What is PFAS?

Per- and polyfluoroalkyl substances (PFAS) are a large group of man-made chemicals characterized by carbon-fluorine bonds, making them extremely resistant to heat, water and degradation. Due to their stability, PFAS are persistent in the environment and the human body, earning them the nickname “forever chemicals”.

They have been used since the mid-20th century in various products like firefighting foams, food packaging, non-stick pans and waterproof textiles.

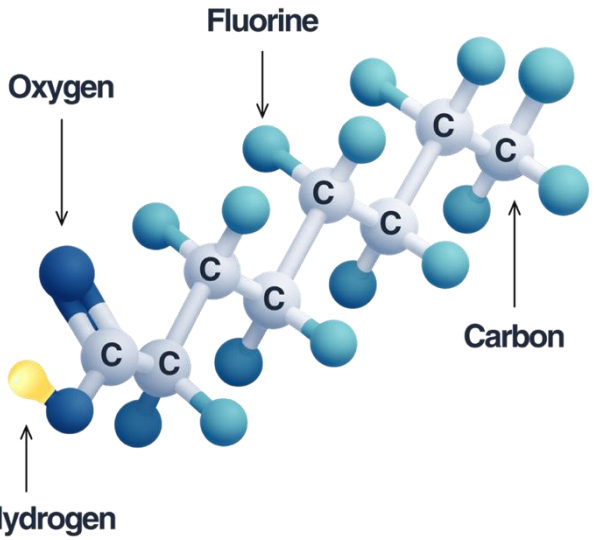
Their widespread utility and chemical resilience have led to global environmental and health concerns. PFAS can bioaccumulate in organisms and persist in soil, water and air over long periods.

- Stable, synthetic chemicals with strong carbon-fluorine bonds
- Used in consumer and industrial products since the 1940s
- Known for persistence, bioaccumulation and toxicity

The three most important ones are:

PFOA (Perfluorooctanoic Acid)

PFOA is a long-chain PFAS used in manufacturing non-stick coatings and industrial applications. It is highly persistent in the environment and has been linked to kidney and testicular cancer, thyroid disease, and immune system suppression. Due to its widespread presence in water and human blood, it has become a global priority for regulation and phase-out.



PFOS (Perfluorooctane Sulfonic Acid)

PFOS, once commonly used in firefighting foams and stain repellents, is among the most persistent and bioaccumulative PFAS. It is found in wildlife, water, and human tissues worldwide and has been linked to developmental toxicity, liver damage, and endocrine disruption. Its high mobility and resistance to degradation make it a lasting threat to both ecosystems and human health.

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GenX (HFPO-DA – Hexafluoropropylene Oxide Dimer Acid)

GenX was introduced as a "safer" replacement for PFOA, but emerging evidence shows it may pose similar health and environmental risks. It is less studied but has been associated with liver toxicity, reproductive effects, and developmental harm in animal studies. GenX is more difficult to detect and treat in water systems, raising new challenges for regulators and utilities.

Why care? Understanding PFAS is critical for informed policy and regulation. These persistent chemicals do not degrade naturally and accumulate in the environment and human bodies, creating long-term liabilities. Their widespread use across industries means that without oversight, they can silently compromise public health, ecosystems, and even national water supplies. Ignorance of PFAS risks may lead to costly remediation, legal challenges, and irreversible environmental damage.

What are the sources of PFAS?

PFAS contamination stems from both point and diffuse sources.

Major contributors include industrial manufacturing, military and firefighting training facilities, wastewater treatment plants and the application of contaminated biosolids in agriculture.

