

Predictability of PFAS Concentrations in Biosolids Composts

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Predicatability of PFAS in Biosolids Composts Outline

- Overview of PFAS sources
- PFAS in Biosolids Products – Why should we care?
- Biosolids Composting Impact on PFAS
- Summary Points and Next Steps

What Are PFAS?

- Per- and poly-FluoroAlkyl Substances
- Thousands of man-made compounds, no natural occurrence
- Used since the 1950s in many products
 - Heat resistant
 - Flame retardant
 - Oil resistant
 - Water resistant
 - Found in blood of people, animals, and fish worldwide
- Properties which make these compounds useful also result in their persistence in the environment



firefighting foam



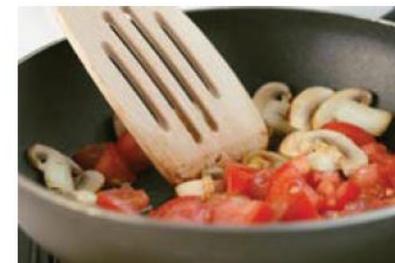
paints and stains



stain – resistant carpets



water – repelling fabrics



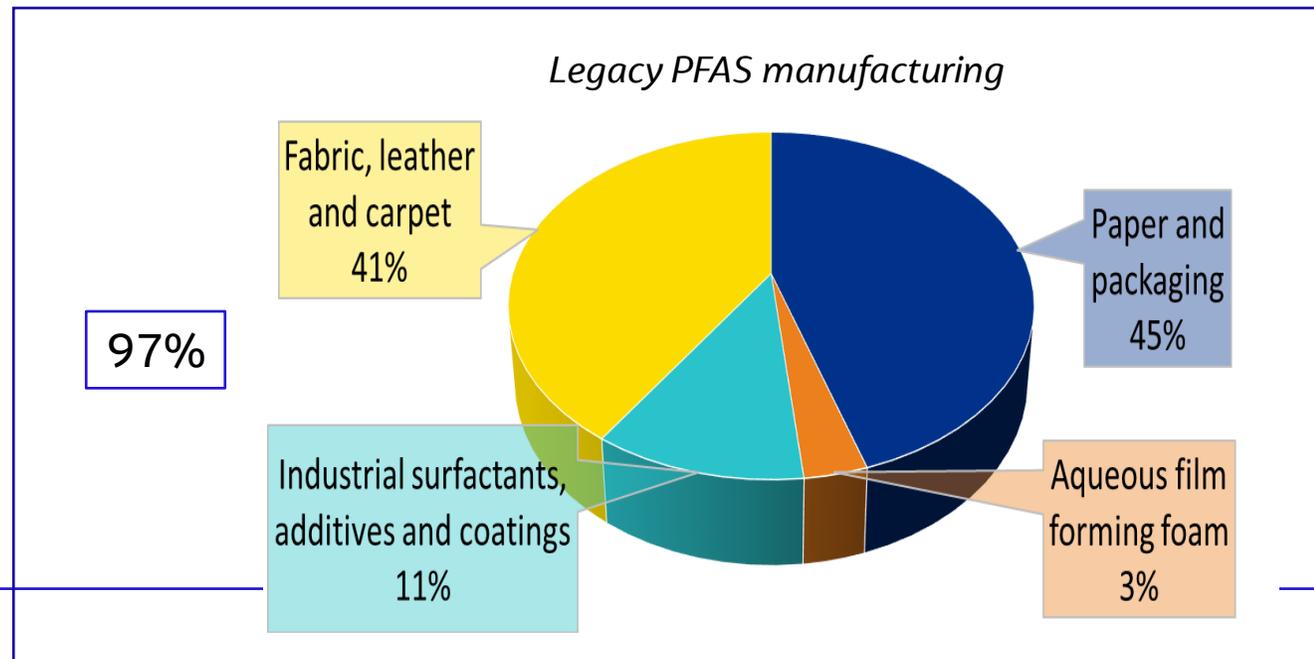
nonstick cookware



food packaging

Where are PFAS Used?

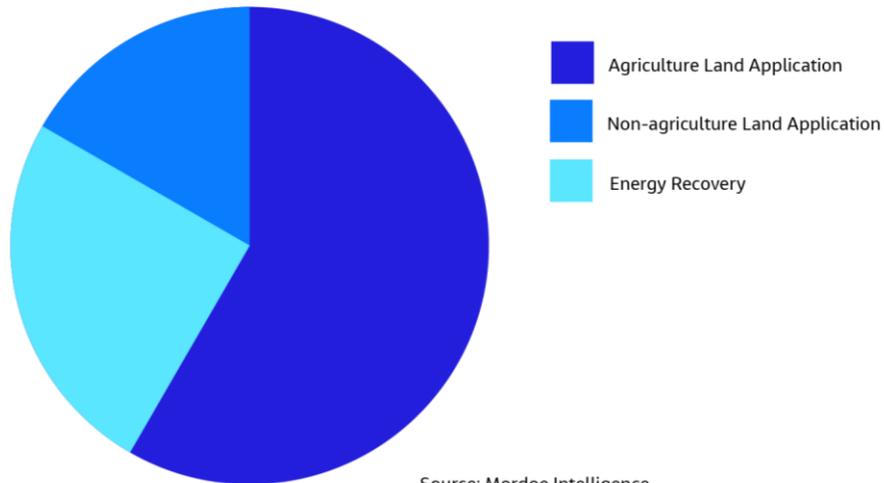
- Aqueous Film-Forming Foam (AFFF)
 - Airports / Airlines
 - Railroads
 - Fire Departments
 - Oil & Gas
- Manufacturing
 - Metals, Plating
 - Automotive
 - Chemicals
 - Pulp & Paper
- Commercial
 - Car Wash Waxes
 - Electronics



PFAS in Biosolids – Why should we care?

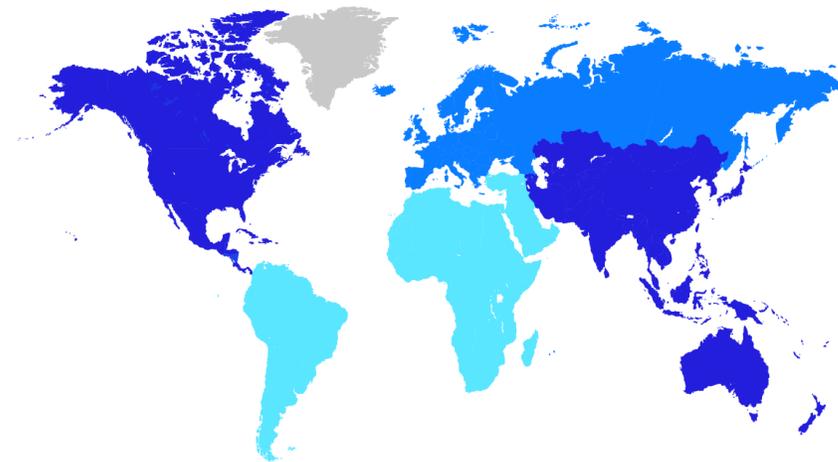
- Land application makes up 60% of the global biosolids market
- In the US, half of the 7.2 M dry tons per year of WWTP biosolids are land applied.
- The US biosolids land application market is valued at \$600M/year and growing 4% per year or more
- Problems with landfills is forcing even more biosolids to land application
- What are the concerns?
 - Surface water, ground water, plant uptake
- What do farmers and compost users think?

