Wisconsin Government Affairs Seminar

Examining PFAS Phase Behavior and Transformation in WWTPs: Potential Mitigation Strategies

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WRF5031
WRF5212

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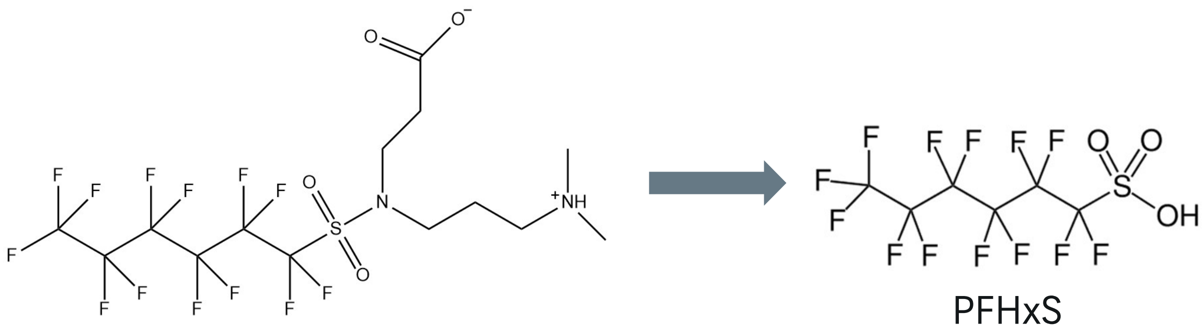
Objectives

- Highlight importance of precursors in WWTPs



- PFAS accumulation in solids dewatering streams

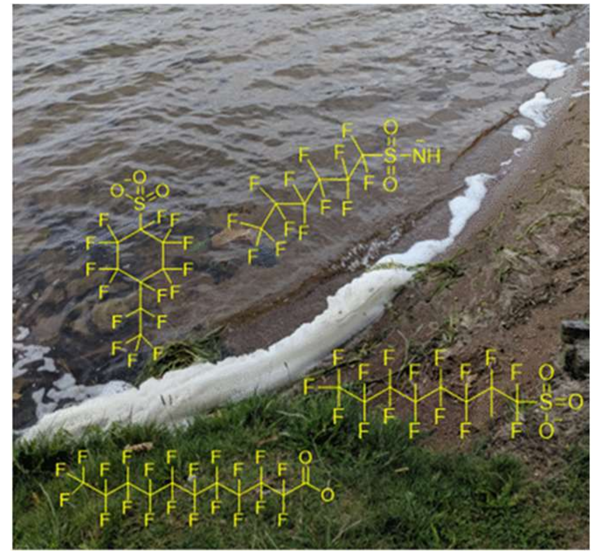
- Understand impacts of aeration on PFAS fate in WWTPs
  - *PFAS accumulation in foams*
  - *PFAS in aerosols*

Background

- PFAS present in nearly all domestic WWTPs

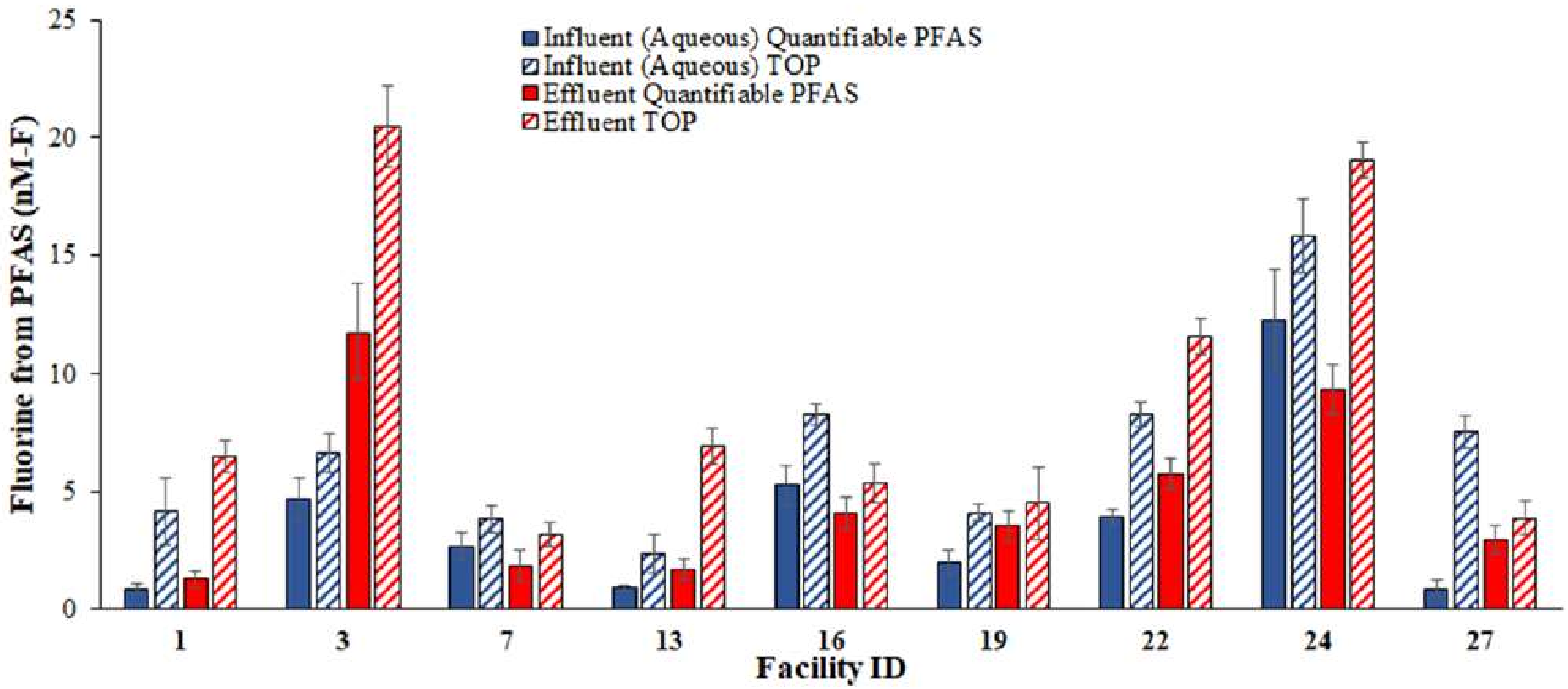
- Typical WWTP processes generally do little to remove PFAS

