Influence of Sludge Management on Per- and Polyfluoroalkyl Substances (PFAS) Within and After Treatment

Presenter: Sydney Adams

Additional Authors: Cassidy Yates, Jim Malley, and Paula Mouser

Department of Civil and Environmental Engineering, University of New Hampshire, Durham, New Hampshire 03824, United States

Contact: ska1024@wildcats.unh.edu

"Pandemic, PFAS and Plastics. . . oh my!" **NEWEA 2021 Virtual Annual Conference & Exhibit,**

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Wastewater treatment facilities act as important conduits for PFAS to the environment.

PFAS use in industry, household, or commercial setting

PFAS concentrated in wastewater treatment facilities

Influent is treated to reduced solids and nutrient load

Solids are removed, dried, and/or stabilized

Increasing their concentration in accepting water bodies

Sludges are disposed of in landfills and treated biosolids are land applied

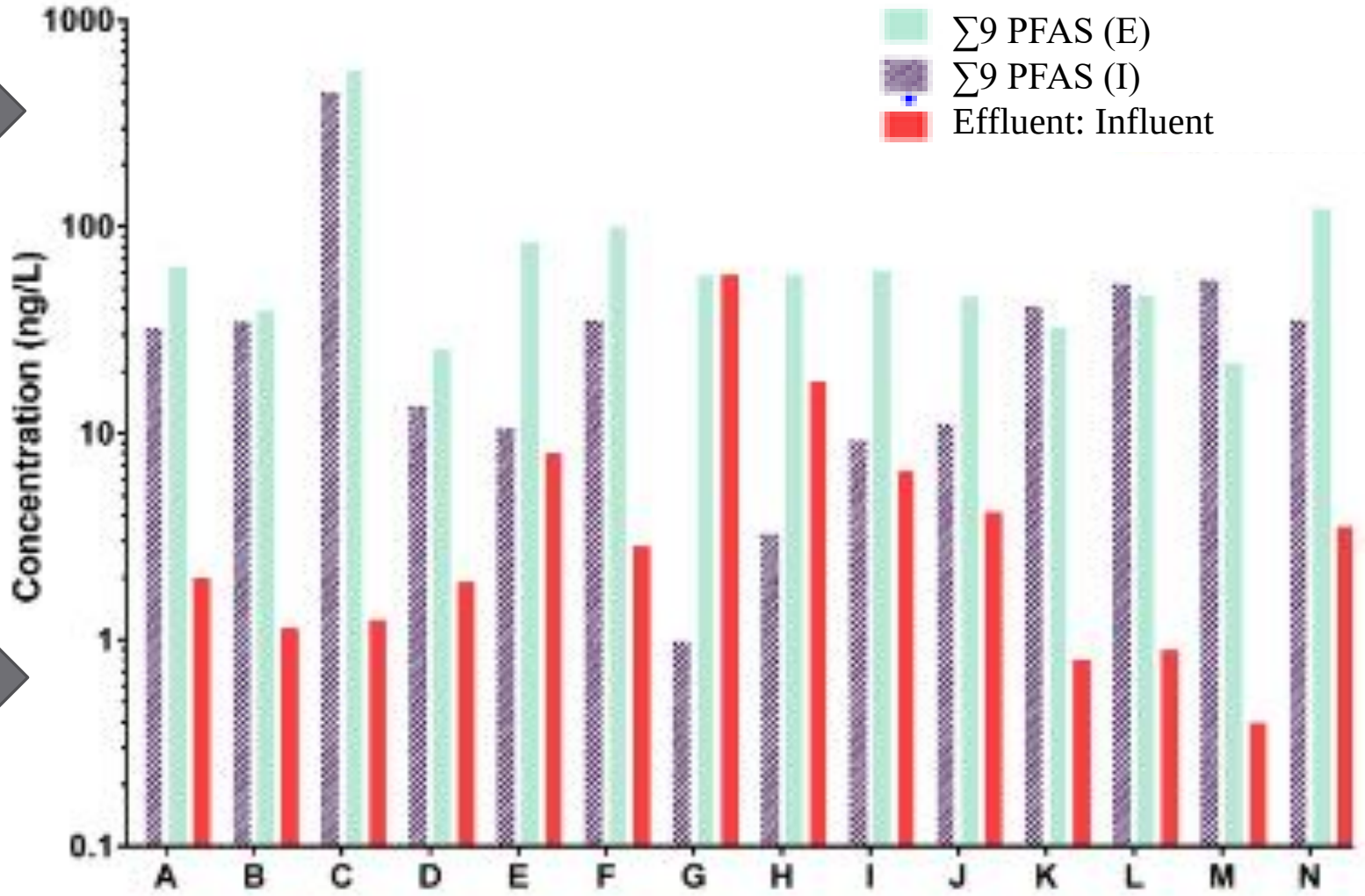
Bioconcentrations & adverse health affects

Wastewater treatment facilities are not optimized to remove CECs, rather large solids, nutrients, and pathogens.

Effluent: Influent Ratios consistently = or > 1

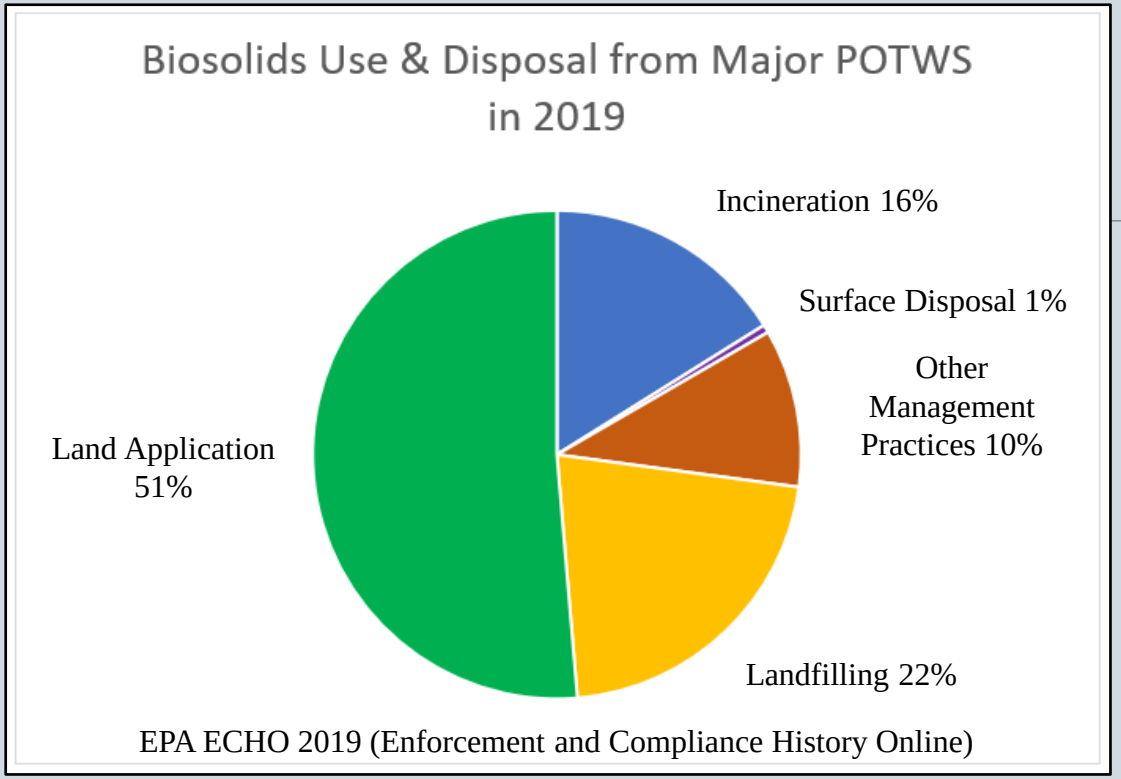
PFAS concentrations increase due to oxidation of unmeasurable precursor PFAS