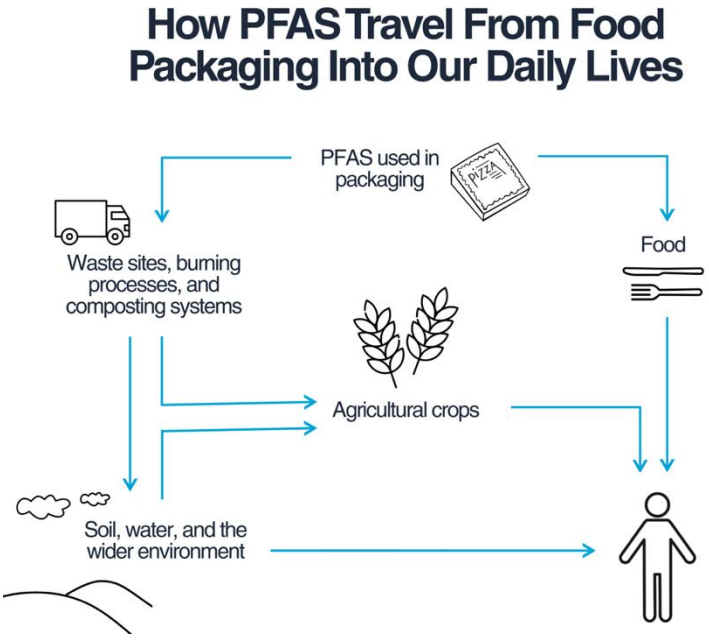
Consumer products such as coated cookware, water-resistant clothing and food wrappers also contribute to domestic PFAS exposure.

Once released, PFAS can travel through air, leach into groundwater and spread through rivers and ocean currents. Their resistance to degradation allows them to accumulate across environmental media and ecosystems.

- Industrial discharge
- Firefighting foams (AFFF)
- Consumer goods: non-stick cookware, stain-resistant textiles
- Landfill leachate and biosolids

Industrial Manufacturing

Industrial production of PFAS and PFAS-containing products (e.g., fluoropolymers, coatings, and textiles) is a primary source of environmental contamination. Facilities often release PFAS through air emissions, wastewater discharges, and accidental spills, contaminating nearby soil and water. These emissions can travel long distances, affecting areas far from the original source. Regulatory oversight of industrial PFAS discharge has historically been limited, contributing to decades of unchecked pollution.



Firefighting Foams (Aqueous Film-Forming Foam – AFFF)

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AFFF, used extensively at military bases, airports, and chemical plants, is a major contributor to localized PFAS hotspots. These foams contain high concentrations of persistent PFAS, which easily infiltrate soil and groundwater after training exercises or emergency use. Contamination from AFFF has led to some of the highest PFAS levels recorded in water systems. Cleanup is particularly difficult due to the depth and dispersion of PFAS in subsurface environments.

Wastewater Treatment Plants and Biosolids

Wastewater treatment plants do not fully remove PFAS, allowing them to pass through into effluent or accumulate in sewage sludge. When these biosolids are applied to agricultural fields as fertilizer, PFAS are introduced into soil and crops. This creates a long-term, diffuse source of environmental and human exposure. Because treatment plants are not designed for PFAS removal, they unintentionally act as redistribution hubs rather than containment points.

