

Motivation

Per- and polyfluoroalkyl substances (PFAS) Issues to Address:

- Biosolids are used for land application to enhance soil health
- Biosolids represent an underexplored source of PFAS

What are current remediation technologies?

- Soil washing, smoldering, ball milling
- Use activated carbon → low anion-exchange capacity (AEC), expensive

Biochar as an alternative....

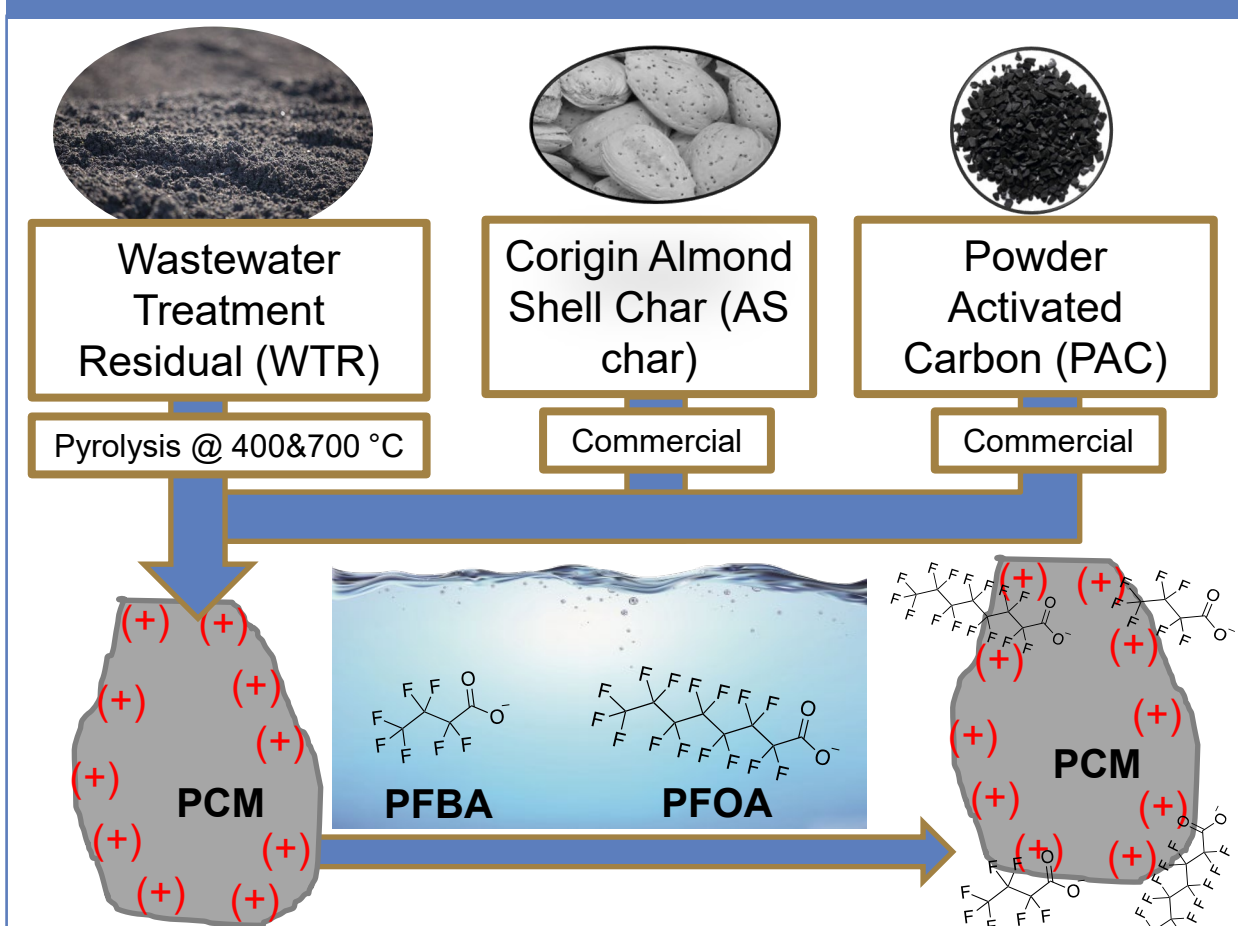
- Fine grained, black charcoal-like material
- High affinity toward contaminants
- Derived from wastes (e.g., biomass of water treatment residuals)
- Produced by pyrolysis (combustion in the absence of oxygen)

The goal of this study is to...

