Per- and Polyfluoroalkyl Substances (PFAS) in Water – An Overview of WRF’s Initiatives

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Government Affairs Seminar
February 21, 2019
Presentation Outline

• WRF 101

• PFAS Background
  – Regs
  – Occurrence
  – treatment

• WRF Research and Resources

• Conclusions

• Parting Thoughts
What does WRF do?

Deliver Balanced Research
- Manage peer-reviewed research to deliver timely, actionable results

Create Collaboration
- Serve as a research hub for the water quality community (utilities, policy makers, consultants, universities, and industry)

Foster Innovation
- Convene experts and support research to accelerate the adoption of new water technologies

Disseminate Results
- Publishes reports annually that are housed in online, searchable databases

Serve as a research hub for the water quality community (utilities, policy makers, consultants, universities, and industry)
Evolution of The Water Research Foundation
• Represents the evolution of water research
  o 2,300 research studies
  o $700M integrated research portfolio
  o 1,200 subscribers
Regional Liaison

Service Areas

Services Provided:
• Quarterly Regional Updates
• In-person Meetings
• Regional, topical workshops
• Guidance navigating resources and research
PFAS in the Headlines

**Fish advisories issued for Michigan lakes, river impacted by PFAS contamination**

Clarendon, Vt., Businesses React To Contaminated Water Notice From State

Contaminant found in drinking water of 11 properties near landfill

**Washington could ban cancer-causing chemicals used to fight fires**

Drinking water in three Colorado cities contaminated with toxic chemicals above EPA limits

80,000 people south of Colorado Springs being warned of high levels of PFCs in water
PFAS in the Headlines

Federal budget bill includes $10M for PFAS health study, $85M for cleanup

By Kyle Segestane
Posted Mar 22, 2018 at 1:51 PM
Updated Mar 23, 2018 at 12:15 PM

The bill could fund a nationwide health study that would include residents of Bucks and Montgomery counties who were exposed to PFAS in drinking water.

Michigan bill proposes nation's lowest PFAS limit in drinking water
What are PFAS?

- **Per- and poly**fluoroalkyl substances (PFAS) are a class of man-made chemicals
- Carbon-Fluorine bond ➔ shortest and strongest chemical bond in nature
- Persistent, resistant to degradation
- PFAS family ➔ thousands of diverse compounds
- Found globally in people, wildlife and fish
PFAS Family of Chemicals

**TERMS**

PFC = Perfluorinated Compound

PFAS = Perfluoroalkyl or Polyfluoralkyl Substance

PFOA = Perfluorooctanoic Acid

\[ C_8H_{17}O_2 \]

PFOS = Perfluorooctane Sulfonate

\[ C_8H_{17}O_3S \]

GenX = \[ C_6H_4F_{11}NO_3 \]

Uses of PFAS

• Commercial and consumer products containing PFAS were first introduced in the 1950s
• PFAS have been used for many years to make products that resist heat, stains, grease and water

http://www.defence.gov.au
Human Exposure to PFAS
Biomonitoring NHANES PFAS Data

<table>
<thead>
<tr>
<th>PFAS in serum</th>
<th>99–00*</th>
<th>03–04 -----11–12</th>
<th>13–14</th>
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<tr>
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<td>X</td>
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<tr>
<td>MeFOSAA</td>
<td>X</td>
<td>X</td>
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</table>

*No serum available in 2001-2
*Measured as isomers
History of PFAS

1950s
- 1949 - 3M began producing PFOS based compounds

1960s
- 1967 - FDA approved use in food packaging

2000s
- 2002 - 3M phased out PFOS production
- 2008 - 3M phased out PFOA production

2010 to Present
- 2015 - All manufacturers phased out PFOA production
Potential Health Effects – Further Research Needed

• Animals
  – Increased liver weight (critical effect)
  – Spleen, thymus, and developmental
  – Cancer—liver, testis, pancreas

• Humans
  – Possible changes in growth, learning and behavior
  – Decreased fertility
  – Increased cholesterol
  – Immune effects
  – Cancer—kidney, bladder, testicular, prostate
Regulations

• No Federal Regulations but EPA released Action Plan
• Health Advisories
  
  *EPA Provisional Health Advisory*, 2009  
  *Short-term* adverse health effects  
  PFOS: 200 ppt, PFOA: 400 ppt

  *EPA Health Advisory*, 2016  
  *Long-term* adverse health effects  
  PFOS: 70 ppt, PFOA: 70 ppt, PFOS + PFOA: 70 ppt

“EPA's health advisories are non-enforceable and non-regulatory and provide technical information to states agencies and other public health officials on health effects, analytical methodologies, and treatment technologies associated with drinking water contamination.”
## Proposed Or Established PFAS Standards/ Guidelines

