

A Survey of Biochars

Interactions with Dissolved Ammonium, Nitrate, and Phosphate

Ed Colosky, Kurt Spokas
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Biochar, why study it?

Agriculture



Engineered Applications

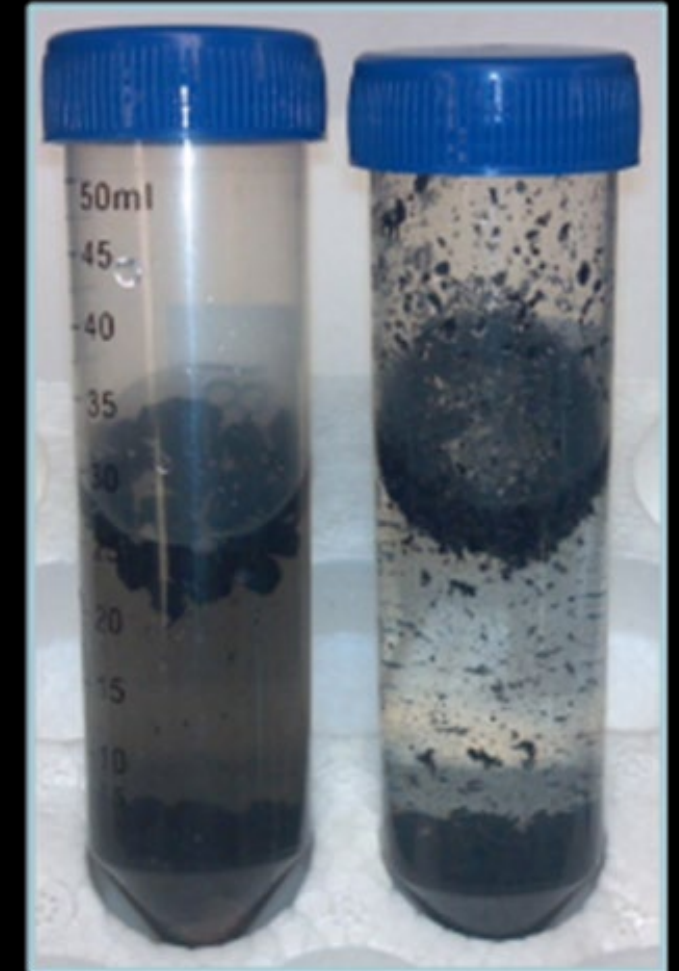
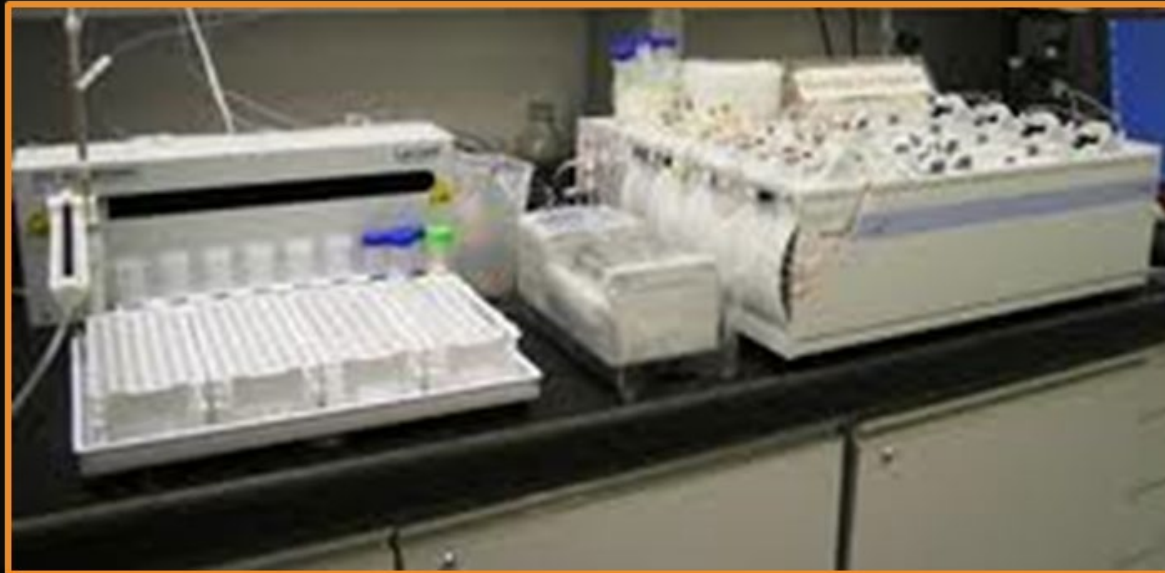


Why a Survey?