- Processes that concentrate/transform PFAS may be important
  - *PFAS accumulation in foam*
  - *PFAS accumulation in biosolids*
  - *PFAS precursor transformation during digestion*



Schwichtenberg et al., ES&T, 2020

Precursors are Prevalent in WWTP Aqueous Flows

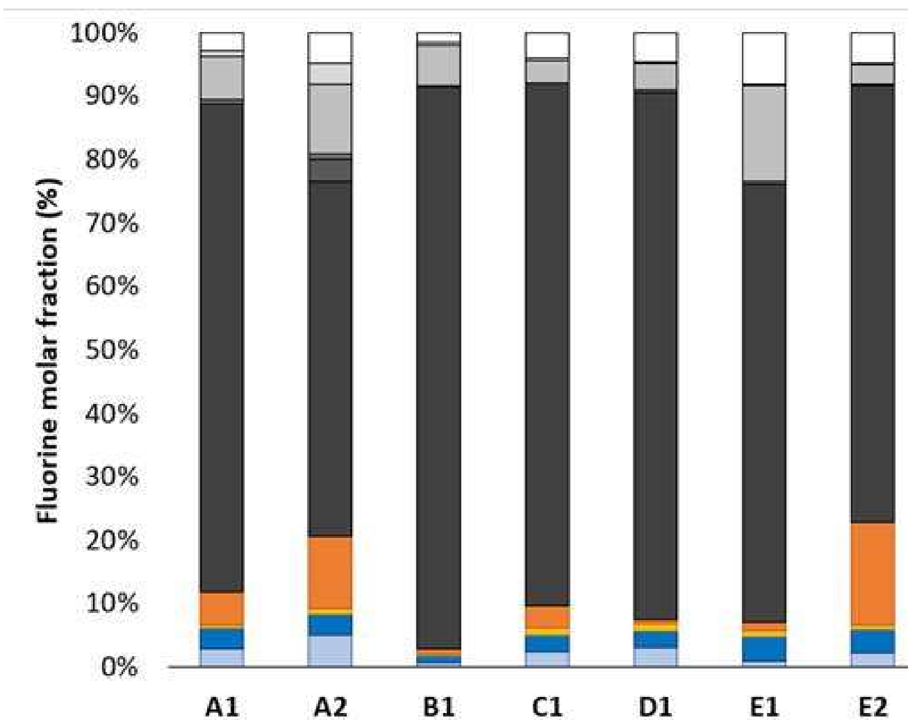


- ~66% of PFAS semi-quantified precursors in influent
- ~51% of PFAS semi-quantified precursors in effluent