Only 3/14 WWTFs had decreasing concentrations of PFAS



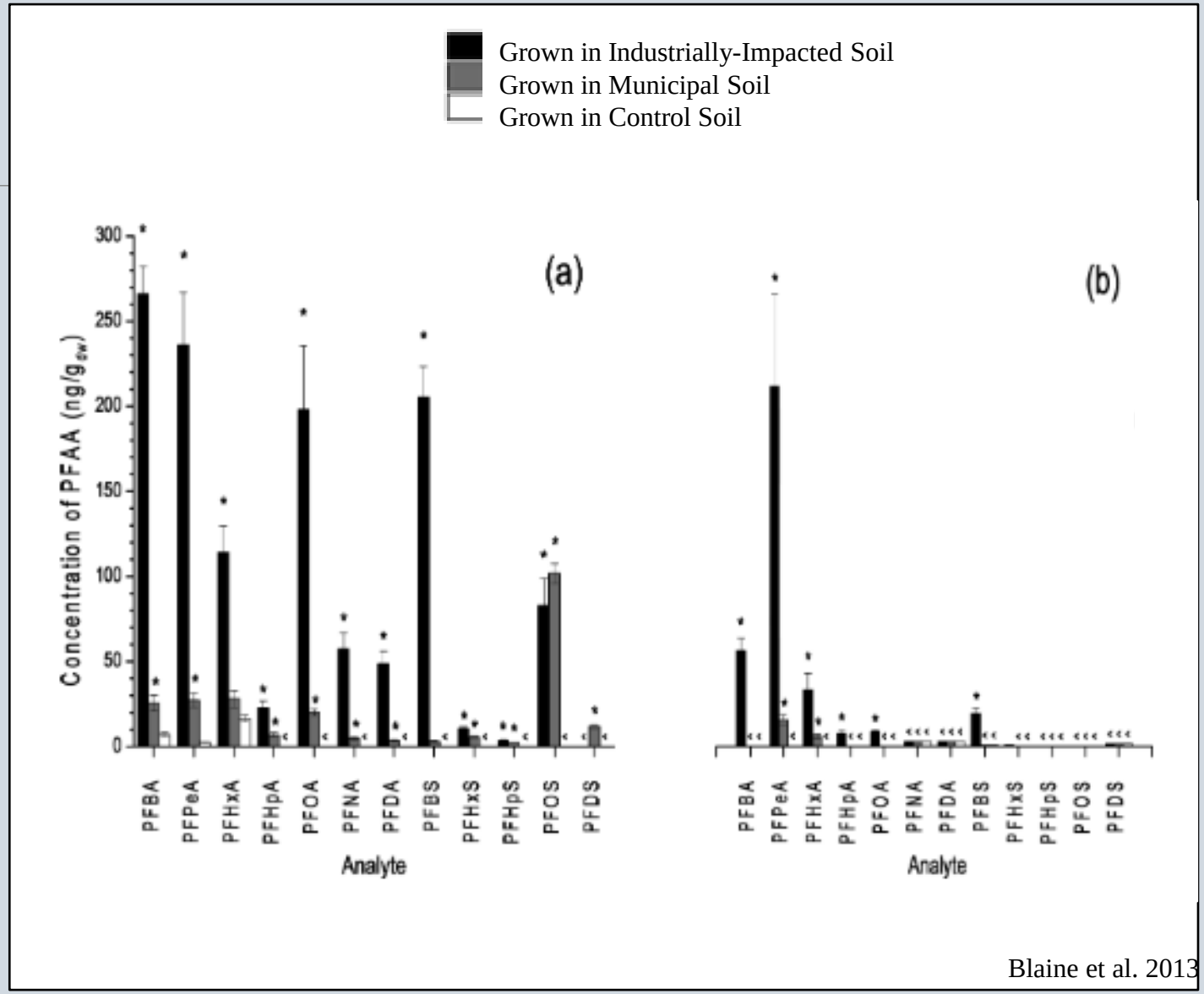
Gallen et al. 2018

One possible route to the environment for PFAS in WWTF is through the land application via biosolids.



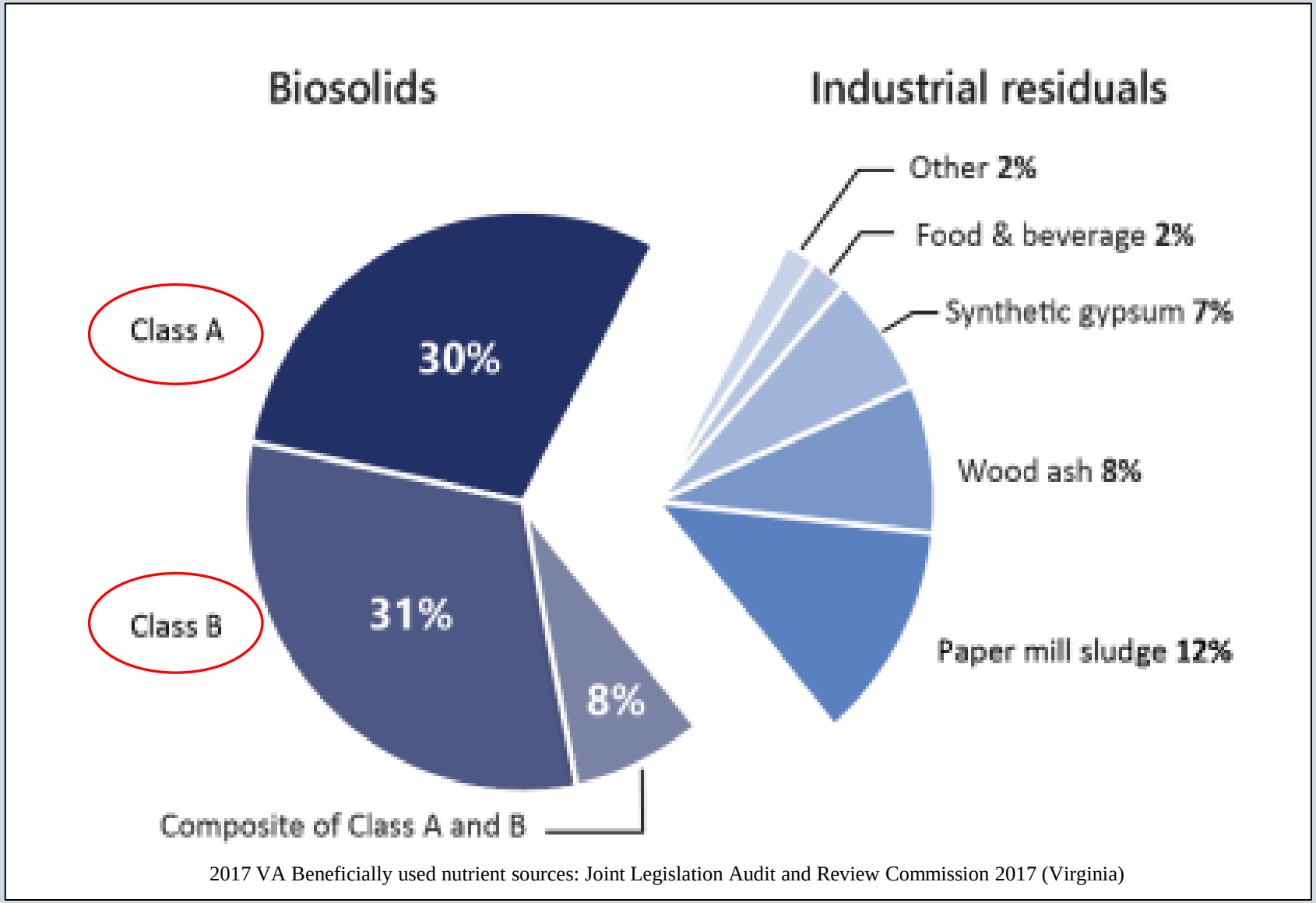
EPA ECHO 2019 (Enforcement and Compliance History Online)

