Poly- and Perfluoroalkyl Substances (PFASs): An Introduction

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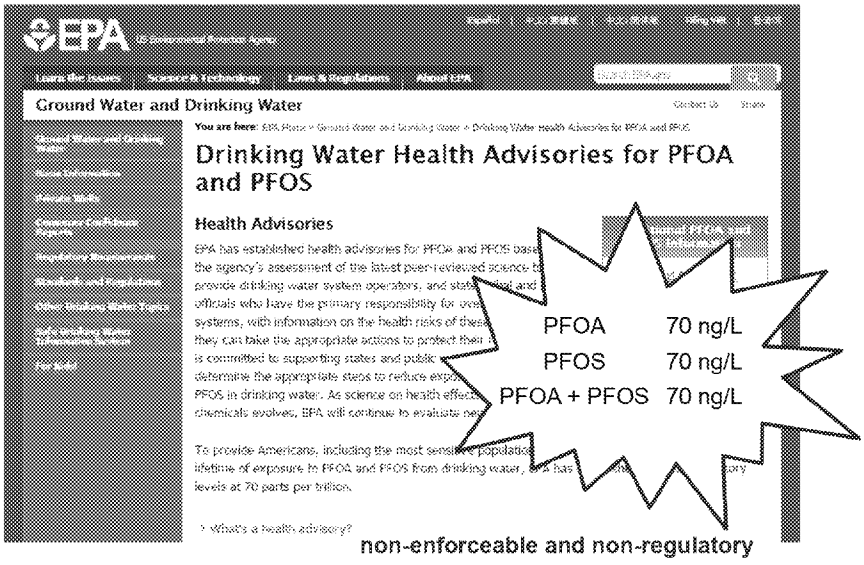
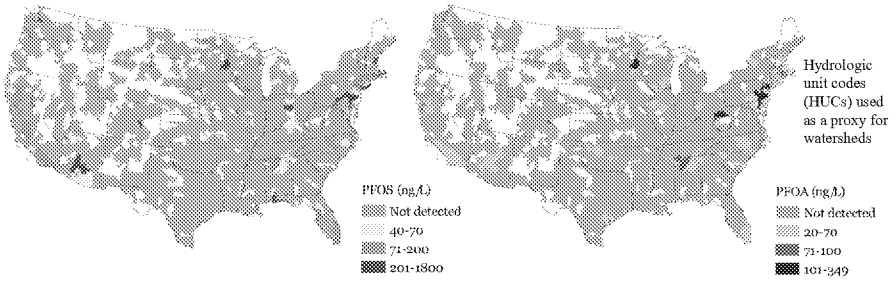
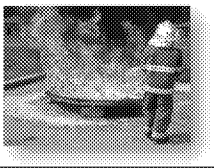


non-enforceable and non-regulatory

A national issue?: UCMR 3 Data



- EPA survey of all public water systems (PWSs) serving 10,000+
- Chemicals monitored: PFBS, PFHxS, PFOS, PFHpA, PFOA, PFNA
- Through 2015, 193 PWSs (3.9%) had detectable PFAAs
- Fire training areas and aqueous film forming foam (AFFF) releases likely important sources



Hu *et al.*, 2016 *ES&TL*

Terminology and Acronyms

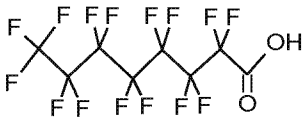
PFC = perfluorinated chemical, "perfluorochemical"

PFC = perfluorocarbons, a family of greenhouse gases

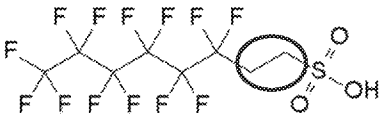
***Poly*- and per**fluoroalkyl substances = **PFASs**

Perfluoroalkyl acids = **PFAAs (a subclass of PFASs)**

PFAAs and PFASs are ***not*** synonymous



Perfluoroalkyl acid



Polyfluoroalkyl acid

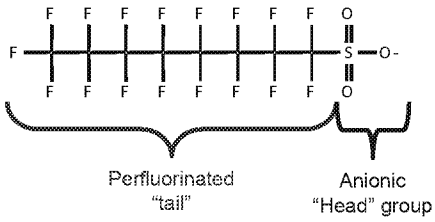
Buck *et al.*, 2011, *IEAM*.

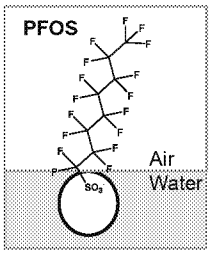
Perfluoroalkyl acids (PFAAs)

- Fully fluorinated chemicals that repel both oil and water
- **PFAA-based precursors** (i.e., ***poly***fluorinated substances) used in coatings for textiles and paper packaging products, fire-fighting foams, etc.
- Persistent, Bioaccumulative, and Toxic (PBT)
- Widely detected in wildlife and humans
- Relatively mobile and yet bioaccumulative

So, again, what are PFAAs?

