The Fate, Transportation, & Transformation of PFAS and Implications for WWTPs: A Case Where 1 + 1 Does Not Equal 2
And now it is even BAD to say or type PFC
PFAS Background – Why Do We Care
PFAS in the News
Quick Chemistry Lesson #1

- Remember: PFAS are **Per** and **Poly**fluoroalkyl substances

- **Per-fluoroalkyl substances**: fully fluorinated alkyl tail
  
  - **Perfluoroalkane carboxylates** (or carboxylic acids): **PFCAs**
    
    - (PFOA)
    
    - **Perfluoroalkane sulfonates** (or sulfonic acids): **PFSAs**
      
      - (PFOS)

  - **PFAAs**
    
    - **COOH = Head**
    
    - **Alkyl tail, fully fluorinated**
    
    - **SO₃H = Head**

- NJDEP MCLs or Proposed MCL
  
  - 13 ppt (PFOA)
  
  - 14 ppt (PFOS)
Quick Chemistry Lesson #2

- **Remember**: PFAS are **Per** and **Polyfluoroalkyl substances**

- **Poly-fluoroalkyl substances**: **non-fluorine atom** (typically hydrogen or oxygen) attached to at least one carbon atom in the alkane chain

Fluorotelomer Alcohol (8:2 FTOH)

Polyfluoroalkyl substances may also be degraded to perfluoroalkyl substances (e.g., PFOS or PFOA): **PRECURSORS**
Transformation of Poly-Fluoroalkyl Substances to PFOA

Currently not a Human Health or Environmental Concern

Potential Carcinogen and other Potential Health Effects
Exposure in Humans

- Majority of US population exposed to PFAS
- Half-life = 2 - 10 years (humans)
- Prevalent in blood and urine samples – baseline exists
- Can cross placental barrier – exposure to developing fetus
- C8 Health project, 70,000 residents with drinking water exposure linked to serum-PFOA concentrations and variety of health outcomes
Transformation of PFAS (Lab)
Transformation of Poly-Fluoroalkyl Substances to PFOA

Currently not a Human Health or Environmental Concern

Potential Carcinogen and other Potential Health Effects
TRC Research - Observed Transformation of 6:2 FTS to PFHpA

Transient Intermediate?

- 0.26 nmoles
- 0.32 nmoles

Date: 3/6/2017 to 11/11/2017
TRC Research - Transformation of Telomers

8:2 FTS Transformation to PFOA

6:2 FTS Transformation to PFHpA
Transformation of PFAS Across WWTPs
NJ Projected/Potential Surface Water Discharge PFAS Concentrations

• PFOA 13 ng/l (ppt)
• PFNA 13 ng/l (ppt)
• PFOS 14 ng/l (ppt)
Michigan WWTP PFAS Discharge Concentrations Limits to POTWs

- PFOS  11 ng/l (ppt)
- PFOA  400 ng/l (ppt)
Figure 5. Aerobic biotransformation pathways for 8:2 fluorotelomer alcohol (8:2 FTOH). Adapted from Wang et al. (2009).
PFAS Mass of WWTP Effluent > Influent
PFAS Accumulation in Biosolids

380 mg/day into the system

PFAS Impacted Biosolids Currently a Major Issue in Michigan

5,250 mg/day Leaving the Facility
Potential Sources to POTWs
Potential PFAS Sources to POTW\text{s}

- Metal (Mainly Chromium) Plating Facilities
- Electronic Manufacturing
- Paper Mills and Process Facilities
- PFAS Manufacturing Plants
- Landfill Leachate
- Textile / Carpet Manufacturing
- Septic Tank Services
- Car Wash Waste Waters
Source Identification and Fingerprinting
Industrial Waste Water vs Car Wash Source

**PFAS Mix Discharged in Treated Industrial Waste Water**
- Total PFAS 6,315 ppt
  - PFOS 4000 ppt
  - PFOA 170 ppt

**Car Wash Waste Water Discharge**
- Total PFAS 8,800 ppt
  - PFOS 19 ppt
  - PFOA 33 ppt
  - Total 52 ppt (2nd round 110 ppt)