Long-term Pollution Caused by Per and Polyfluoroalkyl Substances (PFAS) - should we be concerned?

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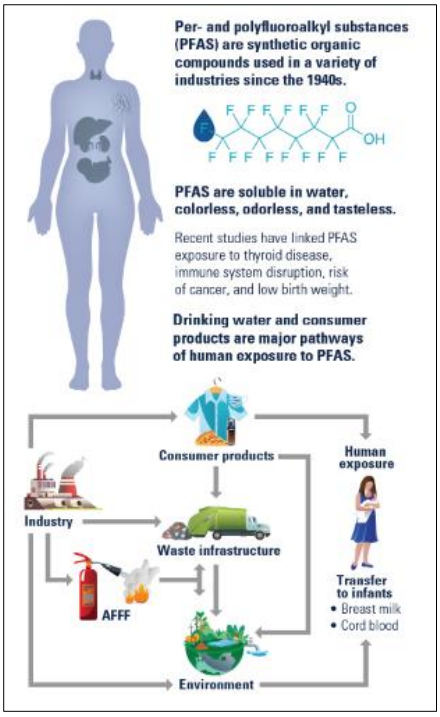
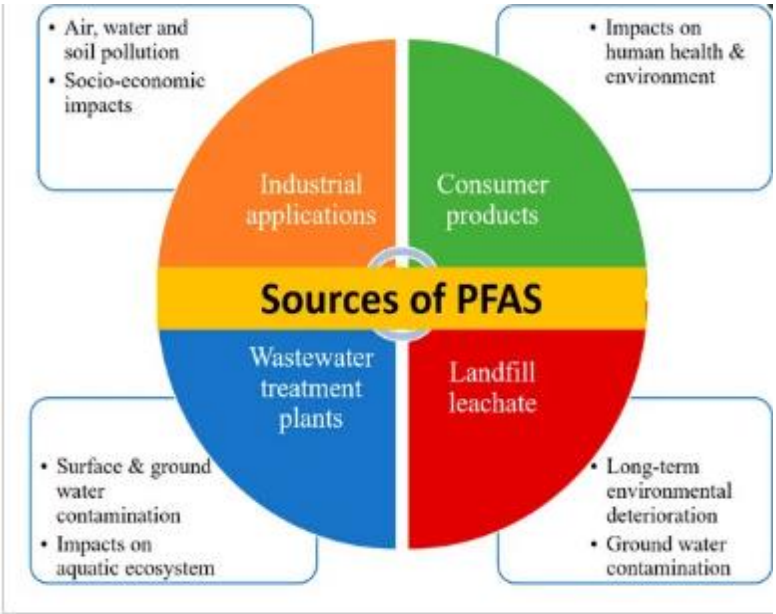


Introduction

Poly- and perfluoroalkyl substances (PFAS) are a group of synthetic compounds which do not occur naturally in the environment but are introduced through human activities (Buck et al., 2011)[1a]. These have been widely used in various industries since the 1940s. Due to their unique chemical properties, such as resistance to heat, water, and oil, PFAS have been utilised in products ranging from non-stick cookware and water-repellent fabrics to firefighting foams and food packaging. However, alongside plastic particulates, their persistence in the environment and potential adverse health effects have raised significant concerns in the context of long-term pollution, biohazard and other environmental impacts. The issues concern, environmental persistence, health impacts, and current regulatory and what remediation efforts may be feasible in addressing PFAS pollution.

https://www.usgs.gov/media/images/what-are-and-polyfluoroalkyl-substances-pfas

Sources of PFAS Pollution



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There are a range of sources of PFAS induced pollution:

Industrial Applications

PFAS are used in a variety of industrial applications, including:

- Manufacturing Processes: PFAS are used in the production of non-stick coatings for cookware, stain-resistant fabrics, and various plastic and rubber products.
- Firefighting Foams: Aqueous film-forming foams (AFFF) containing PFAS are used extensively for fire suppression, especially at airports, military bases, and industrial sites.

Consumer Products

Many everyday consumer products contain PFAS, such as:

- Non-stick Cookware: Teflon and other non-stick coatings are made using PFAS.
- Water-Repellent Fabrics: Outdoor gear and stain-resistant carpets often contain PFAS.
- Food Packaging: Some fast-food wrappers and microwave popcorn bags are treated with PFAS to repel grease.

Environmental Release

PFAS enter the environment through:

- Industrial Discharges: Wastewater from manufacturing plants can contain high levels of PFAS.
- Firefighting Foam Usage: Use of AFFF leads to contamination of soil and water.
- Landfills and Wastewater Treatment Plants: Disposal of PFAS-containing products can leach these chemicals into the soil and groundwater.

Environmental Persistence

Chemical Stability

PFAS are characterized by strong carbon-fluorine bonds, making them highly resistant to degradation in the environment. This persistence leads to accumulation in soil, water, and living organisms.

