PFAS: Chemistry, Sources & Policy

Tom Bruton PhD
Green Science Policy Institute

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EVALUATING TENS OF THOUSANDS OF INDIVIDUAL CHEMICALS IS UNWORKABLE
BUT ADDRESSING **SIX GROUPS** OF CHEMICALS OF CONCERN IS MANAGEABLE
PFAS

Carbon-Fluorine bond strength:

• Leads to oil and water repellency
• “Forever chemicals” -- last for geologic time!

PFOS

PFOA

Courtesy: Dr. Jennifer Field
PFAS

Polymers
- Side-chain fluorinated polymers
  - Fluoropolymers
    - Perf. polyethers
  - Perfluoroalkyl substances
- Nonpolymers
  - Polyfluoroalkyl substances
    - PF acids
    - Perfluorocarbons
    - PF sulfonamides
    - PF iodides
    - PF aldehydes
    - PF sulfonyl fluorides
    - PF sulfonamido derivatives
  - Fluorotelomer substances
    - PF carboxlic acids
    - PF sulfonic acids
    - PF sulfinic acids
    - PF phosphinic acids
    - PF phosponic acids
    - N-alkyl PF sulfonamides
    - (N-alkyl) PF sulfonamidoethanols
    - N-alkyl PF sulfonamidoethyl (meth)acrylates
    - (N-alkyl) PF sulfonamido acetic acids
    - n:2 FT iodides
    - n:2 FT olefins
    - n:2 FT alcohols
    - n:2 Unsaturated FT alcohols
    - n:2 FT (meth)acrylate
    - n:2 Polyf. phosphoric acid esters and phosphates, FT phosphates
    - n:2 FT (unsaturated) aldehydes
    - n:2 FT (unsaturated) carb. acids
    - n:3 (Un)saturated acids
    - n:2 FT sulfonic acids

PF = perfluorinated
FT = fluorotelomer

Perfluoroalkyl substances

Polyfluoroalkyl substances

PF = perfluorinated
FT = fluorotelomer

Degradation pathway

Polymers
- Side-chain fluorinated polymers
  - Perf. polyethers
  - Fluoropolymers
- Nonpolymers
  - Polyfluoroalkyl substances
  - Fluorotelomer substances

PF = perfluorinated
FT = fluorotelomer
PFASs exposure is a health concern

Exposure linked to health risks:
Cancer, elevated cholesterol, obesity, immune suppression, and endocrine disruption

(Ref: Lewis et al., 2015; Grandjean et al., 2012; Braun et al., 2016; Barry et al., 2013)

Courtesy, Cindy Hu, Harvard University
EPA Lifetime Health Advisory Level of 70 ng/L PFOA + PFOS

Scientific publications on PFAS

Grandjean, Environ. Health. 2018
Drinking Water Health Guidelines

DuPont PFOA: 5000

U.S. EPA PFOA: 400

New Jersey PFOA: 14

New York PFOA: 10
Industrial Transition

Long-chain PFAS

Concerns:
- Extreme persistence
- Bioaccumulation
- Toxicity

Short-chain PFAS

- “Favorable toxicological profile”\(^1\)
- “Safe for intended use”\(^2\)

2. [https://fluorocouncil.com/florotechno/terminology/](https://fluorocouncil.com/florotechno/terminology/)
Is C6 a safer substitute for C8?

C8  
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Long-chain PFAS

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• Extreme persistence
• Bioaccumulation
• Toxicity

C6  
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Short-chain PFAS

Concerns:
• Extreme persistence
• Build up in plants
• Suspected toxicity
• More mobile
• Remediation more difficult
Water Treatment Costs: North Carolina

Brunswick County: reverse osmosis filtration:
- $99M to build
- $2.9M to operate

Cape Fear Public Utility Authority activated carbon filtration:
- $46M to build
- $2.7M to operate each year

Wilmington Star News, May 9th and 10th, 2018
Recent comments from CDC

Patrick Breysse, Director of the CDC’s National Center for Environmental Health:

The presence of perfluorinated chemicals in U.S. drinking water is “one of the most seminal public health challenges for the next decades.”

“...it won’t be too long before we think hundreds of millions of Americans will be drinking water with levels of these chemicals above levels of concern.”

- BNA News, Oct. 17, 2017
Congressional PFAS Task Force

• Launched 1/24/19
• Goals
  • Educate
  • Legislate
  • Elevate
  • Appropriate

• Members:
  Lujan (NM-03)
  King (NY-03)
  McGovern (MA-02)
  Upton (MI-06)
  Huizenga (MI-02)

  Dingell (MI-12)
  Turner (OH-10)
  Boyle (PA-02)
  Walberg (MI-07)
  Lawrence (MI-14)

  Bergman (MI-01)
  Dean (PA-04)
  Delgado (NY-19)
  Levin (MI-09)
  Stevens (MI-11)

  Slotkin (MI-08)
  Tlaib (MI-13)
  Maloney (NY-18)
  Pappas (NH-04)
PFAS are Problematic & Difficult to Clean Up

Prevention is Preferable!
EPA Lifetime Health Advisory Level of 70 ng/L PFOA + PFOS

Industrial facilities

• Primary manufacturing
  • Where PFAS are made
  • Relatively few
  • Responsible for massive amounts of emissions

• Secondary manufacturing
  • Where PFAS are used
  • More common
Primary Manufacturing:
West Virginia fluorochemical plant

- PFOA used to manufacture fluoropolymers
- Releases to air, groundwater, surface water
- 70,000+ residents with contaminated drinking water
- C8 Health Study + class action suit
Secondary Manufacturing: Michigan leather tannery

- Wolverine treated leather with Scotchguard (PFOS)
  - Leather scrap dumped
  - Sludge applied to fields

- PFOA + PFOS level up to 58,000 ppt
  842 times EPA health advisory level!

