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Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS): What consumers need to know

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What are PFAS?

Perfluoralkyl and Polyflouroalkyl Substances, also known as 'PFAS', are a group of stable, man-made chemical compounds that have been used worldwide since the 1940s for industrial applications and consumer products. They repel water, oil, grease, and heat and are therefore commonly used to make waterproof and protective coatings, including non-stick cookware and stain resistant carpeting. The PFAS class covers a wide range of compounds, including Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS) as well as newer GenX chemicals which are currently being used in the place of PFOS and PFOA since being phased out by U.S. manufacturing. A defining feature of PFAS is its strong chemical structure due to bonds between carbon (C) and fluorine (F) atoms (Figure 1). These bonds represent some of the strongest bonds in chemistry and therefore can remain for long periods in the environment, in wildlife, and also in people.

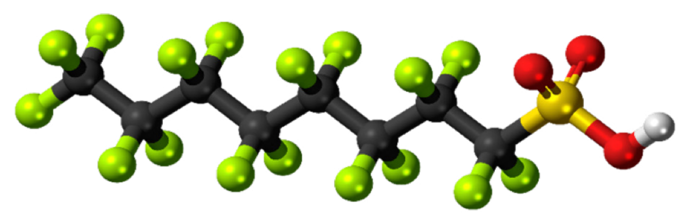

Fig. 1. Chemical structure of Perfluorooctane Sulfonic Acid (PFOS). Black = carbon, green = fluorine, yellow = sulfur, red = oxygen, white = hydrogen. Image credit: Wikipedia.

Table 1. Summary of common PFAS

Acronym	Product/Use
PFDA	Breakdown product of stain and grease proof coatings
PFNS	Surfactants in coating products
PFNA	Surfactant; Production of plastic
PFOS	Fabric Protection; Firefighting Foam
PFOA	Nonstick surfaces; Surfactant
PFHpS	Firefighting foams; Carpet treatments
PFHpA	Surfactant
PFHxS	Firefighting foam
PFHxA	Breakdown product of PFHxS
PFPeS	Firefighting foams; Carpet treatments
PFPeA	Stain and grease proof coatings on food packaging, couches, and carpets
PFBS	Stain repellent; Replacement for PFOS
GenX	Replacement for PFOA

In what products are PFAS found?

As stated above, PFAS are used by many industries, including aerospace, construction, automotive, textiles, and electronics, because of their ability to make surfaces smooth and to reduce friction. Products that contain PFAS include some stain resistant and waterproof clothing and furniture; floor polishes; adhesives; firefighting foams; insulation for electrical wires; paper; products for food packaging, such as pizza boxes, microwavable popcorn bags, fast food wrappers, and to-go boxes; personal care products, such as shampoo and dental floss; and heat-resistant and non-stick coatings on cookware (CDC, 2009; NIH, 2016a). One well known use of PFAS is in aqueous film forming foams (AFFFs), or firefighting foams. While very helpful at reducing damage by fires, they have also contributed to widespread contamination of soil, groundwater, and surface water (Houtz et al., 2013).

Where are PFAS found in the environment?

Because they are so stable, resistant to degradation, and migrate easily, PFAS are ubiquitous (found everywhere) throughout the world. Water, soil, plants, animals, and people in both urban and remote locations have been found to contain trace levels of PFAS (ASTSWMO, 2015). PFAS have also been detected in indoor and outdoor dust and even in the atmosphere (Trudel et al., 2008; Mitro et al., 2016). PFAS are found at particularly elevated levels in areas where firefighting foams have been used or stored, such as military installations, aircraft crash sites, and airport hangars. Although PFAS have been found in tissue and blood samples from humans and animals worldwide, there is good news: the overall levels of PFOA and PFOS, in both the environment and in people, are on the decline. This is largely due to the U.S. no longer manufacturing PFOS and reducing its PFOA production, which will soon be phased out entirely (NIH, 2016; EPA, 2018)

Fig 2. PFAS are found in all environments and across the globe.

What are health concerns associated with PFAS?

Because these substances do not break down easily, it is estimated that PFAS can persist in the human body for up to 4 to 8 years. While that may seem like a long time, exposure does not necessarily mean that a person will get sick, however the long-term effects on people are still being investigated (NIH, 2016a). It has been shown in animal studies that PFAS can disrupt hormonal activity, reduce immune function, and may cause adverse effects on organs such as the liver and pancreas (NIH, 2016a). Other studies have shown that PFAS may contribute to developmental problems in children exposed to PFAS in the womb and can potentially lead to increased risk for certain cancers and reduced fertility (Mitro et al., 2016; NIH, 2016b).

Who is most at risk of exposure to PFAS?

Because both nutrients and chemicals can be passed directly from mother to fetus across the placenta and can be passed from mother to infant through breast milk, fetuses and infants are particularly susceptible to the effects of certain chemical compounds during early development. Young children are also at risk because they are likely to play

Table 2. PFAS health advisories, notification levels, and regulatory standards in the U.S. (ppt = Parts per Trillion)

Location	Target Concentration
U.S. EPA	70 ppt (PFOA+PFOS)
California	13 ppt (PFOS) 14 ppt (PFOA)
Colorado	70 ppt (PFOA+PFOS)
Connecticut	70 ppt (sum of 5 PFASs)
Massachusetts	70 ppt (sum of 5 PFASs)
Michigan	70 (PFOA+PFOS)
Minnesota	27 ppt (PFOS) 35 ppt (PFOA) 27 ppt (PFHxS) 2,000 ppt (PFBS)
New Jersey	13 ppt (PFOS) 14 ppt (PFOA) 13 ppt (PFNA)
Vermont	20 ppt (PFOA+PFOS)
Washington	Banned in food packaging; Proposed drinking water standard

on surfaces where PFAS may be present (e.g., upholstery and carpet) (Mitro et al., 2016). Some potential health effects to infants and children may include learning, behavior, and reproductive problems (Mitro et al., 2015).