- No consensus on BC production or use
- Provides method for examining mechanism of nutrient interactions

Experimental Method

- Batch equilibrium:
 - Global collection of biochars (42 total)
 - 20ppm NH_4^+ , 20 ppm NO_3^- , and 2ppm PO_4^-
 - Triplicate replicates
 - 24 hours agitation (shaker)



Results of 42 BCs (% Sorbtion)

$$\% \text{ Sorbtion} = \frac{\text{Start Conc.} - \text{End Conc.}}{\text{Start Conc.}} * 100\%$$

Summary Statistics	% Ammonia Sorbtion	% Nitrate Sorbtion	% Phosphate Sorbtion
Max	101%	98%	100%
3rd Quartile	56%	15%	39%
Mean	38%	13%	22%
Median	34%	10%	15%
1st Quartile	25%	4%	3%
Min	-8%	-24%	-196%



Biochar Characterization Method

Recorded:

Temperature of Biochar Production

pH

Ultimate and Proximate Analysis

Carbon Content

Nitrogen Content

Oxygen Content

Hydrogen Content

Sulfur Content

Ash Content

% Moisture (As Received)

% Volatile Organics

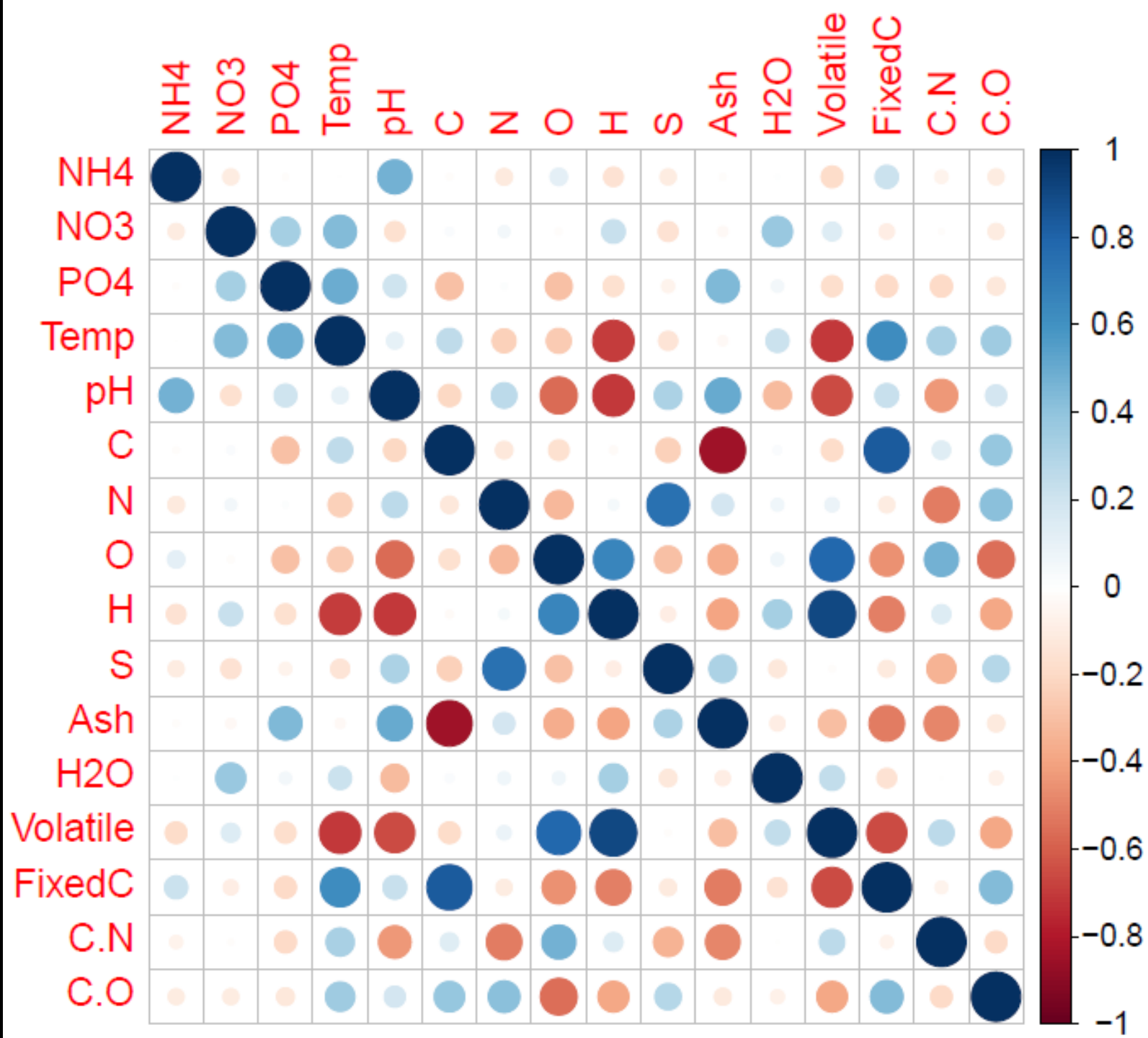
Fixed Carbon

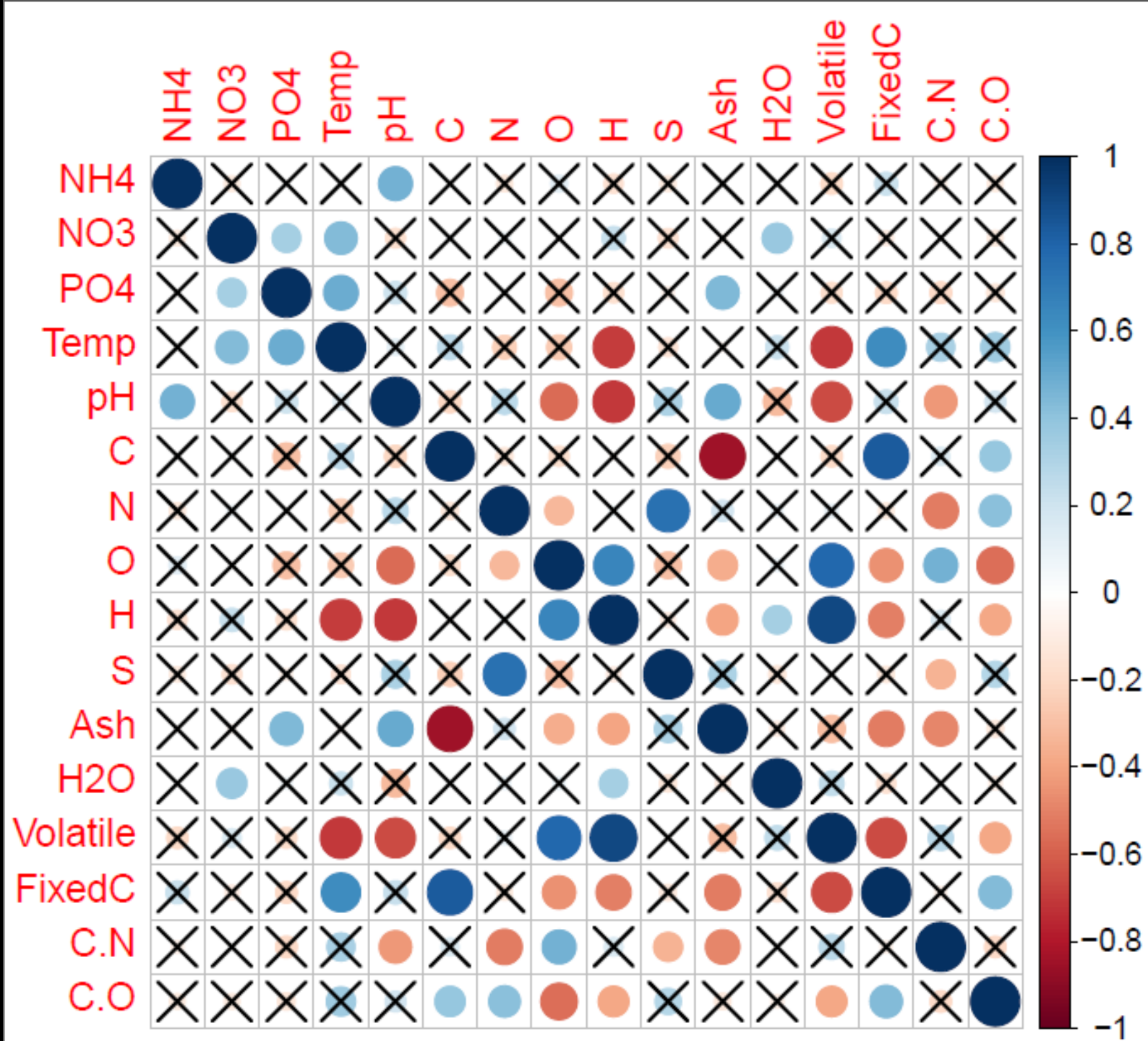


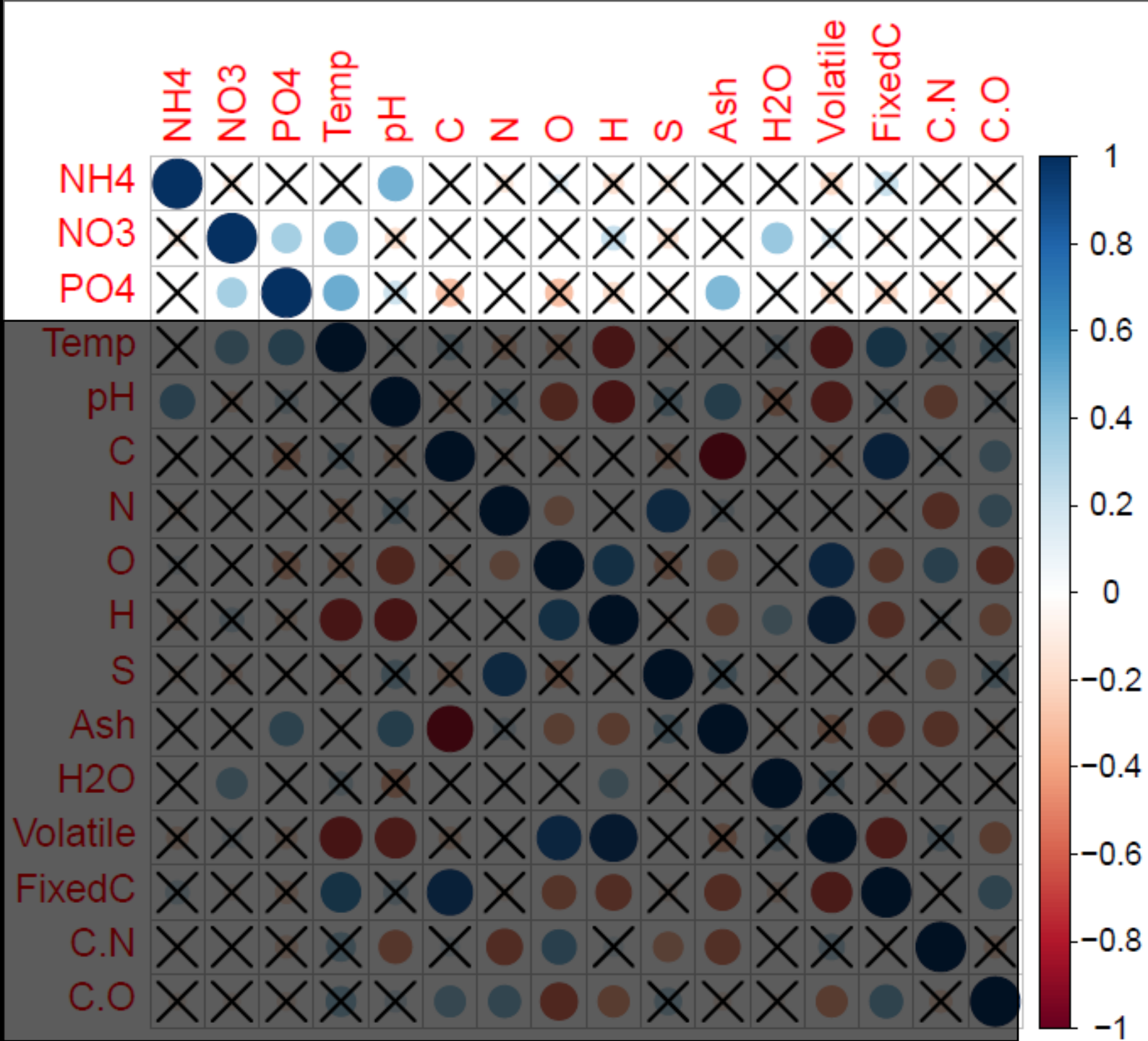
Statistical Analysis



Pairwise Correlational Analysis







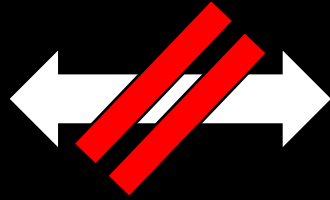
