PROTECTING WATER QUALITY, HEALTH AND THE ENVIRONMENT: URGENT QUESTIONS PERTAINING TO PFAS

Carla Ng
Department of Civil & Environmental Engineering
Department of Environmental and Occupational Health
University of Pittsburgh

Alaska Collaborative on Health and the Environment
November 11, 2021
PFAS: WHY WORRY?

A crash course on PFAS and why they have garnered so much attention across the US and worldwide.

1. PFAS terminology

Per- and Polyfluoroalkyl Substances (PFAS)

- perfluorooctane sulfonate (PFOS)
- perfluorooctanoic acid (PFOA)
- 8:2 fluorotelomer alcohol (8:2 FTOH)

Diagram showing the chemical structures of PFOS and PFOA.
PFAS: WHY WORRY?

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https://www.ewg.org/interactive-maps/pfas_contamination/map/

Still poorly characterized!
PFAS ARE EVERYWHERE

Where we look for PFAS, they are found: in the environment and inside us.
PFAS ARE READILY TAKEN UP

PFAS have been detected in plants, wildlife, and humans in even the most remote environments. They are taken up by multiple exposure routes and many are biologically persistent.

Sources, Fate, and Plant Uptake in Agricultural Systems of Per- and Polyfluoroalkyl Substances
M. Christina Schilling Costello & Linda S. Lee
Current Pollution Reports (2020) | Cite this article

De Silva et al. 2021

Poothong et al. 2020

Poorthong et al. 2020
HOW PEOPLE ARE EXPOSED

If you live near a contaminated site, drinking water is usually the major exposure route.

Without drinking water contamination*, food is usually the major source.

Research is ongoing to better understand other sources (e.g. indoor exposures via cleaning/personal care products, carpets, outdoor air).

*most water has low levels of PFAS; contaminated sites have high levels
WHAT ARE THE HEALTH CONCERNS?
PFAS HAVE A WIDE VARIETY OF HEALTH EFFECTS

For the few PFAS that have been well studied, many biological systems are disrupted.

At least two types of cancer are well established (kidney, testicular) and others have evidence in some studies (e.g. breast cancer).

Based on epidemiological and animal model studies primarily of: PFOA, PFOS, some other long-chain PFAAs (PFHxS, PFDA), emerging/replacement GenX.
Some PFAS have very long lifetimes in the human body, meaning it could take years for levels in blood to go down even after levels in the environment decline.

This makes them a particularly challenging remediation problem due to the time lag associated with action.
CHALLENGES IN EPIDEMIOLOGY

- Not a “controlled experiment.”
- Populations have a lot of natural variability.
- We are co-exposed to other chemicals.
- May have other reasons for being vulnerable to a particular condition.
- Could come from “background” population, contaminated site, or occupationally exposed people.
Recent estimates indicate on the order of **1000 - 9000 PFAS** registered or in commerce.

For the vast majority structurally diverse PFAS there are few available data.
FOR MANY PFAS, WE HAVE VERY LIMITED INFORMATION

- Which PFAS have which effects?
- How can we evaluate health risks from ongoing exposures?
- How do we marshal our limited resources to address widespread PFAS contamination?

Yeung & Mabury 2016 Environ Chem.
The US EPA* recently reduced their safe levels for GenX exposure, based on emerging evidence of their health impacts even at low concentrations, especially liver toxicity.

Chronic reference dose: $3 \times 10^{-6}$ mg/kg/d (about 10x lower than for PFOA and PFOS)

*https://www.epa.gov/chemical-research/human-health-toxicity-assessments-genx-chemicals
WE CAN’T MEASURE ALL EXPOSURES

Transformation of some substances in the body may contribute significantly to toxicity, but are difficult to “catch.”

3. Precursors can biotransform, exert specific toxicity.

Rand et. Al 2013,
Rand & Mabury 2014 ES&T

Winkens et al. +2018
SO WHAT CAN BE DONE?
Addressing Urgent Questions for PFAS in the 21st Century

Carla Ng,* Ian T. Cousins, Jamie C. DeWitt, Juliane Glüge, Greta Goldenman, Dorte Herzke, Rainer Lohmann, Mark Miller, Sharyle Patton, Martin Scheringer, Xenia Trier, and Zhanyun Wang

- What are global production volumes of PFAS, and where are PFAS used?
- Where are the unknown PFAS hotspots in the environment?
- How can we make measuring PFAS globally accessible?
- How can we safely manage PFAS-containing waste?
- How do we describe the health effects of PFAS exposure?
- How do we deal with the costs of PFAS contamination?
Problem: We don’t know the historical and ongoing production volumes of PFAS. We don’t know the identities of the PFAS being produced. We don’t know which products and processes are using PFAS. We don’t know the amounts of past and ongoing releases of PFAS into the environment. Therefore, we cannot protect people from exposure.