Biosolids Market, Volume (%), by Application, Global 2018



Source: Mordue Intelligence

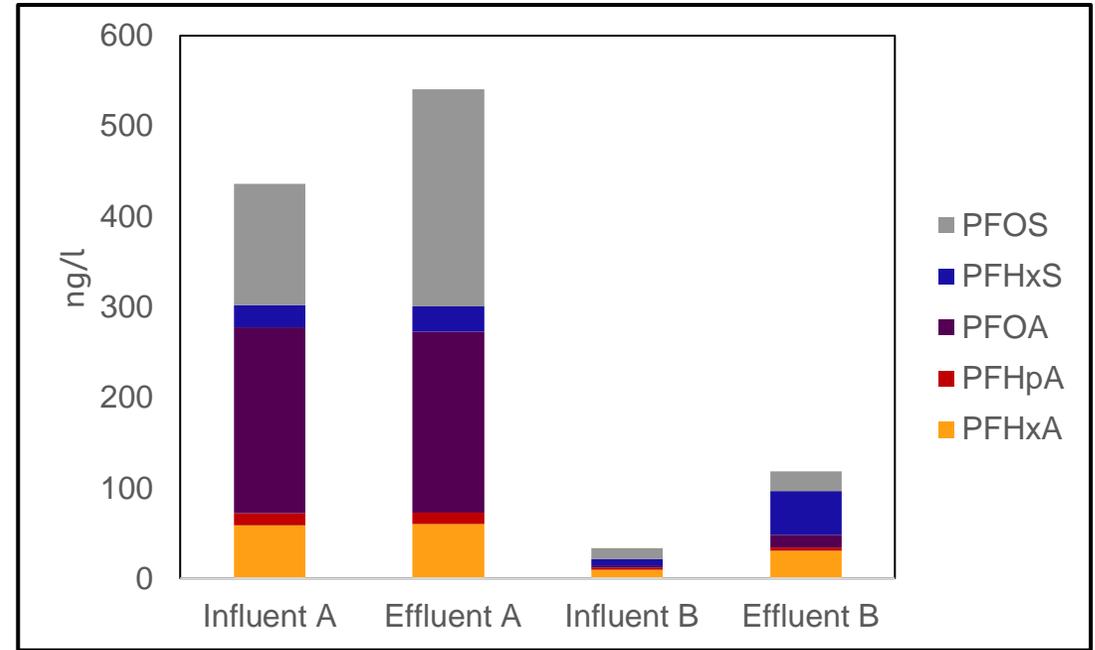
Biosolids Market – Growth Rate by Region, 2019-2024



High Medium Low

PFAS Concentrations Within Wastewater Facilities is Highly Variable (ng/l)

Plant	Location	PFHxA	PFHpA	PFOA	PFHxS	PFOS	Total
A	Influent	59	13	206	24	134	444
	Effluent	60	13	200	28	240	560
B	Influent	9.7	2.2	3.1	6.6	12	35
	Effluent	31	3.7	14	48	22	120

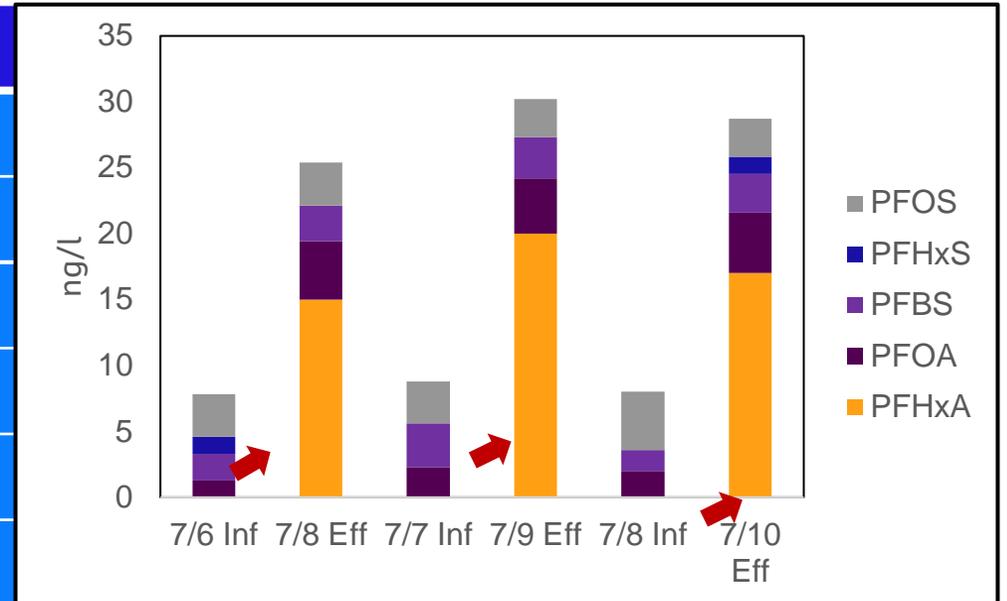


- Measured PFAS pass through WWTP with limited/no reduction
- Precursors discharged to WWTP cause detectable PFAS to increase across aeration
- PFAS also leaves plant through biosolids

Source: Gallen et. al., 2018, *Chemosphere*

A Conventional Wastewater Facility PFAS Concentrations (ng/L)

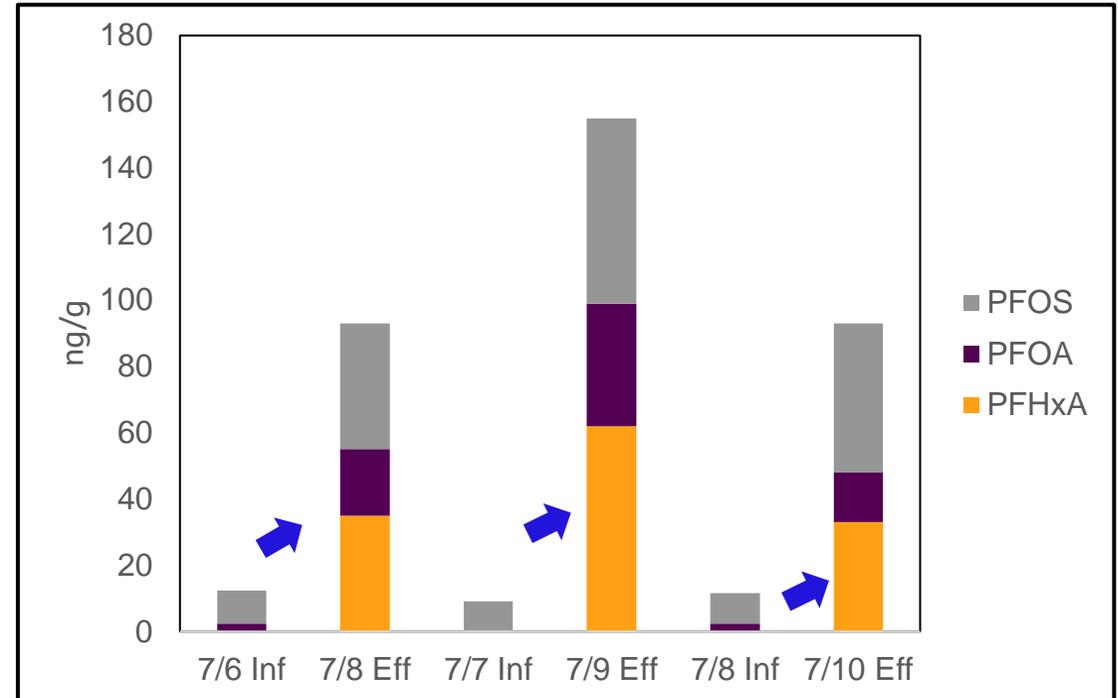
Sample	Location	PFHxA	PFOA	PFBS	PFHxS	PFOS	Total
7/6 Inf 7/8 Eff	Influent	ND	1.3	2.0	1.3	3.2	7.8
	Effluent	15	4.4	2.7	ND	3.3	26.4
7/7 Inf 7/9 Eff	Influent	ND	2.3	3.3	ND	3.2	8.8
	Effluent	20	4.2	3.1	ND	2.9	30.2
7/8 Inf 7/10 Eff	Influent	ND	2.0	1.6	ND	4.4	8.0
	Effluent	17	4.6	2.9	1.3	2.9	28.7



- Low concentrations of PFAS detected
- Often see detectable concentrations due to wastewater source:
 - Domestic products
 - Landfill leachate
 - Human excretion
- Does not appear to have “significant” industrial contribution
- Increase across aeration commonly observed from “precursor” conversion

A Conventional Wastewater Facility Biosolids PFAS Concentrations (ng/g)

