PFAS Exposure at Contaminated Sites

Tom Bruton, PhD
Green Science Policy Institute
August 12, 2019
What is a contaminated site?

• Exposure is everywhere. How to distinguish:
  • background from a contaminated site?
  • contaminated site vs. occupational exposure?

How to characterize exposure?

- What chemicals?
- What pathways?
- What concentrations? (external vs. internal)
- Duration?
- How many affected?

All are related to source type.
What chemicals?

# of studies addressing different subgroups:

- PFCAs: 12,960
- PFSAs: 5,582
- PFPAs: 102
- PFPIAs: 36
- PFECAs & PFESAs: 50
- PASF-based substances: 719
- Fluorotelomer-based substances: 1148

PFOA, PFOS, & PFHxS: 8,654

Wang et al., Environ. Sci. Technol. 2017
What pathways?

- Drinking water may dominate (non-occupational) exposure near contaminated sites

\[
[PFOA]_{DW} = 1.3 \text{ ng/L} \\
[PFOA]_{DW} = 40 \text{ ng/L} \\
[PFOA]_{DW} = 519 \text{ ng/L}
\]

Point Sources

• Fluorochemical manufacturing sites
• Other manufacturing sites
• Aqueous film-forming foam (AFFF)
  • Defense sites, airports, etc.
• Wastewater treatment / biosolids
• Other?
U.S. Contaminated Sites: Source Type

n = 213

Source data from:
SSEHRI PFAS Contamination Site Tracker, last update 7.02.2019
Fluorochemical manufacturing
(makers of PFAS)

- Relatively few sites
- Relatively large amounts of emissions
- Multimedia emissions:
  - Air, surface water, land disposal/groundwater
- Complex chemistries
Fluorochemical manufacturing

- Relatively few sites
- 16 U.S. sites per EPA 2010/2015 PFOA Stewardship Program
- 33 fluoropolymer manufacturing sites worldwide in 2002

Prevedoros et al., Environ. Sci. Technol. 2006
Fluorochemical manufacturing

- Relatively large amounts of emissions
- Up to tons of PFAAs per year per site
- Fluoropolymer manufacturing is the single largest known source of PFCA emissions.

Prevedorous et al., Environ. Sci. Technol. 2006
Herrick et al., Environ. Poll. 2017
Fluorochemical manufacturing

- Multimedia emissions:
  - Air, surface water, land disposal/groundwater

Davis, et al., Chemosphere 2007
Fluorochemical manufacturing

- Complex chemistries:
  - PFOA, PFNA, PFOS, PFBS, but what else?
  - GenX and other perfluoroether acids

Sun et al., ES&T Lett. 2016
Fluorochemical manufacturing

- Complex chemistries:
  - PFOA, PFNA, PFOS, PFBS, but what else?
  - GenX and other perfluoroether acids

Sun et al., ES&T Lett. 2016
Other manufacturing
(users of PFAS)

• More common
• Examples:
  • Fabric and plastic coating
  • Paper mills
  • Leather tanneries
• Metal plating

• Other: photolithography, paints, carpet & upholstery, oil & gas extraction?

• Hoosick Falls, NY
• Bennington, VT
• Merrimack, NH
• Parchment, MI
• Plainfield, MI
Other manufacturing (users of PFAS)

• More common
• Examples:
  • Fabric and plastic coating
  • Paper mills
  • Leather tanneries
  • Metal plating

Firefighting foam (AFFF)

• Many sites

• Emissions: emergency response vs. ongoing training

• Emissions: groundwater vs. surface water

• Complex chemistries

Prevedorous et al., Environ. Sci. Technol. 2006
Herrick et al., Environ. Poll. 2017
Firefighting foam (AFFF)

- Emissions: emergency response vs. ongoing training

- E.g. 75-100 L of AFFF used weekly to monthly for 30+ years

- Accidental release of 22,000L of AFFF

Firefighting foam (AFFF)

- Emissions: groundwater vs. surface water

- Up to 7 mg/L PFCAs in groundwater 7-10 years after last AFFF use

- Up to 99.9% decline of PFOS in surface water 9 years after spill

Awad et al., Environ. Sci. Technol. 2002
Firefighting foam (AFFF)

• Complex chemistries
  • PFOS, PFHxS, and much more...

