Fact Sheet

Treatment Options for Removing PFAS from Drinking Water

April 2024

The U.S. Environmental Protection Agency (EPA) is fulfilling a foundational commitment in the agency's PFAS Strategic Roadmap. Through this National Primary Drinking Water Regulation (NPDWR), the EPA is following the process outlined in the Safe Drinking Water Act for regulating drinking water contaminants, leveraging the best available and most recent science, and building on existing state efforts to limit PFAS and provide a nationwide, health-protective standard for these specific PFAS in drinking water.

Some states have established drinking water regulations or guidance values for some PFAS, leading the way in monitoring for and limiting PFAS. The EPA's PFAS National Primary Drinking Water Regulation (NPDWR) sets nationwide limits for five individual PFAS: PFOA, PFOS, PFNA, PFHxS, and HFPO-DA (known as "GenX chemicals"). And the rule sets a limit for four PFAS contaminants as a mixture: PFHxS, PFNA, HFPO-DA, and PFBS.

What treatment options are most effective in removing PFAS from drinking water?

As part of the final PFAS National Primary Drinking Water Regulation (NPDWR), granular activated carbon, anion exchange, reverse osmosis, and nanofiltration were identified by the EPA as the "Best Available Technologies" (BATs) for meeting the PFAS Maximum Contaminant Levels (MCLs). This is based on six criteria: removal efficiency, historical full-scale operation, geographic applicability, compatibility with other treatment processes, ability to bring the entire water system into compliance, and a reasonable cost to large as well as medium sized systems. Water systems may use any technology or practice to meet the PFAS MCLs and are not limited to the BATs.

What PFAS treatment technologies are most appropriate for small water systems?

For public water systems serving 10,000 or fewer people, the EPA designates technologies that are both effective and affordable as Small System Compliance Technologies (SSCTs). The EPA determined that there are available SSCTs for the PFAS MCL which are the same as the BATs, though some of these technologies are only anticipated to be affordable for certain small systems depending on the populations they serve. Anion exchange was found to be affordable for all system size categories, granular activated carbon in most cases for systems serving between 25-500 people as well as in all cases for larger systems, and reserve osmosis and nanofiltration for systems serving 3,301 – 10,000 people.

Do water systems have to select the treatment technologies designated by EPA?

No, the EPA does not specify how water systems must comply with the PFAS MCLs or specific technologies that must be utilized. At this time, EPA believes most systems will select technologies that are BATs. However, technologies other than the BATs may be used to reduce PFAS levels below the MCLs. Systems may also choose to change their source water or close PFAS contaminated source waters to achieve compliance. There is significant research activity exploring other treatment options and new technologies including novel sorbents, destructive technologies, and foam fractionation. When choosing a novel approach, EPA recommends reviewing data demonstrating PFAS removal efficiency, lack of potential harmful byproducts, and evaluations of treatment residuals that may require disposal. Powdered activated carbon may be an appropriate choice in certain circumstances, however, its efficacy for PFAS removal is variable due to factors such as carbon particle size, background organics, and plant efficiency; this precluded its selection by the EPA as a BAT.

Will water systems that install treatment systems have to dispose of PFAS-containing waste?

Currently available technologies separate PFAS from the drinking water and generate PFAS containing materials that must be managed. Exhausted granular activated carbon can be landfilled, incinerated, or reactivated. Exhausted anion exchange media is typically landfilled or incinerated; while regeneration is possible, it is often not viable for water utilities because conventional regeneration methods are not effective or involve safety and/or disposal concerns (e.g., regeneration relying on brine with strong organic solvents). Reverse osmosis and nanofiltration face challenges associated with brine disposal. Potential options may include discharges to surface water or sanitary sewers, provided those discharges are in compliance with all relevant NPDES permit requirements, or underground injection into a permitted UIC well.

At this time, the EPA does not have any regulatory requirements for the treatment, destruction, and disposal of water treatment residuals that contain only PFAS. Concurrent with this final drinking water rule, the EPA published an updated version of "*Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances*" that describes the options of landfilling, injection and thermal treatment for disposing PFAS laden materials. This guidance recommends materials containing PFAS should be managed to minimize potential releases to the environment and protect human health and provides information that water systems can consider when deciding how to dispose of residuals.

How does Granular Activated Carbon remove PFAS from drinking water?

Contaminated water is passed through a pressure vessel or filter box containing granular activated carbon (GAC); PFAS then "sticks" to the activated carbon. When there is not enough space left for PFAS to stick to the GAC, it must be changed. GAC processes are normally located towards the end of treatment plants. In addition to removing PFAS, GAC may decrease disinfectant byproduct formation (by removing precursors), remove volatile organic compounds, as well as improve water's color, taste, and smell. Potential GAC complications include PFAS displacement by other contaminants that are "stickier" (e.g., total organic carbon), release of certain metals (particularly arsenic, antimony, and iron); pH fluctuation; and reductions in disinfectant residual concentrations.

How does Anion Exchange remove PFAS from drinking water?

