

How Does Composting Change PFAS Concentrations in Organics and Biosolids

Todd O. Williams, P.E., CEE

todd.williams3@jacobs.com

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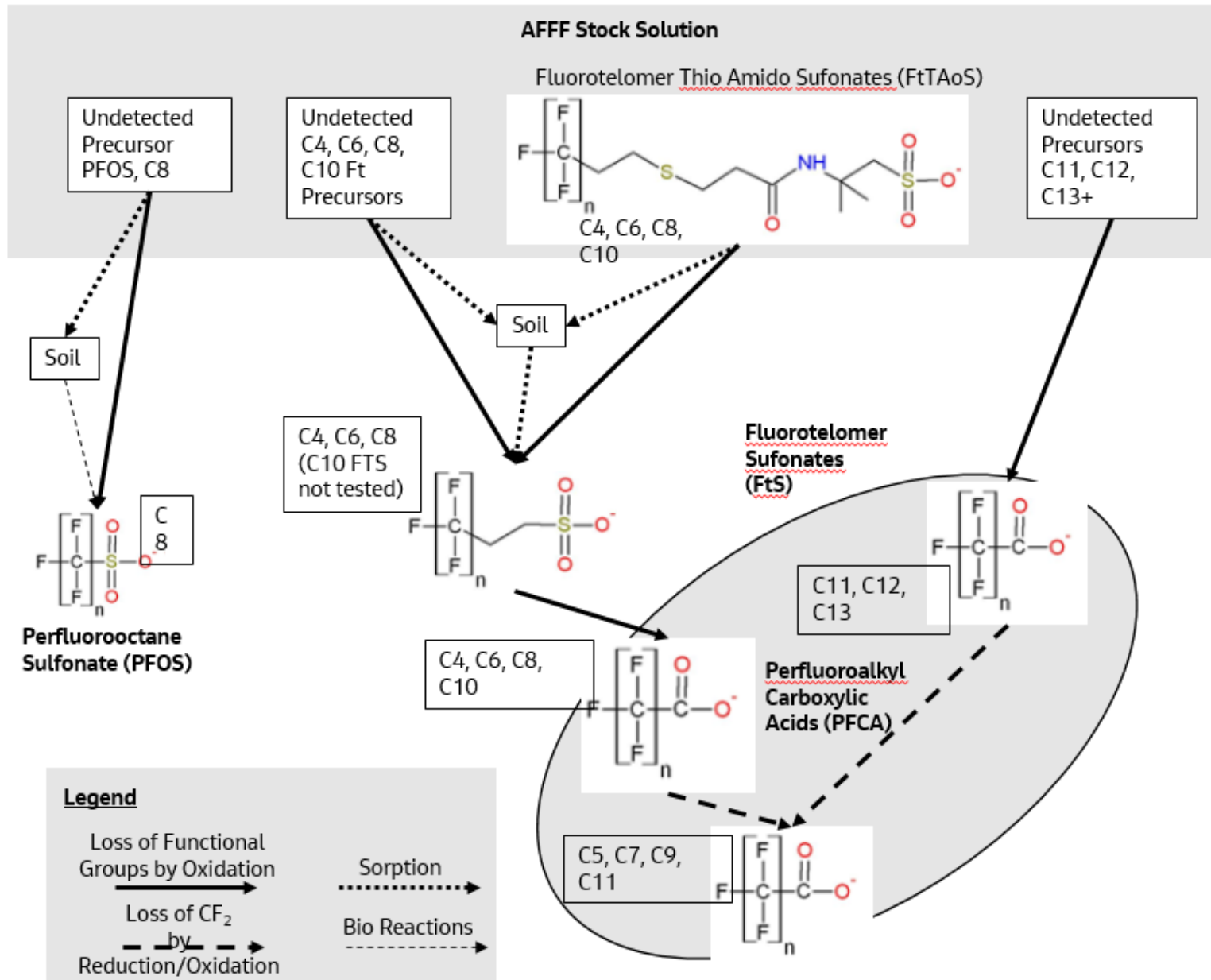
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Composting Impacts on PFAS Outline

- PFAS is a complex issue
- Regulations related to PFAS in composts and soils
- What is Composting?
- Composting Impacts on PFAS
 - SSO Composting
 - Wastewater Solids Composting
- Summary thoughts

PFAS Precursor Biotransformation Background

Interpretation of AFFF degradation pathways

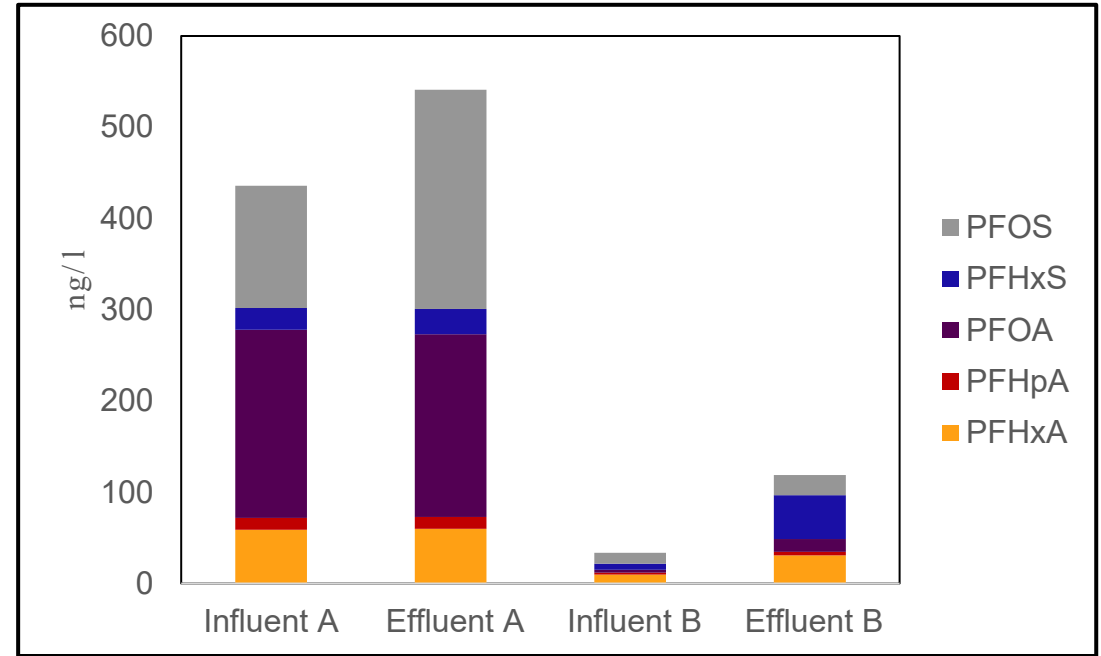


Reference:

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

PFAS Concentrations Within Wastewater Facilities are 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