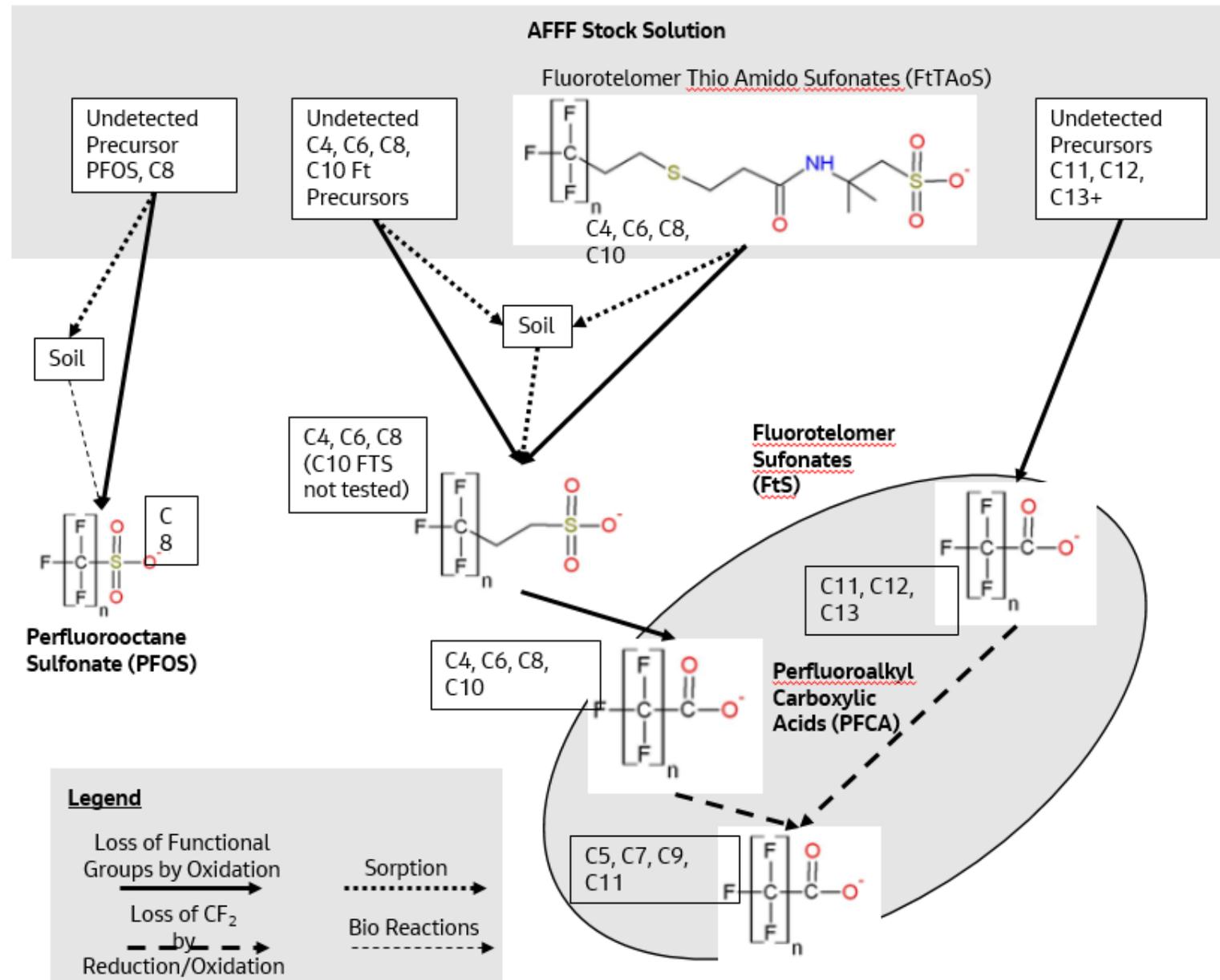
Sample	Location	PFHxA	PFOA	PFOS	Total
7/11 DI 7/6 BS	Digester Inf	ND	2.3	10	12.3
	Biosolids	35	20	38	93
7/13 DI 7/8 BS	Digester Inf	ND	ND	9.1	9.1
	Biosolids	62	37	56	155
7/15 DI 7/10 Eff	Digester Inf	ND	2.4	9.2	11.6
	Biosolids	33	15	45	93
Average	Digester Inf	ND	2.4	9.4	11.8
	Biosolids	43.3	24	46.3	114



- 100% WAS treated through ATAD system
- PFBS and PFHxS not detected
- Increase across digestion from aerobic “precursor” conversion and/or changes in % solids

PFAS Precursor Biotransformation Background

Interpretation of AFFF degradation pathways

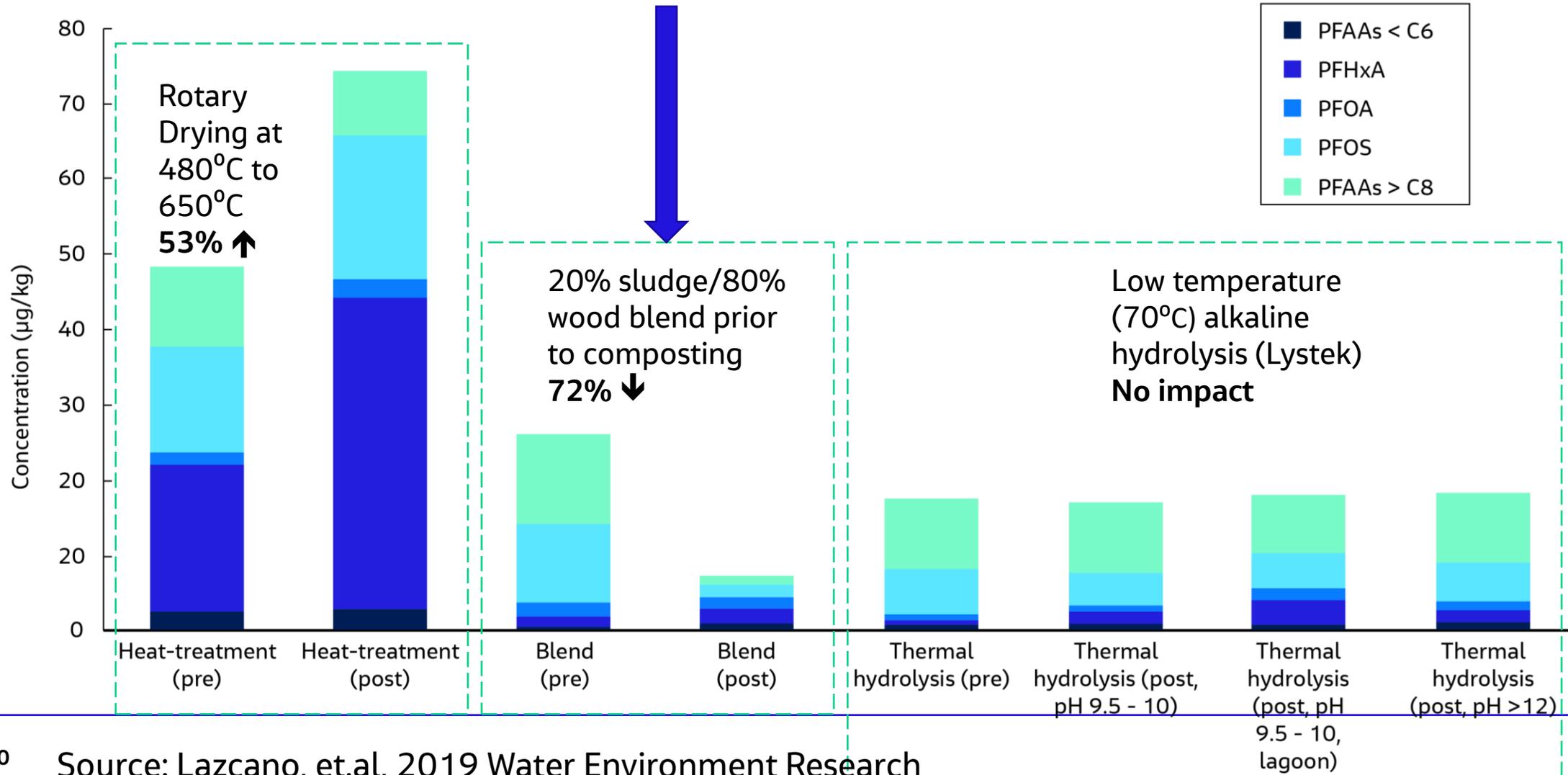


Reference:

James Hatton, Dusty Rose Berggren, Jeremy Bishop and Bill Diguseppi. "Treatability Test: Oxidation Technologies for Destruction of PFAS Compounds". CH2M Hill Innovation Grant Technical Memorandum. December 2014

Impact of thermal drying, blending with bulking agent, and chemical/thermal hydrolysis treatment (not THP)