Precursors in Finished Biosolids

- Biosolids from 7 WWTPs
- Various processing and final solids forms

PFAS analysis: Linda Lee - Purdue



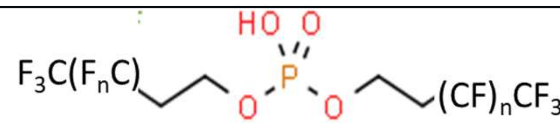
Schaefer et al., *Water Research*, 2022

Sulfonates: >6 PFSA, 4-6 PFSA

Carboxylates: >6 PFCA, 4-6 PFCA

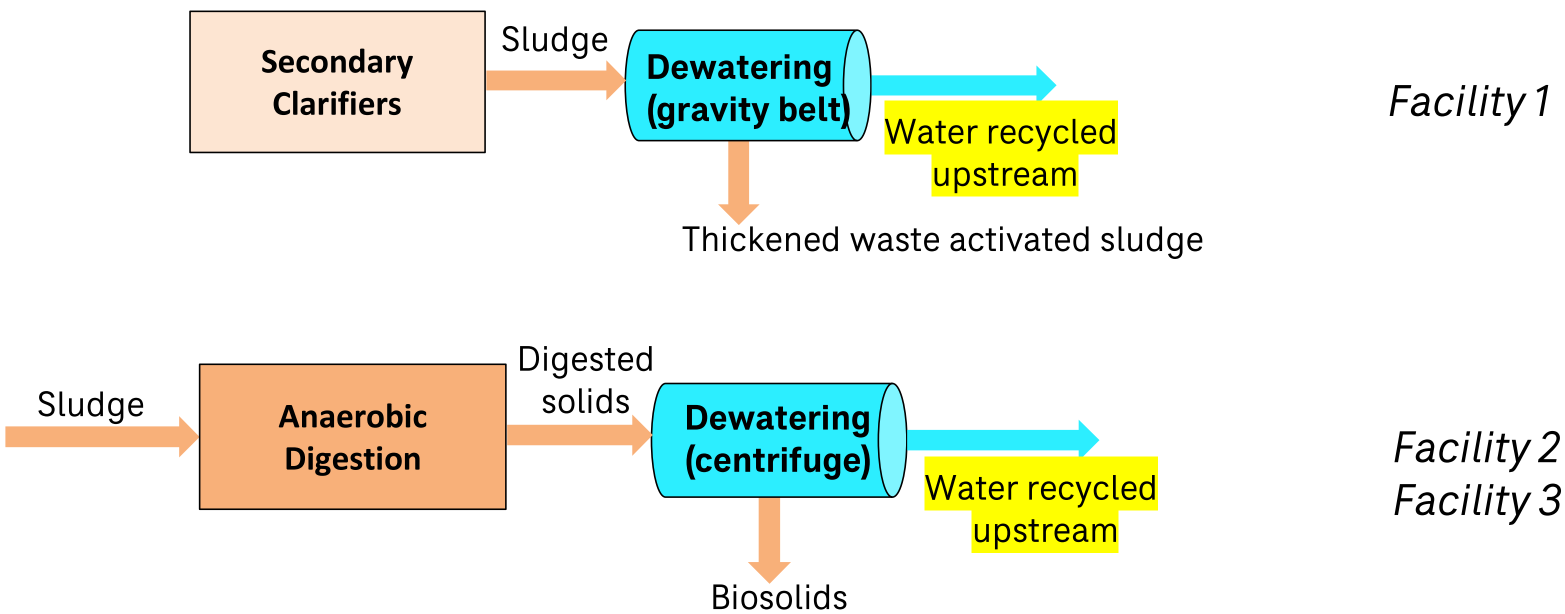
Precursors

- Perfluorooctanesulfonamidoacetic acids
- Fluorinated telomer sulfonates
- Fluorinated telomer acids
- Perfluorinated ether acid
- Suspect-Sodium perfluoroalkyl phosphinates
- Suspect-Fluorinated telomer acids
- Suspect-Di-substituted polyfluorinated phosphate esters (DiPAPs)



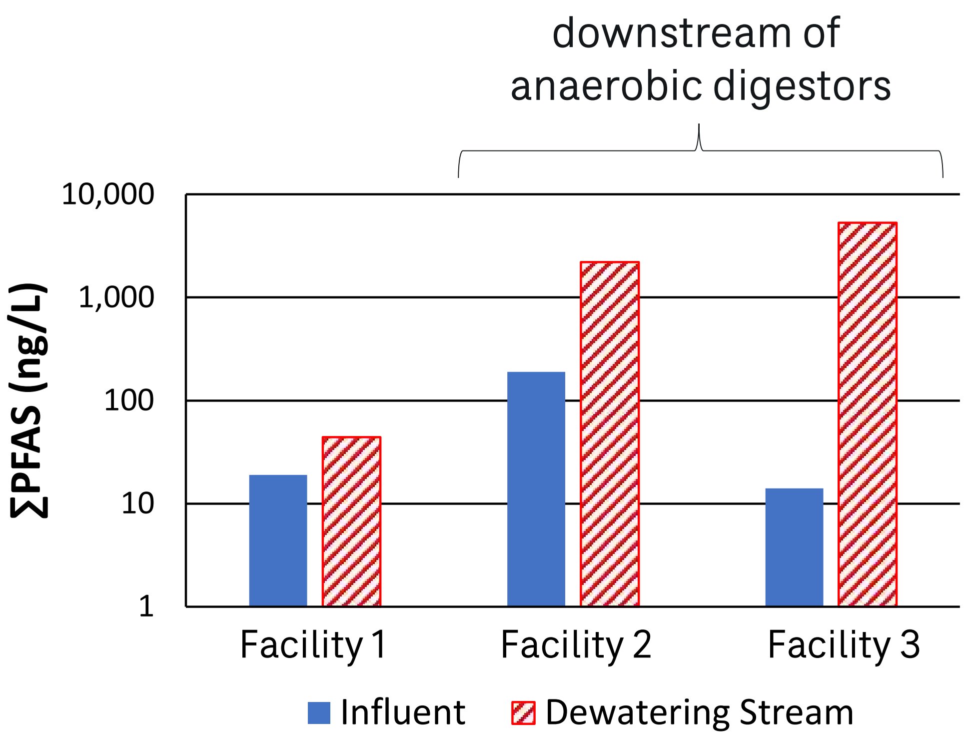
PFAS Enrichment in Solids Dewatering Streams

