Tackling the Widespread Threat of PFAS Contamination

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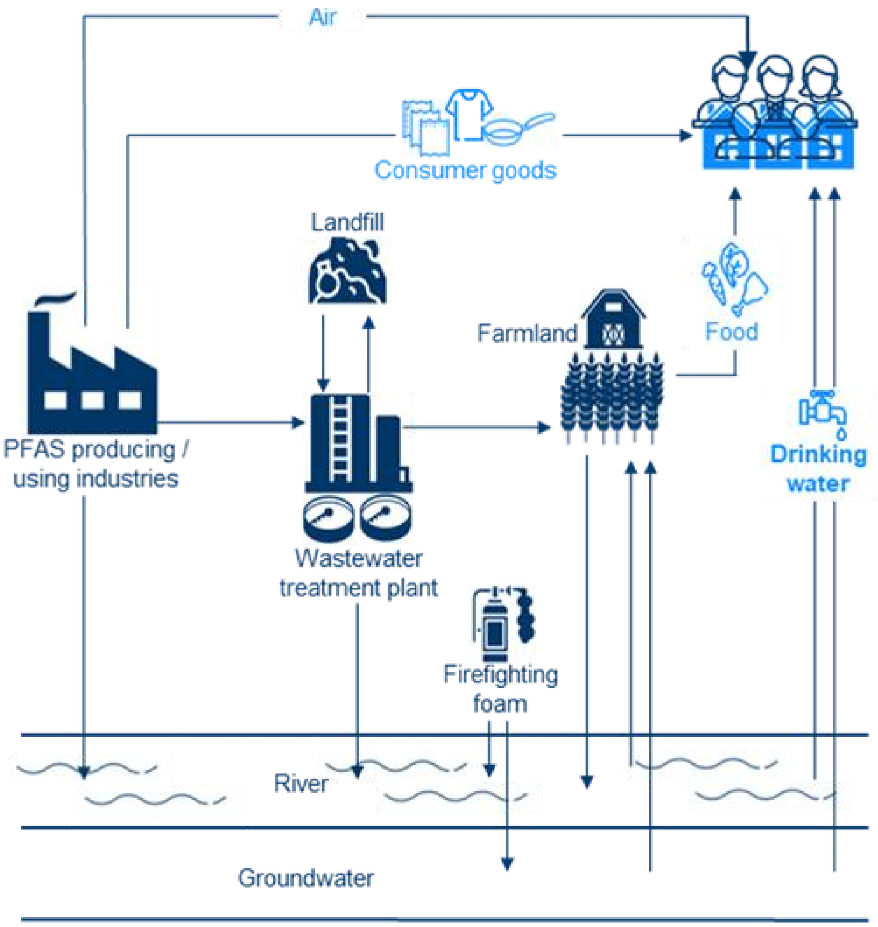
Contextual synthesis

PFAS are a group of man-made chemicals that are used to make fluoropolymer coatings and products that resist grease, heat, oil, stains etc. The chemicals are continuously released into the environment throughout the manufacturing, processing, distribution, use, and disposal stages of the lifetime of the products that contain them. Some PFAS are also used in in firefighting foams and industrial processing, such as in the manufacturing of other chemicals and products.

As of today, there are over 9,000 known types of PFAS and over 47,000 tons of it have been released into the atmosphere in the past six decades in a mixture of soil, water, and air. They are found in a variety of products such as non-stick cookware, water-repellant clothing, stain-resistant fabrics and carpets, cosmetics, firefighting foams, food contact materials etc. One of the first avenues of exposure to PFAS came from Teflon pans which are a household staple in many parts of the US.

PFAS paths to the environment and people



These chemicals move into our water systems through many different avenues and from soil contamination adversely impacting our food and bodies. Scientists estimate that over 200 million Americans are drinking water that has been contaminated with PFAS. Environmental Working Group (EWG) tests found PFAS chemicals in the tap water of 31 states and DC in the tests they conducted in varying amounts at amounts much higher than their proposed safe limit of one ppt. The United States has over 57,000 identified contaminated sites and more are being discovered every day.