So what did we find out?

Property

Correlation

Results/Hypothesis

Sorbtion



Biochar properties

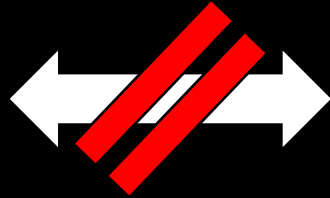
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Property

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Biochar properties

NH4 sorbtion







pH (0.47 r^2) – Surface Chemistry? Volatilization?

So what did we find out?

Property	Correlation	Results/Hypothesis
Sorbtion		Biochar properties
NH4 sorbtion		pH (0.47 r ²) – Surface Chemistry? Volatilization?
NO3 sorbtion		Temp (0.43 r ²), % Moisture (0.37 r ²) – Aromatic Struc? H2O interaction?

So what did we find out?

Property	Correlation	Results/Hypothesis
Sorbtion		Biochar properties
NH4 sorbtion		pH (0.47 r ²) – Surface Chemistry? Volatilization?
NO3 sorbtion		Temp (0.43 r ²), % Moisture (0.37 r ²) – Aromatic Struc? H2O interaction?
PO4 sorbtion		Temp(0.49 r ²), Ash (0.45 r ²) – PO4 precipitation?

What does it mean?

For Nitrogen:

Carbon backbone not a primary factor for BC interaction

pH, Temp, H₂O - more environmental factors than BC properties

What does it mean?

For Nitrogen:

