Introduction to PFASs
Highly Fluorinated Chemicals

Kathryn Rodgers, MPH
Highly fluorinated chemicals or PFASs
Per- and polyfluoroalkyl substances

What makes this family of chemicals unique?

- Persistence
- Complexity
- Versatility
Widely used in household products

- Carpets & upholstery
- Waterproof apparel
- Waxes (floor, skis)
- Non-stick cookware
- Grease-proof food packaging
- Dental floss
- Paints
Many exposure pathways

Okiaei, et al. 2013
Prevalence of fluorinated chemicals in U.S. fast food packaging

Percent with fluorine

- Dessert & bread wrappers: 56%
- Sandwich & burger wrappers: 38%
- Paperboard: 20%
- Paper cups: 0%


PIGE (total fluorine)

- Popcorn bag (w/ PFAS)
- Copier paper (blank)
Sources of drinking water contamination

- AFFF (aqueous film-forming foam) for fuel fires
- Production facilities
- Other industries
- Waste disposal sites
- Wastewater
Sources of PFASs to public water supplies

Subbasins (large watersheds) with detectable PFASs

PFASs in private wells

- PFASs in public and private wells on Cape Cod, MA:
  - County fire training area
  - Municipal airport
  - Military base
  - Household wastewater

---

**Cape Cod Times**

Hyannis residents warned about water quality
Posted May 24, 2016 at 3:05 PM

HYANNIS — Barnstable officials are recommending that pregnant women, nursing mothers and infants in Hyannis not drink or cook with well water until further notice after a federal agency changed thresholds for two contaminants in the drinking water.

On Thursday, the U.S. Environmental Protection Agency changed its advisory level for perfluorinated compounds, known as PFOS and PFOA, from 0.2 micrograms per liter to 0.4 micrograms per liter to 0.07 micrograms per liter for both.

The change put a well at the Mary Dunn well field above the new contaminant limit, according to Daniel Santos, director of the town’s Department of Public Works.

---

**Private wells**

<table>
<thead>
<tr>
<th>Concentration (ng/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

20 wells tested

In our bodies and the environment

- Global transport recognized in early 2000s

- Some can bioaccumulate and biomagnify
  (Conder et al., 2008, *ES&T*. 42:995-1003)

- >98% of Americans have PFASs in their blood (NHANES)
  (Calafat et al., 2007, *EHP*. 115: 1596-1602)
Long-chain PFASs

• Long chain of fluorinated carbon atoms
  – At least 6 for sulfonates, at least 7 for carboxylates
• Some PFASs can be converted to PFOS or PFOA

**PFOS (sulfonate)**

- Tail: Water and oil insoluble
- Head: Water soluble

**PFOA or C8 (carboxylate)**

- Tail: Water and oil insoluble
- Head: Water soluble
Per- versus poly- fluorinated

\textbf{Per} = fully fluorinated

\textbf{Poly} = partly fluorinated

PFOS
Perfluorooctane sulfonic acid

8:2 FtS
Fluorotelomer sulfonate
Phasing out long-chain PFASs

• Concerns about toxicity and persistence led to phase out of U.S. production of PFOS and PFOA
  – 2000: 3M phase-out of PFOS
  – 2006: EPA’s 2010/2015 PFOA Stewardship Program

• Stockholm Convention for Persistent Organic Pollutants
  – PFOS: 2009, Annex B (Restriction)
  – PFOA: 2015, Nominated for listing
In May 2016, EPA issued stricter drinking water guidelines for PFOS and PFOA

- 2009 guidelines:
  - 200 ng/L PFOS, 400 ng/L PFOA

- 2016 guideline:
  - PFOS + PFOA: 70 ng/L

- Guidelines lacking for other PFASs

- Some states have lower guidelines
  - NJ noted effects on mammary gland development
Replacements: Short-chain PFASs

- Mainly shorter versions of PFOA, PFOS, and related compounds
- Retained in body for days to weeks
  - Shorter than long-chains
  - Longer than some other chemicals of concern

<table>
<thead>
<tr>
<th>Half-lives in human blood (geometric means)</th>
<th>Long chain</th>
<th>Short chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFHxS</td>
<td>7.3 years</td>
<td></td>
</tr>
<tr>
<td>PFOS</td>
<td>4.8 years</td>
<td></td>
</tr>
<tr>
<td>PFOA</td>
<td>3.5 years</td>
<td></td>
</tr>
<tr>
<td>PFHxA</td>
<td>32 days</td>
<td></td>
</tr>
<tr>
<td>PFBS</td>
<td>26 days</td>
<td></td>
</tr>
<tr>
<td>BPA</td>
<td>3-6 hours</td>
<td></td>
</tr>
</tbody>
</table>

Concerns about short-chain PFASs

Similar biological activity in in vitro lab testing


Poorer removal during GAC drinking water treatment


Varying patterns of accumulation in animal organs


More accumulation in plant shoots and fruits

Other replacements

Over 3,000 PFASs on the global market
(Wang et al., 2017, *ES&T*, 51:2508.)

**GenX**

![GenX molecule](image1)


**ADONA**

![ADONA molecule](image2)


Firefighting foams and misc.

![Firefighting foams](image3)
Class-based approach

Madrid Statement (2015)

“We call on the international community to cooperate in limiting the production and use of PFASs and in developing safer non-fluorinated alternatives.”

Signed by 230 scientists from 40 countries
Next steps for scientists

• For scientists and regulators, chemical-by-chemical approach is too slow
• How much evidence is enough?
• How can we be strategic in filling gaps?