- Increase electrostatic interactions between AEC-enhanced biochar and negatively charged PFAS
- Prevent PFAS from leaching from biosolid-amended soil
- Produce results competitive with commercial products

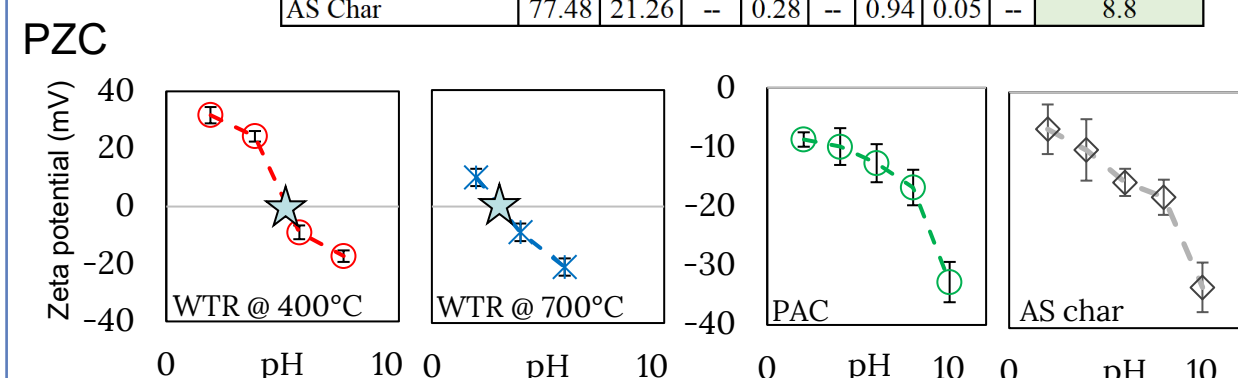


Methodology



Characterization

Elemental Analysis	Sample Name	wt% of Element from SEM/EDS Analysis							Surface Area (m ² /g)
		C	O	Al	Si	Fe	K	Ca	
	WTR Pyr. @ 400°C	34.2	51.0	10.4	3.9	0.6	--	--	258.7
	WTR Pyr. @ 700°C	31.3	54.1	9.7	4.1	0.4	--	--	202.0
	PAC	85.07	14.59	--	0.34	--	--	--	1700.0
	AS Char	77.48	21.26	--	0.28	--	0.94	0.05	8.8