3 WWTPs sampled:

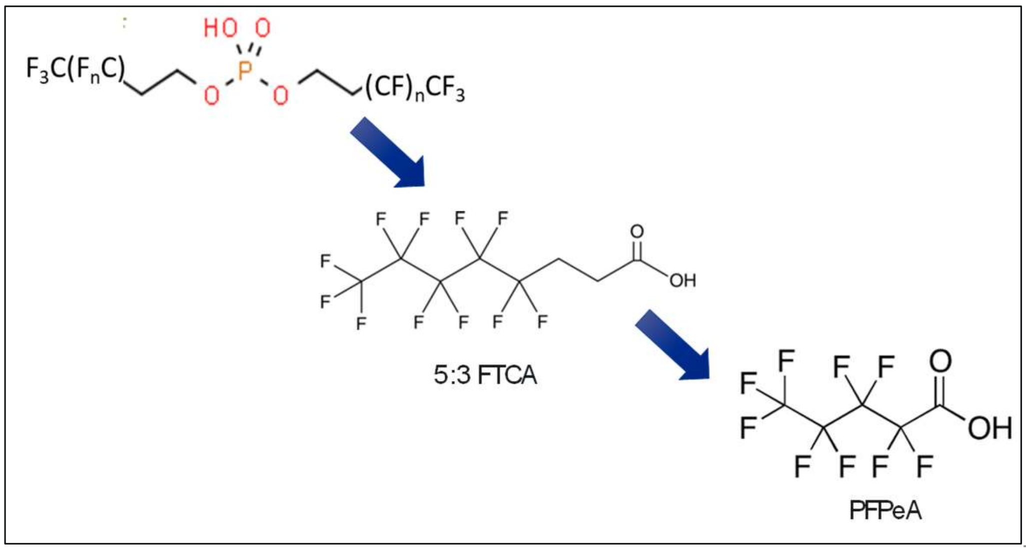


Compare PFAS concentrations and mass flows in recycled dewater stream to WWTP influents

PFAS Enrichment in Solids Dewatering Streams



- For facilities 2 and 3, PFAS in dewatering streams primarily FTCAs *(diPAP transformation product)*
- *diPAPs in facility 3 biosolids 5-times greater than in facility 2*

