A PFAS Primer

Water Reuse Nor Cal Chapter Meeting

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Feb. 21, 2020
PFAS
(Per and Polyfluoroalkyl Substances)

Carbon-Fluorine bond strength:
• Leads to oil and water repellency
• “Forever chemicals” -- last for geologic time!

 Courtesy: Dr. Jennifer Field
Common Uses

- Carpets
- Carpet cleaning products
- Food packaging
- Furnishings
- Cosmetics
- Outdoor gear
- Clothing
- Adhesives and sealants
- Protective coatings
- Non-stick cookware
- Car seats
- Firefighting foam
3M Employee Bulletin
Date: 05/16/2000

3M Phasing Out Some of its Specialty Materials

3M will phase out of the perfluoroctanyl chemistry in certain repellents and surfactant products by the end of this year. We thank the people in these business units for their hard work. They have consistently given the company and our customers their best efforts. For more information, below is a news release issued this morning:

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ST. PAUL, Minn -- May 16, 2000 -- 3M today announced it is phasing out of the perfluoroctanyl chemistry used to produce certain repellents and surfactant products.

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Ohio River Valley: West Virginia Manufacturing Plant

- PFOA used to manufacture Teflon
- Releases to water & air
- 70,000+ residents with contaminated drinking water
- C8 Health Study
Movie: Dark Waters

• The story of attorney Rob Bilott, who uncovered massive PFOA contamination from a DuPont factory in WV
Scientific publications on PFAS

Grandjean, Environ. Health. 2018
Perfluoroochemical Surfactants in the Environment

These bioaccumulative compounds occur globally, warranting further study.

Giesy & Kannan, Environ. Sci. & Technol. 2002
UCMR3 Data

Hydrological units with detectable PFASs

EPA Lifetime Health Advisory Level of 70 ng/L PFOA + PFOS
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
Drinking Water Health Guidelines (ng/L)

- DuPont PFOA: 5000
- DuPont PFOA: 1000
- U.S. EPA PFOA: 400
- U.S. EPA PFOA: 70
- New Jersey PFOA: 14
- New York PFOA: 10

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PFAS

4730 in commerce (OECD, 2018)

240 in fire-fighting foam and contaminated ground water

29 measured by EPA Method 533 and 537.1

6 included in UCMR3

2 with federal Health Advisories
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
PFAS Fate

Industrial or residential source → WWTP → Effluent → Surface water → Drinking water

- Biosolids
- Ground water
- DWTP

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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 & 10th, 2018
PFAS are Problematic & Difficult to Clean Up

Prevention is preferable!

Only use when necessary
Congressional PFAS Task Force

• Launched 1/24/19

• Goals
  • Educate
  • Elevate
  • Legislate
  • Appropriate

• Accomplishments
  • CDC Health Studies
  • USGS monitoring
  • Stop DoD and FAA use of PFAS firefighting foam
Reducing PFAS in food packaging

- 2017 - GSP research & workshops
- 2018 - WA state ban
- 2019 - City of SF ban
- NGO pressure


- Retailer decisions to remove PFAS
Carpet industry phasing out PFAS

- GSP workshops
- Demand from large purchasers
- Potential CA regulation
- Potential liability
- Major manufacturers decide to stop using PFAS
BRANDS ARE ELIMINATING HIGHLY FLUORINATED CHEMICALS

IKEA  H&M  Crate&Barrel  LEVI STRAUSS & CO.

PUMA  benetton  ESPRIT  adidas

MARKS & SPENCER  MANGO  BURBERRY  ZARA
Moving away from PFAS
Thank you!

To learn more:
Sign up for our newsletter
tom@GreenSciencePolicy.org
Sources of PFAS Emissions

• Industrial
  • Plants that produce PFAS
  • Plants that use PFAS: metal finishing, paper mills, etc.

• Firefighting foam
  • Military bases, airports, etc.

• Landfills

• Consumer products* – carpets, apparel, food packaging, cosmetics, other
Conventional treatment trains not effective

- Perfluoroalkyl acids (PFOA, PFOS, etc.) resistant to biodegradation
- Aerobic treatment oxidizes precursor compounds, generating more perfluoroalkyl acids
- Effluent > Influent


![Diagram of fluorotelomer phosphate esters and perfluorocarboxylic acids](image-url)
From WWTPs to the Environment: Biosolids

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

- 2013 study: 10 out of 13 PFAS analyzed consistently detected in US municipal biosolids samples

- Potential for accumulation in agricultural soils & uptake to food crops

Venkatesan & Halden, J. Haz. Mat. 2013
High input = high output. Industrial sources & firefighting foam 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
Maine

• Paper mill sludge 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)

[Link: theintercept.com/2019/06/07/pfas-chemicals-maine-sludge/]
U.S. EPA

• May 2018: PFAS Summit
• Feb. 2019: PFAS Action Plan
  • Drinking water
  • Cleanup
  • Toxics
  • Monitoring
  • Research
  • Enforcement
  • Risk Communication
Drinking water: US states

Adopted or proposed standards & guidelines

- MN  •  NC
- MI  •  NH
- NJ  •  NY
- VT  •  PA
- CA  •  WA

www.saferstates.com/toxic-chemicals/pfas/

PF = perfluorinated
FT = fluorotelomer

**Polymer**
- Fluoropolymers
  - Perfluorocarbons
  - PF acids
  - Perfluorocarbons
  - PF sulfonamides
  - PF sulfonyl fluorides
  - PF carboxlic acids
  - PF sulfonic acids
  - PF sulfinic acids
  - PF phosphic acids
  - PF phosphonic acids
- Side-chain fluorinated polymers
- Nonpolymers
  - PF carboxlic acids
  - PF sulfonic acids
  - PF sulfinic acids
  - PF phosphic acids
  - PF phosphonic acids
- Perf. polyethers
  - N-alkyl PF sulfonamides
  - (N-alkyl) PF sulfonamidoethanols
  - N-alkyl PF sulfonamidoethyl (meth)acrylates
  - (N-alkyl) PF sulfonamidoacetic acids
  - n:2 FT iodides
  - n:2 FT olefins
  - n:2 FT alcohols
- Polyfluoroalkyl substances
  - n:2 Polyl phosphonic acid esters and phosphates, FT phosphates
  - n:2 Polyl phosphonic acid esters and phosphates, FT phosphates
  - FT phosphates
  - n:2 Poly unsaturated (unsaturated) carb. acids
  - n:2 Poly unsaturated (unsaturated) carb. acids
  - n:2 FT sulfonyl fluorides
  - n:2 FT sulfonyl fluorides
  - n:2 FT alcohols
  - n:2 FT alcohols
  - n:2 FT iodides
  - n:2 FT iodides
  - n:2 FT iodides
Polyfluorinated compounds (PFAA-precursors)
- Typically used in products

Perfluoroalkyl acids (PFAAs)
- Typically measured in water

Manufacture

Degradation

Natural processes or engineered treatment

PF = perfluorinated
FT = fluorotelomer

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