Studies have found associations between prolonged PFAS exposure and a variety of health defects such as altered immune and thyroid function, liver disease, lipid and insulin dysregulation, kidney disease, adverse reproductive and developmental outcomes, lowered vaccine efficacy in children, cancer, and more. Current estimates say that exposure to PFAS is costing Americans over $37 billion dollars on an annual basis in healthcare costs.

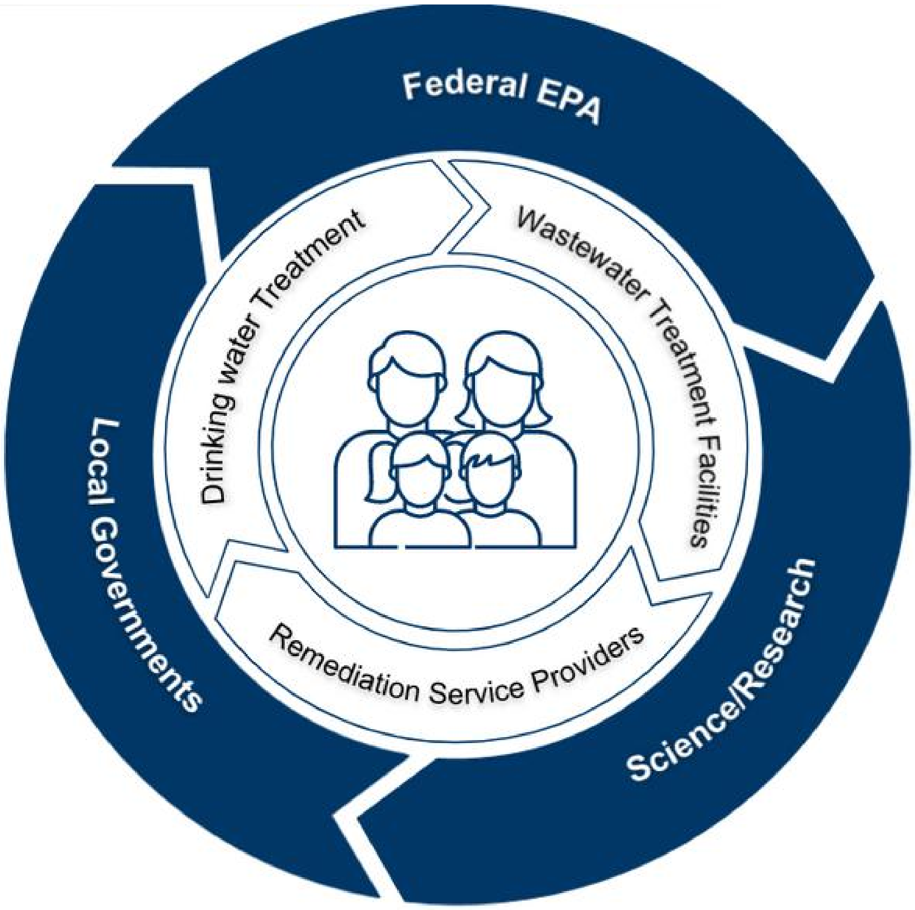
Introduction

Per- and polyfluoroalkyl substances (PFAS) have emerged as a pressing environmental concern due to their widespread use and persistent nature. These man-made chemicals, found in various products, have been continuously released into the environment, leading to widespread contamination of soil, water, and air. The impact of PFAS on human health is alarming, with studies linking prolonged exposure to a range of health defects.

What needs to be done ?

As regulations and technologies are being developed to tackle this issue, this article explores the importance of PFAS remediation and disposal, highlighting the regulatory landscape, stakeholder impact, and emerging technologies in addressing this urgent problem.

1. Regulations today and impact on key players



Local guidelines

At the state level, there are multiple states that have developed their own enforceable standards for drinking water that vary. States with enforceable drinking water standards include ME, MA, MI, NH, NJ, NY, PA, RI, VT, and WI. Both DE and VA are in the process of establishing enforceable standards for drinking water and FL is on track to adopt its own standards if the EPA has not finalized its standards for PFAS in drinking water by 2025.

