAS exposure.

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Analysis of a Passive Sampling Device to Assess the Behavior of Per- and Polyfluoroalkyl Substances in Sediments

Adapted from Atoufi, H.D. and Lampert, D.J 2023

Various manufactured fluorinated compounds, including perfluoroalkyl and polyfluoroalkyl substances, are collectively referred to as PFAS. They are resistant to hydrolysis, degradation, and photolysis [1], and their fate and transport in the environment must be understood to mitigate potential adverse effects on human health. Following PFAS release into the environment, soil and sediments often act as a reservoir for PFAS, often entering the food chain via local benthic organisms.

Passive samplers can be used to estimate the bioaccumulation of PFAS in soils and sediments, reflecting the biological uptake process [2]. Integrative samplers keep the contaminant uptake at a linear level over time, providing a time-averaged concentration estimate over the exposure period [3]. The polar organic chemical integrative sampler (POCIS) is an integrative sampler that is placed into a medium for a sufficiently short period to allow uptake during the linear region. It has been used to assess aqueous concentrations of bioaccumulative polar compounds with higher water solubility, such as pharmaceuticals and pesticides [4]. Such samplers were developed to measure time-averaged PFAS concentrations in surface water, and new approaches are needed to perform this analysis in soils and sediments [5]. The present study aimed to evaluate the use of POCIS to measure PFAS concentrations in saturated porous media. Successfully developing a passive sampler for PFAS-contaminated sediments would shed insight into PFAS release mechanisms, PFAS equilibrium partitioning between interstitial

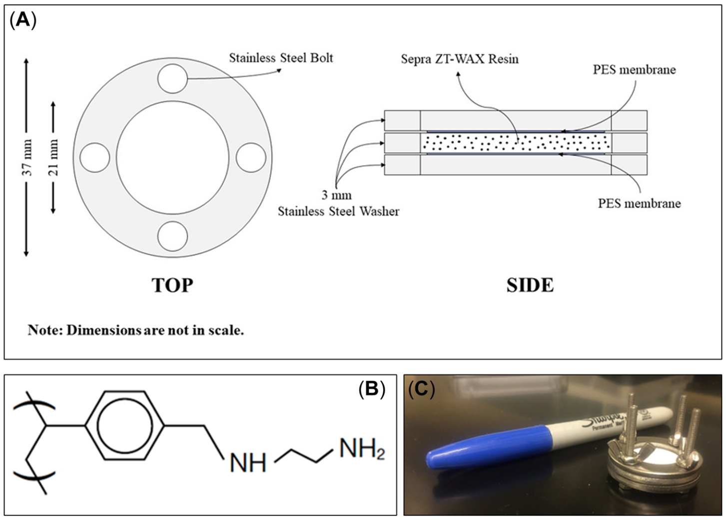

Figure 1: (A) Passive sampler design schematic, (B) resin functional group, and (C) assembled passive sampler. PES = polyethersulfone.

