Emerging Contaminants: Past, Present, and Future

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Outline of Presentation

Definition of Emerging Contaminant (and Emerging Issues)

Approach to evaluating toxicity and risk from ECs

ECs and their historical impact

PFAS compounds as ECs

EPA and Agency actions for PFAS

Definition of Emerging Contaminant

An environmental Emerging Contaminant (EC) is a chemical that:

- has a reasonably possible pathway to enter the environment;
- presents a potential unacceptable human health or environmental risk;
- and does not have regulatory standards based on peer-reviewed science, or the regulatory standards are evolving due to new science, detection capabilities, or pathways (DoD definition)

Often lack adequate toxicity data (health standards) to evaluate risk

Exposures may have been occurring for an unknown amount of time

May also need to consider “emerging issues”, such as vapor intrusion

Where do Emerging Contaminants Come From?

- ECs aren't necessarily rare or unique chemicals, key issue is that they lack toxicity and/or regulatory criteria
  - US chemical regulatory system doesn't always require significant proof of safety prior to widespread use
- DoD, industrial, and commercial uses can result in large releases and/or spills to soil, groundwater, and surface water
- Consumer products, pharmaceuticals and products
- Munitions, fuels, and propellants

Often part of a mixture of different chemicals

Historic Emerging Contaminants

Previous ECs

- 30 Years Ago: PCBs, dioxins/furans, MTBE in gasoline, phthalates
- 20 Years Ago: Perchlorate, 1,4-Dioxane, Trichloroethylene (TCE)
- 10 years ago: Polybrominated diphenyl ethers (flame retardants), Bisphenol A (plastic component)
- Current: Per and polyfluorinated alkyl substances (PFAS), Nanomaterials

Broad categories: POPs (persistent organic pollutants), estrogen disrupters, munitions/ordnance compounds, pharmaceuticals

How are Emerging Contaminants "Discovered"?

- Deliberate or inadvertent discovery during RCRA or CERCLA investigations, or during routine monitoring
  - Use and disposal records, interviews, storage areas, landfills
- Formalized programs for ECs developed by EPA and the Dept of Defense (including Army, Navy, and Air Force)
- Improved analytical techniques and detection limits allows for more thorough investigations of potentially contaminated sites
- Scrutiny from environmental watchdogs, advocacy group, and media
- Worker biomonitoring exams

Once a Possible EC Has Been Identified, What Then?

- Literature search to better understand what is already known
  - Science journals, SDSs (safety data sheets), regulatory guidance
  - What industries are using these compounds?
  - Consider whether chemicals may be metabolized, degraded, or complexed under environmental conditions
- Evaluate regulatory status and legal implications
  - (repeat as necessary)
- Conduct initial Phase I studies to evaluate if chemicals are present in environmental media at select high-impact sites
- Determine if there is on-going non-occupational human exposure

Understanding and Managing EC Sources

It is critical to understand how a particular EC is used so that it can be managed at the source to prevent further impacts

- **MTBE** – gasoline additive, contaminated groundwater from leaking tanks and pipelines
- **1,4-Dioxane** – stabilizer compound, solvent, chemical intermediate
- **TCE** – industrial and military solvent
- **PCBs** – as coolant and heat transfer fluids in electrical systems
- **Dioxins/furans** – primary a contaminant of the synthesis of organochlorines and from burning plastic waste
- **Perchlorate** – rocket fuel, road flares, fireworks
- **PFAS** – consumer products, aqueous fire fighting foam (AFFF)

Regulatory Complexities and Challenges

- There may be formal regulatory definitions that have to be met to trigger in-depth investigation or remediation:
  - “hazardous substance”, “pollutant or contaminant”
- Legal standards may have to be developed
- Added to CERCLA/RCRA studies
- Maximum contaminant level (MCL) for drinking water
- Validated toxicity criteria may not be available
- Chemical mixtures may complicate regulatory management (e.g., PCBs, dioxins/furans, PFAS)

At Some Point……

- Toxicity criteria get approved and lead to health-based standards
  - CERCLA remedial investigations and risk assessments get underway

- EPA or States develop legal standards for drinking water (and may apply them to most or all groundwater and surface water)

- Regulated entities (companies, DoD, municipalities) may be forced to do more comprehensive site investigations and enter into discussions with agencies about risk management options

- Remediation, land use controls, landfills, risk reduction strategies

PFAS – New Class of Emerging Contaminants

- PFAS = Per or poly fluorinated alkyl substances, the term given to a broad group of fluorinated chemicals
  - Over 5,000 individual PFAS chemicals; complex mixtures
- Widely used in numerous industrial and commercial products
- PFAS are bioaccumulative and persistent in the environment, are soluble in water, and can migrate significant distances in groundwater

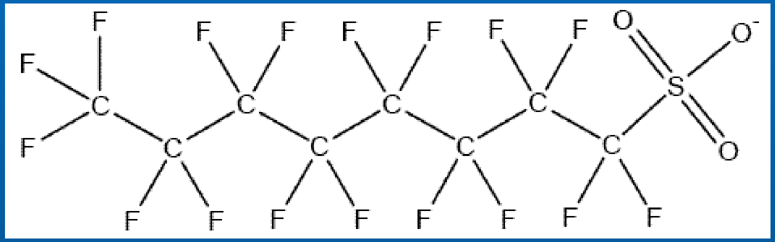
- Main chemical in AFFF, aqueous film forming foam (aka, fire fighting foam) – used historically for aircraft fires and petroleum hydrocarbon fire situations