Results

1. Batch Adsorption Kinetics

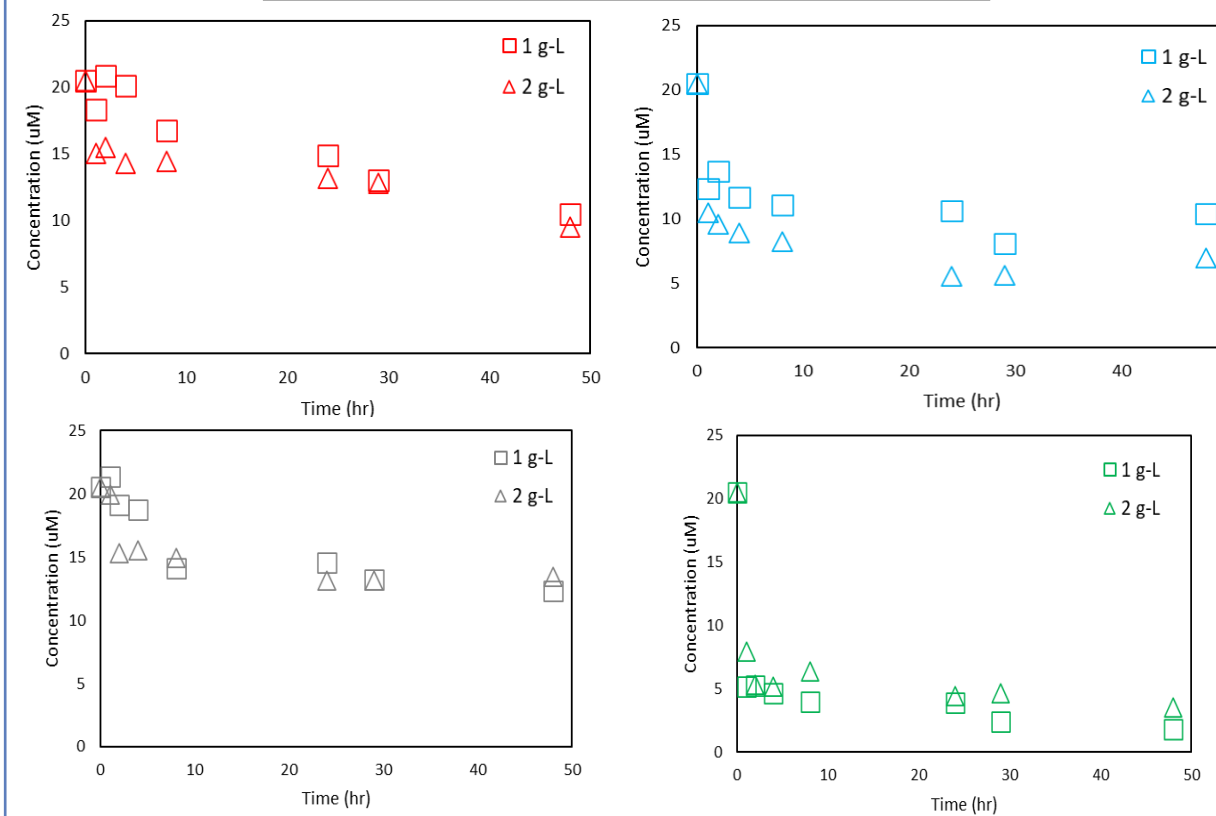
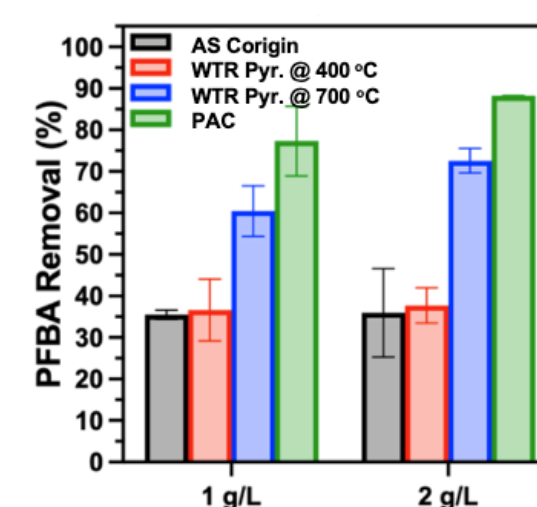


Figure 1. PFBA adsorption kinetics with 1 and 2 g/L char over 48 h.

- All powders reached equilibrium within 10 h
- No significant differences between the two solid-to-liquid ratios
- Adsorption sites not limiting factor
- WTR Pyr. @ 700°C showed comparable PFBA removal to PAC