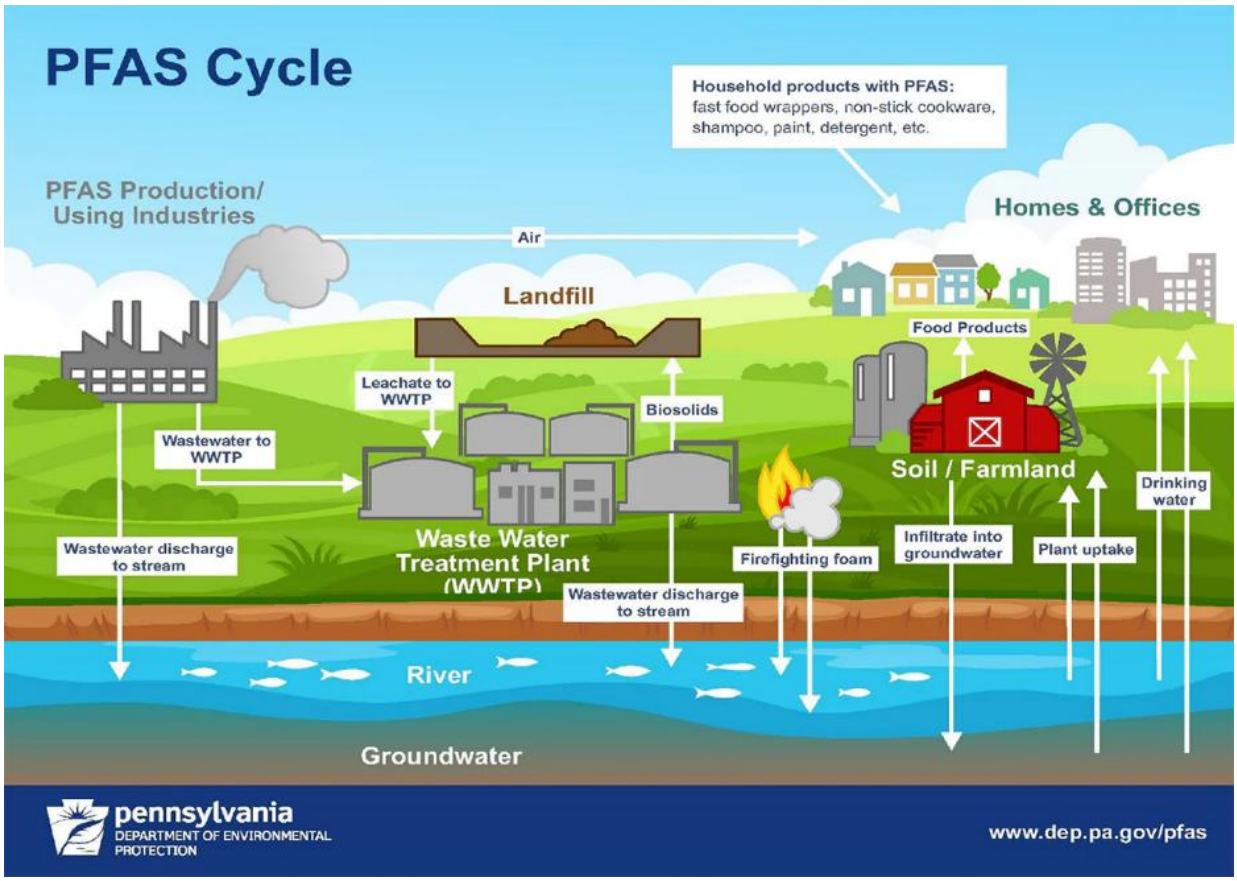
Why care? Identifying and managing PFAS sources is essential for cost-effective prevention. Industrial emissions, firefighting foams, and consumer waste continue to introduce PFAS into ecosystems and drinking water systems. Without strategic source control, mitigation becomes far more expensive and reactive rather than proactive. Decision-makers must act at the source level to prevent future contamination crises and avoid escalating treatment costs.

How widespread is PFAS?

PFAS contamination is now global in scale, with detections in groundwater, surface water, soils, wildlife and even human blood samples worldwide. Research shows presence in remote environments, including the Arctic, due to long-range atmospheric transport.

Monitoring has confirmed contamination near industrial sites, airports and military bases, but low levels are also found in public water systems. The chemicals have been detected in hundreds of U.S. communities and in drinking water across Europe, Asia and Australia. PFAS also appear in food, air and household dust and have been:

- Detected in 75+ countries
- Found in drinking water, food, air, soil and blood
- Long-range transport leads to contamination in remote areas
- Widespread due to decades of unregulated use



Drinking Water

PFAS have been widely detected in municipal and private drinking water supplies across the globe, particularly near industrial facilities, firefighting training sites, and airports. In the U.S. alone, millions of people are exposed to PFAS levels exceeding health advisory limits. These substances are highly mobile in groundwater and can persist in drinking water systems for decades without degradation. Conventional water treatment methods are largely ineffective, making this one of the most pressing exposure pathways for public health.