Land application is more economical and environmentally optimal



Blaine et al. 2013

It remains unclear how biosolids stabilization influences PFAS composition and concentration.



2017 VA Beneficially used nutrient sources: Joint Legislation Audit and Review Commission 2017 (Virginia)

It remains unclear how biosolids stabilization influences PFAS composition and concentration.

Stabilization Treatment		Class A Requirements	Class B Requirements	Changes in Environmental Parameters	Past Trends in PFAS Distribution
Lime Stabilization		Increase in temperature and time (pH > 12 and 25°C for 72 hours)[2]	Holding the high pH to at least 12 for at least 2 hours[2].	pH ↑ Ammonia Ions ↑ Solids Content ↑	No Information Available
Composting		At least 55°C for 3 days[2].	At least 40°C for 5 days and be as high as 55°C for a minimum of 4 hours within the 5 days[2].	pH ~ Organic Matter ↑ Temperature ↑ Aerobes ↑ Carbon Dioxide ↑	PFCAs ↑ Short Chain PFAA (municipal compost)[s]↑ [3]
Anaerobic Digestion		No Information Available	Class B biosolids are treated for a mean cell residence time of 15 days between 35°C-55°C and 60 days for 20°C [2].	pH – Organic Matter ↓ Temperature ~ Anaerobes ↑ Methane ↑ Carbon Dioxide ↑ Nitrogen ↑ Volatile Solids ↓	PFOS ↑ PFDS -- N-EtFOSAA – PFNA ↑ PFDA -- [5]
No PSRP or VAR		n/a	n/a	n/a	n/a

Research Goals and Questions for Analysis

Goals

Investigate trends in PFAS composition and concentration from WWTF media and from biosolid stabilization.

Questions

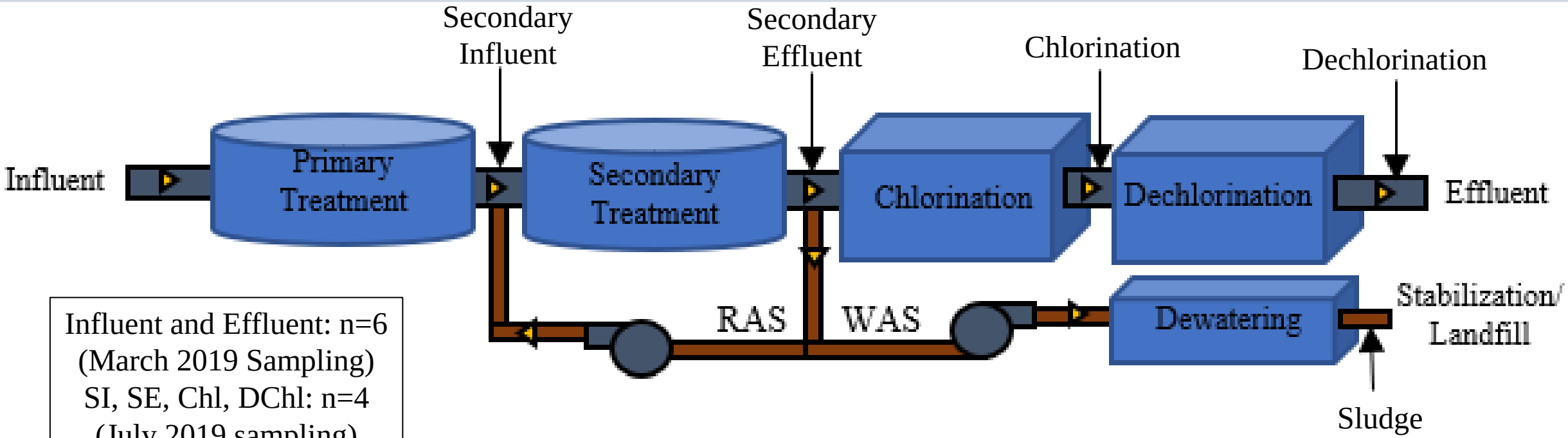
Within the Facility

- How does PFAS composition change through the treatment process?
- How does PFAS composition differ between aqueous to solid phase?
- Do WWTFs in NH and VT have similar PFAS signatures?

During biosolid stabilization

- Do stabilization processes alter the composition or concentration?
- How do concentrations in NH and VT biosolids compare to Maine Department of Environmental Protection screening levels?

