Treatment Options for PFAS

Angie Martin
Vice President, Heritage Environmental Services
PFAS Introduction

- Per- and polyfluoroalkyl substances (PFAS)
- Group of man-made chemicals
- Used in:
  - Water and stain repellents
  - Nonstick coatings
  - Polishes, waxes, and paints
  - Cleaning products
  - Firefighting foams (AFFF)
- Known to cause harmful health effects

Source(s): www.michaelbest.com
PFAS Classifications

- Main Classes:
  - Acids (PFAAs)
  - Precursors
  - Others
- Many Sub-classes
  - Carboxylic acids
  - Sulfonic acids
  - Fluorotelomers
- Thousands of individual compounds

Source(s): Wang et al., 2017, ES&T, 51:2508-2518; Barzen-Hanson et al., 2017, ES&T.
History and Production

• Brief History
  • Began manufacturing in early 1940s, sold for decades
    • Placed in unlined landfills and into rivers
    • Failed to properly alert public of dangers
    • Multiple lawsuits against companies that produced PFAS

• PFOA Stewardship Program (2006)
  • 8 companies agree to reduce PFOA emissions by 95% by 2010
  • PFOA nor PFOS production eliminated in US by 2015
  • Only applied to PFOA, companies now using different PFAS

• Aqueous Film Forming Foams (AFFF)

Health Studies

• 2018 Draft of ATSDR Toxicological Profile
  • Cites 329 more studies on PFAS than 2015 version
  • Recommends drinking water standard 6x lower than EPA

• Known to cause adverse health effects in both humans and laboratory animals

• EPA focusing on 14 different PFAS chemicals with differing toxicities

# PFAS – Regulatory Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Agency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>USEPA</td>
<td>Initiated voluntary phase out of PFOS</td>
</tr>
<tr>
<td>2006</td>
<td>USEPA</td>
<td>PFOA Steardship Program initiated</td>
</tr>
<tr>
<td>2008</td>
<td>Canada</td>
<td>Regulated &amp; prohibited PFOS imports to Canada</td>
</tr>
<tr>
<td>2009</td>
<td>UN</td>
<td>Stockholm Convention - adds PFOS to Annex B</td>
</tr>
<tr>
<td>2015</td>
<td>USEPA</td>
<td>PFOA Steardship Program Completed</td>
</tr>
<tr>
<td>2016</td>
<td>USEPA</td>
<td>PFOS &amp; PFOA Lifetime Health Advisory Limits 70 ppt combined</td>
</tr>
</tbody>
</table>

*Activity is increasing exponentially*
National Defense Authorization Act (NDAA)-House Amendments

As of 7/12/2019

- **Sponsor: Rep. Levin (D-MI)** Require the Secretary of Defense to ensure that all incineration of materials containing PFAS is conducted in a manner that eliminates PFAS while also ensuring that no PFAS is emitted into the air; that all incineration is conducted in accordance with the requirements of the Clean Air Act; that materials containing PFAS and designated for disposal are stored safely; and that no incineration be conducted at any facility that violated the requirements of the Clean Air Act during the year preceding the date of disposal.

- **Sponsor: Rep. Dean (D-PA)** Directs the Secretary of the Navy to publish a military specification for a fluorine-free fire-fighting agent by 2023 to ensure it can be used by 2025. The amendment would also prohibit the use of PFAS fire-fighting foam by the military after September 30th, 2025.

- **Sponsor: Rep. Dingell (D-CA)** Prohibit the Defense Logistics Agency from using any food contact substances to assemble or package meals ready-to-eat (MRE) with PFAS chemicals beginning in FY2021.

- **Sponsor: Rep. Kildee (D-MI)** Require GAO to conduct a review of DoD’s response to PFAS contamination in and around military bases.
Sponsor: Rep. Pappas (D-NH) Creates an online clearinghouse of information for members of the Armed Services to find information about exposure to PFAS and treatment for associated health conditions.

Sponsor: Rep. Turner (R-OH) Requires the Secretary of Defense to enter into agreements with municipalities or municipal drinking water utilities located adjacent to military installations to share monitoring data relating to perfluoroalkyl substances, polyfluoroalkyl substances, and other emerging contaminants collected on military installations.

Sponsor: Kildee (D-MI) Authorizes $5 million for the first year of a five year study by the USGS to survey for PFAS contamination across the country.

Sponsor: Dingell (D-MI) Requires the Department of Defense to enter into cooperative agreements with states to mitigate PFAS contamination resulting from their facilities.
National Defense Authorization Act (NDAA)-Senate Amendments

As of 7/12/2019

- EPA establish final groundwater limits
- EPA issue interim disposal standards
PFAS Bills Reviewed by House Energy & Commerce Committee

• HR 535: “PFAS Action Act of 2019” – EPA must designate all PFAS as hazardous substances under CERCLA

• HR 2377: “Protect Drinking Water from PFAS Act of 2019” – EPA must set drinking water maximum contaminant level for total PFAS

• HR 2533: “Providing Financial Assistance for Safe Drinking Water Act” – Establishes grant for PFAS-affected water systems to install treatment technologies

• HR 2566: “Safer Choice Standards Act” – EPA must establish a label for cookware that is PFAS-free

• HR 2570: “PFAS User Fee Act of 2019” – Establishes a fund through fees from PFAS manufacturers that pays the ongoing costs of drinking water PFAS treatment systems

Source(s): ETC House PFAS Bills
PFAS Bills Reviewed by House Energy & Commerce Committee