Major Barriers: Information about chemicals used in different countries (including the US) is kept confidential. Newer uses are poorly documented. Confidential Business Information (CBI) claims from companies to protect their formulations means little is publicly known about the identity and quantity of specific chemical structures present within a substance, formulation, or product.

Potential Paths Forward: Transparency— from industry to governments and to consumers, and across retailers in the supply chain. An end to CBI claims that keep chemical identities secret. Greater coordination across research networks to build our knowledge base.
WHERE ARE THE UNKNOWN PFAS HOTSPOTS IN THE ENVIRONMENT?

**Problem:** A few types of sites associated with PFAS contamination are well known (airports, military sites, fluoropolymer manufacturing facilities), but many more exist that are poorly documented. Small releases over long periods can lead to substantial contamination, but can go under the radar of regulatory reporting requirements. Local knowledge is needed to identify sites but efforts are not equally distributed regionally or globally.

**Major Barriers:** Small-scale manufacturers in both developed and developing countries have different control practices in place. Lack of access to equipment and facilities to measure PFAS hinders identification of hotspots.

**Potential Paths Forward:** Linking to the first question, a systematic inventory of all PFAS industries is needed to identify current and former sites of emissions. International collaboration, use of advanced mapping and data management systems, and, critically, *funding* is required.
HOW CAN WE MAKE MEASURING PFAS GLOBALLY ACCESSIBLE?

Problem: We need the ability to measure PFAS in all locations, and in all kinds of substances (soil, blood, fat, milk, meat…). We need researchers, communities, health-care providers, utilities, and governments to be able to measure PFAS cost-effectively and accurately to help minimize exposure, protect vulnerable populations of humans and wildlife, and evaluate the effectiveness of interventions. This is especially important in areas where currently very little is known (e.g. Africa, Central America, parts of Asia).

Major Barriers: Established methods require access to expensive equipment, reliable analytical standards, infrastructure (reliable electricity, gas, water supplies), and extensive training.

Potential Paths Forward: Developing fast and reliable screening methods (e.g. total fluorine, EOF, AOF). PFAS “sensors” that could be used at water utilities for real-time monitoring. Capacity building: training, facilities, and equipment made available to scientists from poorly resourced areas.
Problem: Many diffuse sources of PFAS are constantly entering wastewater and landfills and leading to long-term releases to the environment. Presence of PFAS in products hinders recycling efforts, making a circular economy nearly impossible. As PFAS are phased out, how do we deal with the extremely persistent stockpiles?

Major Barriers: Not knowing which PFAS are present at what quantities and in which products are major barriers to safe handling of waste. Waste streams from PFAS removal (e.g. spent carbon from filters) become another waste management problem. Incineration done improperly can lead to emissions of PFAS to air.

Potential Paths Forward: The most effective means of curtailing PFAS waste is to stop using PFAS. Production of PFAS for essential uses must be carefully controlled to approach zero emissions. Legacy contamination may require confined disposal facilities until effective destruction technologies are proven.
Problem: We already know enough about the potential impacts of PFAS exposure to know that they should not be used. However, there are important questions to be answered about current and legacy exposures. We need to be able to link measured exposures to current or anticipated health effects.

Major Barriers: Communities with contaminated water face challenges in court to having health and remediation costs covered by responsible parties. PFAS exposures are complex over time and always to mixtures and for many PFAS there are no data available about their toxicity.

Potential Paths Forward: The use of class-based methods to evaluate PFAS can work as a precautionary approach to managing exposures for new and continuing uses. Funding for large-scale, long-term epidemiological studies, more matrices (e.g. urine, breast milk, hair, lipid tissues) to capture a wider array of PFAS, and links to high-throughput in vitro and in silico studies.
WHO PAYS FOR THE IMPACTS OF PFAS CONTAMINATION?

Problem: In the US, it is estimated that as many as 80 million residents may be receiving water with PFAS levels that exceed health guidelines. Costs of remediation are likely to be passed down from utilities to consumers through their water bills. The projected health-related costs due to effects of PFAS exposure in Europe is 54 – 82 billion euros per year.

Major Barriers: Costs of environmental and health impacts from PFAS exposure continue to be treated as negative externalities— not borne by the polluter but by the exposed. There is lack of political agreement on who is responsible and who should pay.

Potential Paths Forward: It is absurd to continue treating environmental damage as a negative externality. The Polluter Pays principle should be applied, using new and existing mechanisms (e.g. Superfund). “Off-shoring” of pollution must be stopped, and environmental equity upheld.
PFAS WILL BE WITH US FOR A LONG TIME

Based on what we already know from a long history of contamination, technology will not save us. We must learn our lessons and stop the use of highly persistent chemicals!
THE PFAS ROADMAP: NECESSARY - URGENT

How can we all work together to ensure that the goals are met and actions are quickly taken to stop continued use of highly persistent chemicals for non-essential uses while protecting communities from bearing the costs?

PFAS Strategic Roadmap: EPA's Commitments to Action
2021–2024

QUESTIONS?

carla.ng@pitt.edu

@Ng_lab