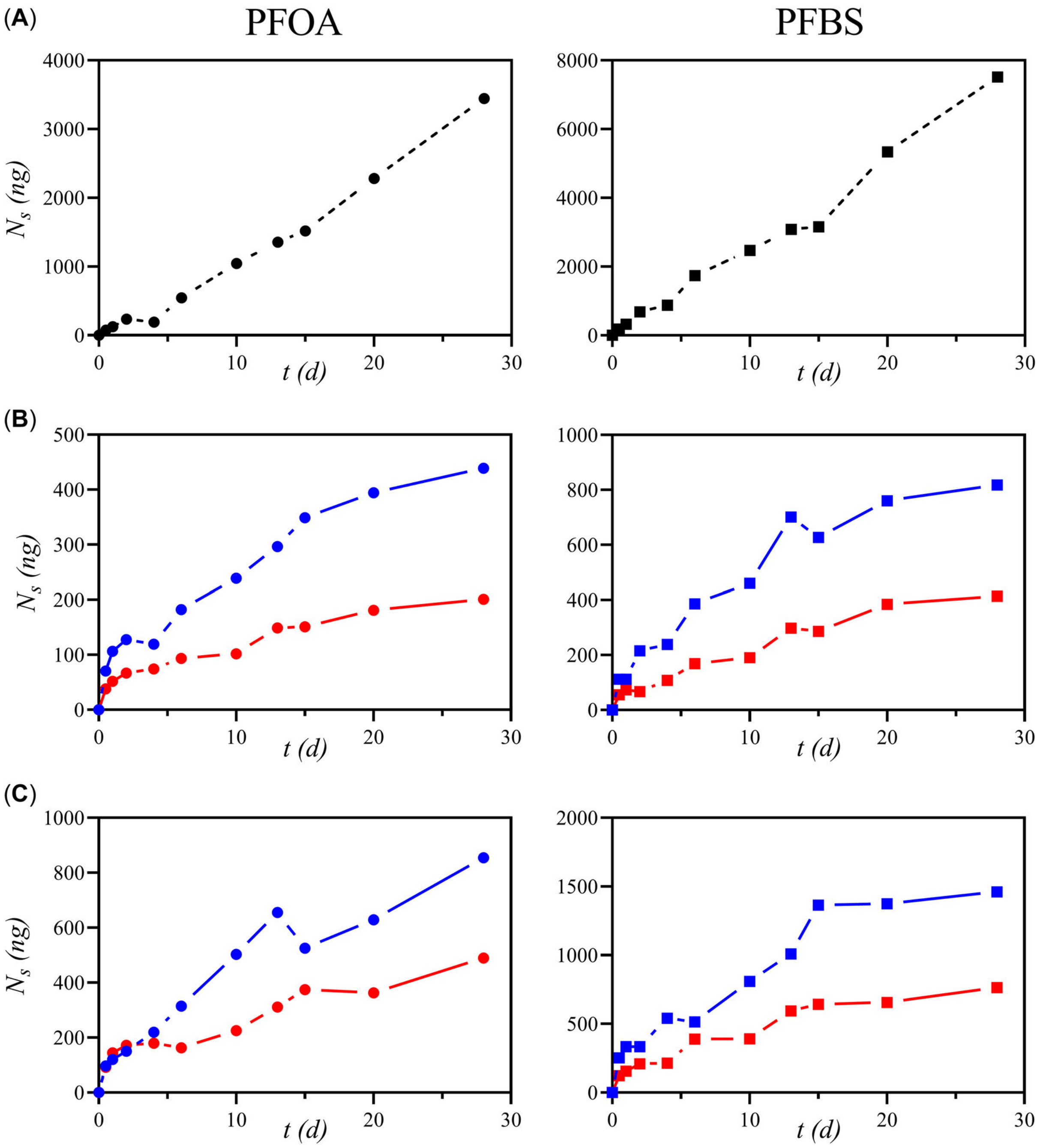

Figure 2: Uptake profile of per- and polyfluoroalkyl substance compounds in samplers in (A) a water tank, (B) noncombusted soil, and (C) combusted soil. Blue and red lines indicate reactors spiked with one and two compounds, respectively. PFOA = perfluorooctanoic acid; PFBS = perfluoro butane sulfonic acid; Ns = mass of components on the sorbent; t (d) = time in days.

water, solid and material phases, and sorption kinetics.

The main objectives of the present study were to (1) assess the sorption uptake of PFAS into the passive samplers deployed in two different saturated sediments in laboratory experiments, (2) compare the uptake of PFAS into the passive samplers in different reactors that contain a mixture of PFAS compounds and a single-analyte solution, and (3) develop a sorption kinetics mass transport model to explain PFAS transport from sediments into the sampler.

Materials and Methods

The passive sampling device utilizes 400 mg of Sepra ZT-WAX as a PFAS sorbent, using an amine-based functional group (Fig. 1B). The sorbent material is enclosed by two 30-mm microporous membranes made of polyethersulfone (PES). The sampling device was constructed from three stainless steel washers with an inside diameter of 21 mm, an outer diameter of 37 mm, and a thickness of 3 mm to secure and provide structural support for the membranes (Fig. 1A). After deploying the sampler (Fig. 1C) in the environment and ensuring that the saturated soil layer has covered it, PFAS begins to accumulate through diffusion via the microporous membrane onto the resin.