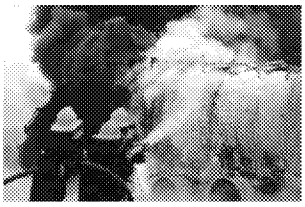
Perfluorooctane sulfonate (PFOS)
$C_8F_{17}SO_3^-$





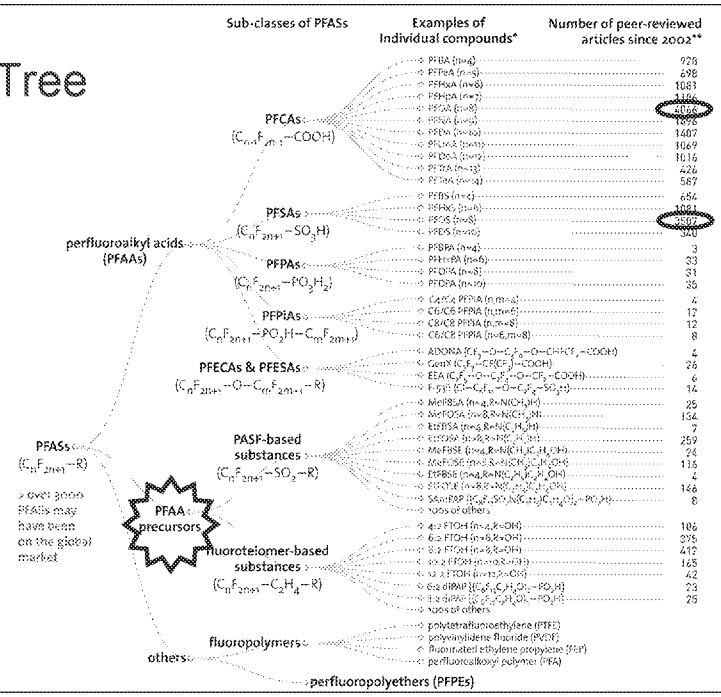
Good news: C-F bond is one of the strongest chemical bonds known
Bad news: C-F bond is one of the strongest chemical bonds known

PFAAs are extremely persistent in the environment



PFAS Family Tree

It's not just PFOS and PFOA



Wang *et al.* 2017, *ES&T*.

PFAS Sources

- Consumer products
  → Wastewater, biosolids, and landfills
- AFFF releases
  - Not just military sites
- Chromium electroplating
  - PFSAs used for mist suppression
  - PFCAs (C4-C11) and PFSAs (C4,6,8) in discharge water[1]
  - 6:2 FtS 'alternative' mist suppression agent[2]
- Industrial (plastics/polymer/textile) manufacturing sources
  - PFNA: West Deptford, NJ Solvay Specialty Polymers[3]
  - PFOA: Saint Gobain Performance Plastics and Honeywell polymer manufacturing in Hoosick Falls, NY[4]

[1]EPA, 2009. PFOS Chromium Electroplater Study
[2]Yang et al., 2014. Environ Sci Pollut 21:4634-4642
[3]http://www.njspotlight.com/stories/15/04/06/drinking-water-panel-calls-for-stricter-standard-on-potential-carcinogen/
[4]http://www.villageofhoosickfalls.com/news.html

Slide content courtesy of ESTCP Project ER-201574-T2. Full FAQ presentation available at https://youtu.be/lyzSc6fF792E

Jennifer Field: End

Aqueous Film Forming Foam (AFFF)

- Only 3% of fluorochemical production is for AFFF
  - 75% of AFFF production used by military
  - 25% used by oil refineries, municipal airports & fire stations, tank farms
- Complex, proprietary mixtures
- PFASs a few % in mixture but still g/L levels
- Brief history
  - Mid 1960s – 1970: 3M sole source supplier of AFFF
  - 1973: National Foam
  - 1976: Ansul
  - 1994 to present: Angus, Chemguard, Fire Service Plus
- Multiple AFFFs used at most sites, **often directly released**

Photo courtesy of John Farley, Director, CBD/ex-USS SHADWELL Fire Test Operations, Naval Research Laboratory, Washington DC; [1]Moody et al., 2000. *ES&T* 34: 3864-3870

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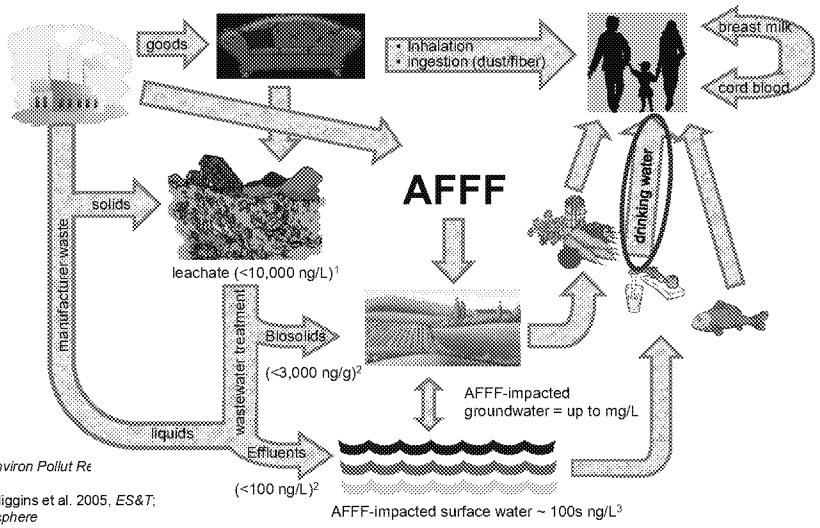
Consider 1,000 mg (1 g/L), when dissolved completely in water, will contaminate a lot of groundwater

PERSONALITY – goes to interface to put out fire (< 1 min)
When we analyze, must dilute 1:1,000,000
We have to stop and think – 'only a few %' = parts per hundred

RITS 2016: Emerging Contaminants

Human Exposure to PFASs



Adapted from Oliaei 2013, *Environ Pollut Re*
[1]Allred *et al.*, 2014. *J Chrom*;
[2]Schultz *et al.* 2006, *ES&T*; Higgins et al. 2005, *ES&T*;
[3]Ahrens *et al.* 2015, *Chemosphere*

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