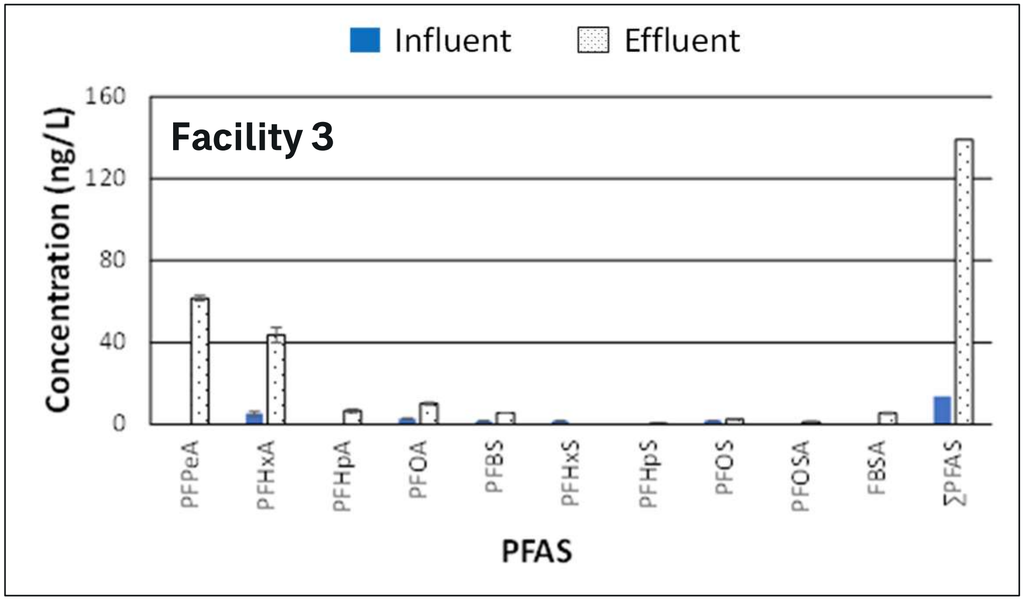


Dewatering Contribution: PFAS Mass Flows [g/day]
(Target Analytes Only)

Facility 1: 0.1% of influent PFAS mass flow

Facility 2: 4.4% of influent PFAS mass flow

Facility 3: 290% of influent PFAS mass flow



from Schaefer et al., *AWWA Water Science*, 2023

WWTP Aeration Basins: Foam Formation & PFAS

At 2 WWTPs:

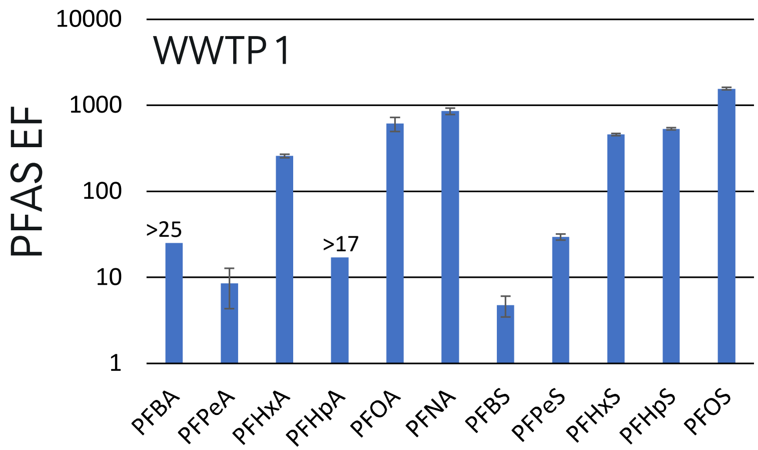
- Collect wastewater entering aeration basin and analyze for PFAS
- Collect foam, then analyze the re-collapsed foam for PFAS
- Calculate PFAS enrichment factors

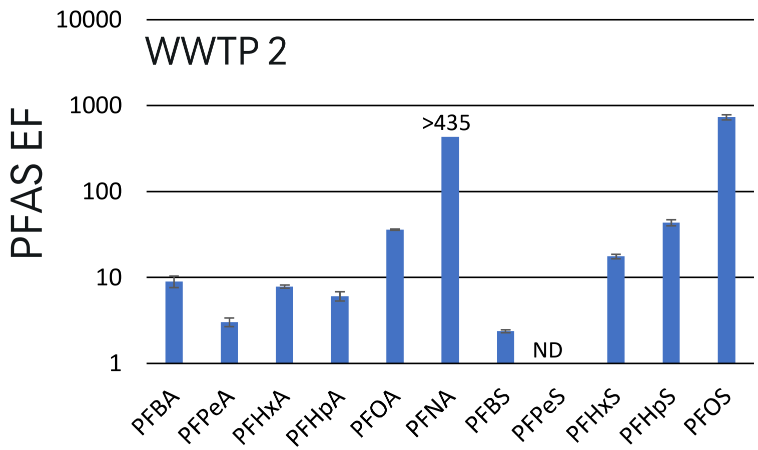
$$EF = \frac{C_f}{C_w}$$

AWWA WATER SCIENCE
Theory and Practice of Safe, Sustainable Water

"PFAS in Foam and Dewatering Streams at Wastewater Treatment Plants"
C.E. Schaefer, J.L. Hooper, L.E. Strom, K. Wu, J.L. Guelfo

WWTP Aeration Basins: Foam Formation & PFAS





- Substantial PFAS enrichment
  - *Up to 14,900 ng/L PFOS in foam*
  - *Up to 7,040 ng/L 5:3 FTCA in foam*
- EF increases with increasing perfluorinated chain length
- No significant decreases in PFAS upstream and downstream of aeration basins
  - *PFAAs in foams represent ~0.1% of PFAA mass*
  - *Should increased foaming be considered?*