Soil and Agriculture

PFAS contamination in soil primarily arises from the land application of contaminated biosolids, industrial runoff, and firefighting foam usage. These substances can be taken up by crops, particularly leafy vegetables and root plants, leading to human exposure through the food chain. Short-chain PFAS are especially mobile in soil and water, making containment and cleanup difficult. This poses significant risks to food safety, soil health, and agricultural sustainability.

Wildlife and Ecosystems

PFAS have been found in a wide range of wildlife, from fish and birds to polar bears, highlighting their global distribution and bioaccumulative nature. They disrupt endocrine and immune systems in animals, leading to reduced fertility, developmental issues, and population decline in sensitive species. Aquatic ecosystems are especially vulnerable due to PFAS runoff from contaminated sites into rivers, lakes, and oceans. The persistence of PFAS across trophic levels signals long-term ecological disruption and biodiversity loss.

Why care? PFAS contamination knows no borders—it affects rural communities, urban centers, military installations, and agricultural regions alike. These substances have been detected in over 75 countries, signaling a global threat with local consequences. Decision-makers must recognize that inaction will likely translate to escalating public health costs and pressure from affected communities. Proactive national and regional strategies are needed before localized problems become systemic failures.

Take a deep dive into how widespread PFAS is in Europe here:

Explore the map of Europe's PFAS contamination (Le Monde)

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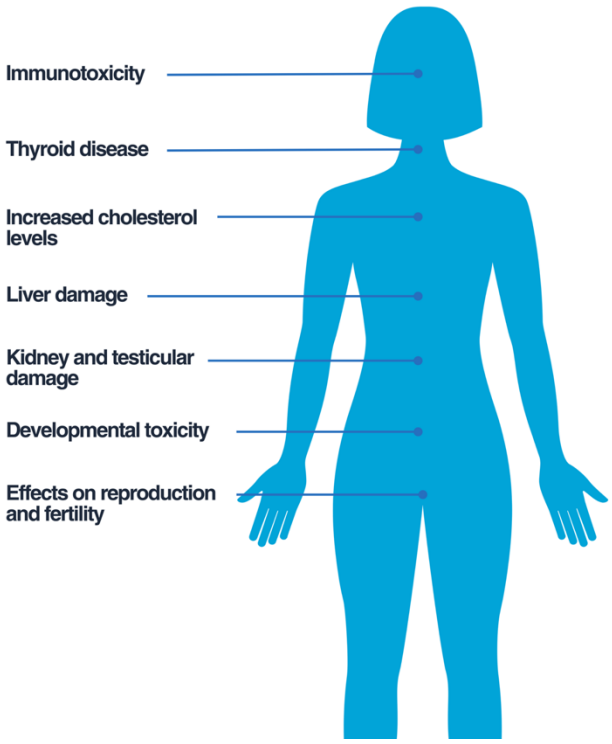
What health issues are related to PFAS?

PFAS exposure has been associated with multiple health problems. Research links them to thyroid disease, immune system suppression, reproductive harm and increased risk of cancers, particularly kidney and testicular cancer.

PFAS can interfere with hormone function and cholesterol metabolism, and they are especially harmful to vulnerable populations like pregnant women and children. Some studies suggest links to developmental delays, liver damage and reduced vaccine efficacy. Health risks grow with cumulative exposure over time:

- Immune suppression and vaccine interference
- Reproductive toxicity and cancer risks
- Thyroid dysfunction
- Cholesterol and liver effects



Immune System Suppression

PFAS exposure has been strongly linked to immune system dysfunction, especially in children. Studies show reduced antibody responses to vaccines (e.g., tetanus and diphtheria), suggesting impaired immune defense. This can increase susceptibility to infectious diseases and reduce the effectiveness of immunization programs. As a result, PFAS are classified by several health agencies as immunotoxic, raising serious public health concerns.

