Groundwater Protection from PFAS Contaminants

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Outline

• PFAS Sources
• Chemistry
• PFAS Lawsuits
• PFAS Regulations
• Treatment Options
• Summary
PFAS is Everywhere

Source: Green Science Policy Institute
PFAS in the Environment

- PFAS has been found in:
  - Groundwater,
  - Surface water
  - Bottle water,
  - Rainwater,
  - Wastewater,
  - Biosolids,
  - Soil,
  - Ash,
  - Air,
  - Animal tissue,
  - Plant tissue.
PFAS Infiltrated our Food Supply

FDA tested a dairy farm near a US Air Force Base in New Mexico
PFAS Related Health Effects

Studies have shown:

• Increased Cancer risk:
  • Colon
  • Kidney
  • Pancreatic

• Affect the immune system

• Increase cholesterol
PFAS Structure

<table>
<thead>
<tr>
<th></th>
<th>kJ/mol of bonds</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-F</td>
<td>485</td>
</tr>
<tr>
<td>C-H</td>
<td>436</td>
</tr>
<tr>
<td>C-C</td>
<td>346</td>
</tr>
<tr>
<td>C-Cl</td>
<td>339</td>
</tr>
<tr>
<td>C-N</td>
<td>305</td>
</tr>
<tr>
<td>C-Br</td>
<td>285</td>
</tr>
<tr>
<td>C-S</td>
<td>272</td>
</tr>
</tbody>
</table>

Sometimes you may hear C8 Chemicals—That’s PFAS.
PFAS Exposure Pathways:

- Bioaccumulation
  - food chain
- Inhalation
  - Indoor Dust
  - Airborne particulates
- Oral
  - Food
  - Drinking water
PFAS Transport Pathways to Groundwater

Source: MI DEQ (2019)
PFAS Class-Action Lawsuits

• Alabama –$35M West Morgan-East Lawrence Water Authority’s (WMEL) settled with 3M in 2019
• Minnesota –$850M settlement with 3M in 2018
• West Virginia -$671M settlement with DuPont/Chemours in 2017
• North Carolina -$13M settlement with Chemours in 2019
• Law Suits pending in Colorado, Michigan, New York, Pennsylvania, New Hampshire, Vermont, and New Jersey, and Nationwide (US)

Lawsuits-Environmental Contamination, Health impacts, & Remediation
Limited Analytical Methods

**EPA 537**

- **SPE LC-MS/MS**
- 18-33 Compounds
- For drinking water
- Holding time: 14 days for extraction
- Typical RL: 5 - 25 ppt
- ~ $250-400/sample
- Approximate 40 laboratories

**Sample collection:**
- Cross contamination
Groundwater Contamination

Source of PFAS Contamination

Aquifer

Contamination Plume

Home with Private Well
PFAS Regulations

**Water**

- **PFOA**
  - AK, 2018: 0.014
  - CA, 2018: 0.07
  - CO, 2018: 0.013
  - CT, 2016: 0.027
  - DE, 2016: 0.035
  - IA, 2016: 0.02
  - ME, 2016: 0.013
  - MA, 2018: 0.022
  - MI, 2018: 0.013
  - MN, 2017: 0.667
  - NV, 2015: 0.014
  - NH, 2015: 0.02
  - NJ, 2016: 0.013
  - NC, 2018: 300
  - OR, 2011: 0.56
  - PA, 2016: 0.29
  - RI, 2017: 0.014
  - TX, 2016: 0.02
  - VT, 2018: 0.02

- **PFOS**
  - AK, 2018: 0.001
  - CA, 2018: 0.001
  - CO, 2018: 0.001
  - CT, 2016: 0.001
  - DE, 2016: 0.001
  - IA, 2016: 0.001
  - ME, 2016: 0.001
  - MA, 2018: 0.001
  - MI, 2018: 0.001
  - MN, 2017: 0.001
  - NV, 2015: 0.001
  - NH, 2015: 0.001
  - NJ, 2016: 0.001
  - NC, 2018: 0.001
  - OR, 2011: 0.001
  - PA, 2016: 0.001
  - RI, 2017: 0.001
  - TX, 2016: 0.001
  - VT, 2018: 0.001
**PFAS**: State Level Directives