Expectation is that bulking agent dilution effect would reduce concentrations of PFAS in compost compared to input sludge

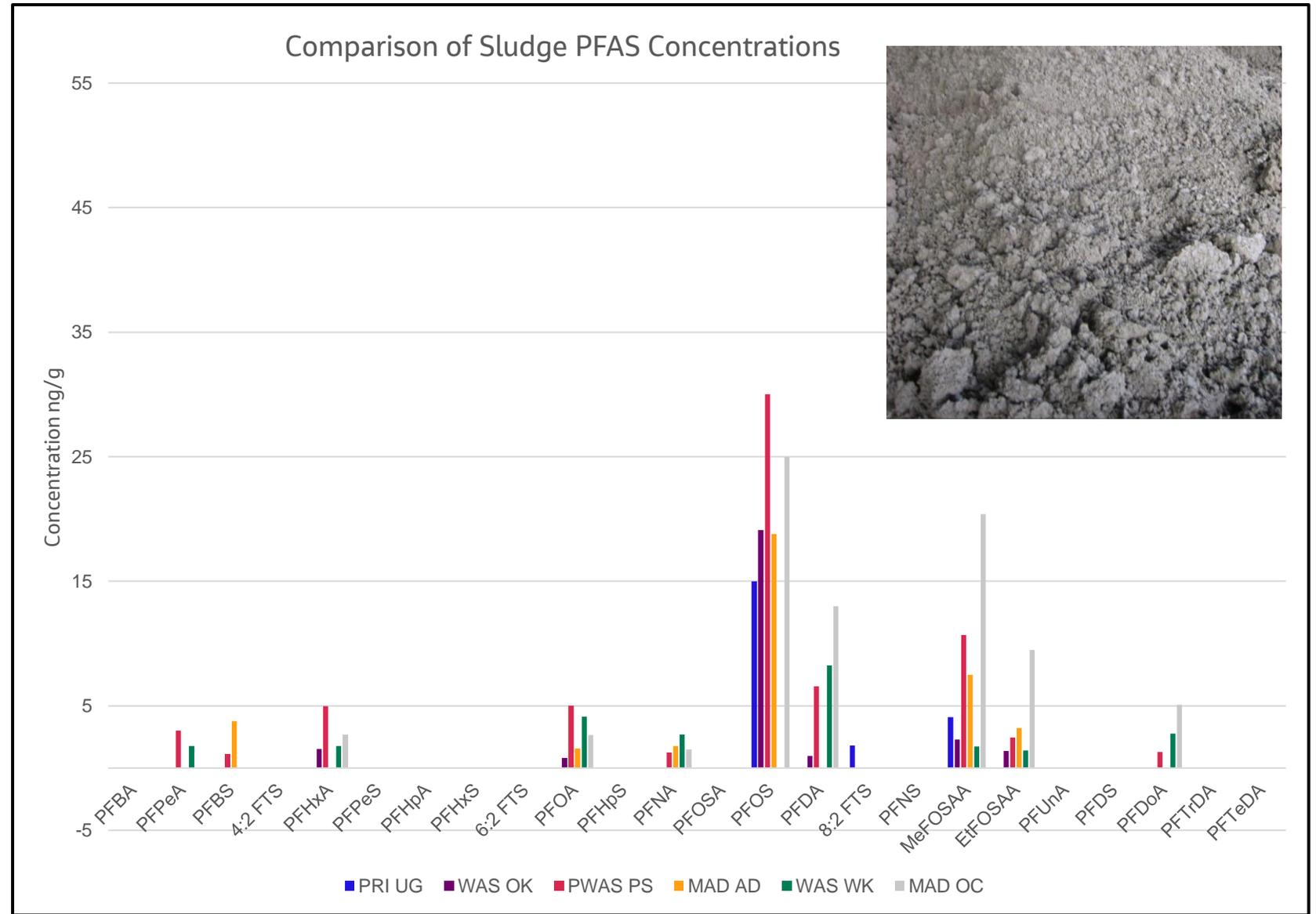


Biosolids Composting and its Impact on PFAS Concentrations

- Jacobs conducted sampling and testing of six biosolids composts for analysis of 24 PFAS compounds using isotope dilution/LC-MS/MS method (modified 537)
- Wastewater treatment systems where compost sampled have minimal industrial contribution
- Wastewater treatment schemes prior to composting included the following:
 - Primary treatment and primary sludge only (PRI-1)
 - Conventional secondary treatment with nutrient removal, mixture of primary and waste activated sludge (PWAS-1)
 - Conventional secondary treatment with nutrient removal, waste activated sludge only (WAS-2)
 - Conventional secondary treatment, mixture of primary and waste activated sludge, then mesophilic anaerobic digestion (MAD-2)
- All operations sampled utilized the aerated static pile method of composting
 - Meet all EPA 503 time and temperature requirements to achieve Class A and EQ standards

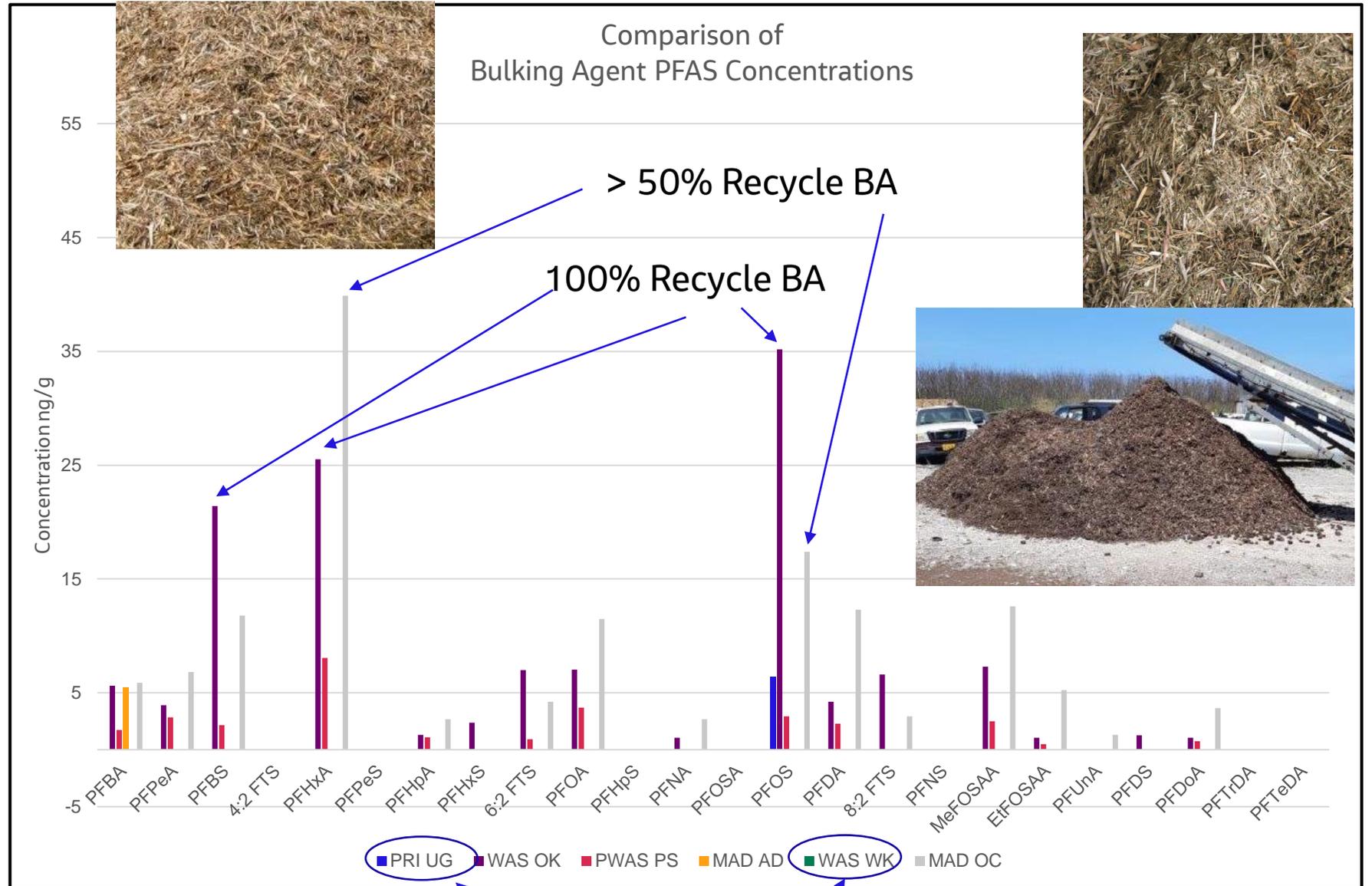
PFAS Concentrations in Sludge Cakes (ng/g dry)