Cancer (Kidney & Testicular)

Long-term PFAS exposure—particularly to PFOA and PFOS—has been associated with elevated risks of kidney and testicular cancers. Epidemiological studies from contaminated communities and occupational settings provide consistent evidence for this link. These cancers may arise from PFAS-induced oxidative stress, endocrine disruption, or chronic inflammation. The classification of PFOA as a possible human carcinogen by the International Agency for Research on Cancer (IARC) underscores the severity of this risk.

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Reproductive and Developmental Effects

PFAS can interfere with reproductive hormones, leading to reduced fertility, menstrual irregularities, and altered testosterone levels. In pregnant women, exposure has been linked to low birth weight, preeclampsia, and developmental delays in children. These chemicals can cross the placental barrier and accumulate in breast milk, posing early-life risks. As reproductive outcomes have generational impacts, this makes PFAS a long-term public health challenge.

Why care? The health effects of PFAS carry long-term societal and economic burdens. From immune suppression to cancer risks, PFAS-related illnesses can increase healthcare costs, reduce workforce productivity, and generate public outrage. Regulations that fail to account for these risks expose governments and industries to lawsuits, reputational damage, and loss of public trust. Forward-thinking leaders must prioritize public health to safeguard both people and institutions.

In recent decades, PFAS exposure has been linked to a growing list of health problems, including immune system suppression, lower birth weight, and increased risk for some cancers.

These chemicals are added to many materials to make them resistant to grease, water, and stains, and to add nonstick properties.

But their effects on human health and the environment have put their widespread use under increased scrutiny.

Read more:

How PFAS Can Harm Your Health?

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Removing PFAS

Removing PFAS is technically challenging due to their chemical stability. Common treatment methods include adsorption using activated carbon or ion exchange resins, membrane filtration and advanced oxidation processes like photocatalysis.

These technologies can reduce PFAS levels in water but often require costly infrastructure and regular maintenance. Short-chain PFAS are more difficult to remove than long-chain variants due to their different chemical characteristics.

Emerging methods such as electrochemical degradation and thermal destruction show promise in specialized settings:

- Granular activated carbon (GAC)
- Ion exchange resins (IEX)
- Reverse osmosis/membrane filtration
- Photocatalysis and advanced oxidation
- Thermal and electrochemical treatments

Technology	Pros	Cons
Granular Activated Carbon (GAC)	Widely used and commercially available (high TRL Effective for long-chain PFAS (e.g., PFOA, PFOS) Relatively low capital cost	Poor removal of short-chain PFAS Requires frequent replacement and regeneration Performance reduced by organic matter and fouling
Ion Exchange Resins	High selectivity for a broader range of PFAS (incl. short-chain) Faster adsorption kinetics than GAC Reusable with regeneration	Higher upfront and operational costs Sensitive to water chemistry and co-contaminants Disposal of spent resins poses challenges
Reverse Osmosis (RO) / Nanofiltration	High rejection of almost all PFAS types Suitable for drinking water and industrial reuse	High energy costs and membrane fouling Generates a PFAS-rich brine requiring further treatment High O&M complexity

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	Compact systems for modular deployment	
Advanced Oxidation Processes **(e.g., photocatalysis, electrochemical)**	Potential for complete mineralization (destruction) Effective on both long- and short-chain PFAS Suited for concentrated streams	Low technical readiness (lab/pilot-scale) High energy demand and reagent costs Complex system integration for full-scale use
instrAction resin technology	High productivity and low resin demand Broad Selectivity Easy to adapt with IEX equipment	Early-stage technology High upfront cost

Why care? The cost of inaction is far greater than the cost of prevention and treatment. As PFAS clean-up becomes legally mandated in more jurisdictions, failure to invest in effective removal technologies could result in billions in remediation liabilities. Decision-makers must support scalable, science-based solutions to remove PFAS from drinking water and ecosystems. Early investment not only mitigates health risks but also positions governments and organizations as responsible stewards of public resources.