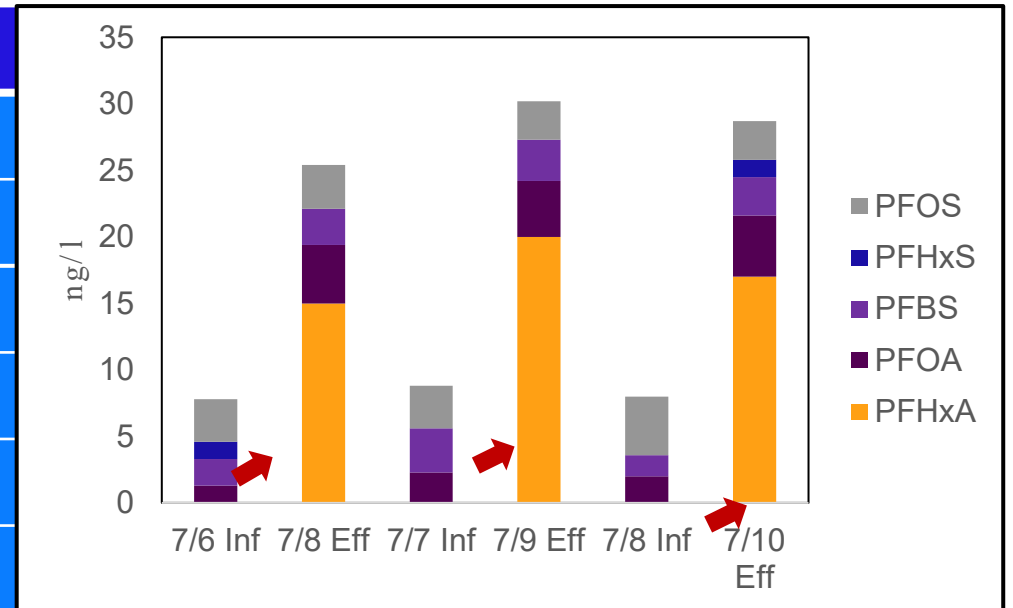


- Measured PFAS pass through WWTP with limited/no reduction
- Precursors discharged to WWTP cause detectable PFAS to increase across aeration
- PFAS also leaves plant through biosolids

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

A Conventional Wastewater Facility PFAS Concentrations (ng/L)

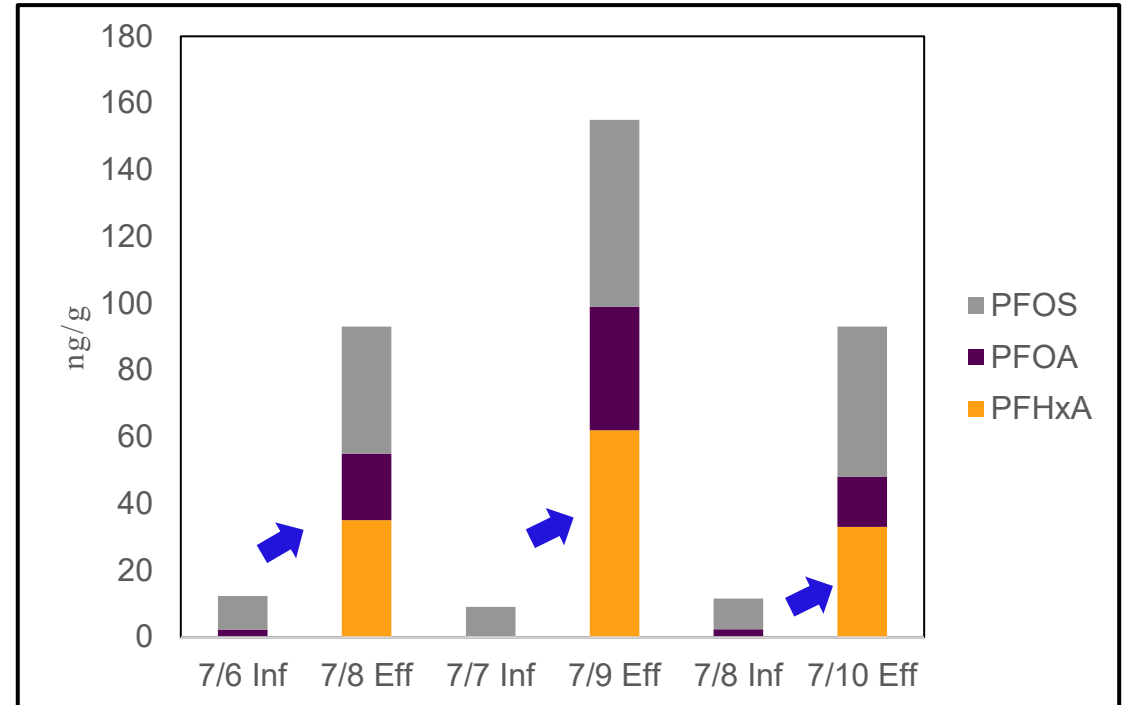
Sample	Location	PFHxA	PFOA	PFBS	PFHxS	PFOS	Total
7/6 Inf 7/8 Eff	Influent	ND	1.3	2.0	1.3	3.2	7.8
	Effluent	15	4.4	2.7	ND	3.3	26.4
7/7 Inf 7/9 Eff	Influent	ND	2.3	3.3	ND	3.2	8.8
	Effluent	20	4.2	3.1	ND	2.9	30.2
7/8 Inf 7/10 Eff	Influent	ND	2.0	1.6	ND	4.4	8.0
	Effluent	17	4.6	2.9	1.3	2.9	28.7



- 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% Waste Activated Solids treated through Autothermal Aerobic Digestion (ATAD) system
- PFBS and PFHxS not detected
- Increase across digestion from aerobic “precursor” conversion and/or changes in % solids

PFAS regulations in soil with values protective of groundwater vary

Entity	µg/Kg (ppb)		
	PFOA	PFOS	PFBS
US EPA (Soil Screening Level)	0.017	0.038	13
State values *	0.6 – 350	0.22 - 25	53 – 910
Maine (Biosolids Specific Screening)	2.5	5.2	1900

* Current states: AK, MI, NE, NC, TX. Enforceable value in AK.

What is Composting?