The soil used in this study was from the Tallgrass Prairie Preserve in northeastern Oklahoma. The organic matter content of the soils was analyzed by the loss-on-ignition method [6]. Experiments were performed on the soils spiked with PFAS. Six experimental reactors filled with soil, water, and PFAS were monitored for behavior. Approximately 500 µg of PFOA, PFBS, or the mixture (PFOA + PFBS) were added per kilogram of dry soil to each reactor. The aqueous-phase PFAS concentration and the soil-phase PFAS concentration were analyzed at the beginning and end of the experiments. Samplers were taken out and analyzed at 0.5, 1, 2, 4, 6, 10, 13, 15, 20, and 28 days for PFAS concentrations. Concentrations of PFAS were determined using liquid chromatography/tandem mass spectrometry (LC-MS/MS). A method based on USEPA 533 was developed for six PFAS compounds, including the two target PFAS [7]. Sample preparation used solid-phase extraction (SPE) cartridges to enrich PFAS and to remove matrix interferents. Concentrations of PFAS in soils and sediments were measured based on a previously published technique [8].

Results and Discussion

The POCIS-based passive sampling device showed consistent uptake of PFAS compounds into Sepra ZT-WAX resin in water and in contaminated sediments over time, which demonstrates its feasibility for sediment porewater passive sampling applications, in addition to integrative sampling of surface water. The sorbent captures PFAS compounds with shorter chains like PFBS more rapidly because of their lower sorption potential and more rapid diffusion. All of the samplers demonstrate increasing PFAS levels over time, which provides evidence for the technology to passively sample the surrounding environment (Fig. 2).

The SRM fitted the results better for the water phase, consistent with previous studies of integrative samplers. In contrast, the external resistance model (ERM) fits the sediment-phase data more accurately, as reflected by the values of the root mean squared.

In summary, the present study develops a framework that could be utilized for the estimation of porewater concentrations at contaminated sites.

Conclusion

In the present study, a derivative of the POCIS sampling device combined with a mass transport model was developed. to provide an estimate of PFAS porewater concentrations in saturated soils and sediments The results of these experiments demonstrated the feasibility of the passive sampling device to accumulate PFAS in soil-water matrices in accordance with an external transport theory.

Limitations

Certain measurements such as physicochemical characteristics of the PFAS contaminant, resin, and sediments, which can be measured in the laboratory may introduce uncertainty in the results due to variations in sampling and analysis methods, or spatial heterogeneity of the sampled sediment. Additionally, the presence of other contaminants can interfere as well. The calibration parameters, such as the sampling rate and the effective sampling volume, may vary depending on the specific conditions at the site, such as the flow rate and the chemical properties of the contaminants. Thus, the accuracy of the estimates may also be limited by the uncertainty in the calibration values and measured parameters. To reduce these uncertainties, additional measurements or calibration under different conditions may need to be conducted.

Still, the approach of this study may be useful to environmental regulators and other stakeholders involved in environmental remediation processes.

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A geospatial and binomial logistic regression model to prioritize sampling for per- and polyfluorinated alkyl substances in public water systems

Adapted from Ojha, S. et al. 2022

Per- and polyfluoroalkyl substances (PFAS) are examples of complex, pervasive compounds, often globally contaminating environmental systems, such as drinking water [1]. They are receiving increasing attention due to adverse health effects, such as cancer and neurodevelopmental effects [2]. Due to this, the United States Environmental Protection Agency (USEPA) has recognized them as contaminants of emerging concern [3]. Possible routes of human exposure include air and diet, which includes drinking water. This study aimed to develop a statistical screening model to help prioritize public water systems (PWS) sampling sites, locate industries highly likely to utilize PFAS in their processes and predict whether PFAS are likely to be detected in a particular PWS.

Screening model development

Drinking water can be exposed to PFAS through various pathways (Fig. 1). To assist in prioritizing PWS sampling locations, a binomial logistic regression model was developed, capable of predicting whether PFAS are likely to be detected in a certain location. Two hypotheses are crucial: H1 assumes that the number and quantity of releases into the atmosphere and water would increase the likelihood of PWS contamination, and H2 assumes that the distance between PWS and the release source would decrease the likelihood of PWS contamination.

Mapping potential hot spots for priority sampling

Potential PFAS direct users include metal plating facilities, paper manufacturing facilities, textile manufacturing facilities, electronic manufacturing facilities, and facilities known to be contaminated with chlorinated volatile organic compounds (Table 1).

Specific scores were assigned to geographical sites of interest that indicated their potential to be PFAS hotspots (Fig. 2). The heatmap density was manipulated with the help of the Kernel density process.

Screening Model Application

The state of Kentucky does not currently have specific guidelines for any PFAS compounds, and PFAS policy formulation for drinking water regulations is in the early stages. The screening approach presented in this study is a tool to augment existing information for the decision-makers, helping them prioritize sampling locations, and assess drinking water exposure risks during policy implementation, despite uncertainty regarding PFAS users and PFAS sources.