- In general, concentrations in sludges are not high
- PFOS, MeFOSAA and PFDA are 3 largest components in sludges
- MeFOSAA typically degrades to PFOS
- PFDA typically is very stable



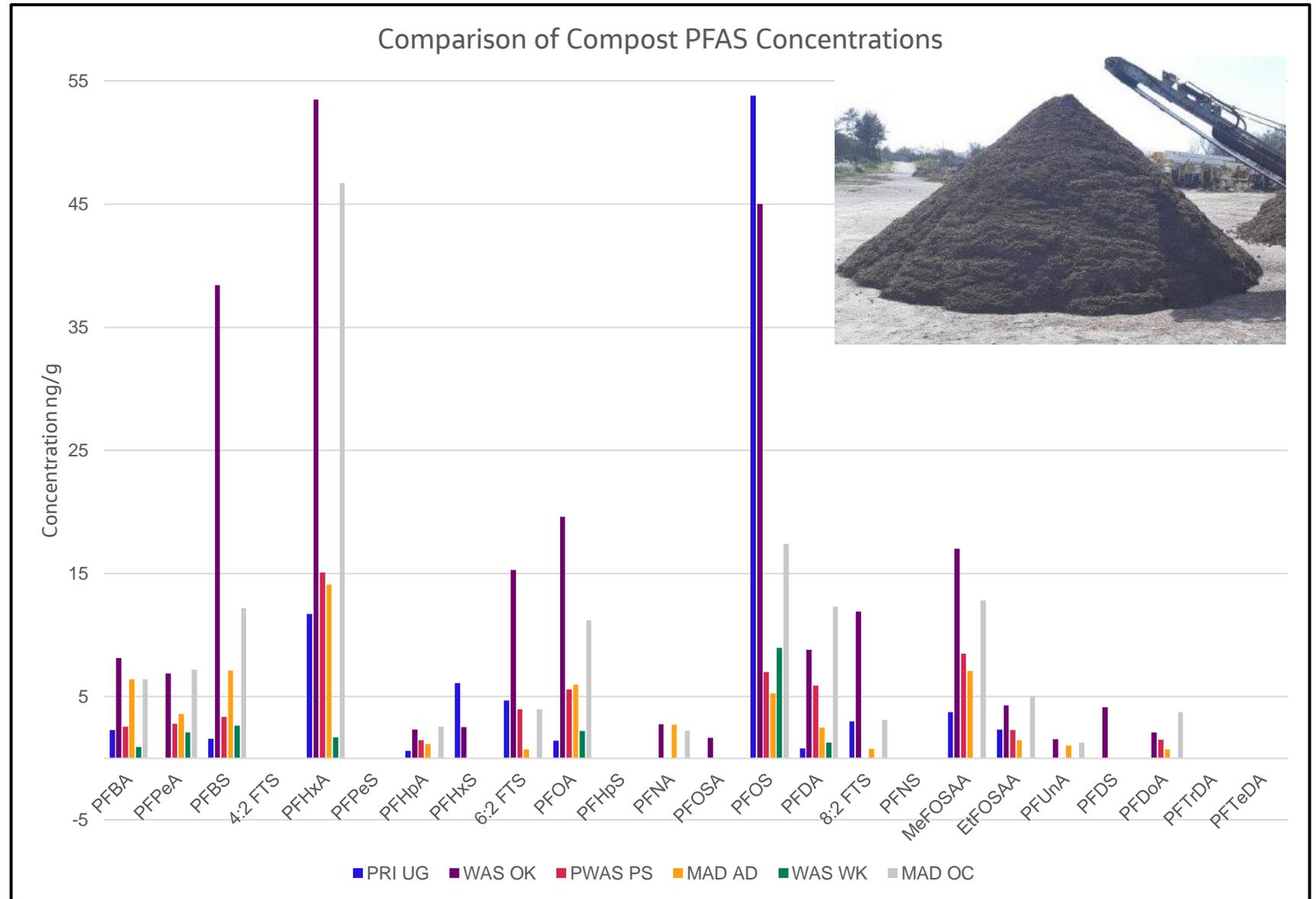
PFAS Concentrations in Bulking Agents (ng/g dry)

- Bulking agents used included wood chips, ground pallets, ground yard waste and recycled screen overs
- Most bulking agent concentrations are very low
- Recycling significant amounts of bulking agent may increase PFAS concentration