2. Batch Adsorption Isotherms

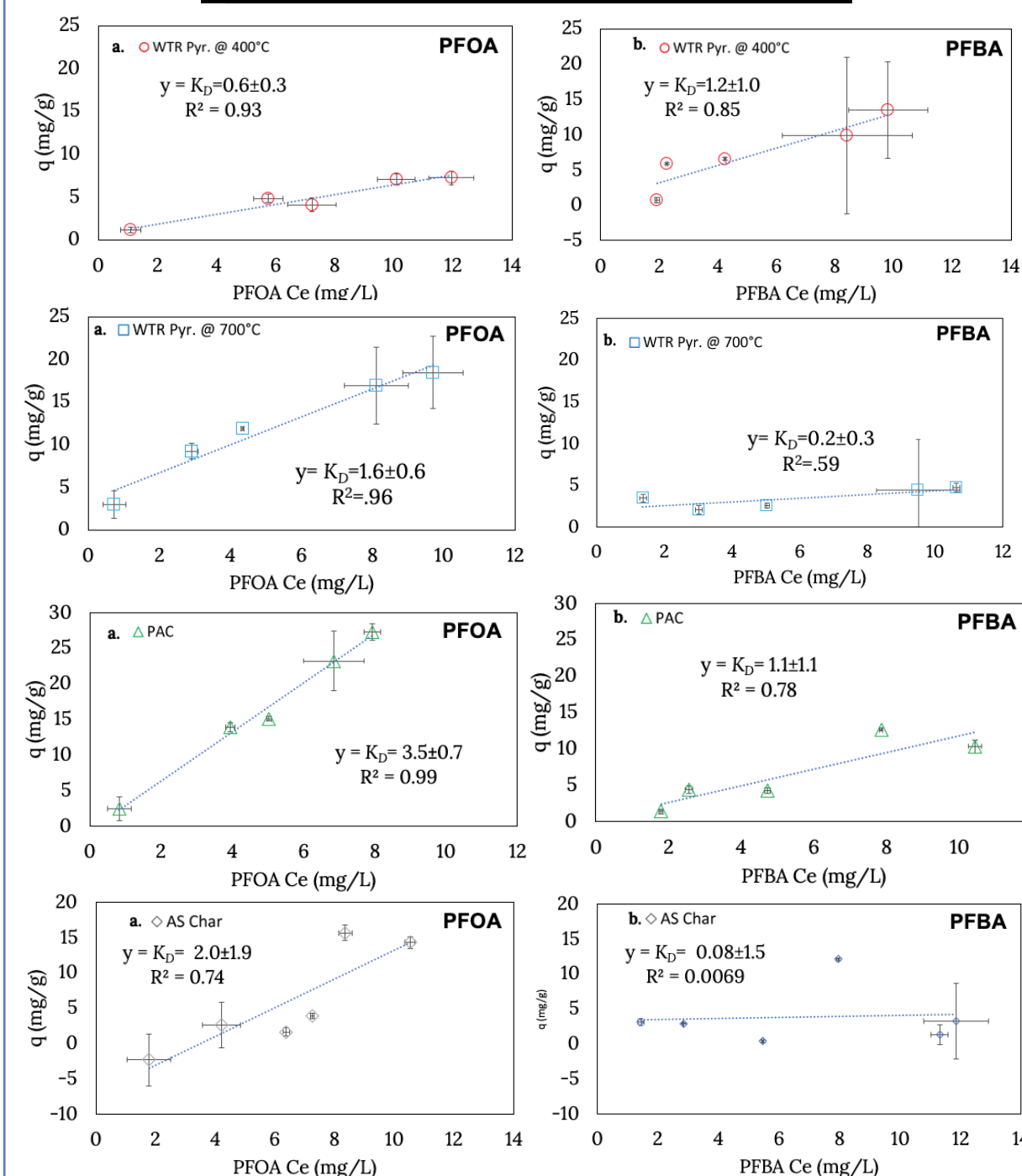


Figure 2. PFOA and PFBA adsorption isotherms with 0.2 g/L char after 24 h.

- Greater sorption capacity for PFOA compared to PFBA; attributed to the differences in chain length
- PFOA adsorption: WTR 700°C > WTR 400°C

Results

3. Lysimeter Testing

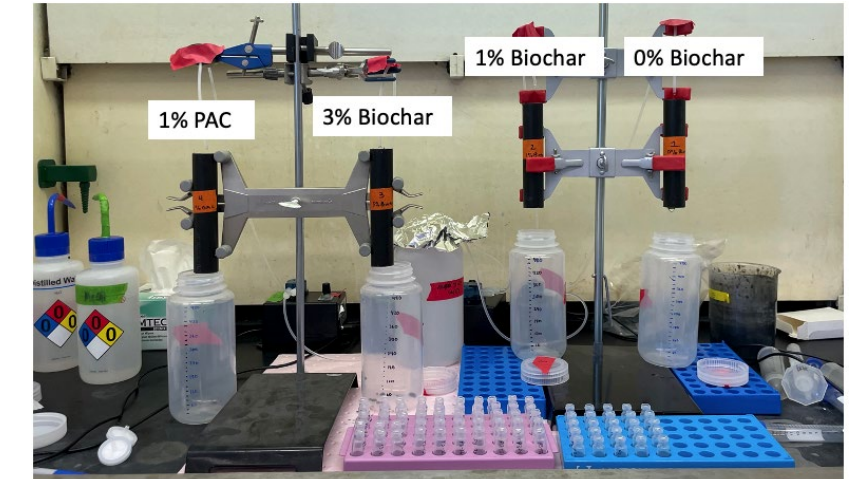


Figure 3. Lysimeter setup.

