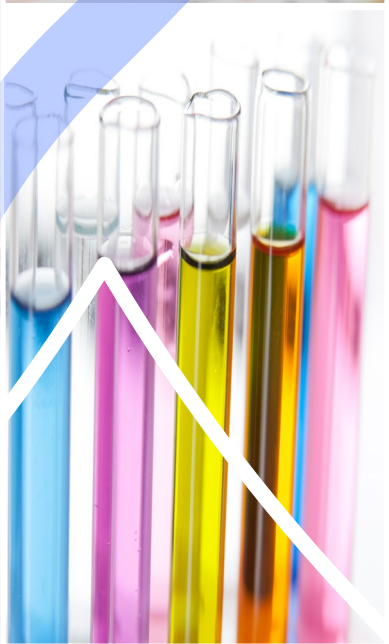


Polyfluorinated & Perfluorinated Substances (PFAS)

The PFAS Experts

- Responsible Party Identification
- GIS and Geomatics
- Contaminant Hydrogeology
- Fate and Transport Modeling
- Risk Assessment
- Remediation Feasibility Studies
- Soil and Groundwater Remediation
- Natural Resource Damage Assessment
- Water Resources Assessment
- Source Water Assessment and Protection
- Drinking Water Treatment
- Environmental Risk Management
- Litigation Support/Expert Witness
- Forensic Engineering
- Stakeholder/Public Participation
- Regulatory Strategy



environment • water • strategy

Polyfluorinated and Perfluorinated Alkyl Substances in the Environment

Polyfluorinated and Perfluorinated Alkyl Substances (PFAS) are a large group of manufactured chemicals that have been widely used for over 50 years to make everyday products more resistant to stains, grease, and water, and include over 6,000 different chemicals. PFAS are used to keep food from sticking to cookware, to make sofas and carpets resistant to stains, or to make clothes and mattresses more waterproof. They are also used in some food packaging, as well as in some fire-fighting materials. Because they help reduce friction, they are also used in a variety of other industries, including aerospace, automotive, building and construction, and electronics.

In May 2016, the United States Environmental Protection Agency (USEPA) announced the release of lifetime health advisories (HAs) for the PFAS perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). The HA identified a concentration of 0.07 micrograms per liter (ug/L), or 70 parts per trillion (ppt) in drinking water.

Key Points

- Highly soluble in water
- Extremely stable
- Resistant to hydrolysis, photolysis, or biodegradation
- Extremely persistent in the environment
- Mobile in soil and leaches to groundwater

This updated HA concentration supersedes the 2009 provisional HAs for PFOA and PFOS of 400 ppt and 200 ppt, respectively. USEPA Method 537, developed in 2009, has only been validated for 14 different PFAS (see table below).

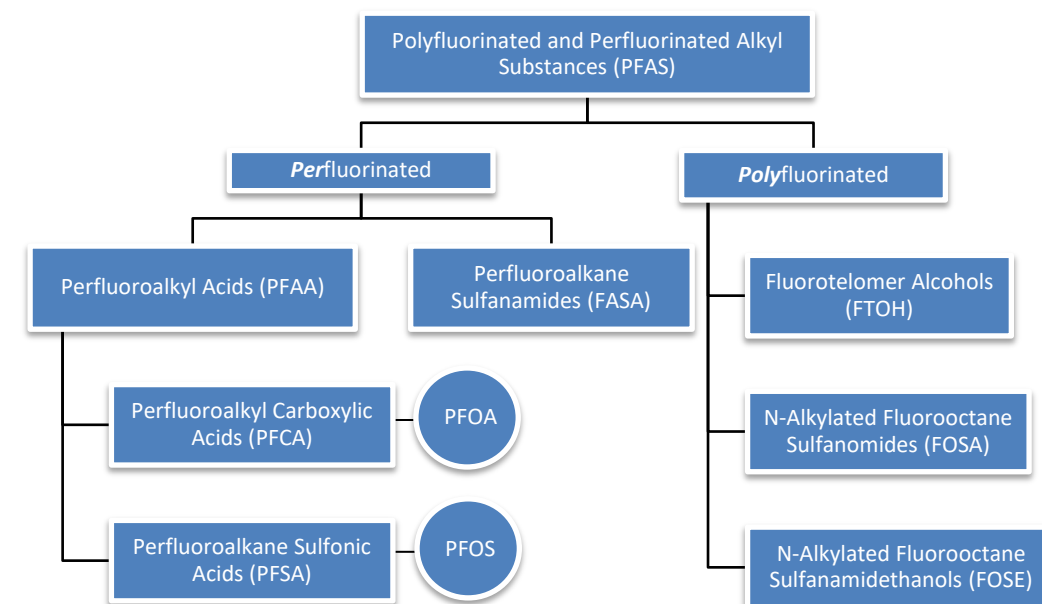
PFOS and PFOA compounds are highly soluble in water and have very low volatility due to their ionic nature, and as a result, the use of conventional treatment technologies can be difficult. In groundwater, the most common treatment is extraction and filtration through granular activated carbon (GAC). This technology has been shown to consistently remove PFOS to parts per billion concentrations with an efficiency of 90 percent (%); however, it is not as efficient at removing PFOA and other PFAS. Alternative treatment technologies for groundwater include ion exchange, surfactant and ultrasonic treatment, reverse osmosis, and advanced oxidation (AOP).