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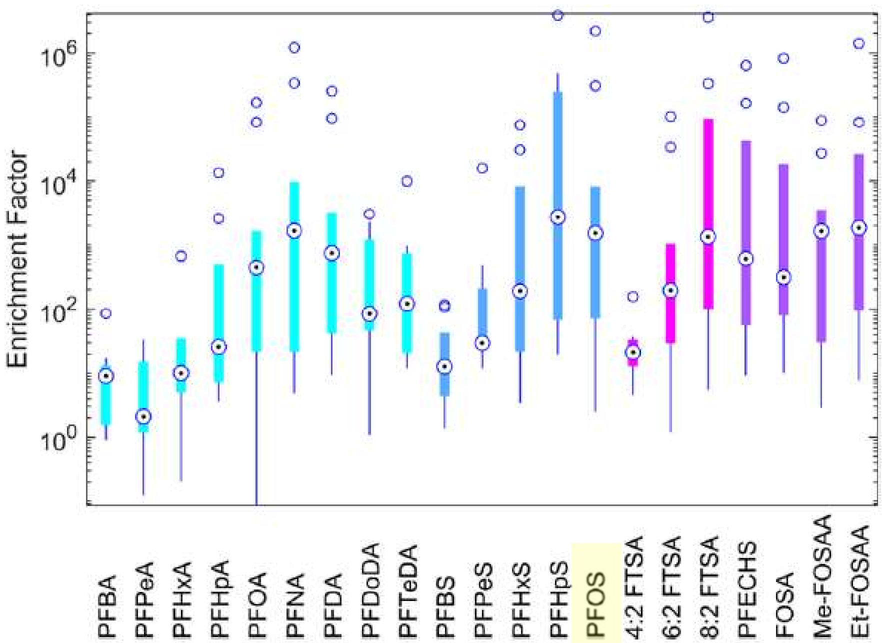
Article

Integrated Treatment of Per- and Polyfluoroalkyl Substances in Existing Wastewater Treatment Plants—Scoping the Potential of Foam Partitioning

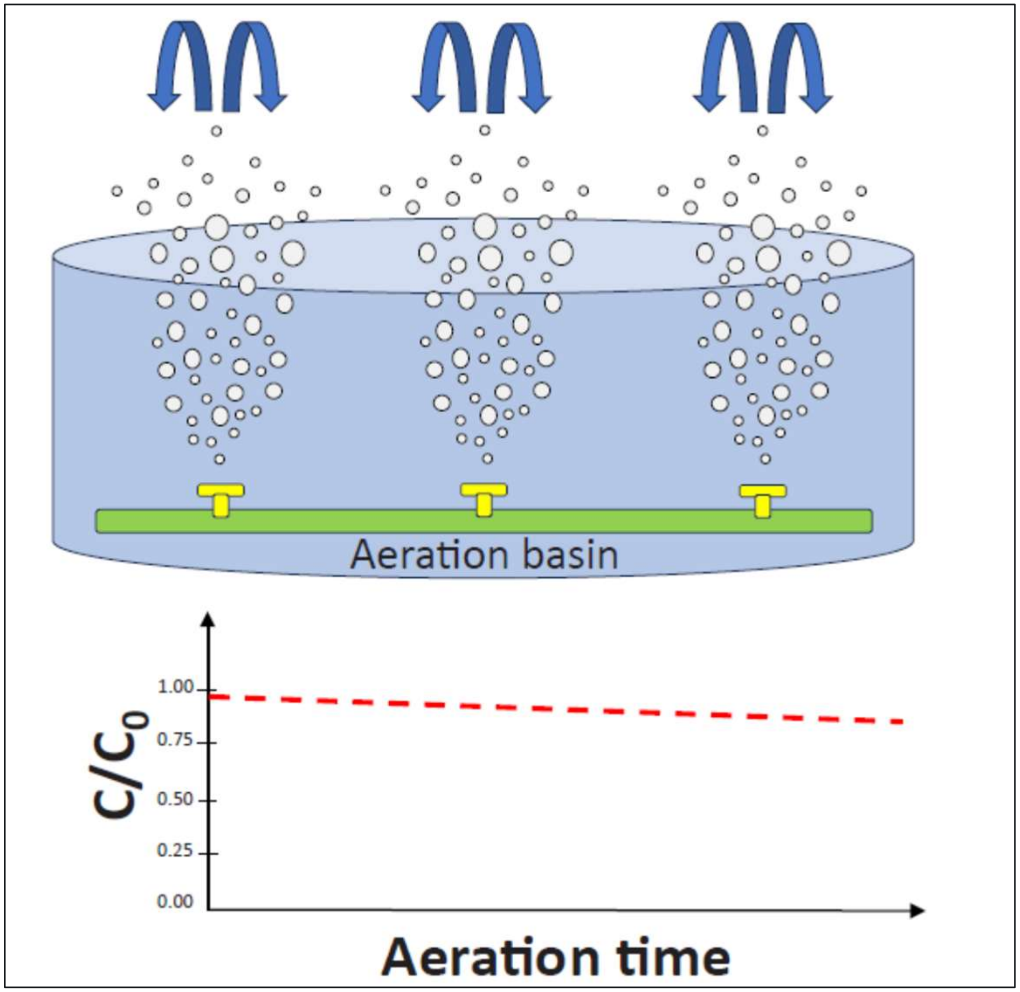
Sanne J. Smith,* Chantal Keane, Lutz Ahrens, and Karin Wiberg