Bioaccumulation

PFAS can accumulate in the tissues of living organisms, leading to biomagnification in the food chain. This means that top predators, including humans, can have higher concentrations of PFAS in their bodies compared to organisms lower in the food chain.

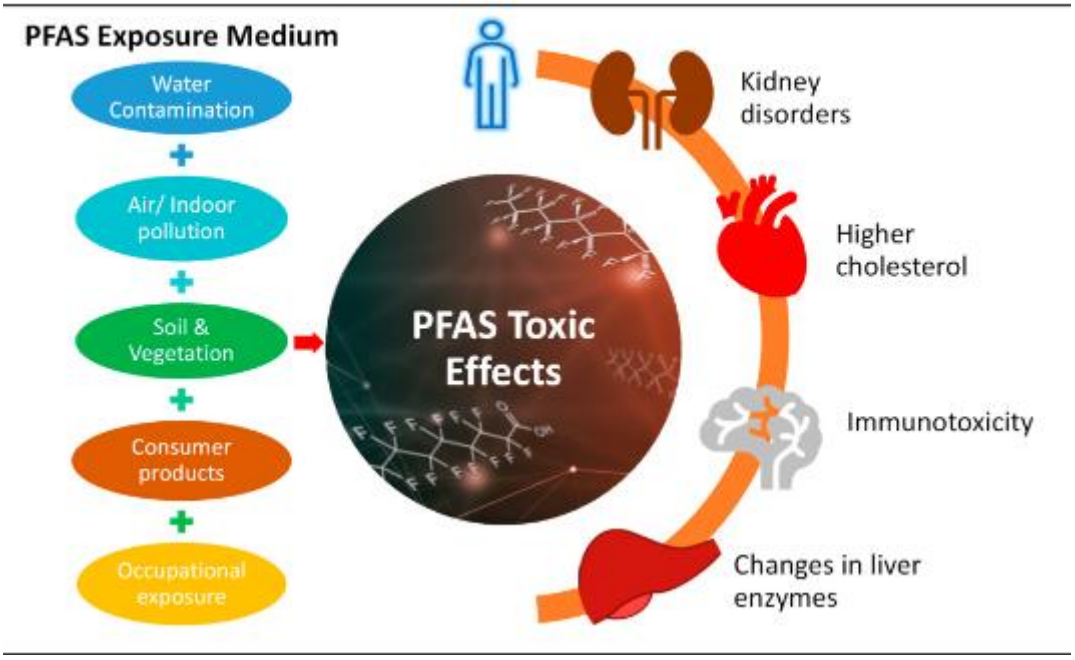
Global Distribution

PFAS have been detected in remote areas, such as the Arctic, indicating their ability to travel long distances from their original sources. This widespread distribution poses a global environmental challenge.

Health Impacts

Growing evidence suggests potentially catastrophic on exposure to PFAS (see figure 2)

Figure 2. Overview of PFAS exposure media and toxic effects to humans.



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Human Exposure

Humans can be exposed to PFAS through:

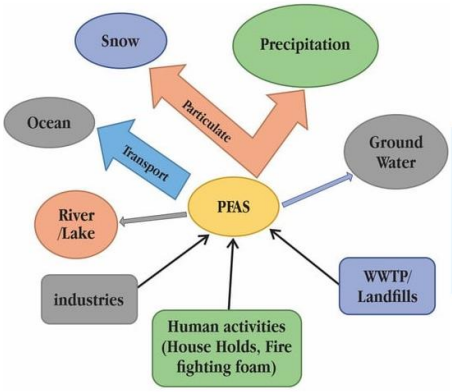
- Drinking Contaminated Water: Groundwater near industrial sites or military bases can be contaminated with PFAS.
- Consuming Contaminated Food: Fish and livestock raised in contaminated areas can accumulate PFAS.
- Using Consumer Products: Direct contact with PFAS-containing products can lead to exposure. (Habib, Z.et al 2024 [8])

Potential Health Effects

Research has linked PFAS exposure to various health issues, including:

- Cancer: Studies suggest associations between PFAS exposure and kidney and testicular cancers.
- Immune System Effects: PFAS may impair immune system function, reducing the body's ability to fight infections.
- Developmental Issues: Exposure to PFAS during pregnancy has been associated with developmental delays in children.
- Hormonal Disruption: PFAS can interfere with hormonal functions, leading to thyroid disease and other endocrine disorders.

Regulatory and Remediation Efforts



https://watermanaustralia.com/product/pfas-removal-plants-pfas-treatment/

Regulatory Measures

Governments and The ITRC [7] based in the district of Columbia has researched this and is recommended reading:

- Setting Limits: The U.S. Environmental Protection Agency (EPA) has established health advisory levels for PFOA and PFOS in drinking water.
- Banning Specific PFAS: Some jurisdictions have banned the use of certain PFAS in consumer products and firefighting foams with concerns in SA about the continued use of fire foam.