PFAS Commonly Evaluated in Drinking Water

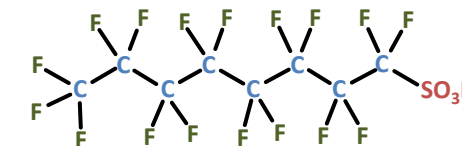
PFAS	Acronym	Under Study by NIEHS and NTP ¹	Included in EPA Method 537
Perfluorobutane sulfonate	PFBS (C4)	•	•
Perfluorohexanesulfonic acid	PFHxS (C6)	•	•
Perfluorohexanoic acid	PFHxA (C6)	•	•
Perfluoroheptanoic acid	PFHpA (C7)		•
Perfluorooctanesulfonic acid	PFOS (C8)	•	•
Perfluorooctanoic acid	PFOA (C8)	•	•
Perfluorononanoic acid	PFNA (C9)	•	•
Perfluorodecanoic acid	PFDA (C10)	•	•
Perfluoroundecanoic acid	PFUnA (C11)		•
Perfluorodecanoic acid	PFDoA (C12)		•
Perfluorotetradecanoic acid	PFTA		•
Perfluorotridecanoic acid	PFTTrDA		•
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA		•
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA		•

1. Currently studied by the National Institute of Environmental Health Sciences (NIEHS) and National Toxicology Program (NTP).

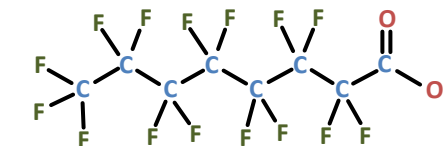
PFAS Classification System



PFOS - Perfluorooctanesulfonic Acid



PFOA - Perfluorooctanoic Acid



Selected Properties of PFOA and PFOS

Property	Units	PFOS	PFOA
Molecular Weight	gram/mole	500	414
Density	g/cm ³	1.8	1.8
Melting Point	(°C)	> 400	45 - 50
Boiling Point	(°C)	133	188
Vapor Pressure	mmHg at 20°C	2.48e ⁻⁶	0.017
Solubility	mg/L at 25°C	570	9,500
Henry's Constant (K _h)	atm*m ³ /mole	3.05e ⁻⁹	Not Measurable
Partition Coefficient (log K _{ow})	---	6.43	5.3
Sorption Coefficient (log K _{oc})	---	2.57	2.06
Half-Life in Water	years at 25°C	> 41	> 92
Notification Level (CA)	ug/L	0.014	0.013
Health Advisory (2016)	ug/L	0.07	0.07

Sources:

USEPA. (2012). Emerging Contaminants – Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA). May.
 USEPA. (2016). Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA). May.
 USEPA. (2016). Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS). May.
 ITRC. (2018). Per- and Polyfluoroalkyl Substances (PFAS) Fact Sheet. Retrieved from: <http://pfas-1.itrcweb.org/fact-sheets/>.
 September.