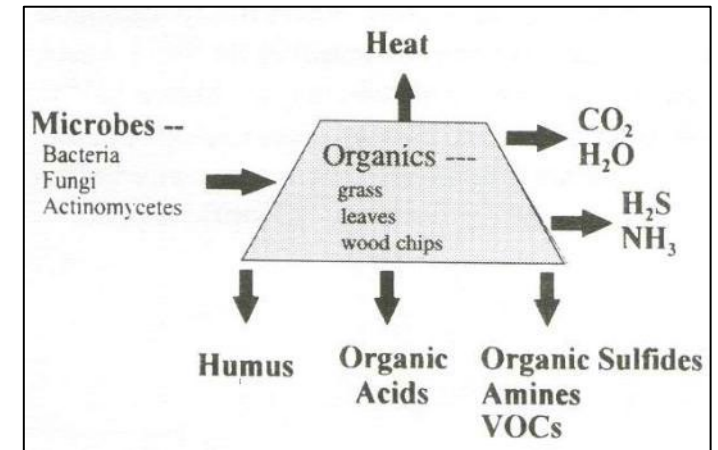
- Composting Is The Biological Decomposition Of Organic Matter Under Controlled Aerobic Conditions
- Controlled - The Process Is Managed or Optimized to Achieve Desired Process Objectives
 - Temperatures to meet pathogen reduction criteria
 - Oxygen
 - Moisture
 - Carbon to Nitrogen
 - Porosity
- Composting Objectives
 - Kill pathogens and stabilize organics
 - Destroy odor causing compounds
 - Eliminate food source for pathogen regrowth
 - Vector attraction reduction
 - Dry the mixture
 - Produce a high-quality marketable product



Composting Definition

- Composting is the biological decomposition of organic matter under controlled aerobic conditions. Temperatures typically rise to the thermophilic range in order to stabilize organic matter. The goal is to maintain conditions that encourage a healthy community of microbes to destroy pathogens and produce a marketable product.
- This is done by monitoring and manipulating six main process parameters.

Aeration/Oxygen Particle Size, Porosity and Structure
Nutrients Moisture
Temperature

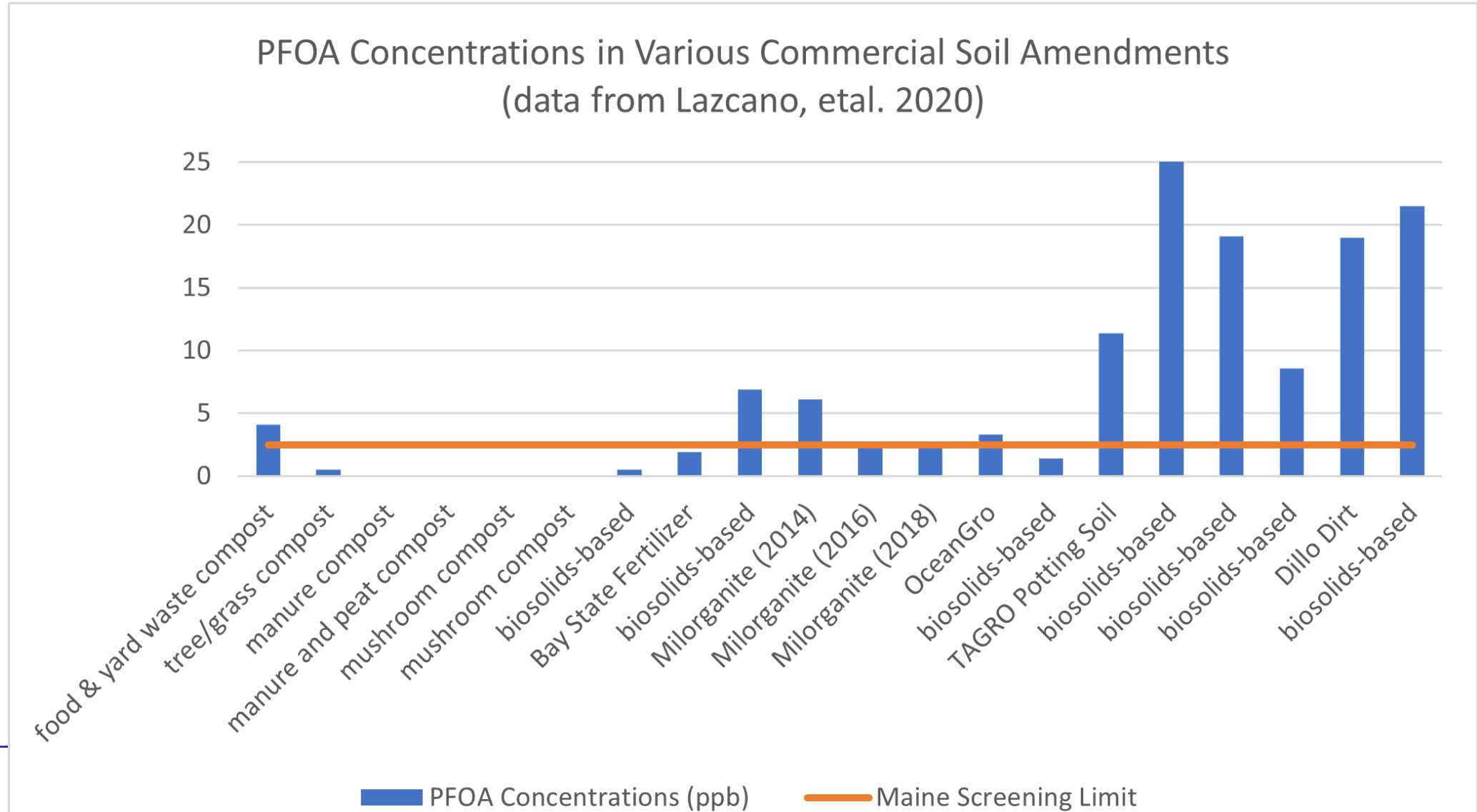


Materials that can typically be composted

- **Yard Wastes**
 - leaves, grass, brush
- **Source Separated Organics**
 - pre-consumer and post-consumer food wa
- **Wastewater Solids**
- **Manures**
- **Clean Wood Wastes**