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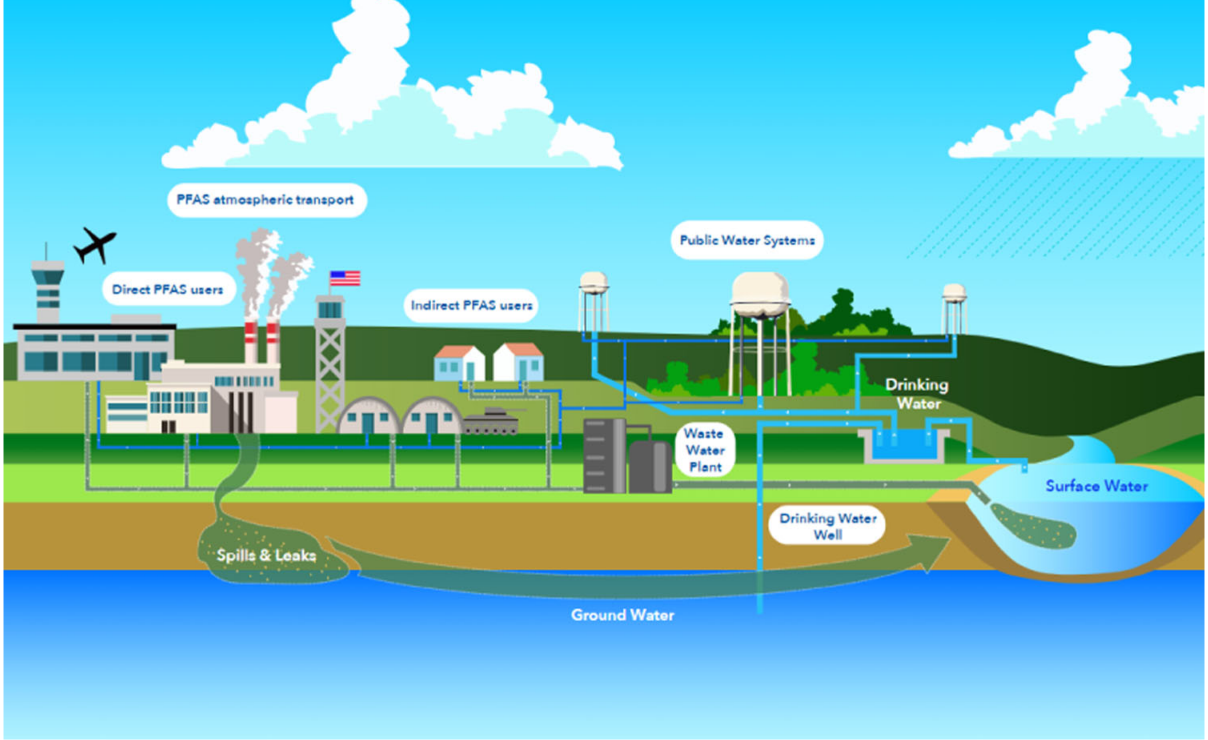

Figure 1: Conceptual model for per- and polyfluorinated alkyl substances (PFAS) entering drinking water systems. Note that the sewer system shown in this figure is intended to represent various scenarios, including storm, wastewater, and combined sewers. Direct PFAS users intentionally use PFAS as part of their operations. Examples of direct users include military operations, airports, sites that conduct fire training operations using PFAS-containing firefighting foams, and chemical manufacturing industries that produce or use PFAS in their processes. Indirect PFAS users include residences, commercial businesses, and offices that do not use PFAS intentionally but use PFAS-containing consumer materials.

PFAS sampling and results in Kentucky

In Kentucky, 434 PWS provide drinking water for more than 95% of Kentuckians. The majority of Kentucky PWS (71% or 307 systems) use surface water (SW), while 29% (127 systems) rely on groundwater (GW) as their drinking water source (EPA, 2019). One or more PFAS were detected in 41 of the 81 samples taken from these PWS Results also show that one or more PFAS were detected in 66% of sampled surface water systems, while PFAS were detected in only 22% of the sampled groundwater systems. KDEP sampled and analyzed PWS for eight PFAS, including perfluorobutane sulfonate, hexafluoropropylene oxide dimer acid (also referred to as Gen X), perfluoroheptanoic acid, perfluorohexane sulfonate, ammonium 4,8-dioxa-3Hperfluorononanoate, PFOA, PFOS, and perfluorononanoic acid.