However, the American Academy of Pediatrics states that "even though a number of environmental pollutants readily pass to the infant through human milk, the advantages of breastfeeding continue to greatly outweigh the potential risks in nearly every circumstance", (The American Academy of Pediatrics, 2012).

How are people exposed to PFAS?

Human exposure is mainly through eating or drinking contaminated food or water, or exposure to products containing PFAS. However, more research is needed to understand all potential exposure routes and their impact on human health (NIH, 2016a).

Are PFAS regulated in drinking water?

PFAS are ubiquitous worldwide and may therefore be found in many drinking water supplies. In fact, a recent study found PFOS and PFOA in more than 70% of the surface water supplies tested (Appleman et al., 2014). Finished drinking water supplies (after treatment) were found to have similar levels of PFAS to samples collected prior to treatment due to the resistance of these substances to breakdown or degradation through conventional water treatment processes. Because PFOS and PFOA are known or anticipated to be found in public water systems and are not yet regulated at the federal level in the United States, they have been included in the U.S. EPA's Contaminant Candidate List 4 (CCL4). The U.S. EPA CCL4 is a list of chemical and microbiological contaminants that have been targeted for priority research to help improve understanding of their presence in the environment and their potential impact on public health. Only recently, in 2016, the U.S. EPA established lifetime health advisories for PFOS and PFOA at a combined concentration of 70 nanograms (ng)/L, or parts-per-trillion (ppt). For reference, one part per trillion is equivalent to one droplet of water in an Olympic-sized swimming pool.

Fortunately, it is rare for PFOA and PFOS concentrations to exceed or even approach this health advisory unless there are significant sources of contamination. However, some states have decided to set more stringent notification levels or regulatory limits as low as 13 ppt for PFOS (Table 2) (Bloomberg, 2018). In addition, some utilities are voluntarily taking steps to reduce concentrations of PFOA and/or PFOS in their water supplies before public health advisory limits are reached (Tucson Water, 2018). People concerned about PFAS levels in drinking water, can contact their local water utility for a copy of their Consumer Confidence Report (CCR).

What are the treatment options for PFAS?

As mentioned earlier, conventional drinking water treatment processes are generally ineffective for the removal of PFAS. However, water utilities can reduce PFAS concentrations in public water supplies by blending contaminated water with other water sources or eliminating the use of contaminated source waters altogether, such as contaminated groundwater wells (EPA, 2018). Reverse osmosis (RO) is an advanced water treatment process that uses special membrane filters effective for the removal of nearly all PFAS. Other treatment methods, such as granular activated carbon (GAC) which can absorb natural and synthetic organic compounds, are also effective for many of the longer-chain PFAS (i.e., C≥8 including PFOS and PFOA) but not necessarily the shorter-chain PFAS (i.e., C≤7; see Table 1) (Appleman et al., 2014; AWWA, 2016b). Devices that treat water at the faucet, or 'point-of-use' devices, with GAC and RO are also effective for in-home use.

How do consumers reduce their exposure?

Consumers can reduce their exposure to PFAS by avoiding contact with consumer products that may contain PFAS. Avoiding foods that are packaged in grease-repellent containers (some pizza boxes, to-go boxes, and microwavable popcorn bags) may also be helpful. Consumers can also reduce exposure from water contaminated with PFAS by using point-of-use devices in their home, specifically activated carbon and reverse osmosis systems, however most point of use devices are not guaranteed to reduce concentrations of PFAS.

What are the next steps in PFAS research?

PFAS will continue to be a critical research topic in the U.S. and abroad. As mentioned earlier, PFOA and PFOS are both listed on the U.S. EPA's CCL4, which means they have been targeted for priority research.

Recent and ongoing research conducted at principle research agencies include:

- Relationships between carbon chain length, toxicity, and human health impacts.
- Environmental dissemination and impacts to fish and wildlife.
- Occurrence of PFAS in public water systems and treatment options for drinking water.
- Remediation technologies

Future research also aims to better characterize the persistence of PFAS in the environment as well as better understand public health implications of PFAS other than

PFOS and PFOA, including shorter-chain compounds and alternatives (e.g., GenX). Agencies such as the Agency for Toxic Substances and Disease Registry (ATSDR), the Centers for Disease Control and Prevention (CDC), the National Institute of Environmental Health Sciences (NIEHS) and its National Toxicology Program (NTP), and the U.S. EPA are currently partnering with both public and private drinking water utilities and a number of academic institutions like the University of Arizona to learn more about PFAS and to develop strategies to protect public health.

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For additional information:

Agency for Toxic Substance and Disease Registry (ATSDR)
https://www.atsdr.cdc.gov/pfas/index.html

EPA PFAS
https://www.epa.gov/pfas

EPA Ground Water and Drinking Water
https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos

Information about private wells can be found here
epa.gov/privatewells

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