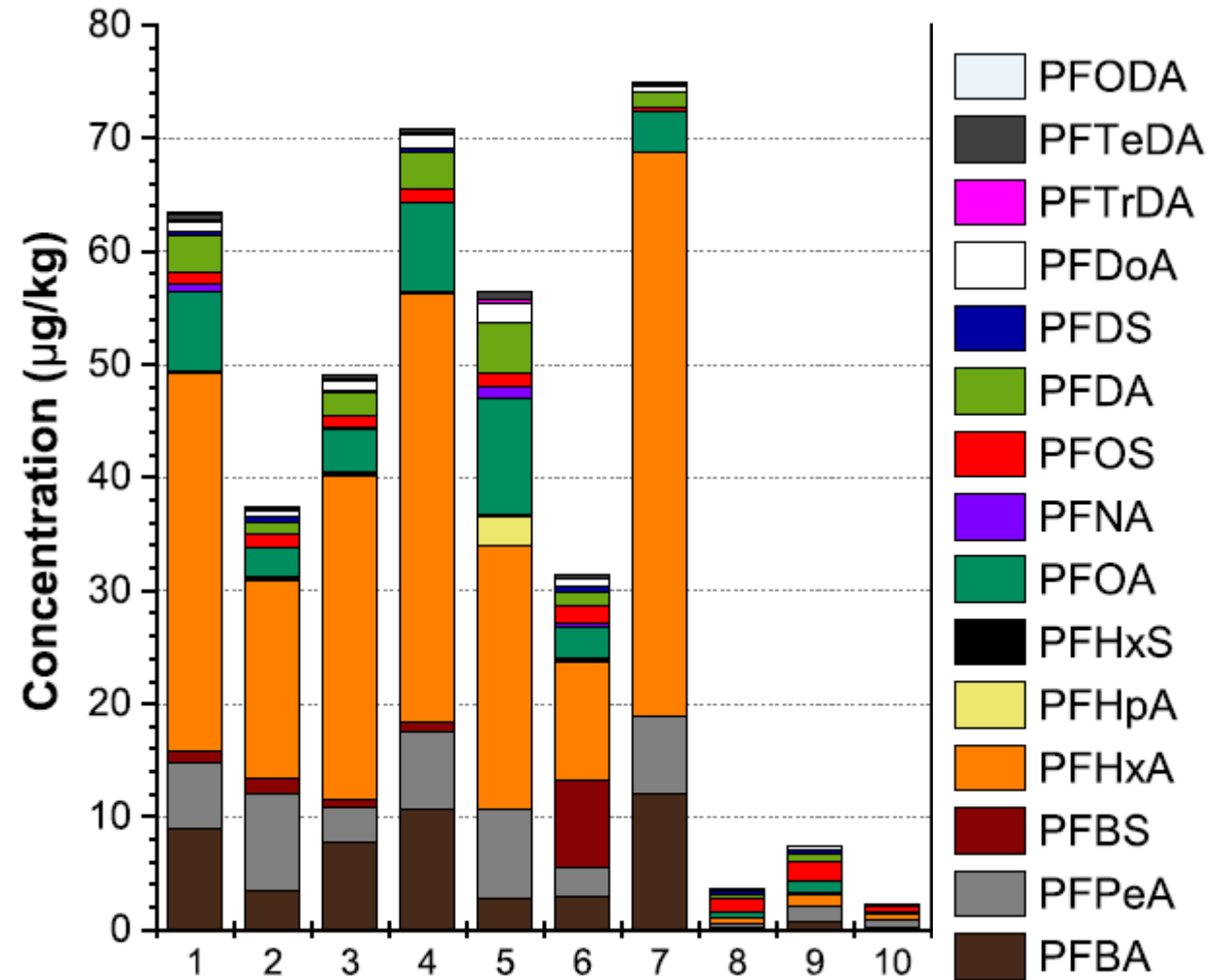


Research summarized by NEBRA on various compost and other products



Food Waste and Yard Waste Composts PFAS Concentrations

- 1-7 are commercial and residential food waste composts and allowed compostable food packaging
- 8 is leaves and grass compost
- 10 is leaf compost
- 9 is backyard compost bin with yard trimmings and food waste, no paper or packaging except unbleached coffee filters



Source Separated Organics Material (Food Contact Materials)

- MPCA PFAS Organics Recycling Report 2021

- Big Sources

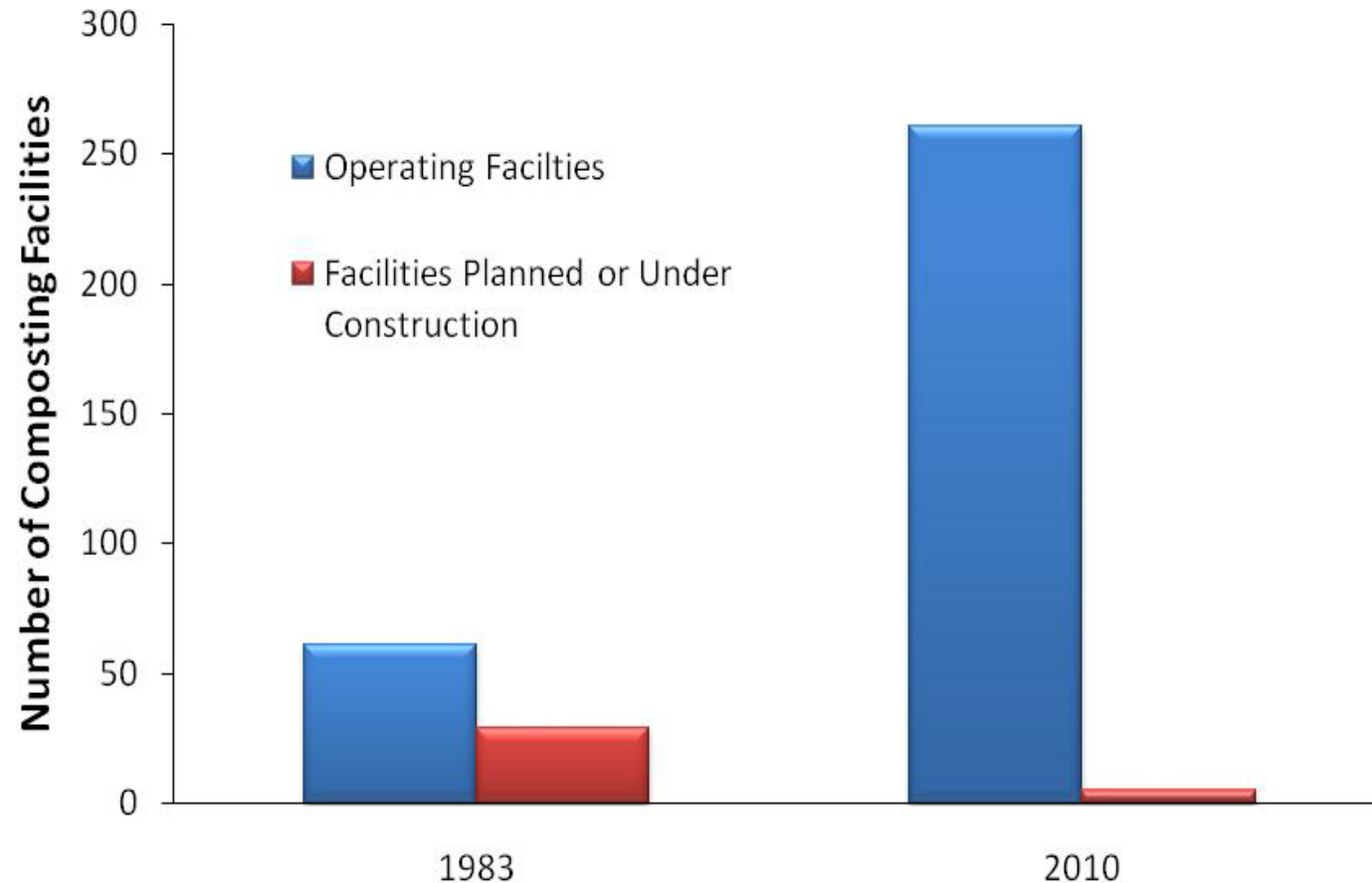
- Microwave Bags
- Paper Tableware
- Food Wrappers