Modeling the outcomes from the Kentucky case study

For GW, the regression model predicted correctly for 24 of 28 water systems with an 86% accuracy. For SW, the model predicted correctly for 33 of 47 water systems with a 70% accuracy (Table 2). Overall, 57 out of 75 water systems (77%) were predicted correctly by the model (within the acceptable range of 70%). When the TRI for PFAS is available in other states, the model can easily be applied to other locations. Of the 359 PWS that have not been sampled by KDEP, the statistical screening model recommends that 98 be sampled, and predicts that PFAS is likely to be detected in 143 PWS.

Table 1: Potential direct PFAS users and assigned indicator scores for potential PFAS contamination.

Risk score	Facility	Upper magnitude	Source
100	Department of Defense	10 000 μg/L (28 PFAS)	AFFF
	Landfill	1000 μg/L (13 PFAS)	Waste streams from landfills
	Chemical manufacturing Industries	1000 μg/L (11 PFAS)	PFAS or fluoropolymer manufacturer and user
75	Airport	100 μg/L (28 PFAS)	AFFF
	Fire training areas	100 μg/L (28 PFAS)	AFFF
	Petroleum refineries	10 μg/L (28 PFAS)	AFFF
50	Textiles	10 μg/L (13 PFAS)	Fluoropolymer coating
	Furniture	10 μg/L (13 PFAS)	Fluoropolymer coating
	Paper	10 μg/L (13 PFAS)	Fluoropolymer coating
25	Rubber and plastics	10 μg/L (13 PFAS)	Fluoropolymer coating
	Fire station	Not available	PFAS foam
	Fabricated metal	Not available	Fluoropolymer coating

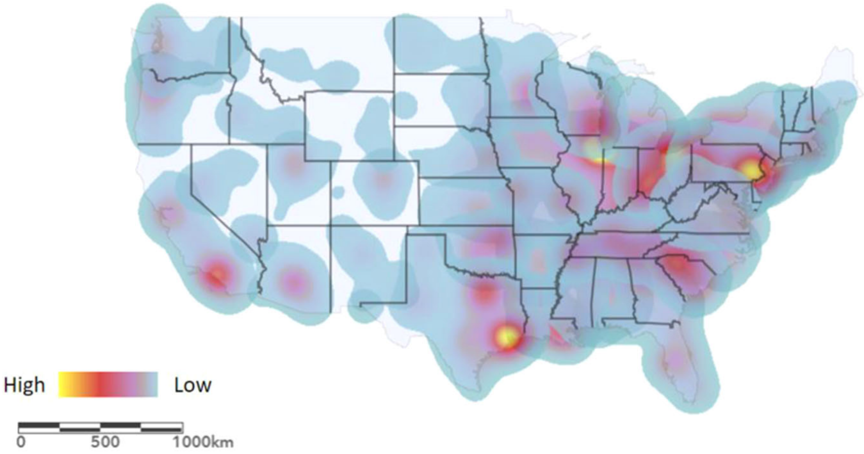

Figure 2: Example of screening model showing potential per- and polyfluorinated alkyl substances hotspots in the United States using Toxic Release Inventory data.

Results and Discussion

The study shows that the proposed screening approach is translatable to other states and countries where the input data are available. Given the distances from PWS, indicator score for each industry, and waste released from each industry from TRI, binomial regression modeling can be done using the "JMP pro 14" statistical model. Using the proposed formulation, the model will generate results regarding the water systems that may have a high probability of detection. PFAS releases to the environment could be controlled if industries stop using and producing PFAS, its precursors, and residuals. For instance, brands such as IKEA, H&M, Danish COOP, and ChemSec have stopped using the entire class of PFAS [4].

Given uncertainties related to emerging PFAS science and regulations, many people may be unaware of potential PFAS-related hazards. Communicating this model's findings with various stakeholders is important to identify challenges, analyze opportunities, and develop risk-reducing strategies. Public and private stakeholders collaborating for risk management may produce more feasible and acceptable solutions for reducing PFAS use in manufacturing processes, as well as for performing cleanup efforts [4].

The results of the screening model, coupled with stakeholder engagement, can be used to improve knowledge about the location of potential PFAS users and toxic chemicals discharged.