Sampling Locations within WWTFs



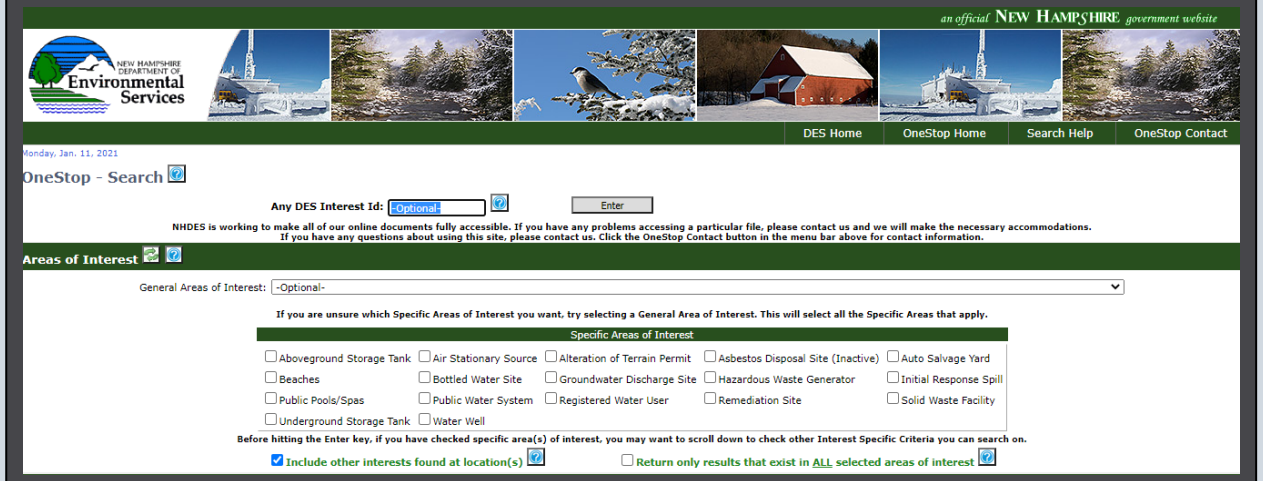
Influent and Effluent: n=6
(March 2019 Sampling)
SI, SE, Chl, DChl: n=4
(July 2019 sampling)

Samples were taken at each of the black arrows from four WWTFs in the Seacoast NH region.

Data collected converted to molar mass to determine percent total abundance of PFAS congeners.

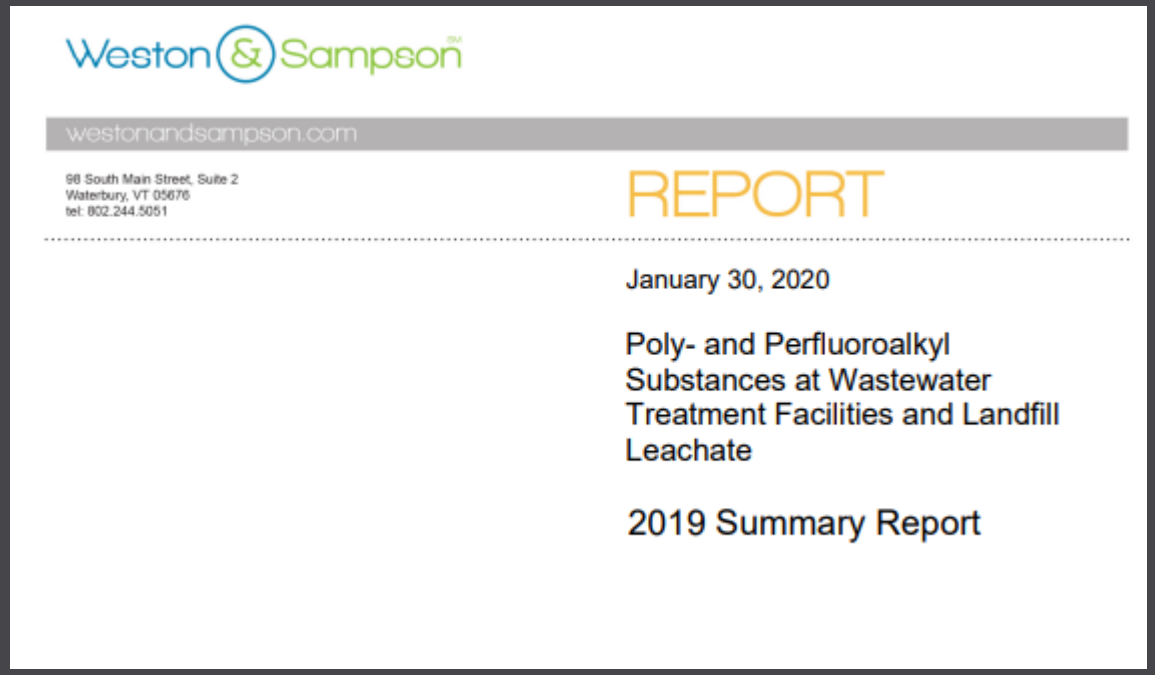
Obtaining New England Data

Data from New Hampshire Department of Environmental Services:



NHDES One Stop Database

Data from Vermont Department of Environmental Conservation:



VTDEC Available Investigation Reports

More PFAS species were detected in sludge samples over that of effluent samples.

