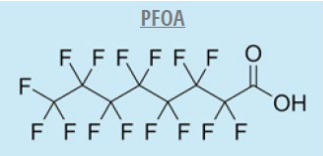
Per- and Polyfluoroalkyl Substance (PFAS)

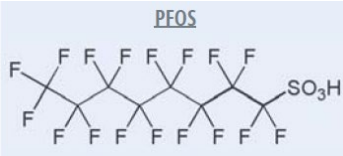
Overview and Prevalence

What are PFAS?

Per- and polyfluoroalkyl substances (PFAS) are a large group of environmentally persistent man-made chemicals used in industrial applications and commercial household products. As a group, PFAS are well-known for thermal and water resistance, contributing to their use in a variety of applications including non-stick coatings, waterproof fabrics, protective coatings, and firefighting foams. Due to their stability and widespread use, PFAS have received attention as an emerging contaminant of concern in the environment.

The characteristics of PFAS are attributable to their structure and chemical composition. PFAS are comprised of fluorinated carbon chains attached to functional groups (such as carboxylic acids, sulfonic acids, alcohols, etc.). PFAS are often described in terms of two groups – long- and short-chain PFAS. Long-chain PFAS typically are designated as perfluoroalkyl sulfonic acids containing ≥ 6 carbons, such as perfluorooctanoic acid (PFOA) and perfluoroalkyl carboxylic acids with ≥ 7 carbons. Short-chain PFAS have fewer carbons such as perfluorobutanoic acid (PFBA). Long- and short-chain PFAS were manufactured, but they can also be the result of degradation of more complex PFAS.





History and Use

PFAS are a complex family of several thousand compounds that have been produced since the late 1930s. Common uses of PFAS have included:

- Factory- or consumer-applied coating to repel water, oil, and stains on textiles and leathers;
- Electrical wiring insulation and coating;
- Photoresistant and anti-reflective coatings for the photolithography and semiconductor industries;
- Corrosion prevention and mechanical wear reduction products used in metal plating and etching; and
- Firefighting activities.

The use of PFAS has changed over time, specifically the reduced use of long-chain PFAS, as understanding and application of PFAS chemicals has evolved and as a result of regulatory pressure. The two PFAS most commonly found by water systems are legacy long-chain compounds that have been phased out of manufacture, PFOA and perfluorooctane sulfonic acid (PFOS). Currently there are over 600 PFAS compounds that United States Environmental Protection Agency (EPA) allows to be imported to or sold in the United States.

Health Concerns

Long-chain PFAS have been found to have comparable bioaccumulation potential as other well-known contaminants, such as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT). DDT and PCBs have a half-life in the human body that range from 6 to 10 years and 10 to 15 years, respectively. By comparison, the half-life of PFOS and perfluorohexane sulfonic acid (PFHxS) in the human body is upwards of 5 years. Alternatively, the half-life of PFBA, a short-chain PFAS with 4 carbons, is 3 to 4 days.

In 2009, PFOS was added to the United Nations Stockholm Convention's list of Persistent Organic Pollutants (POP). PFHxS and PFOA have also been proposed for listing as POPs.

The EPA and the Agency for Toxic Substances and Disease Registry (ASTDR) both report that the most consistent health effect from PFAS exposure is increased cholesterol levels. There are more limited findings related to:

- Interference with the body's natural hormones impacting growth and reproduction,
- Effects on the immune system,
- Cancer, and
- Low infant birth weights.

The health effects of PFAS exposure are still being studied extensively by numerous agencies. In 2018 the ASTDR published draft minimum risk values for PFOA, PFOS, PFHxS, and perfluorononanoic acid (PFNA) to guide remediation of contaminated sites. ATSDR has not yet finalized these values. EPA is expected to develop toxicity assessments for PFNA, PFHxS, perfluorobutanoic acid (PFBA), perfluorohexanoic acid (PFHxA), perfluorodecanoic acid (PFDA) in 2019 or 2020.