Many state governments have devoted their own resources to the sampling and remediation of PFAS in waterways. The California Budget Act of 2021 appropriated $30 million from the General Fund to the State Water Resources Control Board (State Water Board) to address PFAS. Another $50 million was allocated for fiscal year 2022/23. In the summer of 2020 the Michigan Departments of Transportation and Environment, Great Lakes, and Energy awarded $4 million in PFAS testing and monitoring grants to 19 commercial services airports. In 2022, $31.9 million was awarded to projects that include enhanced treatment systems for addressing emerging contaminants including PFAS in New York. Some states are more concerned than others about PFAS contamination in the region and its timely remediation.

Federal guidelines

At the federal level, the Biden-Harris 2021-2024 plan was unveiled which aimed at gaining an understanding on the prevalence and distribution of PFAS chemicals around the country. The EPA announced a plan to require all public water systems to test for 29 PFAS chemicals as part of the next round of unregulated contaminant monitoring on an annual basis at the end of 2021. In March 2023, EPA announced the proposed National Primary Drinking Water Regulation for six PFAS including PFOA, PFOS, PFNA, HFPO-DA, PFHxS, and PFBS. The Department of Defense (DoD) is currently conducting PFAS cleanup assessments at the nearly 700 DoD installations where PFAS was used or may have been released and expects to have completed all initial assessments by the end of 2023. Clear regulations and restrictions on PFAS in wastewater are anticipated by the end of 2023.

The Biden administration announced $18 million in funding to address PFAS contamination in drinking water and groundwater. In 2022, the distribution of $10 billion in funding to address emerging contaminants under the Bipartisan Infrastructure Law began under the PFAS Clean Water State Revolving Fund ($1 billion), PFAS Small & Disadvantaged Fund ($5 billion), and Drinking Water State Revolving Fund ($4 billion).

Stakeholder Impact

We expect a push in research and adoption of new treatment and disposal methodologies for PFAS as enforceable regulations begin to be adopted across the US at a federal level. The expected legislation will form a basis for the standards that will be enforced throughout the country, although some states will likely adopt stricter policies than the ones released by the EPA. The opportunities in this space will mainly be relevant to:

- Remediation Service Providers – There will be a high demand for service providers of PFAS remediation and disposal both within the drinking water and wastewater treatment spaces. Focus on research and development of treatment methodologies that are continuous, can support massive volumes, and allow for both PFAS remediation and disposal are essential to the future.
- PFAS Emitters – Expected shift of responsibility for treatment of wastewater to releasers of PFAS with legal obligations coming through the regulatory landscape will likely take place within the next 5-10 years.
- Regulators – Continual processes need to be implemented in both the drinking and wastewater spaces that keep up with ongoing research on the presence of different types of PFAS that are polluting our waterways in a way that there is accountability.

2. Technologies today and tomorrow

While there exist over a dozen treatment methodologies for PFAS, the three that are most commonly used are: activated carbon, ion exchange resins, and membranes that allow for reverse osmosis or nanofiltration. The main drawback of these current technologies is that they only remove the PFAS present, not destroy it. For destruction, the remains must then be incinerated.

	Activated Carbon	Ion exchange resin	Membrane (Reverse osmosis, Nanofiltration)
Effectiveness of removal	• Less effective on short-chain PFAS • Remove other organic pollutants	• Effective for a wider range of PFAS • Remove other anionic compounds	• Effective for all PFAS and other pollutants indifferently
Capital and O&M	• Low capital costs even with prefiltration	• Moderate capital costs • O&M costs can be significant	• High capital and O&M costs
Operational costs	Lower impact even with prefiltration	Resin more costly than carbon with prefiltration	High because of energy consumption and pre- and post- treatment
Footprint	Large footprint	Smaller footprint compared to Carbon	Compact system – lower footprint
Pros	• Treats other water quality concerns • Effective on long-chain PFAS • Universally accepted	• Smaller footprint • Effective for a wide range of PFAS • Accepted by many	• Effective for a wide range of PFAS and also other quality concerns
Challenges	• Possible desorption of PFAS • Availability vs. demand • Disposal spent of media by incineration • Efficacity varies by type • Low efficiency on short-chain PFAS	• Single purpose • Disposal spent of media by incineration • Competitive exchanges impacting effectiveness	• High CAPEX & OPEX • Concentrate disposal, fouling, scaling requiring incineration