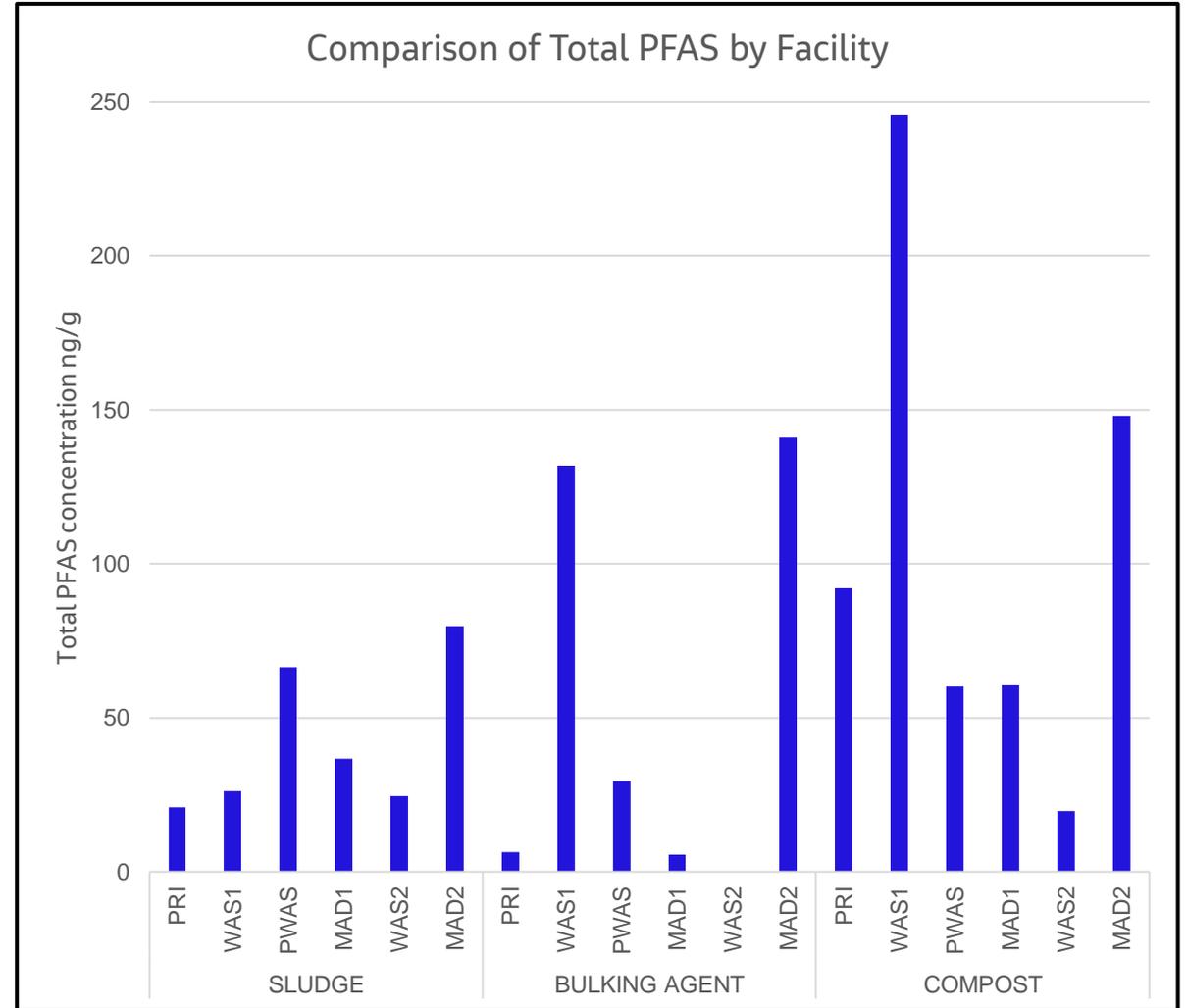
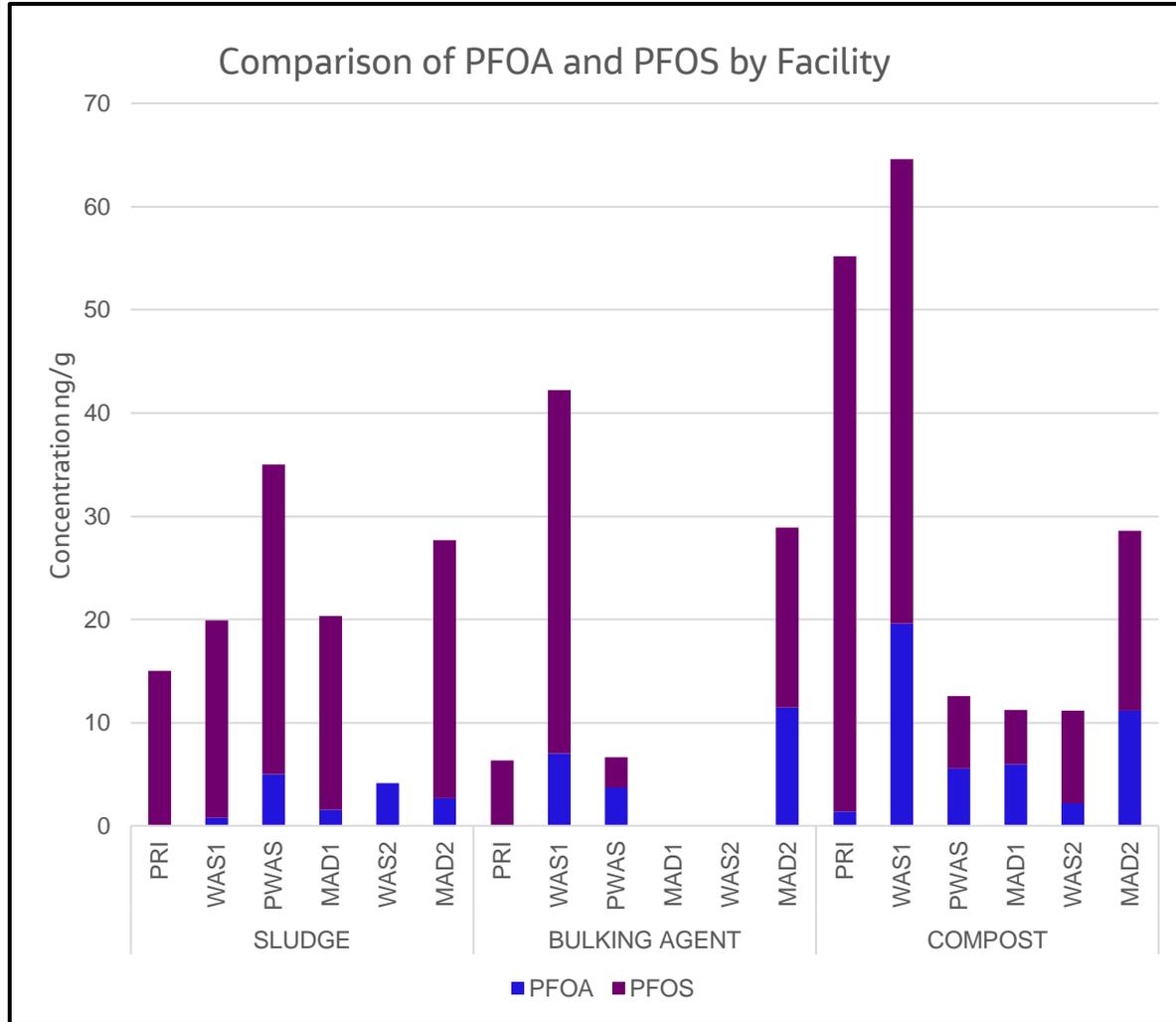


PFAS Concentrations in Composts (ng/g dry)

- PFOS, PFHxA, PFBS, PFOA, and MeFOSAA are largest components in composts
- High PFOS with Primary Sludge and with High % Recycled Bulking Agent