- HR 2577: “Inclusion of Per- and Polyfluoroalkyl Substances on the Toxics Release Inventory Act” – Includes PFAS on the toxic release inventory
- HR 2591: “PFAS Waste Incineration Ban Act of 2019” – Places a ban on the incineration of fire-fighting foam containing PFAS
- HR 2596: “Protecting Communities from New PFAS Act” – Prevents the introduction of any new PFAS into commerce
- HR 2600: “Toxic PFAS Control Act” – Amends TSCA to regulate PFAS, prohibits the manufacture of new PFAS
- HR 2605: “Prevent Release of Toxic Emissions, Contamination, and Transfer Act of 2019” – EPA must list PFAS as a hazardous air pollutant

Source(s): ETC House PFAS Bills
PFAS Bills Reviewed by House Energy & Commerce Committee

- HR 2608: “PFAS Testing Act of 2019” – Requires health testing of all PFAS under TSCA, as well as reporting on HSE impacts of PFAS
- HR 2626: “PFAS Accountability Act of 2019” – Amends CERCLA to require cleanups at federal facilities to meet state limits for PFAS
- HR 2638: “PFAS Guidance Act” – EPA must issue guidance for first responders to minimize the use of foams containing PFAS
**Regulatory Challenges**

- **Formal Guidance**
  - EPA has not issued any enforceable regulations.
  - Issued 70 ppt health advisory in 2016
  - EPA did release an Action Plan in February 2019
  - States have begun passing their own regulations
    - State regulations vary widely

- **Screening levels**
  - First contaminants to be regulated at the *parts per trillion (ppt)* level (others regulated at ppm or ppb)
  - This adds a serious analytical testing challenge

- **Target analytes**
  - Thousands of versions of PFAS chemicals exist
  - Toxicity testing has only been done on a small number of them

- **Testing Methods**
  - EPA has only approved methods for 14 analytes in drinking water
PFAS Legislation

Other Guidelines and Standards

• EPA Lifetime Health Advisory (LHAs) for PFAS: 0.07 μg/L (70 ppt)
• 19 states have water criteria

As of Jan. 2019; does not include proposed values
Identified Contamination Sites

- Northeastern University Social Science Environmental Health Research Institute (SSEHRI)
  - 172 Contaminated sites
    - 117 Military sites
    - 29 Industry/manufacturing sites
    - 15 Civilian airports
- DoD estimates cleanup costs of $2B

Treatment Considerations

• Thousands of versions of PFAS chemicals have been produced
• They vary in several ways that affect cleanup effectiveness:
  • Multiple ionic states
  • Variable isomers
  • Differing alkyl groups
  • Co-contaminants
• Treatment method effectiveness must be proven in the lab prior to using in the field
Treatment Considerations

- Drinking water – common treatment methods include:
  - Sorption with GAC or other media
  - Ion exchange
  - Reverse osmosis

- Groundwater – very challenging and site specific. Possibilities include:
  - Remove soil hot spots
  - On site soil treatment
  - Water pump and treat system

- Incineration is only proven method of destruction
Concepts in PFAS Treatment and Disposal

- **Media Type**
  - Soil
  - Drinking Water
  - Groundwater
  - Wastewater
  - Leachate
  - Concentrated forms
    - e.g. AFFF

- **Treatment Type**
  - Separation
  - Destruction
  - Disposal
PFAS Treatment Technologies

Separation: Granular Activated Carbon

- Constraints
  - Co-contaminants
  - Reuse of GAC is possible, but requires thermal re-activation
  - Matrix
  - Generation of PFAS waste

- Positives
  - Effective for almost all PFAS species
Separation: Ion Exchange Resin

- Constraints
  - Co-contaminants
  - Single-use vs. regenerable resins
  - Short chain PFAS break through quickly
- Matrix

- Positives
  - Media is regenerable
PFAS Treatment Technologies

Separation: Membrane Filtration

- **Constraints**
  - Matrix and co-contaminants
  - Type of membrane (RO vs. nanofiltration vs. ultrafiltration)
  - May require pre-treatment
  - Generation of PFAS waste

- **Positives**
  - Well-established method of treatment

Source(s): [http://cen.acs.org/environment/persistent-pollutants/Forever-chemicals-technologies-aim-destroy/97/i12](http://cen.acs.org/environment/persistent-pollutants/Forever-chemicals-technologies-aim-destroy/97/i12)
PFAS Treatment Technologies

Separation: Precipitation

• Constraints
  • Only available as ex situ solution
  • Requires dewatering
  • Generation of PFAS waste

• Positives
  • Certain applications may be able to meet EPA health advisory levels

Source(s): Teh et al., 2016, I&EC, 55, 16, 4363-4389.
PFAS Treatment Technologies

Transformation: Oxidation (in situ soil)

• Constraints
  • Co-contaminants, especially BTEX
  • Type of PFAS
  • Oxidized PFAS is still PFAS
  • Bench scale trials, mostly

• Positives
  • No PFAS waste generation

Source(s): Teh et al., 2016, I&EC, 55, 16, 4363-4389.
PFAS Treatment Technologies

Destruction: Biodegradation

• Constraints
  • Co-contaminants that are “easier to eat” than PFAS
  • Biodegraded PFAS precursors become PFOA, PFHxA, PFPA, etc.

• Positives
  • In situ
  • “Green” solution

Source(s): Lee, L. S., PFAS in the Environment: Fate, Transport, & Analysis, 21 March 2019, The Center, Indianapolis, IN.
PFAS Treatment Technologies

Destruction: Incineration

• Currently required by DLA
• Only known method of actual destruction
  • Breaks the C-F bond
  • Other treatments break the C-C bonds, creating more total PFAS molecules
PFAS Treatment Technologies

Disposal: Landfill

• Solubility and Mobility
  • Effects of PFAS chemistry
  • Some PFAS species are both mobile and soluble
What is the engineering answer to all questions?

It depends.

Thank you