Contaminated water is passed through a vessel containing anion exchange media, and anions from the media (typically chloride or hydroxide), are exchanged for the PFAS (much like sodium cations are exchanged for calcium or magnesium in water softeners which employ cation exchange). When the exchange anions are exhausted, the media needs to be replaced. The footprint for anion exchange equipment is typically ¼ that of GAC. Removal is strongly pH dependent and may require adjustment; better removal is generally achieved with more acidic (lower pH) water. Similar to GAC, anion exchange is normally located towards the end of treatment plants. Anion exchange also may reduce disinfectant byproduct formation (although typically less so than GAC). It may remove other unwanted anions, such as nitrate or sulfate. Corrosion control practices may need to be adjusted when using anion exchange.

How do Reverse Osmosis and Nanofiltration remove PFAS from drinking water?

Reverse osmosis and nanofiltration are high pressure membrane processes. Reverse osmosis is typically used for desalinization. Nanofiltration is a slightly lower pressure version of reverse osmosis that cannot remove small, dissolved salts but can remove larger molecules, such as PFAS. These processes split water into two streams - clean water (also known as permeate), and a contaminated stream (known as reject, concentrate, or brine). The volume of the contaminated stream is generally about 20% of the influent water and the PFAS are concentrated by a factor of roughly 5x. Membranes require cleaning to prevent scaling or fouling. Capital and operational costs of high-pressure membranes are very high compared to other treatment processes. Reverse osmosis and nanofiltration are normally placed towards the end of a water treatment plant and are rarely chosen for single contaminant removal because of the high costs associated with them. These processes are very effective at reducing disinfection byproducts and can remove bacteria as well as viruses. The major challenge associated with these processes is brine disposal; available disposal options are site specific. Corrosion control is also a concern that may need to be addressed downstream from the process.

Can Point of Use or Point of Entry devices be used to meet the MCL?

Point of use (POU) or point of entry (POE) devices are building water treatment systems; POU devices treat only the water intended for direct consumption (drinking and cooking), typically at a single tap or limited number of taps and POE treatment devices are typically installed to treat all water entering a single home, business, school, or facility. POU and POE treatment systems are certified to reduce contaminants to a specific level in accordance with ANSI/NSF standards. EPA has not designated POU and POE treatment systems as compliance options because the PFAS regulations require treatment to concentrations below current ANSI/NSF certification standards for these devices. The EPA expects that the ANSI/NSF drinking water treatment certifications will be revised to demonstrate the ability of the devices to meet the EPA's MCLs. When that happens, the EPA anticipates that POU and POE devices may become a regulatory compliance option for small systems. For more information, please see: https://www.epa.gov/system/files/documents/2024-04/water-filter-fact-sheet.pdf.

How should water systems select the most appropriate compliance approach for the MCLs?

There are a multitude of factors which may affect a water system's approach to PFAS management. These may include the ease of access, continuity, quantity, and quality of alternative sources or interconnections, ease of integrating an alternative source, interconnection, or treatment process into existing operations, treatment residuals disposal, and local laws or regulations. Additionally, other considerations including capital, operations, maintenance, and residual disposal costs may influence the approach selected. When selecting a method to meet the PFAS MCLs water systems should consult with their primacy agency, seek technical assistance, and conduct pilot testing of alternatives.

What is the compliance deadline extension?

Because of the additional time required for capital improvements for systems to comply with the PFAS MCLs, the EPA is exercising its authority under the Safe Drinking Water Act to provide an additional two years for systems nationwide. Therefore, regulated PWSs must comply with all regulated PFAS MCLs in 2029, five years after the date of rule promulgation, including providing public notification for violations of the PFAS MCLs.

What are some helpful resources available to water systems related to drinking water treatment and compliance with the PFAS MCLs?

There are many resources EPA and other organizations have developed including:

- **Best Available Technologies and Small System Compliance Technologies for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water**: EPA technical support document that evaluates treatment technologies.
- **Drinking Water Treatability Database**: Provides scientific literature on the effectiveness of various treatment processes for specific contaminants in drinking water, including some PFAS
- **Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances:** Includes information on PFAS destruction and disposal, uncertainties for current commercially available disposal or destruction technologies, and options to manage PFAS waste that may destroy or control its migration, among other topics.
- **Drinking Water Treatment Technology Unit Cost Models**: Technical tools to help estimate treatment costs for implementing treatment methods, including GAC, anion exchange, and membrane (RO/Nanofiltration) treatment

processes.

- **Per- and Polyfluoroalkyl Substances (PFAS): Incineration to Manage PFAS Waste Streams:** This technical brief provides options and considerations for the disposal of PFAS waste via incineration.
- **PFAS Innovative Treatment Team**: Overviews and assessments on 4 promising technologies (electrochemical oxidation, mechanochemical degradation, pyrolysis and gasification, and super critical water oxidation) for PFAS destruction and disposal.
- **Information on U.S. EPA's PFAS Website**: Provides general information on PFAS, including resources and data, among other topics.
- **Research on PFAS EPA Website**: Contains links to pilot and case studies as well as recent scientific publications on PFAS drinking water treatment.
- **PFAS Research Funding Opportunities Website**: Links to ongoing projects revolving around PFAS in drinking water as well as destruction and disposal.