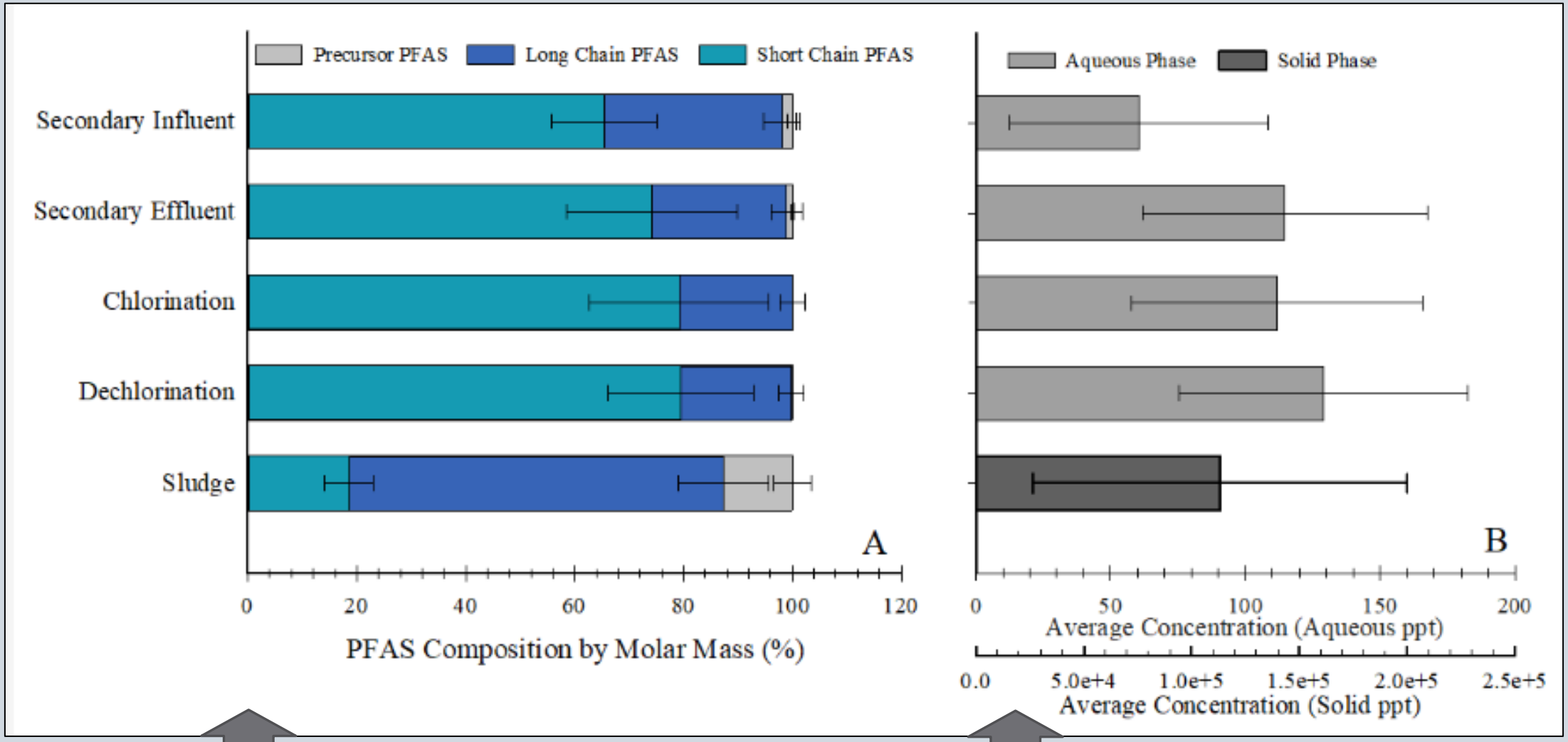
Not Detected Detected A

Group	Compound	WWTF 1		WWTF 2		WWTF 3		WWTF 4	
		Effluent	Sludge	Effluent	Sludge	Effluent	Sludge	Effluent	Sludge
Short Chain PFCA	PFBA	■	■	■		■		■	
	PFHxA	■	■	■	■	■	■	■	■
	PFPeA	■	■	■	■	■	■	■	■
Long Chain PFCA	PFHpA	■	■	■		■		■	■
	PFDA	■	■	■	■	■	■	■	■
	PFDoA		■				■		■
	PFNA	■	■	■		■		■	■
	PFOA	■	■	■	■	■	■	■	■
	PFTA		■				■		■
	PFTrDA								■
	PFUnA		■	■					■
Short Chain PFSA	PFBS	■	■	■		■		■	■
Long Chain PFSA	PFDS		■						■
	PFHpS							■	
	PFHxS	■	■	■		■		■	
	PFNS								
	PFOS	■	■	■	■	■	■	■	■
	PFPeS								
Fluorotelomers and Precursors	8:2FTS								
	4:2FTS								
	6:2FTS								
	NEtFOSAA		■		■		■		■
	NMeFOSAA	■	■			■	■		■
	FOSA		■				■		■

Of 24 PFAS species analyzed for, 18 were detected in at least one WWTF aqueous sample, while 19 were detected in at least one sludge sample

Several long chain and precursor compounds were detected in sludge that were not found in their respective influent, including FOSA, PFDoA, PFTA, and PFDS

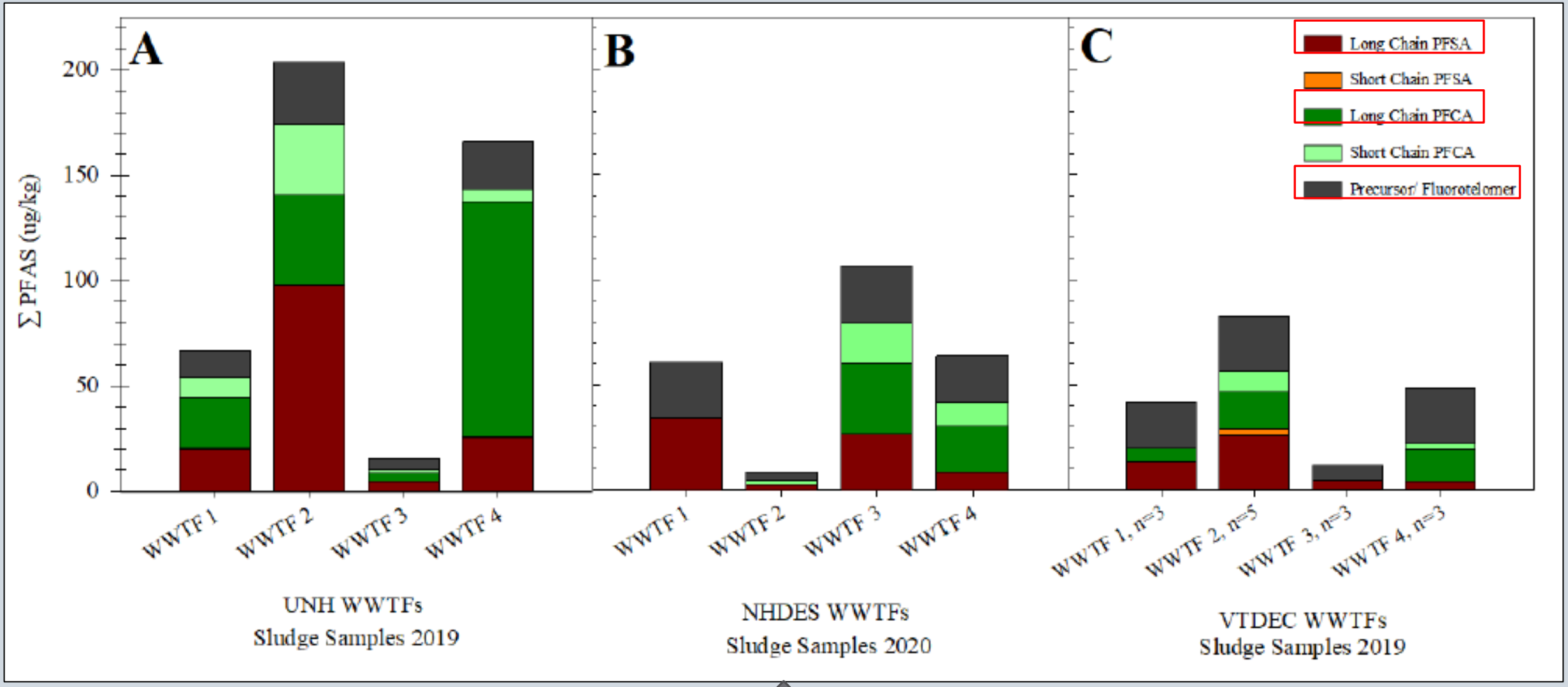
Chain length is the driving factor determining the fate of PFAS within WWTFs.



Short Chain compositions generally increase through the WWTF, from influent to dechlorination, in each facility.

Long chain PFAS are fractionating out of the aqueous solution and dominating sludge compositions.

Sludges across New England are primarily dominated by long chain PFSAs and PFCAs.