Conclusion

This work provides a key contribution to developing a systematic approach for prioritizing PFAS sampling. Although these analyses used Kentucky PWS as a case study, the screening approach is translatable to other states and countries. Data is unclear for past chemical use for many industries, thus limiting the ability to identify the distribution and presence of PFAS at various sites.

Limitations

Because this study uses publicly available sources, it only considers distances between PWS and direct user sites. The water path analysis of water systems and characteristics of water valves within the system have not been included in the model. Also, buying and selling of water are complex economically driven processes, and the developed screening approach is not able to account for these aspects. As KDEP analyzed for only eight of 9,000 possible PFAS, other PFAS that were not tested may be present. Although PFAS user sites such as industries and military installations are included in the model, other potential PFAS sites such as landfills are not. These limitations are necessary to maintain a simple, and broadly applicable screening approach; however, like all other models, there is a trade-off between simplicity and reality.

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Table 2: Screening results for groundwater (GW), surface water (SW), and combined.

	Sample size	Sample-Y Model-Y	Sample-Y Model-N	Sample-N Model-Y	Sample-N Model-N	Accuracy	True precision	False precision
Combined	75	32	5	13	23	0.76	0.86	0.83
GW only	28	2	4	0	22	0.86	0.33	0.85
SW only	47	30	1	13	3	0.70	0.97	0.75

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PFAS | “Forever Chemicals”

Per- and Polyfluoroalkyl Substances

Per- and Polyfluoroalkyl Substances (PFAS) are a family of more than 4,700 chemical molecules that exhibit non-stick, chemical-resistant, heat-resistant, and waterproof characteristics, among others. The US Environmental Protection Agency (EPA) database lists more than 12,000 PFAS with confirmed structures. However, European agencies have adopted a broader definition of PFAS than the US EPA.

Due to their unique chemical properties, PFAS have been used in various industries and consumer goods, including cosmetics, firefighting foam, food packaging, textiles, cookware, and automobiles. After being released from industrial plants, PFAS eventually enter water bodies and oceans, from where they are released into the atmosphere via aerosols. Rainfall then brings these chemicals back to the earth’s surface, where they can persist for decades.

The same stable chemical bonds that make PFAS attractive to manufacturers also make them resistant to degradation. Due to their inherent durability, PFAS persist in the environment and can be found in air, water, sediment, soil, and even rain. One study detected PFAS in remote locations such as Antarctica and the Himalayas. This is concerning due to the growing evidence of the harmful health and environmental impacts of these chemicals.

Although the largest global producers of PFAS have discontinued certain products, the production of alternative fluorochemicals continues. This necessitates ongoing research and surveillance.

shampoo
paints
stain-resistant products
photography
pesticides
firefighting foams
fast food packaging
cosmetics
non-stick cookware
cannabis
drinking water
pharmaceuticals
beverages
medical devices

Negative Impacts of PFAS

Effects on human health

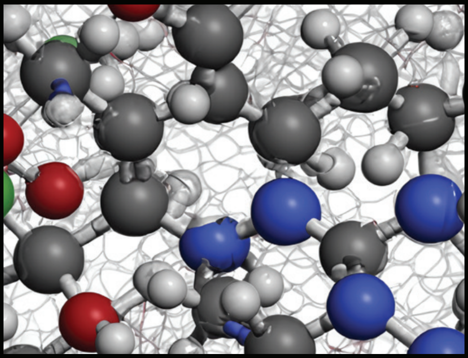
- Development of kidney and testicular cancer
- Liver damage
- Elevated cholesterol levels
- Weakened immune function
- Decreased fertility or complications during pregnancy
- Interference with hormone function

Effects on environment

- Bioaccumulation
- Contamination of groundwater and drinking water
- Harmful effects on reproduction, development and the immune system of animals

PFAS as “Forever Chemicals”

PFAS have stable carbon-fluorine bonds, the strongest covalent bonds in chemistry, along with varying carbon chain lengths. These chemical bonds require significant energy to break, which makes them extremely durable or stable to degradation in the environment—and the human body. Currently, the US Food and Drug Administration (FDA) assesses food products for six PFAS contaminants (PFOA, PFOS, PFNA, PFHxS, HFPO-DA, GenX, and PFBS) that may pose a risk to human health.



Regulations

International

The Stockholm Convention on Persistent Organic Pollutants, established in 2004, is a global treaty aimed at protecting the environment and human health from the effects of Persistent Organic Pollutants (POPs), which include PFAS.

