

Perfluorinated Compounds

Treatment and Removal

What are PFCs?

The presence of perfluorinated compounds (PFCs) in source waters and drinking water is of growing concern to water professionals. This group of organic compounds, used for industrial and consumer applications such as nonstick coatings and firefighting foams, has potential health implications for humans and wildlife. PFCs are persistent in the environment and highly soluble in water. The U.S. Environmental Protection Agency (EPA) listed the following PFCs as suspected drinking water contaminants with presence in drinking water under the Unregulated Contaminant Monitoring Rule 3 (UCMR 3): perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS), perfluorohexanoic acid (PFHxA), perfluorobutanesulfonic acid (PFBS).

Current Regulation of PFCs

Currently there are no enforceable federal drinking water limits for PFCs. In May of 2016, EPA released Lifetime Health Advisories of 0.070 microgram per liter (µg/L) (70 ng/L) for PFOA and PFOS (individually or combined) for exposure from drinking water. These advisory levels are set at concentrations which EPA is certain are protective for the most sensitive individuals against reproductive and developmental impacts with a margin of safety. EPA has identified PFCs as an emerging contaminant because they have a pathway to enter the environment, may pose a human health or environmental risk, and do not have federal regulatory standards. In addition, individual states have begun to develop state PFC guidelines for monitoring and reducing PFCs in the environment.

Levels of PFCs above state guidance levels and the national lifetime health advisory should be reported to your state's primary agency to determine the course of action. EPA recommends that public health officials provide information on PFOA/PFOS exceedances to consumers with specific information regarding reproductive and developmental risks associated with elevated PFOA/PFOS levels.

Treatment Options for PFCs

Although the removal efficiency of PFCs from source waters depends on water treatment variables such as influent concentration and treatment conditions, several treatment methods have proven to remove up to 90% or greater of PFCs in finished water. Ultimately, systems facing a PFC treatment challenge will want to evaluate treatment strategies that best fit their source water, treatment objectives, and other system-specific considerations.



PFC Concentration Guidelines		
Agency	Matrix	Contaminant
U.S. EPA	Drinking Water	Lifetime Health Advisory: PFOA & PFOS (Combined or Individually) – 0.070 µg/L
State	Matrix	Contaminant
Illinois	Groundwater	PFOA – 0.400 µg/L PFOS – 0.200 µg/L
Maine	Groundwater	PFOA – 0.060 µg/L PFOS – 0.100 µg/L
Michigan	Surface Water	PFOA – 0.420 µg/L PFOS – 0.012 µg/L
Minnesota	Drinking Water + Fish Consumption	PFOA – 0.610 µg/L (Lake) PFOA – 0.720 µg/L (River) PFOS – 0.012 µg/L (Lake) PFOS – 0.006 µg/L (River)
New Jersey	Drinking Water	PFOA – 0.040 µg/L
North Carolina	Groundwater	PFOA – 2 µg/L
Vermont	Drinking Water	PFOA – 0.020 µg/L

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Treatment Method	Treatment Process	Documented PFC Removal Percentages	Relative Treatment Cost	Application	Treatment Considerations	
					Pros	Cons
Activated Carbon	Granulated activated carbon (GAC) or powdered activated carbon (PAC)	PFOA ≥ 90% PFOS ≥ 90% PFNA ≥ 90%	\$\$	Surface Water, Groundwater, PWSS, Households	<ul style="list-style-type: none"> Widely used for PFC removal, high removal rates possible GAC provides better removal than PAC PAC is useful for responding to spills In-house options are available for point-of-use or point-of-entry systems 	<ul style="list-style-type: none"> Conflicting results on which PFCs are removed most effectively Possibility of competitive adsorption with other compounds present, such as natural organic matter Slow GAC adsorption rates may extend operating time and require optimization Requires thermal regeneration of GAC Creates waste residuals to dispose of exhausted carbon Process optimization necessary (pH, temperature, contact time)
Anion Exchange	Special ion exchange material (commercial resins or petrochemical compounds) shaped as beads exchange anions and replace hydroxyl groups	PFOA = 10-90% PFOS = ≥ 90% PFNA = 67%	\$\$	Surface Water, Groundwater	<ul style="list-style-type: none"> PFOS removed well by anion exchange but sorption rates depend on polymer matrix and porosity Can partially remove PFOA, PFNA, PFOS 	<ul style="list-style-type: none"> Reject brine must be properly disposed of Costs are similar to activated carbon but depend greatly on resin and treatment system Rate of exchange will depend on many factors, including influent PFC concentration, design of the anion exchange, solution ionic strength and bead material Potential for competing anions Surface water supplies may need clarification/filtration before treatment Less effective at short-chain PFC removal
Membrane Filtration	Reverse Osmosis (RO): semi-permeable membrane to allow osmotic pressure to retain PFCs Nanofiltration (NF): uses filters with pore sizes around 0.001 micron and a high water flux to filter PFCs	PFOA = ≥ 90% PFOS = ≥ 90% PFNA = ≥ 90%	\$\$\$	Surface Water, Groundwater, PWSS, Households (RO)	<ul style="list-style-type: none"> Excellent PFC removal May be designed for under-sink or residential well water PFC treatment Can be successfully combined with GAC for higher PFC removal rates Multi-contaminant removal Reasonable for groundwater systems 	<ul style="list-style-type: none"> Reject water must be treated before discharging High capital expense with high energy demands Susceptible to fouling May require pre-treatment due to high fouling tendencies RO is preferable to NF due to higher removal efficiency
Advanced Oxidation Processes (AOP)	UV/H ₂ O ₂ UV/S ₂ O ₈ ²⁻	PFOA < 10% PFOS = 10 to 50% PFNA < 10%	\$\$\$	Surface Water, Groundwater	<ul style="list-style-type: none"> Can oxidize a multitude of contaminants to degradation products using reactive hydroxyl radicals 	<ul style="list-style-type: none"> Less effective at breaking down organic compounds such as PFCs No significant difference in removal of PFCs observed between different AOP methods Significant energy input is needed to achieve moderate PFAS oxidation with AOP

References

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