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Secondary Manufacturing: other examples

- Hoosick Falls, NY
- Bennington, VT
- Merrimack, NH
- Parchment, MI
- Wixom, MI

\[ \text{PFAS-coated fabrics/plastics} \]

\[ \text{Paper mill} \]

\[ \text{Chrome plater} \]

- Likely other industries
Aqueous Film-Forming Foams (AFFF)

- For fighting Class B (petroleum) fires
- Contains PFAS
- Used by military, airports, municipal firefighters, oil & gas industry
- High concentrations of PFAS now found in soil and groundwater at training sites
Foam as a Source of Water Contamination
Northeastern U. and EWG Site Tracker, 10/4/18

76% of sites likely related to firefighting foam use

- Military sites
- Airports
- Fire training
- Past fires
SE Pennsylvania

• 3 military installations:
  • Horsham
  • Warminster
  • Willow Grove

• 230-340k gallons foam used over 46 years

• PFAS leached to groundwater

• Water systems serving > 85k people impacted

• PFOS+PFOA level up to 329,500 ppt
  >4000 times EPA health advisory level!
New Mexico

- Cannon Air Force Base
  - Firefighting foam entered groundwater
  - PFAS migrated from base to dairy wells to cows to milk
  - Farmer: “I can’t sell the milk. I can’t sell beef. I can’t sell the cows. I can’t sell crops on my property.”

- PFOS level up to 12,000 ppt
  171 times EPA health advisory level!
Government policy is a major driver of AFFF use

- Class B firefighting foams used by the U.S. military are required to contain PFAS.
  - MILSpec: “Concentrates shall consist of fluorinated surfactants…”

- U.S. civilian airports are also required to use PFAS-containing foam
  - FAA policy refers to MILSpec
Fluorine-Free Foams

“Current fluorine-free ... firefighting foams are now viable operational alternatives to fluorinated AFFF.”

“Unlike fluorinated AFFFs, fluorine-free foams do not give rise to environmentally persistent, toxic, or bio-accumulative chemically stable end-products.”

https://ipen.org/documents/fluorine-free-firefighting-foams
Washington State’s Ban on PFAS in Firefighting Foam
(HB 2793/SB 6413)

- Signed into law on March 27, 2018
- Bans sale of firefighting foam containing any PFAS beginning July 1, 2020
- The states of CT, GA, KY, MA, MN, NY have similar bills this year

More info https://toxicfreefuture.org/key-issues/legislative-priorities-2018/
Congress to FAA: allow the use of fluorine-free foams

2018 FAA Reauthorization

• Directs FAA to allow airports to use PFAS-free Class B firefighting foams (within 3 years)

• Signed into law Oct. 5

• Response from FAA?
Congress to DoD: allow the use of fluorine-free foams

2020 defense bill:
• Senate: Bans most use of PFAS-containing foam after 2023
• House: Phase-out of PFAS foam 2027-2029

Trump threatens veto on defense bill that targets 'forever chemicals'
WWTPs
WWTPs

• Sources of PFAS loading
  • Industrial – electroplating, firefighting foam, other?
  • Landfill leachate
  • Consumer – carpets, apparel, food packaging, cosmetics, other

• Conventional treatment trains not effective for PFAS removal
  • Effluent > influent

• Partitioning to biosolids
  • Long-chains > short-chains

• Air emissions?
Maine

- Biosolids spreading led to contamination of
  - Local municipal supply well
  - Milk at dairy

- Maine DEP:
  - All biosolids must now be tested for PFAS prior to use
  - Initial testing: nearly all biosolids exceed state screening levels for PFOS and/or PFOA (5.2 and 2.5 ng/g)

[See also: Venkatesan and Halden, J. Hazard Mater., 2013](https://theintercept.com/2019/06/07/pfas-chemicals-maine-sludge/)
WWTPs - the impact of firefighting foam

Landfills – C6 PFAS dominate

Figure 1. Group 1 PFAS release in U.S. landfill leachate for 2013 demonstrating a dominance of compounds with five fluorinated carbons (PFHxA and 5:3 FTCA). Releases were calculated from mean concentrations in each climate and age category (Table 3). The individual columns are based on eq. 1 while the total is based on eq. 2

See: J. Lang, et. al, ES&T, 2017
Moving away from PFAS

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2020 Defense Bill (NDAA)

House
- DoD foam phaseout
- $ for USGS monitoring
- $5M for ATSDR health study
- Clean Water Act
- Superfund
- More...

Senate
- DoD foam phaseout
- $ for USGS monitoring
- $10M for ATSDR health study
- Drinking water standard for PFOA + PFOS in 2 y
- Toxics Release Inventory
- Firefighter blood testing
By reducing use of Six Classes

We can have a healthier world.

For more information
Green Science Policy Institute
www.greensciencepolicy.org