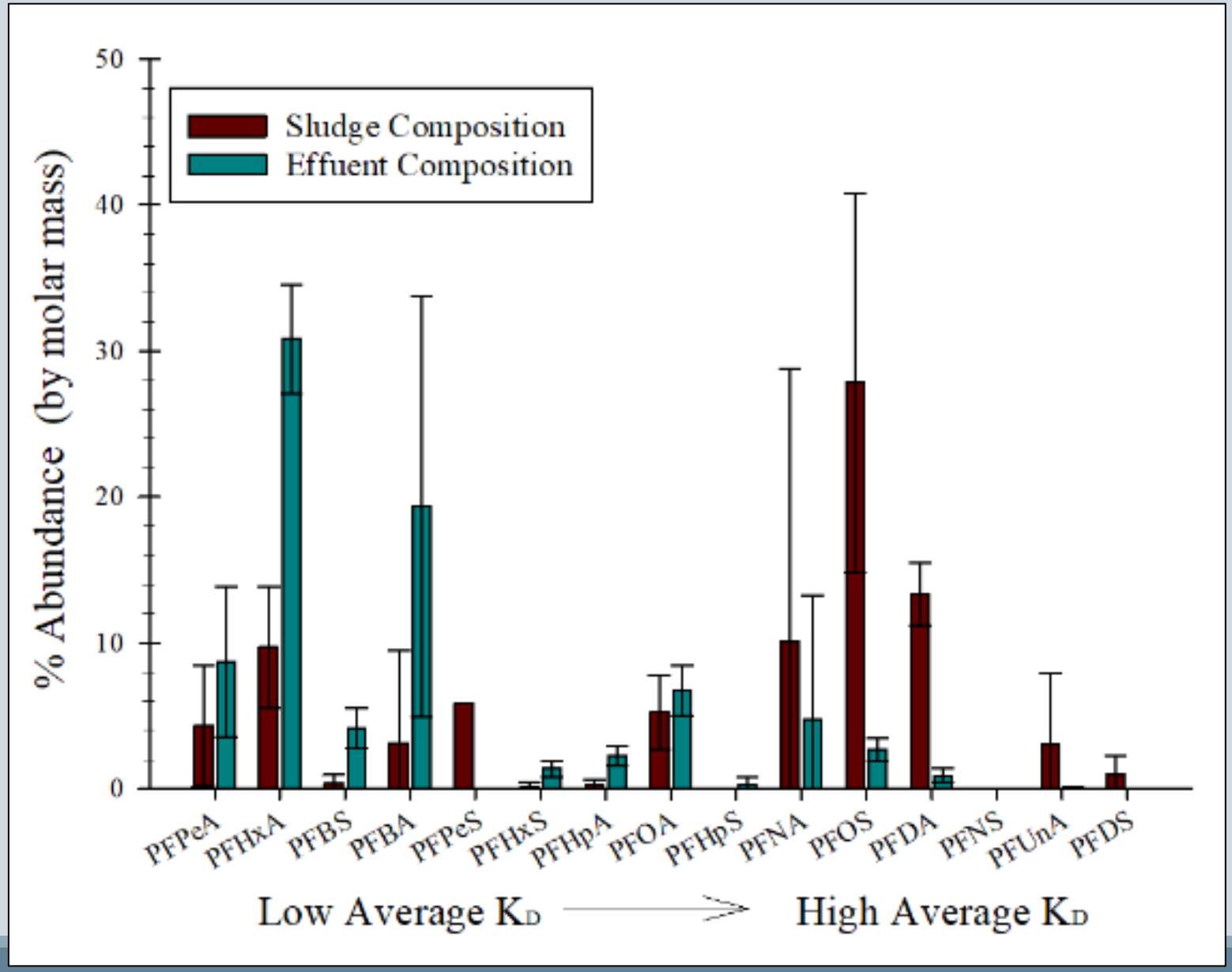


Chain length and functional group changes mobility and toxicity of the compound strongly influencing its fate in the environment.

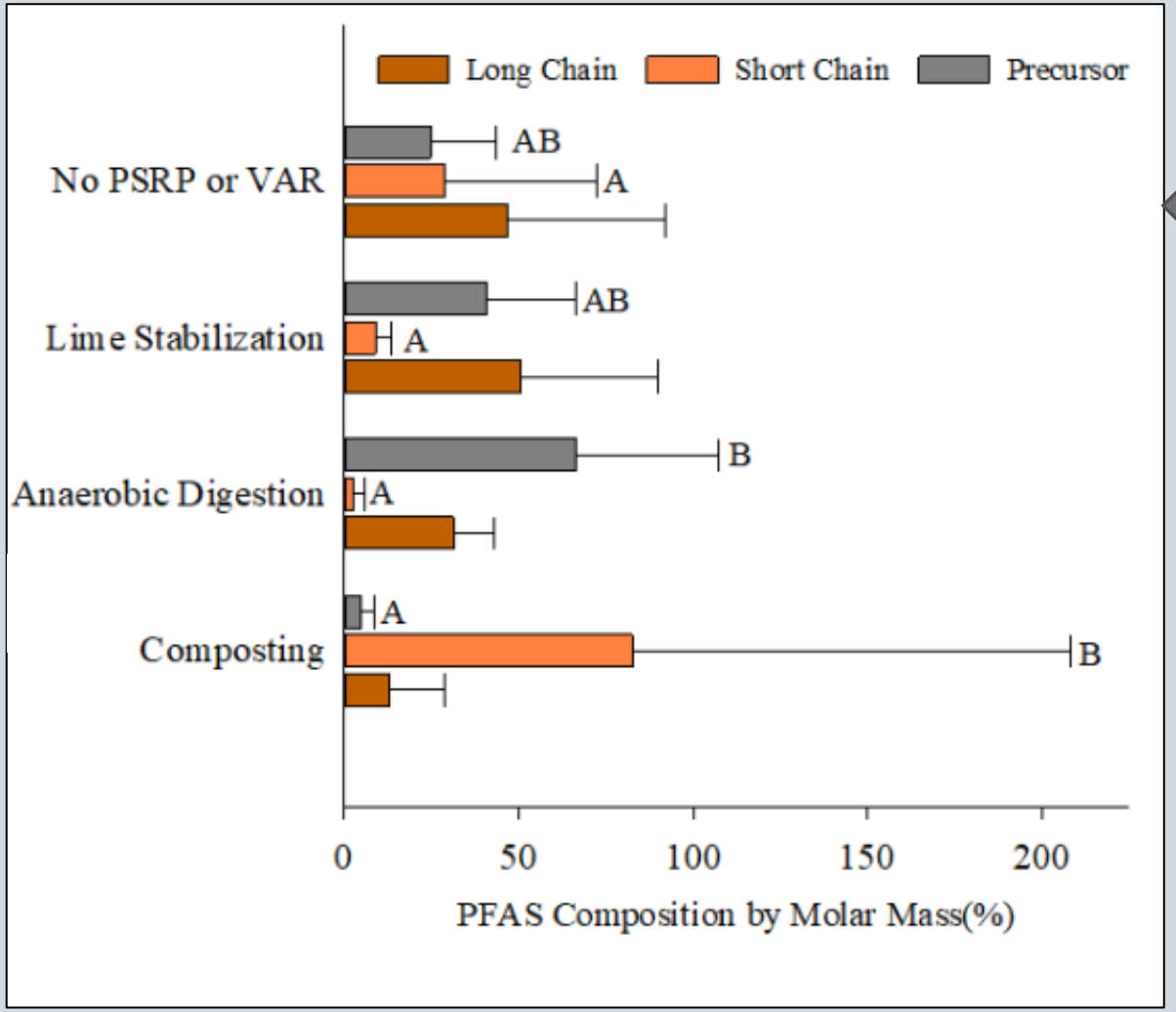
There is a weak correlation between K_D value and abundance within effluent and concentration.