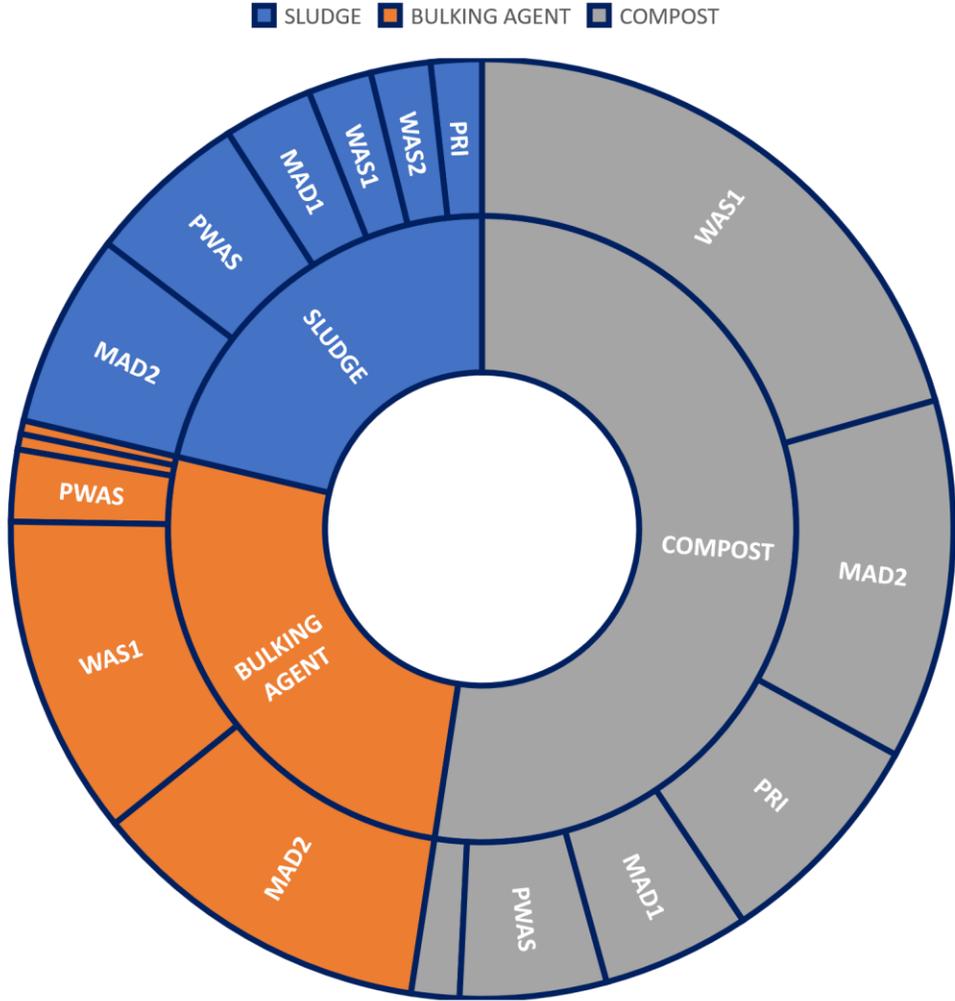


PFOA, PFOS and Total PFAS by Sludge and BA Type

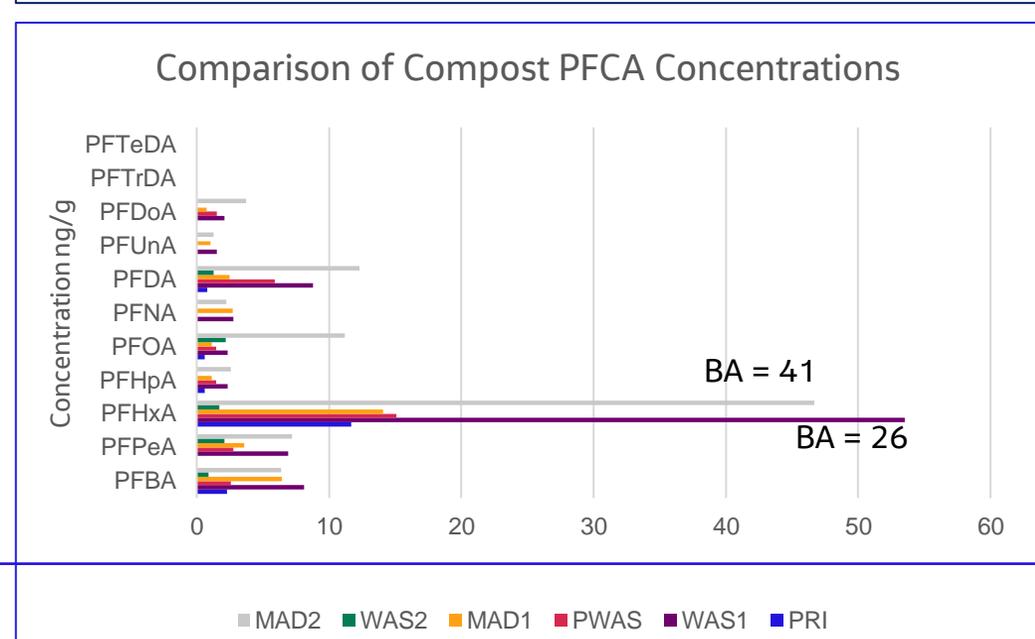
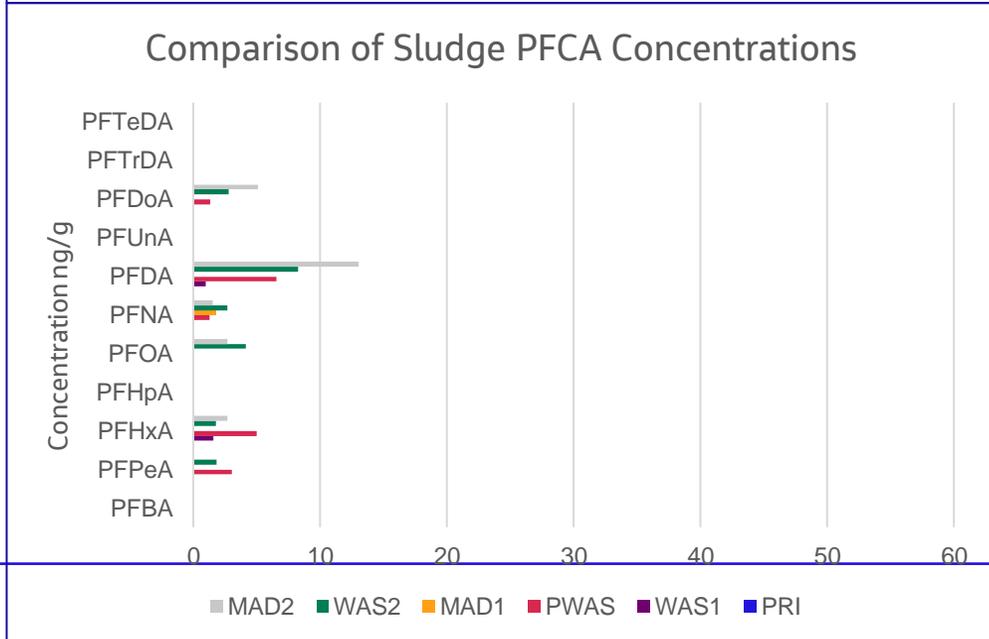
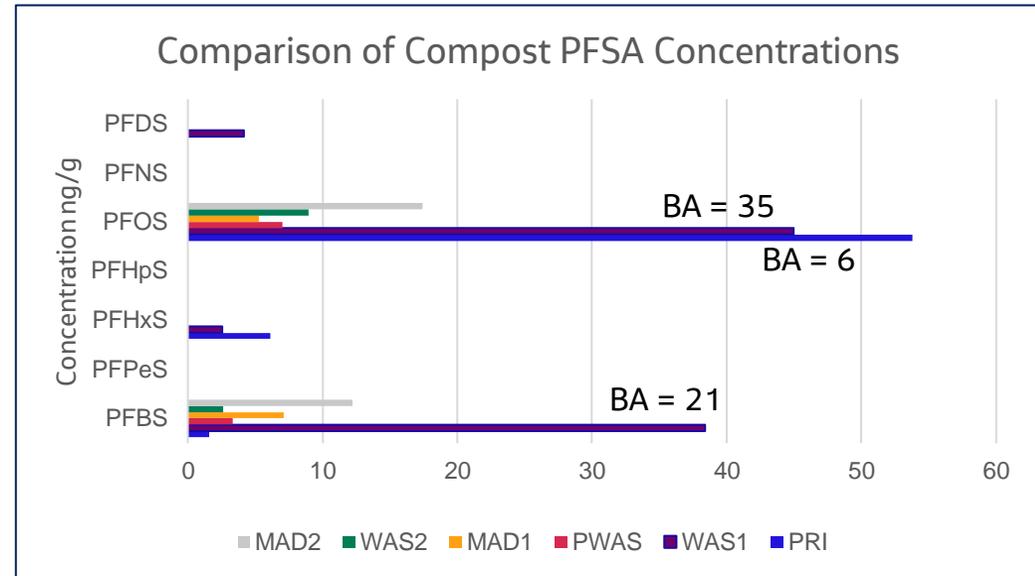
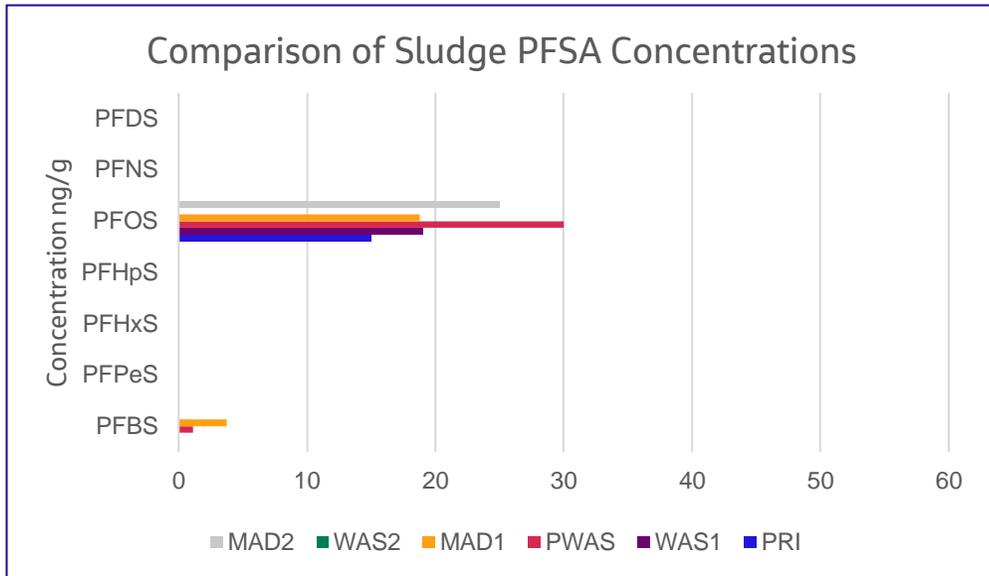