Chemical Structures of PFOS and PFOA

PFOS

Perfluorooctane Sulfonate

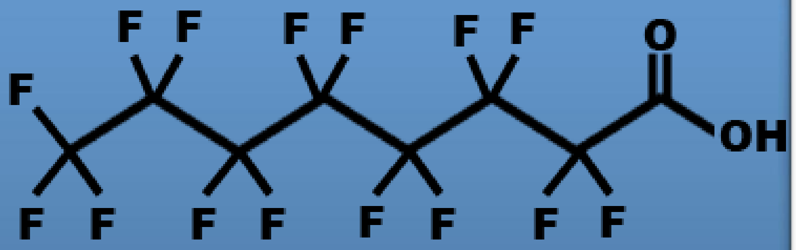
Formula: C8HF17O3S



PFOA

Perfluorooctanoic Acid

Formula: C8HF15O2



Widespread Uses of PFAS

- Managing and extinguishing petroleum based fires
  - Airports, refineries, fire training areas, fire trucks, military
- Chrome and copper plating and fume suppression
- Anti-stick cookware and kitchenware
- Water repellants for fabric, carpeting, clothing and shoes
- Waterproofing and grease resistance for paper products
- Commercial and industrial cleaning products
- Oil and gas industry - as surfactants to enhance recovery in oil or gas wells and as evaporation inhibitors for storage of petroleum products

Example Use for Aircraft Fires at Military Bases

What are the Toxic Effects Associated with PFAS?

- Organs most commonly associated with PFAS toxicity:
  - Liver: enzyme release into bloodstream, changes in liver weight
  - Reproduction and Development: decreased maternal weight gain and fetal body weight
  - Immune System: delayed response to vaccine based stimuli
  - Elevated blood cholesterol

- Most of the observed effects in animals considered relevant to humans

- Mechanism of action of toxicity not clear – effects are generally non-specific

- Significant difference in how animals eliminate PFAS from their system
  - Half life – measured in days in animals, but years in humans (clearance rates)
    - Remains in humans for much longer than in animals
  - Presumably due to differences in protein binding, but not totally clear yet

GHD

Estimated Elimination Half-Lives of Selected PFAS in Humans, Nonhuman Primates & Rodents

PFAS Compound	Humans	Non human primates	Rats	Mice
PFOA	8 years	20.1-32.6 days	M: 44-322 hours F: 1.9-16.2 hours	
PFOS	5.4 years	110-170 days	179-1968 hours	731-1027 hours
PFHxS	8.5 years	87-141 days	M: 382-688 hours F: 1.03-41.3 hours	597-643 hours
PFBus	665 hours	8.0-95.2 hours	2.1-7.42 hours	
PFBA	72 hours	40.3-41.0 hours	1.03-9.22 hours	2.79-13.34 hours

Potential Carcinogenicity of PFAS

Australian Government

Department of Health

Expert Health Panel's PFAS advice

the panel concluded there is “no current evidence that suggests an increase in overall cancer risk”.

US EPA (2016)

there is equivocal evidence that PFOA exposure might be associated with an increased risk for cancer from the human epidemiology database and animal studies.

In the case of PFOS, the existing evidence does not support a strong correlation between the tumor incidence and dose to justify a quantitative assessment.

US EPA PFAS Management Strategy to Date

- Prepared Health Advisory (HA) levels for PFOA and PFOS in drinking water at 70 ng/L (either separately or combined)
  - Has not yet formally identified PFAS as a “hazardous substance(s)”
  - Has not promulgated Maximum Contaminant Levels for PFAS under the Safe Drinking Water Act
- Non-cancer toxicity criteria available for PFOA, PFOS, and several “GenX” chemicals
- Risk-based screening values for soil, surface water, and other media not currently available
- Recently announced PFAS “Action Plan” roadmap for EPA PFAS assessment program

EPA PFAS Action Plan - February 2019

- USEPA moving forward with the Maximum Contaminant Level (MCL) process outlined in the Safe Drinking Water Act (SWDA) for:
  - PFOS and PFOA
- Considering the addition of PFAS chemicals to the Toxics Release Inventory (TRI) and rules to prohibit the uses of certain PFAS
- Continue strengthening enforcement authorities and clarifying

cleanup strategies through actions such as designating PFOA and PFOS as hazardous substances and developing interim groundwater cleanup values

- Enhancing the way in which agencies communicate about PFAS

Human Health Advisory/Guidelines – Drinking Water

Jurisdiction	PFOA (µg/L)	PFOS (µg/L)	Year
US EPA	PFOA + PFOS 0.07		2016
Delaware	PFOA + PFOS 0.07		2016
California	0.014	0.013	2018
Massachusetts	Sum of 5 PFAS 0.07		2018
Michigan	PFOA + PFOS 0.07		2017
Minnesota	0.035	0.027	2017
New Jersey	0.014	-	2017
Vermont	PFOA + PFOS 0.02		2016
Australia	0.56	0.07	2017
Canada	0.2	0.6	2018
Germany	0.3	0.3	2006
Netherlands	-	0.53	2011
Sweden	Sum of mix of PFASs 0.09		2016
UK	0.3	0.3	2009

Note- Some North American criteria are enforceable at this time: e.g., AK, IA, NC, MI, NC, NH, NJ, OR, TX, and VT.

Future Challenges for PFAS

- Will regulators consider revisions to cleanup values if future studies indicate that PFAS is more or less toxic to humans than currently understood?
- Can we get past using Screening Levels to make all decisions and use a site-specific risk-based approach?
- Exposures have been ongoing in places for decades, with no clear public health or disease crisis. Can data from epi studies be used to counterweight animal data?
- Given that PFAS risks appear modest when compared to many other societal risks (e.g., lead contamination, opiates), will it be possible to provide some balance to risk-based decision making?

More Questions – Contact:

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