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Mitigate PFAS contamination in the future

Mitigation requires a multi-pronged approach: regulating production and use, improving detection technologies and developing safer alternatives. Preventing release at the source is the most effective strategy, including phasing out high-risk PFAS and enforcing discharge limits.

Broader environmental monitoring and global data sharing are critical for managing risks. Public education, policy reform and investment in R&D will support long-term solutions. Collaborative international frameworks are essential to address this persistent pollutant globally.

- Ban or phase out harmful PFAS compounds
- Stricter regulations and monitoring
- Develop PFAS-free alternatives
- Invest in R&D for treatment technologies
- Promote global cooperation and public awareness

instrAction provides PFAS removal technology that can be adapted to different sites and regulatory needs. We're expanding our research to keep up with emerging PFAS and offer hands-on support, from pilots to system integration. We also collaborate with regulators, companies, and municipalities to share data and experience so that better decisions can be made around PFAS treatment.

On a personal level, you can reduce PFAS exposure by avoiding products known to contain them—such as non-stick cookware, water-repellent clothing, and certain food packaging. Advocate for PFAS transparency by supporting labeling initiatives and companies that commit to PFAS-free alternatives. You can also raise awareness in your community or workplace about PFAS risks and the importance of responsible consumption. Making informed choices sends market signals and contributes to broader systemic change.

Why care? Future mitigation strategies will define how resilient your community, industry, or nation is to chemical threats. Regulatory frameworks, innovation incentives, and infrastructure planning must evolve now to avoid long-term ecological and financial damage. Leaders who act early will shape policy, protect vulnerable populations, and avoid being caught in reactive cycles. The path forward demands foresight, cross-sector coordination, and commitment to sustainable environmental health.

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About instrAction

instrAction is dedicated to bringing ground-breaking innovations to the water treatment industry. Since its foundation, instrAction has expanded its activities at a rapid pace.

The expertise acquired combines the selectivity of absorber resins with the requirements of modern water treatment.

Visit us on our website www.instraction.de or find us on LinkedIn.

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Further Reading

PFAS: forever chemicals—persistent, bioaccumulative and mobile. Reviewing the status and the need for their phase out and remediation of contaminated sites

Brunn, et al., Environmental Sciences Europe, Vol. 35, Article 20, **2023**.

https://doi.org/10.1186/s12302-023-00721-8

Comprehensive analysis of PFAS presence from environment to plate

Dimitrakopoulou, et al., npj Science of Food, Volume 8, Article 80, 2024.

https://doi.org/10.1038/s41538-024-00319-1

Environmental impacts, exposure pathways, and health effects of PFOA and PFOS

Wee, et al., Ecotoxicology and Environmental Safety, Volume 267, 115663, 2023.

https://doi.org/10.1016/j.ecoenv.2023.115663

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Disclaimer

This document contains important information and must be read in its entirety.
The instrAction resins have been developed for the treatment of drinking water and industrial applications. They are intended for the binding of heavy metals or micropollutants from solutions. The resins have a remarkable buffering capacity; therefore, careful pH control is strongly recommended to ensure reproducible performance.
The instrAction resins are generally used in cartridges, columns or stirred tanks. The use as bulk material is limited to exceptional cases.
This information is provided in the best possible detail, but without guarantee. This document does not exempt you from carrying out your tests on our products with regard to their suitability for the intended processes and purposes. The application, use and processing of our products and the products manufactured by you on the basis of our technical application advice are beyond our control and are therefore exclusively your responsibility.
Our products are sold on the basis of our General Terms and Conditions of Sale and Delivery as amended from time to time.
If you have any questions, please contact an instrAction specialist!

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