Per- and Polyfluoroalkyl Substances (PFAS) and the Environment – State of the Practice

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Agenda

- Overview of PFAS
- Regulatory Status
- PFAS in the News
- PFAS in the Environment
- Affected Industries
- Approaching PFAS Projects

OVERVIEW OF PFAS



PFAS vs. PFCs

We have been looking at these for years, so why the change?

PFAS									
<u>Per</u> flu	Polyfluorinated Compounds								
Perfluo (F	roalkyl Acids PFAAs)		Thousands of Compounds including: Fluorotelomer alcohols Sulfonamido carboxylates						
Perfluorocarboxylic Acids (PFCAs)	Perfluoroalkane Sulfonates (PFSAs)								
Perfluorobutanoic acid (PFBA) Perfluoroheptanoic acid (PFHpA) Perfluorohexanoic acid (PFHxA) Perfluorononanoic acid (PFNA) <u>Perfluorooctanoic acid (PFOA)</u> Perfluorodecanoic acid (PFDA) Perfluoroundecanoic acid (PFUA) Perfluorododecanoic acid (PFDA)	Perfluorobutane sulfonate (PFBuS) Perfluoroheptane sulfonate (PFHpS) <u>Perfluorooctane sulfonate (PFOS)</u> Perfluorohexane sulfonate (PFHxS) Perfluorodecane sulfonate (PFDS)	Perluoralkane Sulfonamides (FASAs)	Fluorotelomer betaines Sulfanomidoethanol Fluorotelomers Sulfonamide ketones, aldehydes, and ethers More *INCLUDES PERFLUORINATED PRECURSORS*						

Note - Diagram presents common compounds and chemical groups and is not complete

CHEMISTRY





Fluorotelomer alcohol, (8:2 FTOH)

HISTORICAL USE

- 1950s US Manufacturing began
- Products
 - Teflon[™], Scotchgard[™]
 - Textiles, paper, and surface treatment (shoes, mattresses, food packaging, rubber, plastics, leather...)
- Aqueous Film Forming Foams (AFFF)
 - 1968 U.S. Navy develops first AFFF
 - Chemically Complex Mixture of 100s or 1,000s of PFAS.
 - Primary AFFF manufacturers 3M, Ansul, National Foam, Angus, Chemguard, Buckeye, and Fire Service Plus, Inc.
- Manufacturing processes
 - Metal plating and coating mist control
 - Surfactant/Addative
- Largely phased out of production via 2002, 2009, and 2013 TSCA significant new use rules





POTENTIAL HEALTH EFFECTS – PFOA and PFOS

- Primary exposure routes consumption of contaminated drinking water & food
- PFOA and PFOS have been most studied
- Proven to be bioaccumulative
 - Half-life of 2 to 9 years in humans.
- Accumulate in serum, liver, and kidneys
- Uncertainty over toxicity
 - Human studies on worker populations
 - Debate over validity of lab studies



REGULATORY STATUS

FEDERAL ADVISORIES

- EPA Drinking Water Health Advisories
 - 2009 USPA established a provisional health advisory (PHA) of 0.2 μ g/L for PFOS and 0.4 μ g/L for PFOA.
 - May 2016 USEPA established a health advisory (HA) for PFOA and PFOS.

"To provide Americans, including the most sensitive populations, with a margin of protection from a lifetime of exposure to PFOA and PFOS from drinking water, EPA established the health advisory levels at 70 parts per trillion."

REGULATION BY THE STATES/OTHER AGENCIES

Eight states and Region IV have issued risk-based screening levels, advisories, and/or corrective action objectives for PFOA or PFOS in the following matrices:

State/Agency	Drinking Water	Surface Water	Groundwater	Soil	Sediment	Fish Tissue
USEPA Region IV				Х		
Illinois			Х	Х		
Maine		X	Х	Х	Х	Х
Michigan		Х				Х
Minnesota	Х	X		Х		Х
New Jersey	Х					
North Carolina			Х			
Texas			Х	Х		
Vermont	Х					

PFAS IN THE NEWS





BURNS

PFAS IN THE ENVIRONMENT



BEHAVIOR IN THE ENVIRONMENT

- Soluble Under Normal pH
- Dead-end PFAAs will not Degrade Attenuate via Physical Mechanisms only.
- Form Long Groundwater Plumes (miles).
- Precursor Compounds act as Source



PFAS SITE CHARACTERIZATION

- Source Investigation and Delineation
 - Not your typical contaminant <u>requires special sampling</u> <u>protocols</u>
- Analytical Procedures
 - USEPA Method 537 Rev 1.1 LC/MS/MS Provides a quantitative result for at most ~40 PFAS compounds.
 - Total Oxidizable Precursor (TOP) Assay Analysis of two split samples, one of which is oxidized prior to analysis. Comparing the results provides the amount of dead end PFAAs that may form from precursor compounds.
 - Particle Induced Gamma Emission (PIGE) Spectroscopy Assess total fluorine content to be used as a screening tool.
- Hydrogeology

REMEDIATION ALTERNATIVES

Proven Remedies

- Source Remediation
 - Substantial mass removal >> mass flux reduction >>Long-term risk & cost reduction
 - Excavation and Disposal
 - Incineration currently the most common disposal method
 - Landfilling is unsustainable
 - Ex Situ Thermal Treatment New Proven Technology
 - Performed onsite
 - Requires > 1,300 °C for destruction
- ► GW Pump & Treat
 - Proven treatment methods
 - ► GAC
 - Ion Exchange
 - Nanofiltration
 - Reverse Osmosis
 - MNA

REMEDIATION ALTERNATIVES

Emerging Remedies

- Advanced / Enhanced
 Adsorption & Immobilization
 - RemBind[™]
 - matCARE[™]
 - Nanoparticles
 - Coagualation
- Chemical Oxidation / Reduction
- Pyrolysis (plasma arc)

- ► Soil Washing
- Precipitation / Sedimentation
 - PerfluorAd™
- Catalytic / Electro-catalytic Reactions
- In-Situ Bioaugmentation
 - Using fungi and assoc. enzymes

AFFECTED INDUSTRIES



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- DoD (Air Force, Navy, Army, USACE)
- Aviation
- Oil & Gas
- Commercial (flammable liquids)
- Transportation
- Municipal Water and Waste Water
- Landfills (Leachate)



APPROACHING PFAS



APPROACHING PFAS PROJECTS

- AFFF Systems/Industrial Process Inventory and Retrofit/Upgrade
- Preliminary Assessment (if needed)
- Is Investigation Warranted?
- Identify Project Drivers/Data Gaps
- Collect Appropriate Data
- Critically Evaluate Data and Conclusions
- Solidify CSM
- Respond as Appropriate





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USEPA NOTICE ON METHOD 537 – Sept. 2016

- "Technical Advisory-Laboratory Analysis of Drinking Water Samples for Perfluorooctanoic Acid (PFOA) Using EPA method 537 Rev 1.1." Revision 1.1 presents an improved technique allowing laboratories to more consistently account for isomeric forms of PFOA (linear and branch-chained, the less common form) in the absence of a quantitative analytical standard that includes the various isomers. The approach described in the advisory is more inclusive and more protective.
- EPA recommends that laboratories use Revision 1.1 for future analysis.
- EPA recommends revisiting results 50-70 ppt for combined PFOA and PFAS.