- MPCA Approach

- Source Reduction

Analyte	Chain Length	aluminum foil bags/wrappers	Bakery paper/bags	Beverage cups	Food paper bag	Food Paper box	Food paper wrapper	Microwave bag	Milk bottle (plastic)	Paper tableware
(ppt)										
POLYFLUOROALKYL SUBSTANCES										
Fluorotelomer Alcohols										
18:2 FTOH	18	NA	ND	ND	ND	ND	NA	7500	NA	9700
16:2 FTOH	16	NA	ND	ND	ND	ND	NA	61000	NA	72000
14:2 FTOH	14	NA	ND	20	ND	190	NA	384000	NA	287000
12:2 FTOH	12	NA	ND	310	110	540	NA	5650000	NA	705000
10:2 FTOH	10	NA	ND	440	570	970	NA	6700000	NA	780000
8:2 FTOH	8	NA	ND	ND	830	800	NA	4810000	NA	1050000
6:2 FTOH	6	NA	NA	ND	ND	ND	NA	80000	NA	65000
Fluorotelomer Carboxylic Acids										
6:2 FTCA	6	NA	ND	ND	NA	ND	ND	161600	ND	NA
6:2 FTUCA	6	NA	ND	ND	NA	ND	ND	114400	ND	NA
5:3 FTCA	5	NA	ND	ND	NA	ND	ND	24600	ND	NA
Polyfluoroalkyl Phosphoric Acid Esters										
8:2 diPAP	8	NA	16900	13300	NA	15400	15000	12100	14300	NA
6:2 diPAP	6	NA	ND	ND	NA	2000	ND	ND	ND	NA
6:2PAP	6	NA	NA	NA	NA	NA	NA	NA	NA	NA
Polyfluoroalkane Sulfonamides										
FOSA	8	NA	NA	NA	NA	NA	NA	NA	NA	NA
PERFLUOROALKYL SUBSTANCES										
Perfluorocarboxylic Acids										
PFTeDA	14	ND	ND	ND	NA	ND	ND	ND	NA	NA
PFTrDA	13	ND	ND	ND	NA	ND	ND	ND	NA	NA
PFDoA	12	ND	ND	ND	NA	ND	19120	ND	NA	NA
PFUnDA	11	ND	ND	ND	NA	ND	ND	ND	NA	NA
PFDA	10	ND	ND	ND	NA	ND	28250	ND	ND	NA
PFNA	9	ND	ND	ND	NA	ND	4970	ND	NA	NA
PFOA	8	ND	ND	ND	NA	ND	ND	ND	ND	NA
PFHpA	7	ND	ND	ND	NA	ND	10020	5190	ND	NA
PFHxA	6	ND	ND	25560	NA	ND	19170	341210	ND	NA
PFPeA	5	ND	ND	ND	NA	ND	ND	20500	ND	NA
PFBA	4	ND	ND	ND	NA	ND	3190	291000	ND	NA
Perfluorosulfonic Acids										
PFDS	10	ND	ND	ND	NA	ND	ND	ND	NA	NA
PFOS	8	ND	ND	ND	NA	ND	ND	ND	NA	NA
PFHxS	6	ND	ND	ND	NA	ND	ND	ND	NA	NA
PFBS	4	ND	ND	ND	NA	ND	ND	ND	NA	NA

Increasing Trends in Biosolids Composting in the US



Data Source: Beecher and Goldstein, 2010; BioCycle

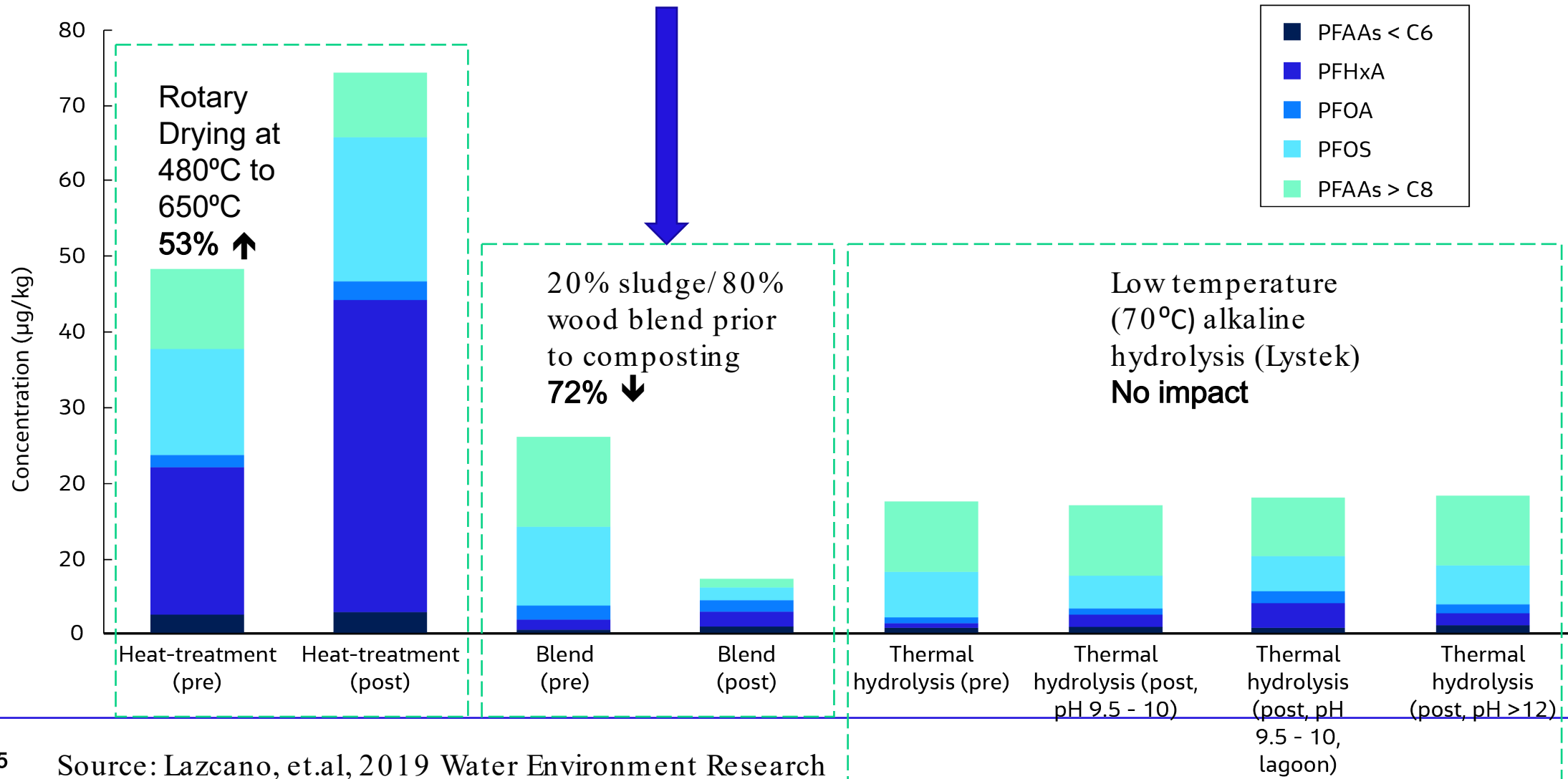
- Biosolids composting practiced in 44 States, Canada and Puerto Rico for the past 30+ years