They classify the chemicals according to Annexes A–C:
- Prohibited **(A)**
- Restricted **(B)**
- Unintentional production **(C)**

United States of America

The EPA is committed to implementing specific actions and adopting more robust policies to protect public health, preserve the environment, and hold polluters accountable.

In the EPA’s fifth Unregulated Contaminant Monitoring Rule (UCMR 5), the agency established minimum reporting levels (MRLs) for the contaminants under UCMR 5, which include 29 PFAS.

Europe

The revised Directive 2020/2184, dated 16 December 2020, pertaining to the quality of drinking water includes parameters for PFAS. It targets 20 PFAS and sets a limit of 0.10 µg/L for the combined total of these compounds in drinking water.

REACH Regulation, introduced in 2006 to regulate the production and use of chemical substances, classifies PFOA, PFOS, GenX, and PFBS as Substances of Very High Concern (SVHC).

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Sample Preparation for PFAS Determination

Materials and tools used for environmental sampling should be free from contaminants or interfering substances at levels less than one-third of the MRL. Sartorius offers a variety of trusted solutions for sample preparation workflows, ensuring time efficiency and robust, reproducible results.

PFAS guidelines for testing are governed by various regulations and standards, including EPA 533, EPA 537.1, EPA 8327, EPA 1633, ISO 25101, ISO 21675, and ASTM E3302. These standards are evolving due to the growing global awareness of PFAS and their adverse effects.

Workflow

Step 1: Preparation of solvents

The preparation of solvents for LC-MS requires ultrapure water to ensure accuracy and reliability in the analysis. Any contaminants present in the water can interfere with the measurements.

Step 2: Preparation of standards

Precise weighing is crucial when calculating standards or laboratory control samples. Deviations can lead to significant errors in concentration, potentially compromising the validity of the results.

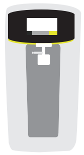
Step 3: Pipetting

To reliably detect trace contaminants, it is critical to utilize every microliter of sample. Accurate pipetting is also vital to ensure reliable data from the sample and surrogate spiking solutions.

Step 4: Filtration

Filtration devices play a vital role in clarification, prefiltration, and sterile filtration, as they help remove particles that could interfere with detection and potentially block the chromatography column.

Solutions



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Minisart® Syringe Filters

Tips for Contamination-Free PFAS Sampling

Do's

- **Wear cotton clothing or well-laundered synthetic fabrics**
- **Use nitrile gloves without powder**
- **Use PFAS-free equipment and supplies, including caps**
- **Use pesticide-free or higher-purity reagents and solvents**
- **Use pipettes that are free of target analyte with disposable polyethylene tips**

Dont´s

- **Wear water-repellent, waterproof,** stab-resistant, fire-repellant clothes
- **Use cosmetics, moisturizers, sunblock, or insect repellents, which include PFAS**
- **Use plastic clipboards, waterproof logbooks**
- **Bring packaged food/drinks**
- **Use aluminum foil labels, permanent markers, sticky notes**
- **Use chemical ice**

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References

1. https://stormwater.wef.org/2022/08/scientists-contend-pfas-in-rainfall-represents-global-crisis/
Perfluoroalkyl chemicals (PFAS) - ECHA (europa.eu)
2. PFASs: chemicals in the spotlight | Anses - Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024 | US EPA
3. https://pfas-1.itrcweb.org/11-sampling-and-analytical-methods
4. https://echa.europa.eu/hot-topics/perfluoroalkyl-chemicals-pfas
5. https://www.anses.fr/en/content/pfass-chemicals-spotlight
6. https://www.epa.gov/sdwa/questions-and-answers-drinking-water-health-advisories-pfoa-pfos-genx-chemicals-and-pfbs

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Further Readings and Resources

A worldwide evaluation of trophic magnification of per- and polyfluoroalkyl substances in aquatic ecosystems
https://setac.onlinelibrary.wiley.com/doi/10.1002/ieam.4579

A Guide to High-Quality Laboratory Water
https://www.sartorius.com/en/products/water-purification/water-purification-resources/a-guide-to-high-quality-laboratory-water

Ultrapure Water: The Basis for Reliable Laboratory Results – Webinar
https://www.sartorius.com/en/products/water-purification/water-purification-resources/ultrapure-water-reliable-laboratory-results-webinar

Ultrapure Water for HPLC Analysis
https://www.sartorius.com/en/products/water-purification/water-purification-resources/ultrapure-water-for-hplc-analysis-app-note

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