• 13 classes found only in groundwater (transformation products)
• We know little about fate & toxicity

Barzen-Hanson et al., Environ. Sci. Technol. 2017
Wastewater treatment plants

• Not sources, but concentrators

• High input = high output. Industrial sources & AFFF are important.

• Key exposure route is land application of biosolids

Prevedorous et al., Environ. Sci. Technol. 2006
Herrick et al., Environ. Poll. 2017
Wastewater treatment plants

• High input = high output. Industrial sources & AFFF are important.

PFAS in WWTP effluent with and without AFFF use

No known AFFF

With AFFF use (note y-axis scale)

Houtz et al., Water Res. 2016
Wastewater treatment plants

- High input = high output. Industrial sources & AFFF are important.

3M Environmental Monitoring – Multi-City Study, 2001
Venkatesan and Halden, 2013
Maine DEP, 2019
Wastewater treatment plants

- Key exposure route is land application of biosolids.
  - Arnsberg, Germany
  - Decatur, AL, USA
  - Arundel, ME, USA

Industrial wastewater

Public WWTP

Biosolids

Effluent

Air?

Land application

Soil

Plants

Surface & ground water

Livestock

Milk

Lindstrom et al., 2011
Holzer et al., 2008
Does type of point source affect the magnitude of exposure?
Serum PFOA in community studies
(not comprehensive)

<table>
<thead>
<tr>
<th>Location</th>
<th>PFOA (geo. mean, ng/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Hocking, OH, U.S. 2006</td>
<td>423</td>
</tr>
<tr>
<td>C8 Health Study, U.S. 2004-2005</td>
<td>33</td>
</tr>
<tr>
<td>Arnsberg, GE 2006</td>
<td>24</td>
</tr>
<tr>
<td>Hoosick Falls, NY, U.S. 2016</td>
<td>22</td>
</tr>
<tr>
<td>Ronneby, SE 2014</td>
<td>18</td>
</tr>
<tr>
<td>Decatur, AL, U.S. 2009</td>
<td>16</td>
</tr>
<tr>
<td>East Metro, MN, U.S. 2008</td>
<td>15</td>
</tr>
<tr>
<td>Bennington, VT, U.S. 2016</td>
<td>10</td>
</tr>
<tr>
<td>Merrimack, NH, U.S. 2016-2017</td>
<td>4</td>
</tr>
<tr>
<td>Buxmont, PA, U.S. 2018</td>
<td>3</td>
</tr>
<tr>
<td>Pease, NH, U.S. 2015</td>
<td>3</td>
</tr>
<tr>
<td>Colorado Springs, CO, U.S. 2018</td>
<td>3</td>
</tr>
<tr>
<td>Uppsala, SE 1996-1999</td>
<td>3</td>
</tr>
<tr>
<td>Westhampton, NY, U.S. 2018</td>
<td>2</td>
</tr>
</tbody>
</table>

- Primary manufacturing
- Secondary manufacturing
- AFFF
Serum PFOS in community studies (not comprehensive)

- Ronneby, SE 2014: 345 ng/mL
- Decatur, AL, U.S. 2009: 40 ng/mL
- East Metro, MN, U.S. 2008: 35 ng/mL
- Uppsala, SE 1996-1999: 20 ng/mL
- Buxmont, PA, U.S. 2018: 10 ng/mL
- Colorado Springs, CO, U.S. 2018: 10 ng/mL
- Pease, NH, U.S. 2015: 9 ng/mL
- Arnsberg, GE 2006: 7 ng/mL
- Westhampton, NY, U.S. 2018: 7 ng/mL
- Merrimack, NH, U.S. 2016-2017: 6 ng/mL

Diagram showing PFOS concentrations in various locations with primary and secondary manufacturing and AFFF sources.
Conclusions

1. When drinking water is contaminated, it is the dominant exposure

2. Research needs:
   • Environmental levels and exposure to chemicals other than PFOA, PFOS, PFHxS, PFNA, etc.
   • Exposure pathways other than drinking water
     • Fish, game, crops, livestock...

3. The world is a contaminated site.
Questions?
tom@greensciencepolicy.org

New website: PFASCentral.org