- Today over 4 million tons of dewatered biosolids composted annually

- Production of over 10 million cubic yards of salable compost product

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

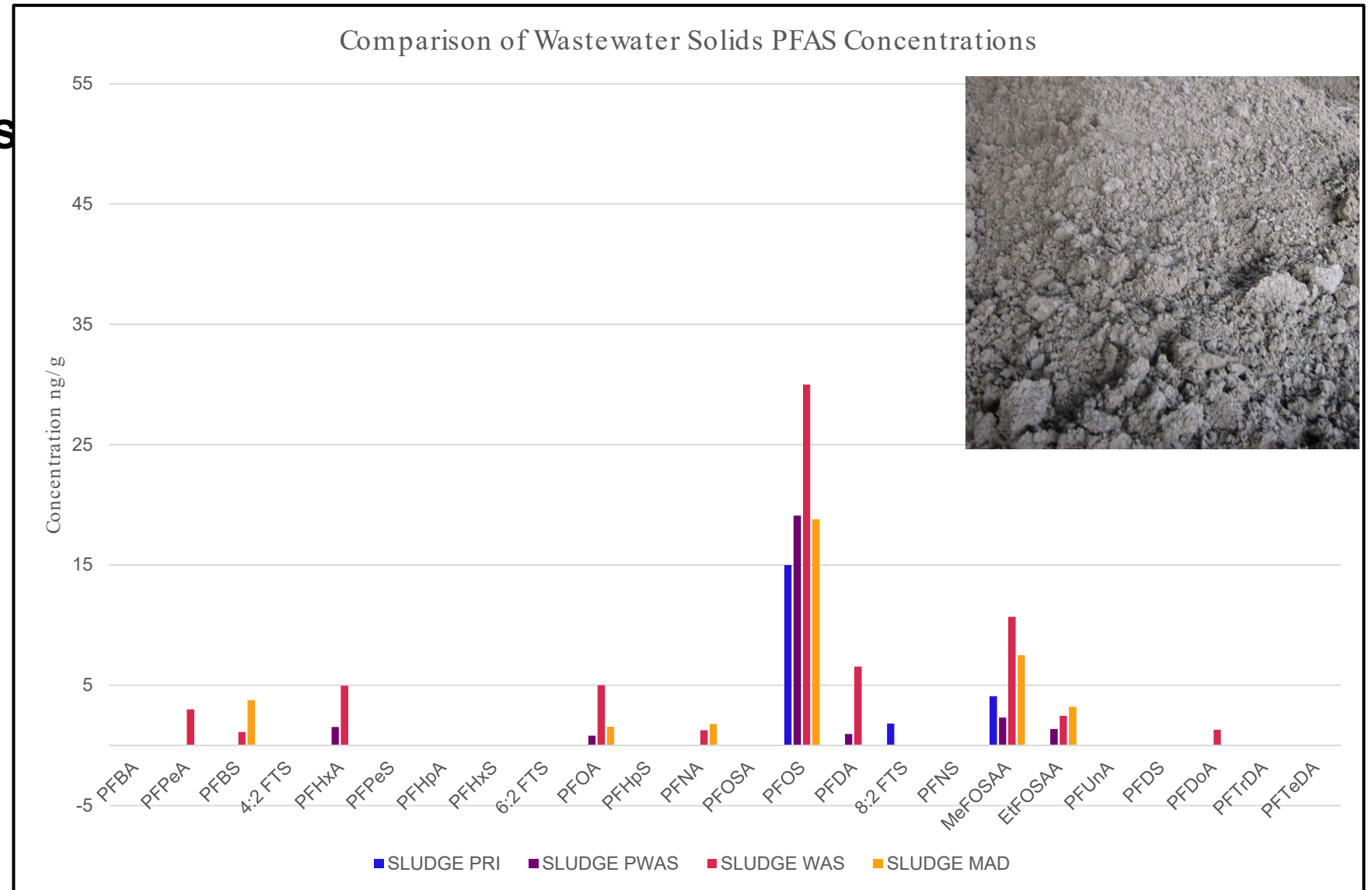


Composting Wastewater Solids and its Impact on PFAS Concentrations

- Jacobs conducted sampling and testing of several biosolids composts in 2020 for analysis of 24 PFAS compounds using isotope dilution/LGMS/MS method compliant with Table B-15 of Department of Defense Quality Systems Manual 5.3
- 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)
 - Conventional secondary treatment with nutrient removal, mixture of primary and waste activated sludge (PWAS)
 - Conventional secondary treatment with nutrient removal, waste activated sludge only (WAS)
 - Conventional secondary treatment, mixture of primary and waste activated sludge, then mesophilic anaerobic digestion (MAD)
- All operations sampled utilized the aerated static pile method of composting
- Expectation was that bulking agent dilution effect would reduce concentrations of PFAS in compost compared to input solids. But, what about biotransformation?