<table>
<thead>
<tr>
<th>State</th>
<th>Compound</th>
<th>Level (ppt)</th>
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<tr>
<td>Connecticut</td>
<td>Sum of PFOA, PFOS, PFNA, PFHxS, PFHpA</td>
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<tr>
<td>Maine</td>
<td>Sum of PFOA and PFOS</td>
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<tr>
<td>Minnesota</td>
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<td>PFHxS</td>
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<td>Sum of PFOA and PFOS</td>
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PFAS Analysis

- EPA Method 537
- Perfluorinated alkyl acids
- Drinking water
- SPE, LC/MSMS
- 250mL sample
- MRLs < 1ng/L vs UCMR MRLs
- New EPA method coming

Table 2. PFASs detected by EPA Method 537 and UCMR3

<table>
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<tr>
<th>PFAS</th>
<th>UCMR (Y/N)</th>
<th>EPA HA Conc (µg/L)</th>
<th>UCMR MRL (µg/L)</th>
<th>UCMR PWSs &gt; MRL</th>
<th>UCMR PWSs &gt; Ref Conc</th>
<th>% PWSs &gt; Ref Conc</th>
<th>Max Conc (µg/L)¹</th>
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¹Based on UCMR data available as of January 2016
PFAS Occurrence

Source: Hu XC et al., Environmental Science & Technology Letters
PFAS Research and Resources
## PFAS Removal Summary – WRF Project 4322

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<tr>
<th>Command</th>
<th>M.W. (g/mol)</th>
<th>AER</th>
<th>COAG/DAF</th>
<th>COAG/FLOC/SED/G- or M- FIL</th>
<th>AIX</th>
<th>GAC</th>
<th>NF</th>
<th>RO</th>
<th>MnO₄, O₃, ClO₂, Cl₂, CLM, UV, UV-AOP</th>
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</tr>
</tbody>
</table>

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Point of Entry / Point of Use

• GAC, AIX, RO can be used in POU/POE devices such as whole house water filtration units or systems installed under sinks or in refrigerators

• Can be effective for PFAS BUT questions remain regarding:
  – Removal efficiency
  – Maintenance (how often to change the media, and responsibility for maintenance if for compliance)
  – Cost

• Raise social justice concerns, since not all can afford
WRF Focus Area “Management, analysis, removal, fate and transport of per- and polyfluoroalkyl substances (PFAS) in water”

Objectives:

1. Assess effectiveness of analytical methods
2. Evaluate vulnerability of waters to PFAS, identify sources and hotspots
3. Understand behavior, fate, and transport of PFAS in treatment and environment
4. Evaluate treatment for removing PFAS and reliability of technologies
5. Develop risk communication strategies
Multi-Year Research Agenda

In Contracting: Investigation of Treatment Alternatives for Short-Chain PFAS

Future Years:

• Development of An Analytical Procedure For Total PFAS Measurement In Drinking Water, Natural Water, And Wastewater
• Interlaboratory Studies of PFAS Methods
• Qualitative Structure Activity Relationships For Predicting Removal of New and Emerging PFAS
• PFAS Residual Handling And Treatment Options
WRF Project U2R16 “Concept Development of Chemical Treatment Strategy for PFOS-Contaminated Water”

- University of Texas at Austin
- Proof of concept project to determine if advanced oxidation integration (AIR) with chemical reduction using zerovalent iron (Fe) nanoparticles conjugated with common oxidants (FECO) is able to decompose PFOS
- Hypothesis is that AIR strategy has a high potential to decompose PFOS through oxidative decomposition with reductive dehalogenation
WRF DoD PFAS Project

• Evaluation and Life Cycle Comparison of Ex-Situ Treatment Technologies for Poly- and Perfluoroalkyl Substances (PFAS) in Groundwater

• Research Team: Colorado School of Mines (Chris Bellona, Chris Higgins), North Carolina State University (Detlef Knappe), University of Colorado – Boulder (Sherri Cook), CDM Smith (Charles Schaefer)

• Budget $1,090,000
WRF DoD Project Objectives

• To compare established & emerging PFAS treatment approaches on a life-cycle assessment (LCA) and costing (LCC) basis

• To provide a framework for selection of effective treatment technologies
PFAS Conclusions

• PFAS are useful in society, but extremely persistent and bioaccumulative

• No Federal Regulations – Health Advisories and different state initiatives – communication challenges

• Conventional treatment ineffective for PFAS

• AIX treatment preferably remove longer-chain PFAS

• RO and NF demonstrate significant removal for all PFAS

• Tradeoffs of replacement compounds – harder to remove from water but less persistent
Parting Thoughts

• CECs are a moving target, as science evolves
• Multiple routes of exposure
• Emerging → Emerged → Re-emerging
• Regulatory challenges to keep up with new or replacement compounds
• Consider unintended consequences
  – Byproducts, residuals, biosolids, fate and transport, replacement chemicals, GHGs, rate impacts on affordability of water, …
• Destructive treatment vs removal using media that requires disposal or further treatment
• Scientists need communication training
• Need more research!
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YOUR REGIONAL LIAISON

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