Total PFAS Comparison by Sludge Type and Bulking Agent Contribution

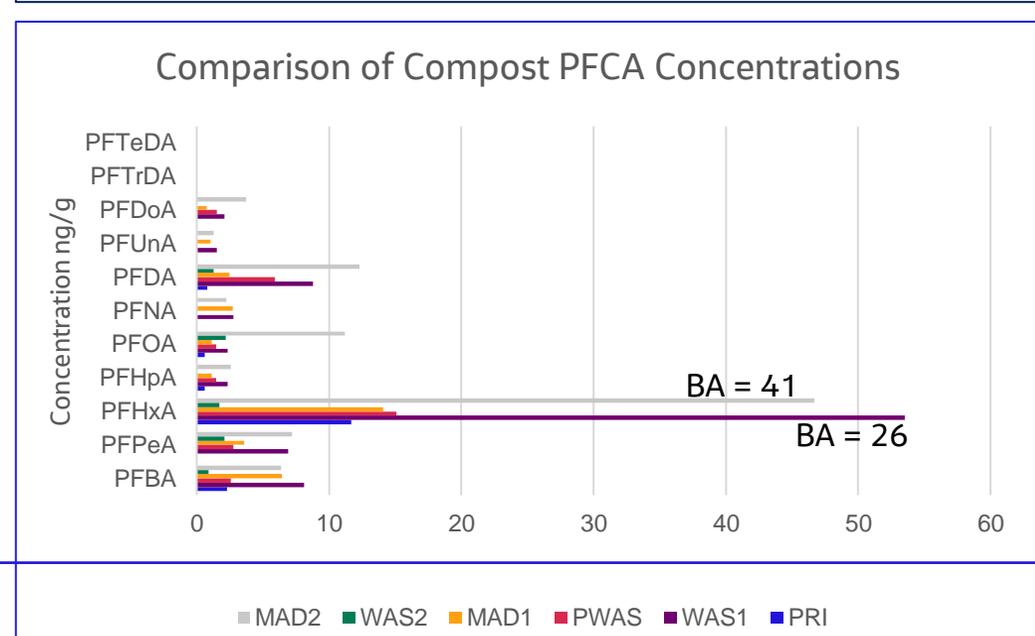
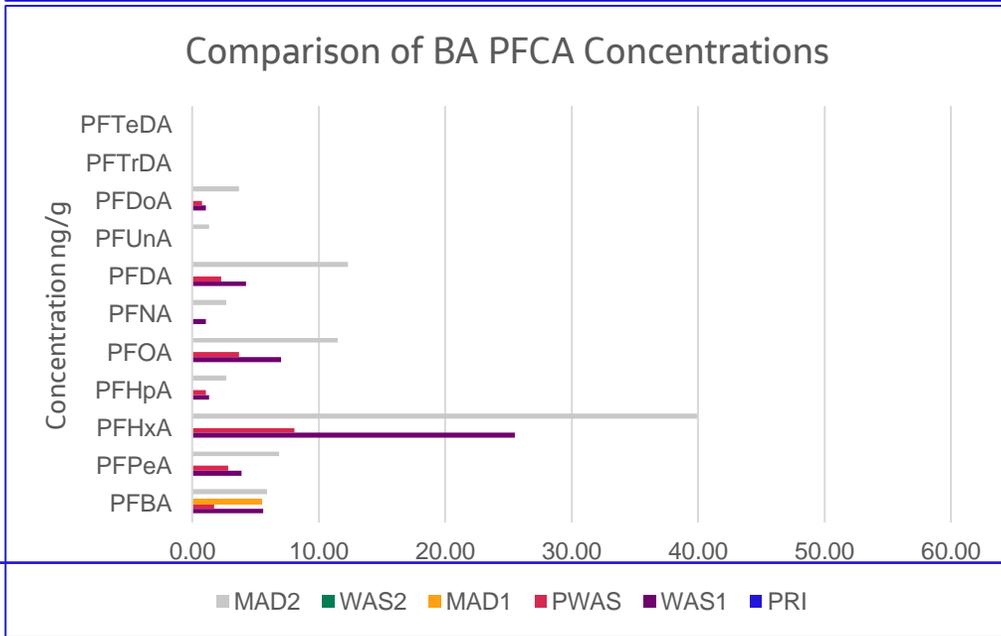
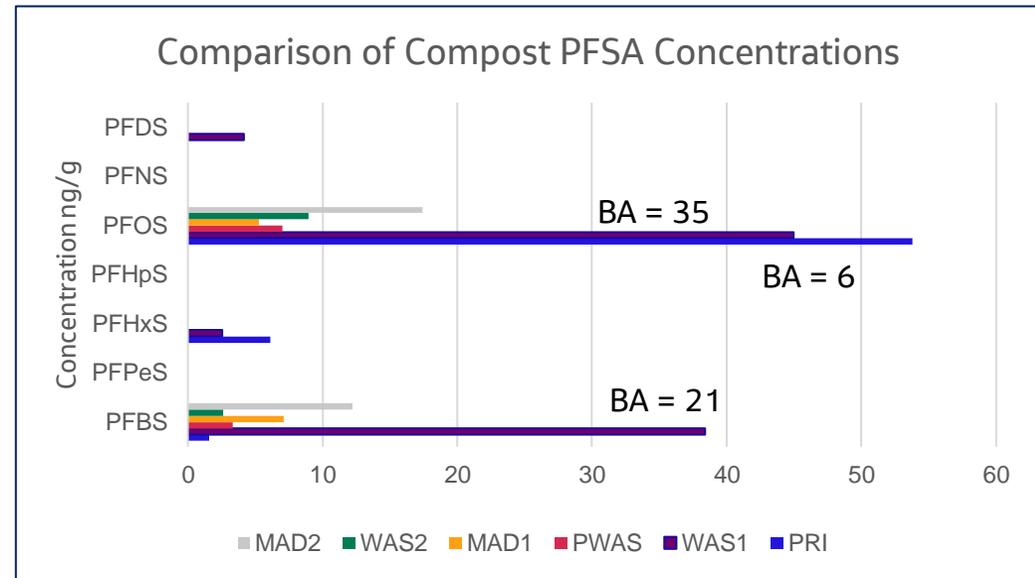
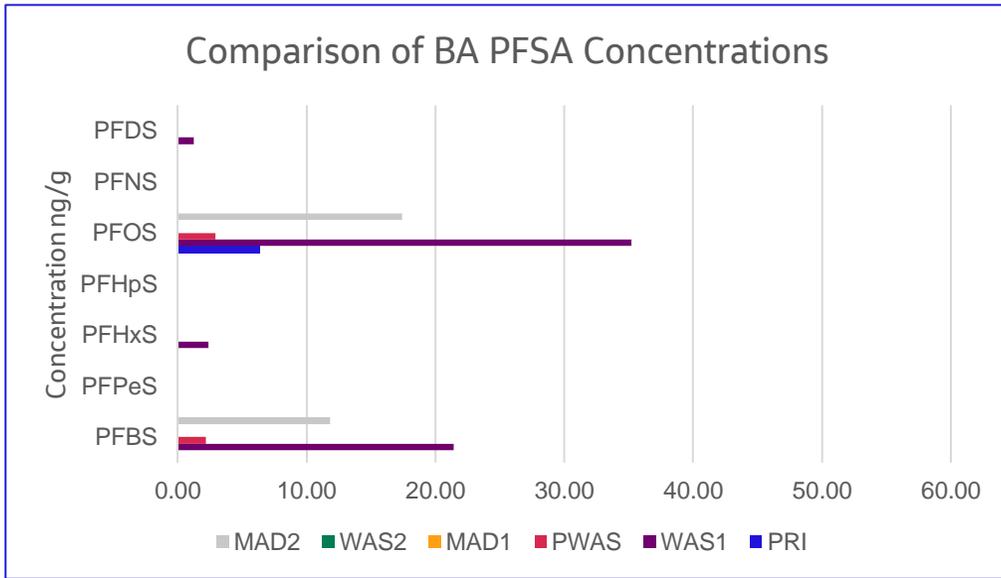
Comparison of Total PFAS by Sludge Type



PFSA and PFCA Compound Concentrations by Sludge Type



PFSA and PFCA Compound Concentrations by Sludge Type



Summary Points

- This is a small data set. However, there are some observations
- PFOS is the most commonly detected compound in all materials (sludge, bulking agent and composts)
- Primary sludge not treated aerobically first appears to be more susceptible to precursor transformation into multiple PFAS terminal compounds (PFOS) through composting
- Aerobically processed sludges and anaerobically digested sludges may result in less precursor transformation during composting
- Bulking agent recycling appears to increase PFAS concentrations in the bulking agent and the resulting compost
- Every sludge is different.....know what you've got through sampling and testing!
 - By understanding wastewater processes before composting and testing solids and bulking agents, predictability of compost PFAS concentration impacts may be possible

Next Steps

- Continue studying the role of precursors in sludges and impact on compost
- Test the leachability of PFAS in biosolids compost amended soils
- Testing of biosolids compost products for plant uptake of PFAS
- Continue sampling and testing more biosolids composts

Predictability of PFAS Concentrations in Biosolids Composts

Thank You!

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Reinventing tomorrow.