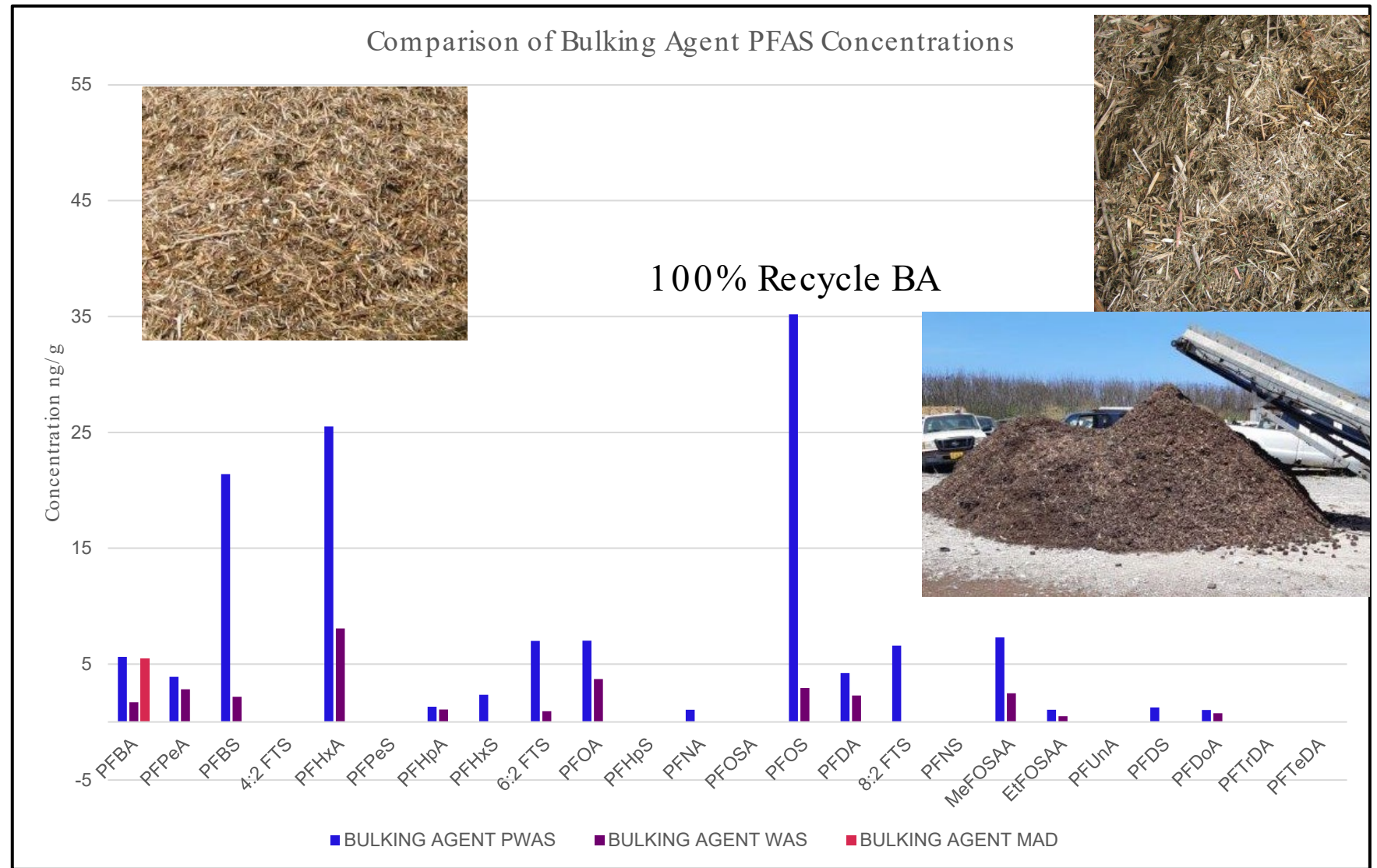
PFAS Concentrations in WWTP Solids Cakes (ng/g dry)

- In general, concentrations in WW solids are not high
- PFOS and MeFOSAA are 2 largest components in WW solids
- MeFOSAA typically degrades to PFOS



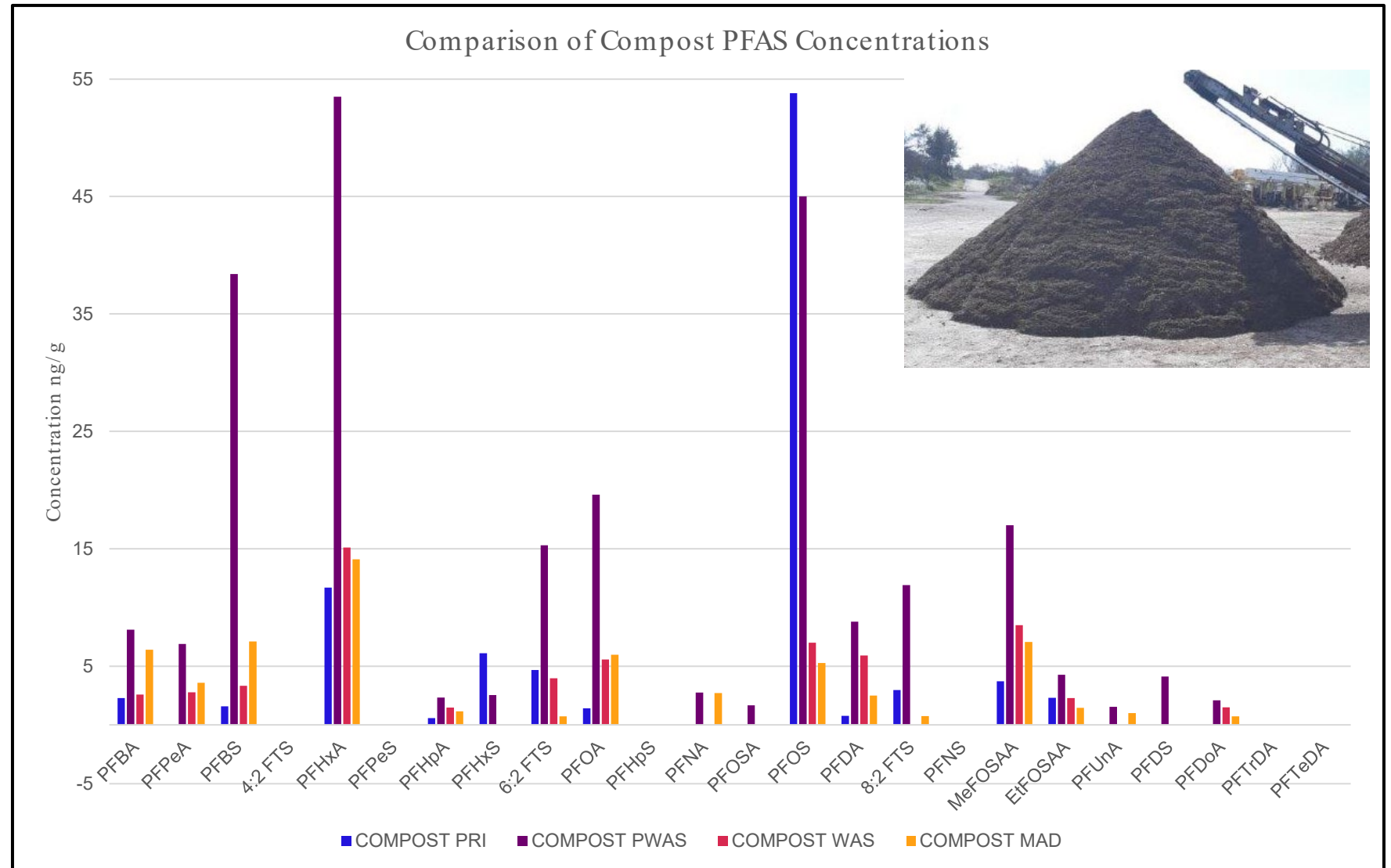
PFAS Concentrations in Bulking Agents (ng/g dry)