Remediation Techniques

Efforts to remediate PFAS contamination include:

- Activated Carbon Filtration: Effective in removing PFAS from drinking water.
- Ion Exchange Resins: Used to treat contaminated water by exchanging harmful ions with harmless ones.
- High-Temperature Incineration: Destroying PFAS in industrial waste through incineration at very high temperatures.

Research and Innovation

Ongoing research aims to develop more effective and sustainable methods for detecting and removing PFAS from the environment. Innovative approaches include:

- Electrochemical Treatment: Using electrical currents to break down PFAS molecules.
- Bioremediation: Exploring the use of microbes to degrade PFAS.

Regulatory Frameworks and Impact Assessment in Australia

https://www.infrastructure.gov.au/infrastructure-transport-vehicles/aviation/pfas-your-questions-answered

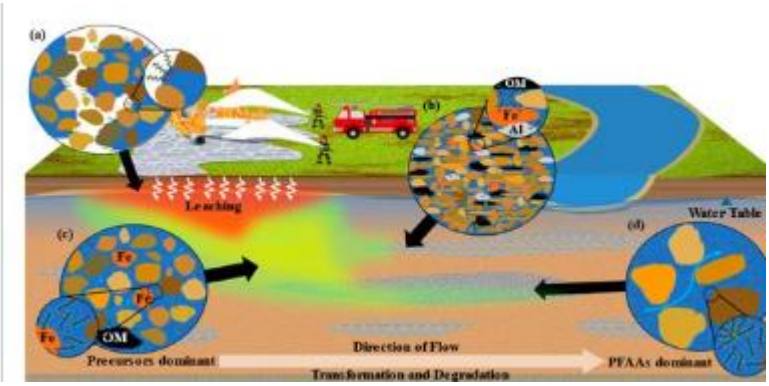
Regulatory Measures

In Australia, both federal and state governments have implemented regulatory measures to address PFAS pollution:

Federal Level: The Australian Government has developed a National PFAS Position Statement and PFAS National Environmental Management Plan (NEMP). These documents provide guidelines for assessing and managing PFAS contamination. The NEMP outlines recommended actions for monitoring, assessing, and managing PFAS at contaminated sites.

State Level: States have enacted their own regulations and guidelines. For example, New South Wales has developed the PFAS Investigation Program, which focuses on assessing and managing PFAS contamination at key sites.

Impact Assessment

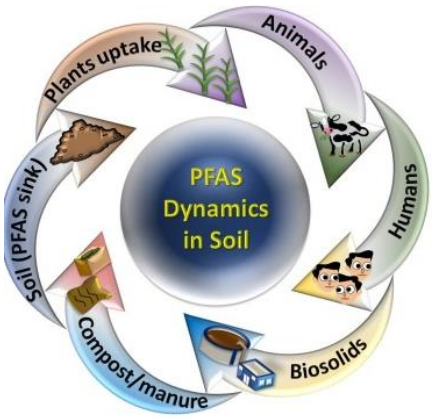


https://doi.org/10.3390/soilsystems7020053

Impact assessments are crucial in understanding the extent and implications of PFAS contamination globally due to transportation methods, pourous borders and other factors:

- Environmental Assessments: Detailed environmental assessments are conducted to determine the levels of PFAS in soil, water, and biota. These assessments help in identifying hotspots and prioritizing remediation efforts.
- Health Risk Assessments: Health risk assessments evaluate the potential impacts of PFAS exposure on human health. These assessments consider factors such as exposure pathways, population vulnerabilities, and toxicological data to estimate health risks

Conclusion



Poly- and perfluoroalkyl substances (PFAS) present increasing risk to both humans and other flora and fauna. Introduced through human activities (Buck et al., 2011) PFAS pollution represents a significant and complex environmental challenge due to the persistence, bioaccumulation, and potential health impacts of these substances. Addressing this issue requires a coordinated approach involving stringent regulations, effective remediation technologies, and continuous research. Public awareness and involvement are crucial to mitigate

https://doi.org/10.1016/j.envint.2021.106600

the long-term effects of PFAS and protect human health and the environment.

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Glossary

- AFFF: Aqueous Film-Forming Foam used for firefighting.
- Bioaccumulation: The accumulation of substances, such as pesticides, or other chemicals in an organism.
- Biomagnification: The increasing concentration of a substance in the tissues of organisms at successively higher levels in a food chain.
- Data Governance Framework: A collection of practices and processes aimed at ensuring the formal management of data assets within an organization.
- Electrochemical Treatment: A water treatment process that uses electrical currents to remove contaminants.
- Ion Exchange Resins: Polymers that can exchange specific ions within them with ions in a solution that is passed through them.
- Non-stick Coatings: Surfaces engineered to reduce the ability of other materials to stick to them.
- PFAS: Per and polyfluoroalkyl substances, a large group of man-made chemicals that are resistant to water, oil, and heat.
- Remediation: The process of cleaning, removing, or mitigating pollution or contaminants from an environment.
- Teflon: A brand of non-stick coating commonly used on cookware, made from polytetrafluoroethylene (PTFE).
