

Forever Chemicals: Persistence, Health, and Cleanup

Some chemicals stick around in the environment for so long that scientists call them “forever.” A major group with this reputation is PFAS—per- and polyfluoroalkyl substances. PFAS include thousands of man-made compounds used since the mid-20th century to make products resist water, oil, heat, and stains. They appear in nonstick cookware coatings, water-repellent clothing, firefighting foams, food packaging, certain cosmetics, and many industrial processes. The problem is that the same chemistry that makes PFAS useful also makes them extremely persistent. PFAS can travel through air and water, accumulate in soils and living organisms, and linger long after the original product is thrown away. This reading explains what PFAS are, how they move and build up, what scientists know about health risks, and the tools communities are using to limit exposure and clean up contaminated sites.

What are PFAS?

PFAS share a common feature: chains of carbon atoms strongly bonded to fluorine atoms. The carbon-fluorine (C–F) bond is among the strongest in organic chemistry, which is why PFAS resist heat and chemical breakdown.

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PFAS backbone with strong C–F bonds

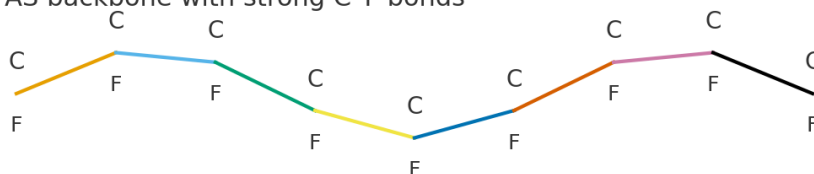


Figure 1. Simplified PFAS backbone highlighting strong C–F bonds.

Where do they come from?

PFAS enter the environment during manufacturing, through consumer product use, and when products are washed, discarded, or burned. Firefighting foams used for fuel fires at airports and training facilities have been major sources in groundwater. Water- and stain-resistant textiles can shed PFAS-containing residues during

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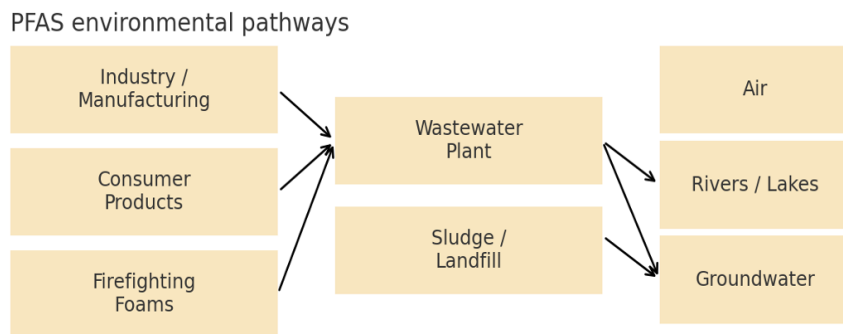


Figure 2. From sources to environmental sinks for PFAS.

How do PFAS move and persist?

Because many PFAS dissolve in water and resist breakdown, they can move far from where they were released. Rain can wash residues off paved surfaces into storm drains. In soils, some PFAS bind to organic matter while others remain mobile and travel downward into groundwater. PFAS can also evaporate in small amounts and

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Exposure and health considerations

Scientists study PFAS exposure by measuring levels in blood, water, and food, and by following populations over time. Some PFAS can build up in the body, with half-lives measured in years. Research has linked certain PFAS to

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Cleanup and treatment technologies

Removing PFAS from water typically uses a “separate and destroy” approach. Separation tools like granular activated carbon (GAC), ion-exchange resins, and reverse osmosis (RO) can capture PFAS from drinking water or industrial waste streams. These methods transfer PFAS into a concentrated waste that must then be handled safely. For destruction, researchers are advancing options such as supercritical water oxidation, electrochemical methods, advanced reduction processes, non-thermal plasma, and high-temperature treatment under carefully controlled conditions. Each method has trade-offs in cost, energy use, scalability, and the potential for byproducts. Communities often start with proven separation (e.g., GAC) while piloting emerging destruction technologies for the collected waste.

Limiting exposure at the source

The most effective long-term strategy is prevention—designing products and processes that do not rely on

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Why PFAS are called “forever” and what progress looks like

PFAS earned their nickname because natural processes remove them very slowly. The C–F bond resists sunlight, heat, and most biological decay. Even so, progress is possible. Reducing unnecessary uses lowers the amount

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Reading comprehension questions

1. What chemical feature makes PFAS so persistent in the environment?
2. Distinguish between
3. Give
4. Why are airports and fire-training sites often hotspots for PFAS in groundwater?
5. Describe two ways
6. Explain why wastewater
7. What does it mean that some PFAS have multi-year half-lives in people? Why does that matter?
8. List two
9. Identify
10. Name two
11. Why is prevention at the
12. What actions can communities take to reduce PFAS exposure while longer-term solutions are developed?

Extension questions

1. Create a
2. Compare granular activated carbon and reverse osmosis for household water treatment. Which would you recommend for a small school, and why?
3. Draft a
4. Propose a

Reading comprehension questions — key

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Extension questions — key

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