Presence in Drinking Water Supplies

PFAS are highly soluble in aquatic environments and can dissolve into water. In the United States, drinking water source waters including lakes, rivers, tributaries, and groundwater have been found to have low ng/L levels of PFAS. As part of the third Unregulated Contaminant Monitoring Rule (UCMR 3), the EPA required water systems to monitor for six PFAS (see table). PFOS and PFOA were the most frequently detected PFAS; this is consistent with other reports on measured PFAS in finished drinking waters. During the UCMR 3 process, PFOS and PFOA were detected above the method reporting limit (40 and 20 ng/L, respectively) in drinking water in approximately 1.9% and 2.4% of Public Water Systems (PWSs), respectively.

Point sources of PFAS in the environment include runoff plumes from aqueous film-forming foams used for firefighting activities and industrial discharges from facilities manufacturing or utilizing PFAS. PFAS are most often found in environmental sampling at elevated levels downstream of nearby airports and manufacturing facilities, but contamination has been found where there is not a clear link to an identifiable source.

PFAS Monitored for UCMR 3	Source of PFAS
Long-Chains	
Perfluorooctanoic acid (PFOA)	Nonstick Surfaces
Perfluorooctane sulfonate (PFOS)	Fabric Protection, Firefighting Foam
Perfluorononanoic acid (PFNA)	Surfactant for Plastic Production
Short-Chains	
Perfluorohexane Sulfonic Acid (PFHxS)	Firefighting Foam
Perfluorohexanoic Acid (PFHxA)	Degradation Product of PFHxS
Perfluorobutyrate Acid (PFBA)	Photographic Film

During the next UCMR cycle (UCMR 5, 2022-2026), drinking water systems will monitor for 29 individual PFAS compounds. This process will use analytical methods with lower detection limits and capture a broader range of PFAS chemical structures based on EPA Methods 533 and 537.1.

EPA Actions to Address PFAS

In May 2016, following UCMR 3, the EPA established health advisories for PFOA and PFOS. The health advisory was set at 70 nanograms per liter (individual or total) limit for lifetime exposure to PFOA and PFOS in drinking water. In cases where the health advisory is exceeded in drinking water EPA recommends that utilities should expand monitoring to assess the characterization, communicate with consumers about the levels and health concerns of PFOA and PFOS, and/or consider steps to limit exposure.

In 2019 EPA initiated a coordinated agency-wide PFAS Action Plan. The EPA Plan is a multi-media, multi-agency approach to identify and understand PFAS, prevent future contamination, and effectively communicate with the public about PFAS. The Action Plan includes a wide variety of specific actions including: (i) proposing a national drinking water regulatory determination (proposed March 2020), (ii) initiating steps to propose designation of PFOA and PFOS as "hazardous substances", (iii) developing groundwater cleanup recommendations, and (iv) developing toxicity values for heptafluoropropylene oxide ("GenX"), perfluorobutane sulfonic acid (PFBS). The Action Plan also includes research efforts to develop new methods to detect PFAS as well as to continue studying health effects of PFAS.

Draft interim recommendations for addressing groundwater contaminated with PFOA and PFOS were released in April 2019 and are undergoing finalization. The draft recommendations include a screening level of 40 ng/L and a preliminary remediation goal of 70 ng/L. These recommended levels would be used to initiate state regulatory agency oversight and guide remediation of contaminated sites.

State Regulatory Overview

Individual states are also taking steps to address PFAS contamination in the absence of federal regulations. Currently, more than 25 states have established policies to protect drinking water, either through source water protection policies or drinking water quality policies. States with drinking water standards include Massachusetts (proposed), Michigan, New Hampshire, New Jersey, New York, and Vermont. Refer to AWWA's PFAS State Regulatory Overview for details of the types of regulation each state has implemented or is developing.

Additional Resources

AWWA's PFAS State Regulatory Overview:
https://www.awwa.org/Resources-Tools/Resource-Topics/PFAS

Chemical and Engineering News's Guide to the PFAS found in our environment:
https://cen.acs.org/sections/pfas.html

EPA's Health Advisories for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS):
https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos

EPA's PFAS Action Plan:
https://www.epa.gov/pfas/epas-pfas-action-plan

National Institute of Environmental Health Services PFC Fact Sheet:
https://www.niehs.nih.gov/health/materials/perfluoroalkyl_and_polyfluoroalkyl_substances_508.pdf

EPA's Research on Per- and Polyfluoroalkyl Substances (PFAS):
https://www.epa.gov/chemical-research/research-and-polyfluoroalkyl-substances-pfas