Here we have an example of five upcoming technologies in the treatment of PFAS and the disposal of its waste that we believe will be more readily available and accepted as research progresses:

	Oxidation	SCWO *SuperCritical Water Oxidation*	Pyrolysis, gasification	Plasma	Sonolysis
Description process	Oxidation and reduction of chemical pollutants by applying an electrical current through electrodes.	Heating and pressuring water to destroy PFAS.	Decomposition of materials at moderately elevated temperatures in an oxygen-free environment.	Activated gas made of energic electrons, which break the C-F bonds in contact with PFAS.	Using of an acoustic field to create chemical reaction in the solution (generation and implosion of vapor bubbles).
Effectiveness of removal	• Effective for long-chain PFAS with low concentration • Inefficient for short-chain	• Effective for a wide range of PFAS (longer time for short-chain PFAS)	• Effective for a wide range of PFAS but % of destruction varies on the specifications (54% to 98%)	• Effective for a wide range of PFAS • Remove other contaminants	• Effective for a wide range of PFAS • Remove other contaminants
Economical	• Expensive electrodes	• Maintenance issues	• Higher investment than standard methods • Produces valuable products	• High energy requirements	• High energy requirements
Waste management			**No waste generated**		
Challenges	• Can form short-chain PFAS • Toxic by-products	• Corrosion of the reactor and impact on water pH • Toxic intermediate products • Precipitation of salts • Limited full-scale application	• Required treatment for by-products	• Impact on water pH • Can form short-chain PFAS • Technology is not controlled enough • Limited full-scale application	• Mechanism not well understood (optimization of parameters required)

One major difference in emerging technologies and treatment methods is that PFAS is not only isolated and removed from the water, but also disposed of and there is no waste that then needs to be incinerated.

Why is this relevant to you?

A recent March 2023 report from the American Water Works Association (AWWA) estimates the annualized costs of compliance in the US at $2-4.5bn for drinking and wastewater remediation. The PFAS remediation and disposal market is expected to grow at a CAGR of close to 20% over the next 5 years.

We expect the new regulatory environment to address additional kinds of PFAS (beyond the 29 that are currently being screened) which will cause further growth in the market as both the number of treatment sites and the volume that needs treatment will increase exponentially. While current remediation methods focus only on drinking water, there will be a shift in 2024 as we see guidelines on the removal (and disposal) of PFAS from wastewater as well.

Besides remediation and disposal, companies currently emitting PFAS will also have a chance to include alternatives as a major portion of their sustainability goals for the next decade. As an example, 3M has announced that they will be ceasing the manufacturing of PFAS by 2025 and we expect more focus on research and development in that space. There is also research being conducted on alternatives to these PFAS that have become household and industry staples to find solutions that are less hazardous to the environment and human life.

PFAS are an urgent and essential topic as we are in the midst of developing regulations and technologies at both federal and state levels in the US. The market for PFAS remediation and disposal will only continue to grow as we discover more of its harmful effects and danger to human life. As we look towards a developing sustainability strategy, the presence of PFAS chemicals in products around us will be an important thing to take note of.

Conclusion

We already observe multiple actions to respond to the urgent need for regulations and technologies to address the harmful effects of these chemicals on human life and the environment. The PFAS remediation and disposal market is expected to grow at a significant rate over the next decade, with a shift towards including wastewater in the guidelines for removal and disposal. Upcoming technologies and treatment methods now focus on both removing and disposing of PFAS waste. As companies focus on sustainability goals, alternatives to PFAS are being researched to find solutions that are less hazardous. Overall, we see a strong need for continuous research and implementation of processes that keep up with ongoing research on the presence of different types of PFAS. This is the only way to ensure accountability and protect human health and the environment.