Increasing sorption coefficient = greater occurrence in solids

Decreasing sorption coefficient = greater occurrence in effluent



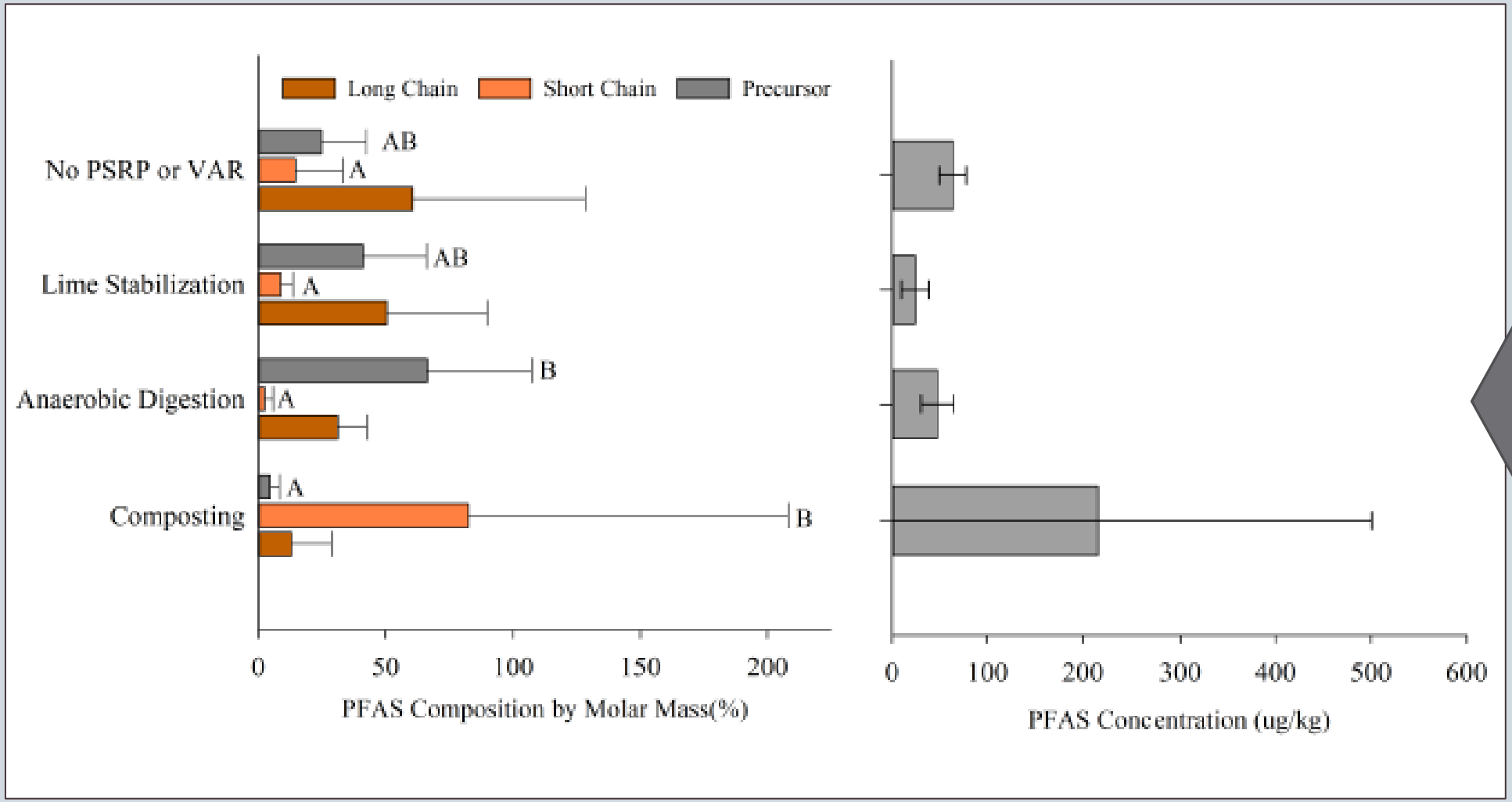
PFAS composition within biosolids is influenced by operational parameters associated with biosolid stabilization treatments.



Composted biosolids contained significantly higher abundances of short chain PFAS over that of all other samples. The same pattern is seen in municipal organic compost samples (Choi et al. 2019).

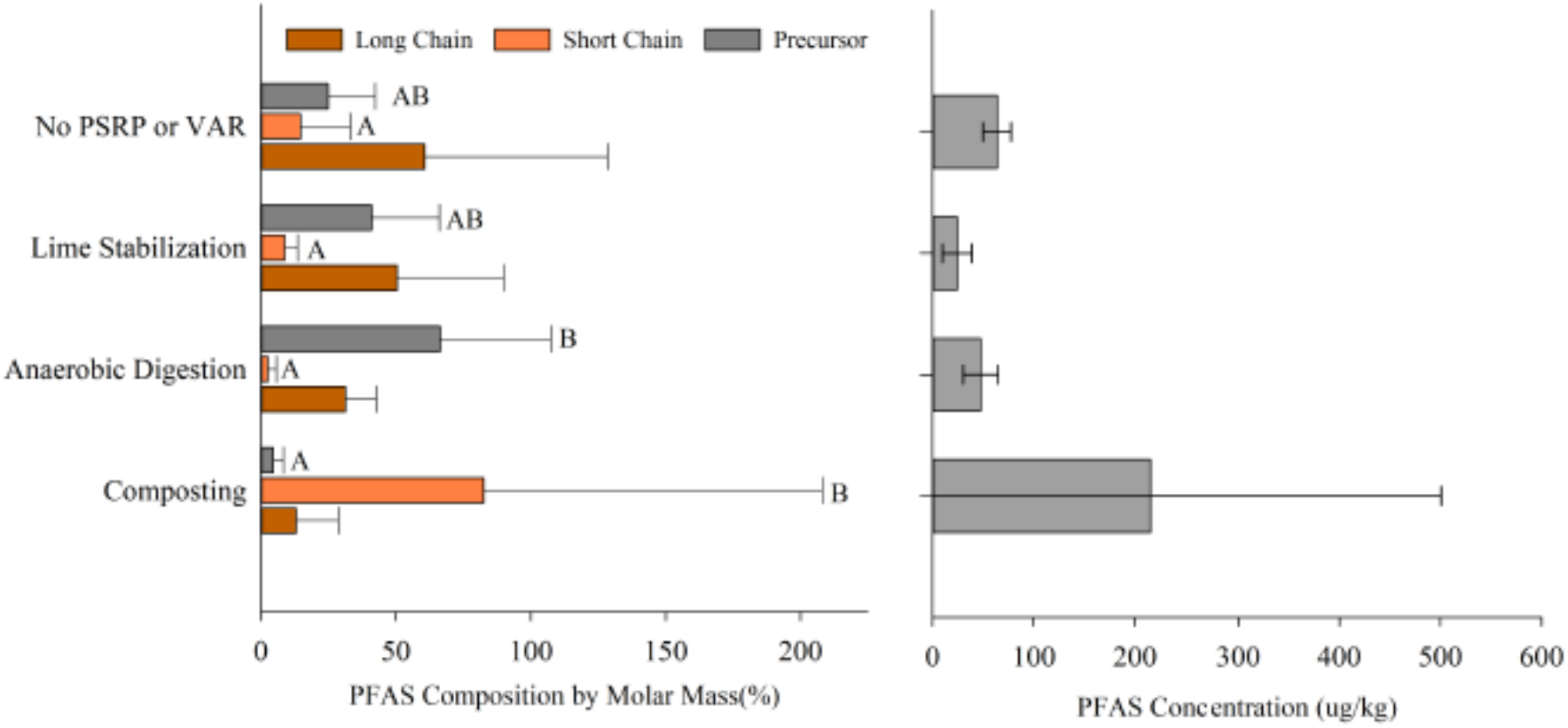
Higher compositions of precursor compounds were found in anaerobically digested samples over that of composted.