**MI, NY, NH, ME, CA, WI**

- Sampling of Groundwater around active and closed landfills
- Addition of PFAS to existing pre-treatment permits
- Directive for WWTP to sample influent, effluent, biosolids
- Directive for WWTP to identify and sample point-source contributors
PFAS Regulations

• 2016 EPA issued Health Advisory for PFOA and PFOS limit of 70 ppt
• 2019 EPA has developed PFAS Action Plan to begin developing a Drinking Water Standard for PFAS
• Several States have established PFAS drinking water limits / advisories
PFAS Treatment (Pump and Treat)

• GAC (Granular Activated Carbon)
• IX (Ion Exchange)
• RO (Reverse Osmosis)
• Concentrate/Waste Management
Typical GAC Process

• Influent/Second GAC vessels
  • “Lead” & “Lag”

• Monitoring
  • Influent
  • Mid-point
  • Effluent

• Carbon Change Out
  • Lead to reactivation
  • Lag to lead
  • New to lag

Diagram courtesy of Calgon Carbon
PFAS Treatment: GAC

• May require pretreatment
• Effectiveness depends on:
  • pH
  • Temperature
  • contact time
  • NOM
  • Chlorine
• Better for long-chain PFAS
• No brine and chemicals
• GAC may be cost-effective
PFAS Treatment: Ion Exchange (IX)

Short Contact Time ~3 mins

PFAS in water

PFAS loaded resin

PFAS free Treated water

Incineration or other disposal alternative

Illustrations courtesy of Purolite, Inc.
PFAS Treatment: Ion Exchange (IX)

- PFAS are anions - IX can remove
- Longer PFAS chains preferred over shorter chains
- Resins disposed offsite (incineration)
PFAS Treatment: Reverse Osmosis (RO)
PFAS Treatment: Reverse Osmosis (RO)

• Effective for PFAS
  • High pressure membrane
  • High energy usage
  • Reject water disposal

• Removes a wide range of constituents:
  • Hardness
  • Dissolved solids
  • PFAS
  • Organics
  • Ammonia-N
## PFAS Treatment Efficiencies

<table>
<thead>
<tr>
<th>Treatment Method</th>
<th>PFOA</th>
<th>PFOS</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granular Activated Carbon</td>
<td>48-90%</td>
<td>89-98%</td>
<td>Requires regeneration or replacement and disposal. May release PFAS into the atmosphere</td>
</tr>
<tr>
<td>Ion Exchange</td>
<td>51-90%</td>
<td>90-99%</td>
<td>Resins need to be regenerated or replaced</td>
</tr>
<tr>
<td>Reverse Osmosis</td>
<td>90%</td>
<td>93-99%</td>
<td>Waste stream contains salts, and filtrate require disposal.</td>
</tr>
</tbody>
</table>
Incineration (PFAS Concentrate/Waste)

• Thermal Method
• High Energy Cost
• Air Emissions
• Limited Availability
• Ash Disposal
Deep Well Injection

- Inject far below drinking water sources
- Construction is Costly ~$4-6 M/Well
- Clogging well during injection may be an issue
- 3rd Party accepting 0.18-0.25/Cents Gallon
SUMMARY - PFAS Treatment

• Treatment is site specific (pilot testing)
• PFAS removal may be influenced by:
  • pH, water temperature, contact time, Organics and Chlorine compounds
• Polishing Step may be required
• Land applied Biosolids is a potential source of PFAS impacts Surface water and groundwater
QUESTIONS?

Groundwater Protection from PFAS Contaminants

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