- Recent study looking at 10 European and Australian WWTPs showed similar results

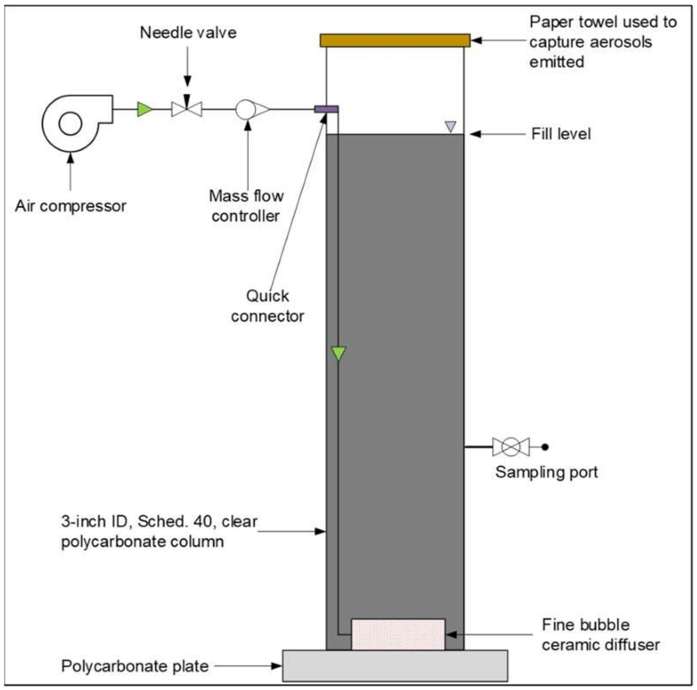
- Large EF range: much to still learn about conditions impacting impact EFs

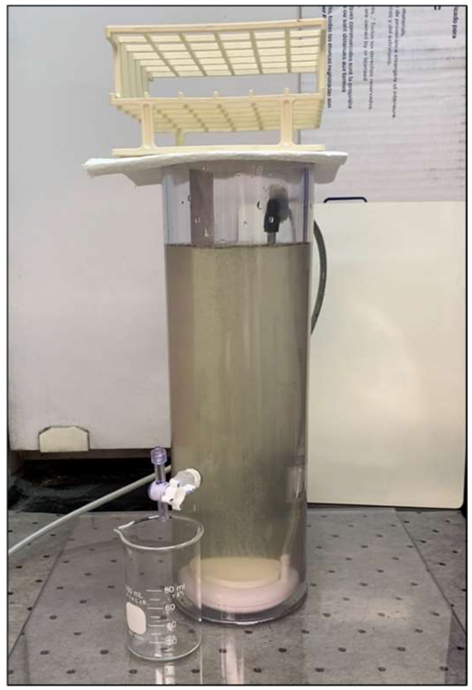
Potential Impact of Aerosols on PFAS in Aeration Basins



PFAS Removal via Aerosolization of Domestic Wastewater

Bench-Scale Testing





- PFAS-spiked wastewater to 1,000 ng/L each (PFAAs and 6:2 FTS)
- 20 to 60 mL/min flow
- 1-2 mm bubble size (fine bubble aeration)
- Scaled aeration rate and geometry
- Aerosol collection 2.5 to 10 cm above water surface
- PFAS sampled in bulk wastewater as a function of time
- Controls with no aerosol collection