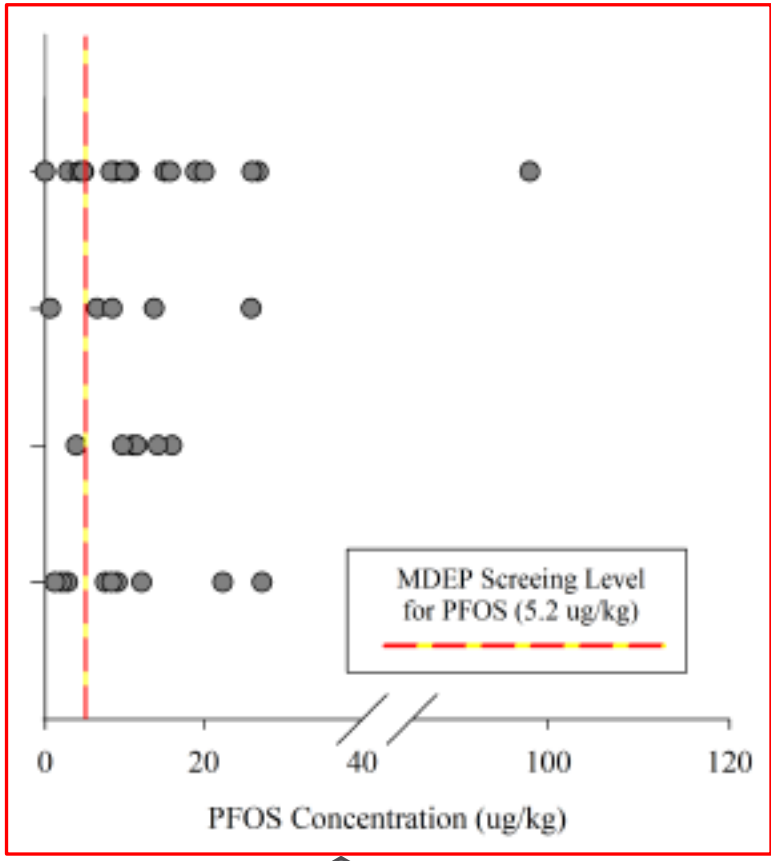
Concentration does not significantly vary with stabilization treatment.



PFAS sources are a greater driver of total concentration in biosolids over that of the stabilization process. Our data is supported by Lazcano et al. 2019.

29/39 (74.4%) of all samples exceed Maine DEP screening levels of PFOS for land application.





There are also screening levels for PFOA: 2.5 ug of PFOA/kg. 14/39 (35.9%) samples exceeded these levels

Implications and key take-aways

1. More PFAS species were detected in sludge samples over that of effluent samples.
2. Chain length and functional group strongly influences PFAS fate within WWTFs.
3. Sludges in NH and VT are dominated by long chain and sulfonate PFAS.
4. There is a weak correlation of K_D value to abundance of PFAS congeners in effluent and sludges.
5. PFAS composition is influenced by stabilization approach
6. No significant difference in total PFAS concentration by stabilization treatment (by this study).
7. More, research needed to better characterize how WWTF design and biosolids handling influence PFAS composition and concentration.

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References

Arthurson V. 2008. Proper Sanitization of Sewage Sludge: a Critical Issue for a Sustainable Society. Appl Environ Microbiol. 74(17):5267–5275. doi:10.1128/AEM.00438-08.

Blaine AC, Rich CD, Hundal LS, Lau C, Mills MA, Harris KM, Higgins CP. 2013. Uptake of Perfluoroalkyl Acids into Edible Crops via Land Applied Biosolids: Field and Greenhouse Studies. Environ Sci Technol. 47(24):14062–14069. doi:10.1021/es403094q.

Choi YJ, Kim Lazcano R, Yousefi P, Trim H, Lee LS. 2019. Perfluoroalkyl Acid Characterization in U.S. Municipal Organic Solid Waste Composts. Environ Sci Technol Lett. 6(6):372–377. doi:10.1021/acs.estlett.9b00280.

EPA 832-F-06-029. 2006 Sep. Biosolids Technology Fact Sheet, Heat Drying. :13.

Gallen C, Eaglesham G, Drage D, Nguyen TH, Mueller JF. 2018. A mass estimate of perfluoroalkyl substance (PFAS) release from Australian wastewater treatment plants. Chemosphere. 208:975–983. doi:10.1016/j.chemosphere.2018.06.024.

Giesy JP, Kannan K. 2001. Global Distribution of Perfluorooctane Sulfonate in Wildlife. Environ Sci Technol. 35(7):1339–1342. doi:10.1021/es001834k.

References

Kotlarz Nadine, McCord James, Collier David, Lea C. Suzanne, Strynar Mark, Lindstrom Andrew B., Wilkie Adrien A., Islam Jessica Y., Matney Katelyn, Tarte Phillip, et al. Measurement of Novel, Drinking Water-Associated PFAS in Blood from Adults and Children in Wilmington, North Carolina. Environ Health Perspect. 128(7):077005. doi:10.1289/EHP6837.

Lazcano RK, Perre C de, Mashtare ML, Lee LS. 2019. Per- and polyfluoroalkyl substances in commercially available biosolid-based products: The effect of treatment processes. Water Environ Res. 91(12):1669–1677. doi:10.1002/wer.1174.

Sinclair E, Kannan K. 2006. Mass Loading and Fate of Perfluoroalkyl Surfactants in Wastewater Treatment Plants. Environ Sci Technol. 40(5):1408–1414. doi:10.1021/es051798v.

US EPA O. 2016 Jul 13. Basic Information about Biosolids. US EPA. [accessed 2020 Jul 15]. https://www.epa.gov/biosolids/basic-information-about-biosolids.

Thank you for listening!

Any questions?

Contacts

Sydney Adams

ska1024@wildcats.unh.edu

PI: Paula Mouser

paula.mouser@unh.edu