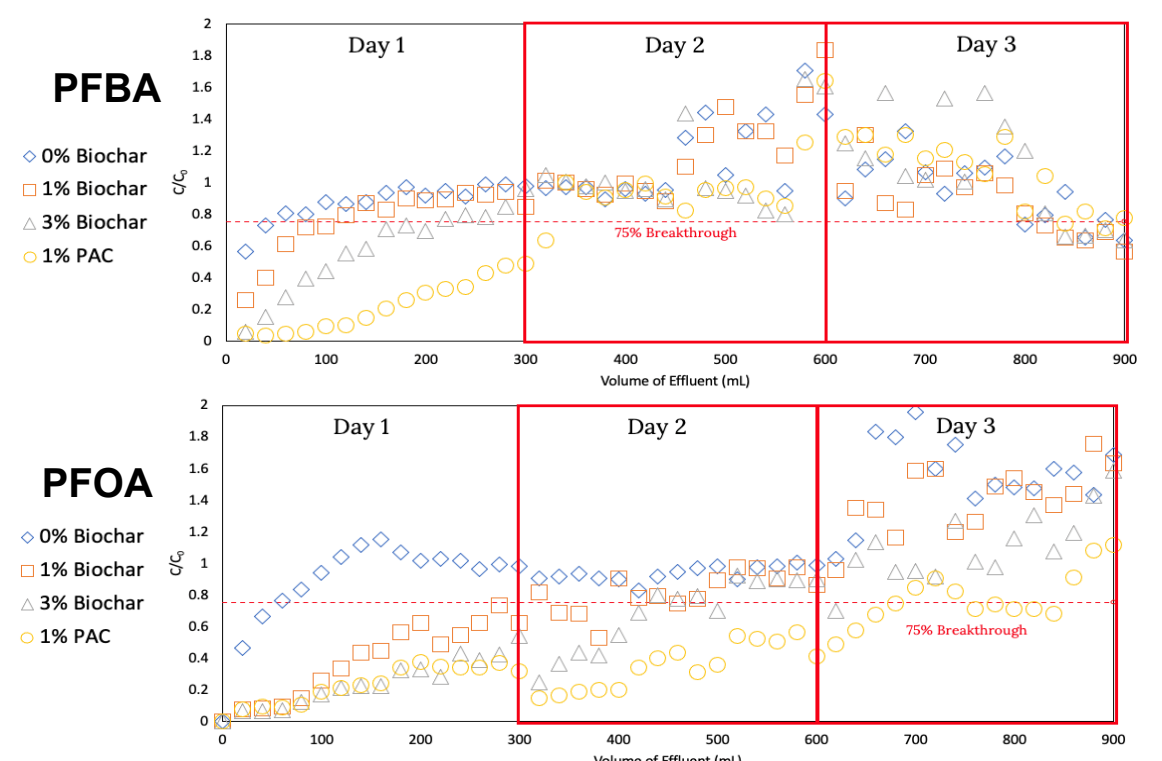


Figure 3. PFBA and PFOA breakthrough curves.

- PFBA breakthrough is delayed following the trend: 1% PAC > 3% Biochar > 1% Biochar
- PFOA breakthrough is delayed following the trend: 1% PAC = 3% Biochar > 1% Biochar
- PFAS leaching on Day 2 and 3

Future Work

- Environmental and Economic impact will be evaluated by Life cycle assessment (LCA) and Technoeconomic analysis (TEA)
- Python (version 5) with the ecoinvent database will be performed for system designed simulation, sustainability characterization and uncertainty and sensitivity analysis.
- Economic analysis will also be conducted to calculate capital, operation, and electricity expenses.



Flow Chart of Life Cycle Analysis