PFAS Removal Via Aerosolization: Bench-Scale Results

Contents lists available at ScienceDirect

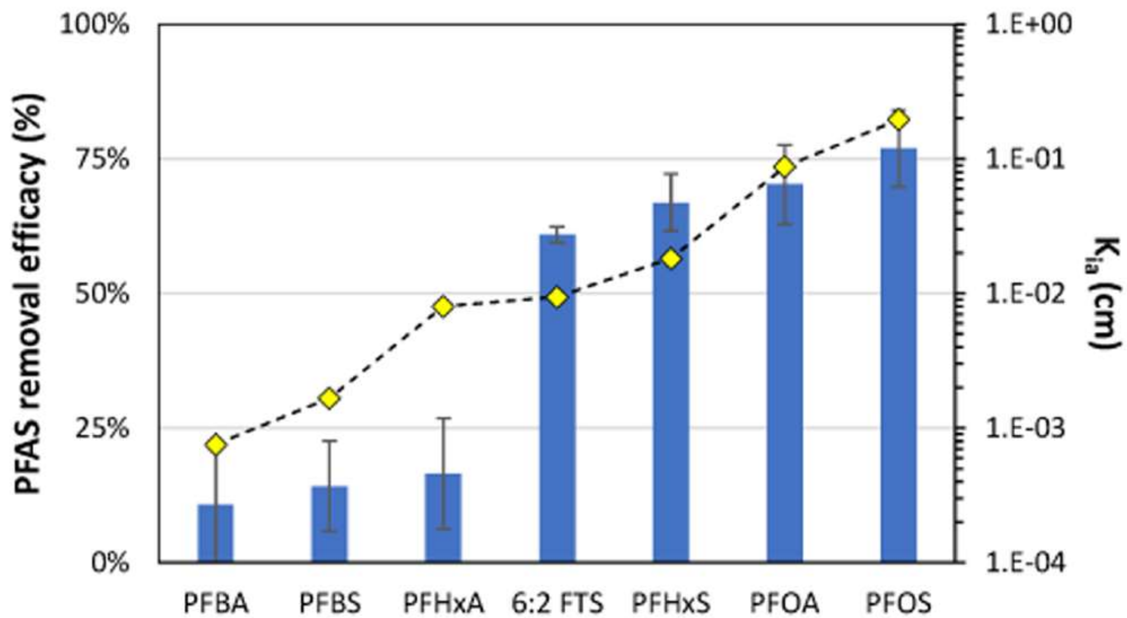
Journal of Hazardous Materials

journal homepage: www.elsevier.com/locate/jhazmat

Removal of per- and polyfluoroalkyl substances from wastewater via aerosol capture

Dung Nguyen[a,*], John Stults[a], Julie Devon[a], Eden Novak[a], Heather Lanza[b], Youn Choi[c], Linda Lee[c], Charles E. Schaefer[d]

- No PFAS removal in controls (no aerosol capture)
- PFAS removal decreases with increasing sorbent pad distance
- PFAS removal increases with increasing aeration rate
- Collected aerosol volume <1% of water volume
- Biotransformation of 6:2 FTS observed



Field Testing: PFAS Removal in Aeration Basin via Aerosol/Froth Capture (proof of concept)

Near surface (2-inch) skimmer

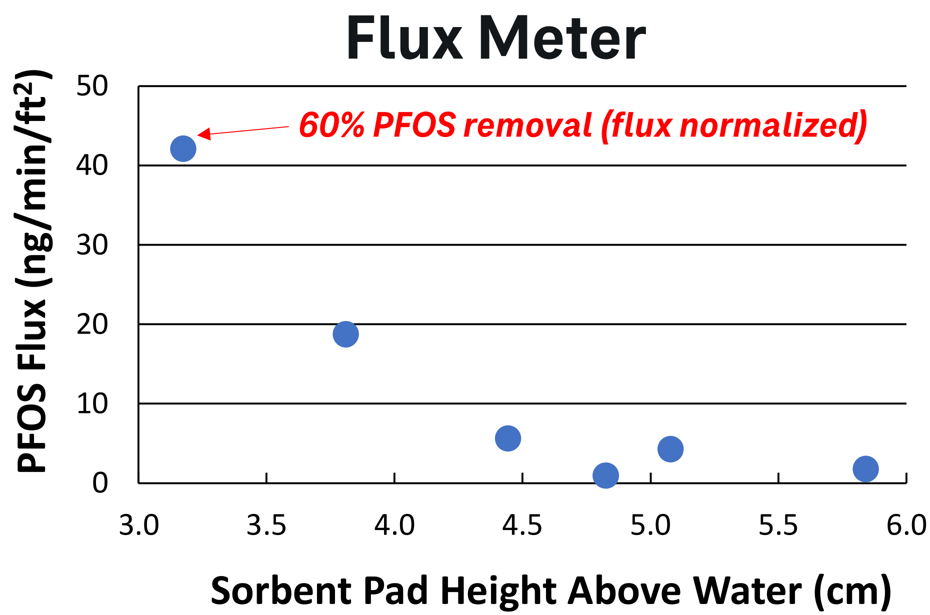
Garrett Screen

Flux Meter

Field Results (Preliminary): PFOS

Sample	PFOS (ng/L)	Enrichment Factor
Bulk wastewater	27	-
Skimmer	47	1.7
Garrett Screen	1,100	41
Stable Foam	27,000	1,000

Preliminary results suggest that near-surface capture of froth/aerosols in aeration basins could result in substantial removal of long-chained PFAS



Final Thoughts

- PFAS accumulation in foams, aerosols, and dewatering streams may serve as potential means to ultimately mitigate PFAS discharges from WWTPS
  - *ultimately, consider destructive technologies for these concentrated low-volume streams*

- Improved insight on PFAS fate, distribution, and transformation in WWTPs is needed

- Importance of total PFAS fluorine balance

Thank You!

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