- Bulking agents used included wood chips, ground pallets, ground yard waste and recycled screen overs
- Most bulking agent concentrations are very low
- Recycling 100% bulking agent may increase PFAS concentration

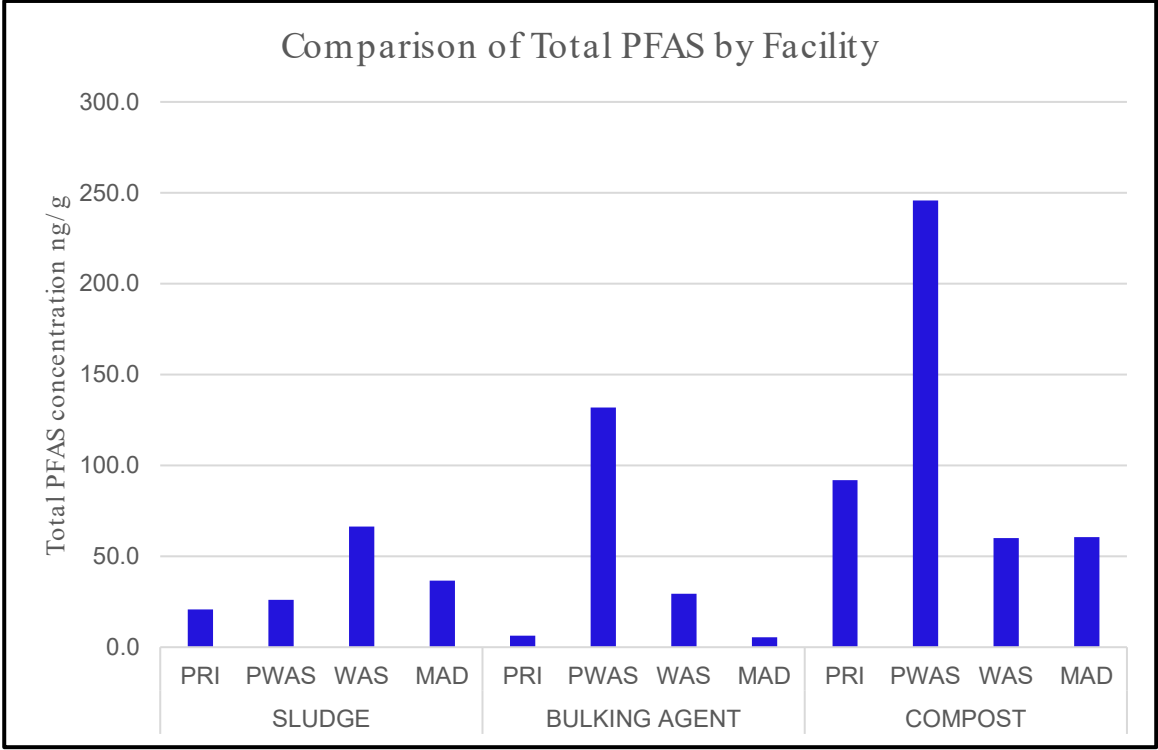
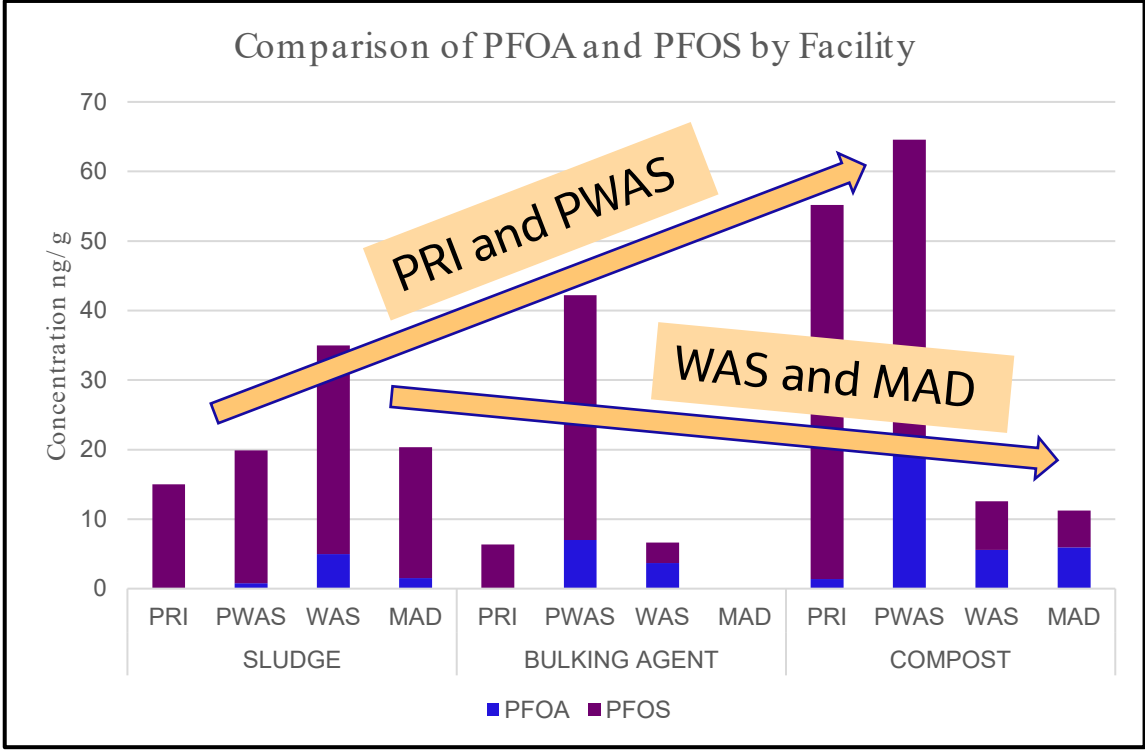


PFAS Concentrations in Composts (ng/g dry)

- PFOS, PFOA, PFHxA, PFBS and MeFOSAA are largest components in composts



PFOA, PFOS and Total PFAS by Facility



Appears to be more precursor transformation of primary solids vs. waste activated solids or digested solids

WWTP Solids Composting Summary Points

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

Where do we go from here?

- Further study on the role of precursors in PFAS assessment in composting
- Evaluate impacts of SSO or WW Solids properties on PFAS transformations in composting
- Test the leachability of PFAS in compost amended soils
- Testing of compost products for plant uptake of PFAS
- Continue sampling and testing more composts from various feedstocks and composting processes

Composting Impacts on PFAS

Thank You!

Todd O. Williams, P.EBCEE

todd.williams3@jacobs.com



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Reinventing tomorrow.