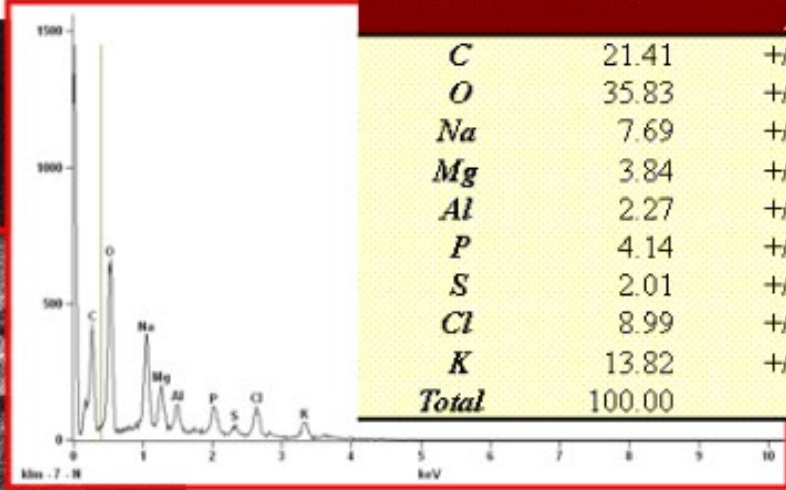
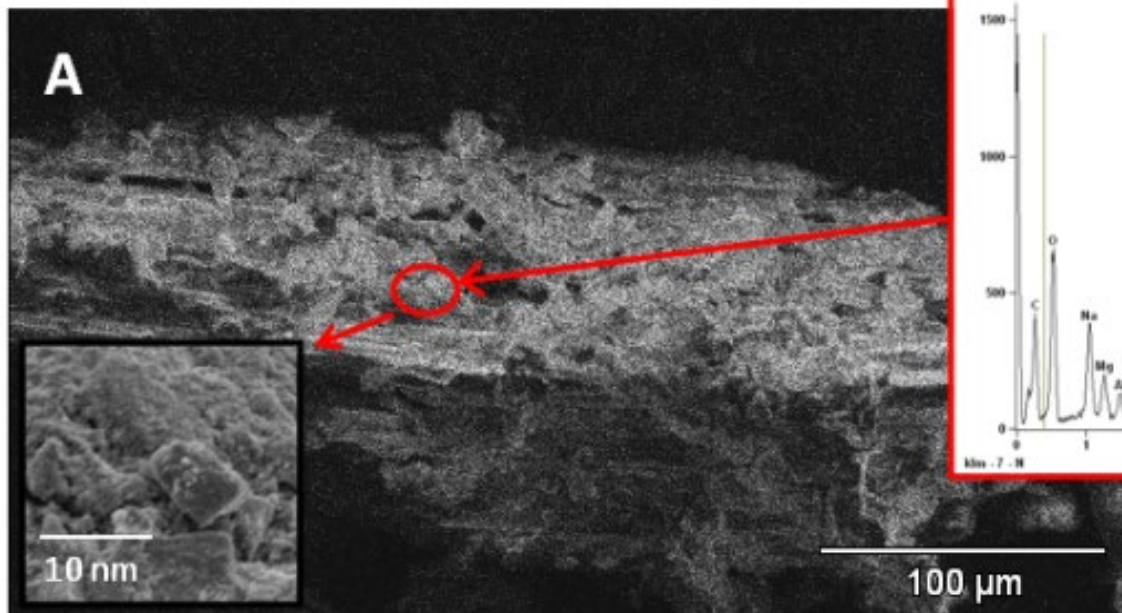
Carbon backbone not a primary factor for BC interaction

pH, Temp, H₂O - more environmental factors than BC properties

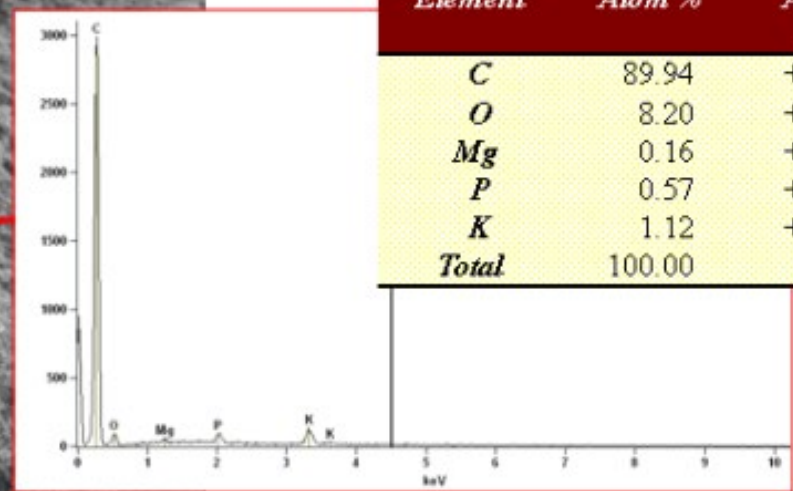
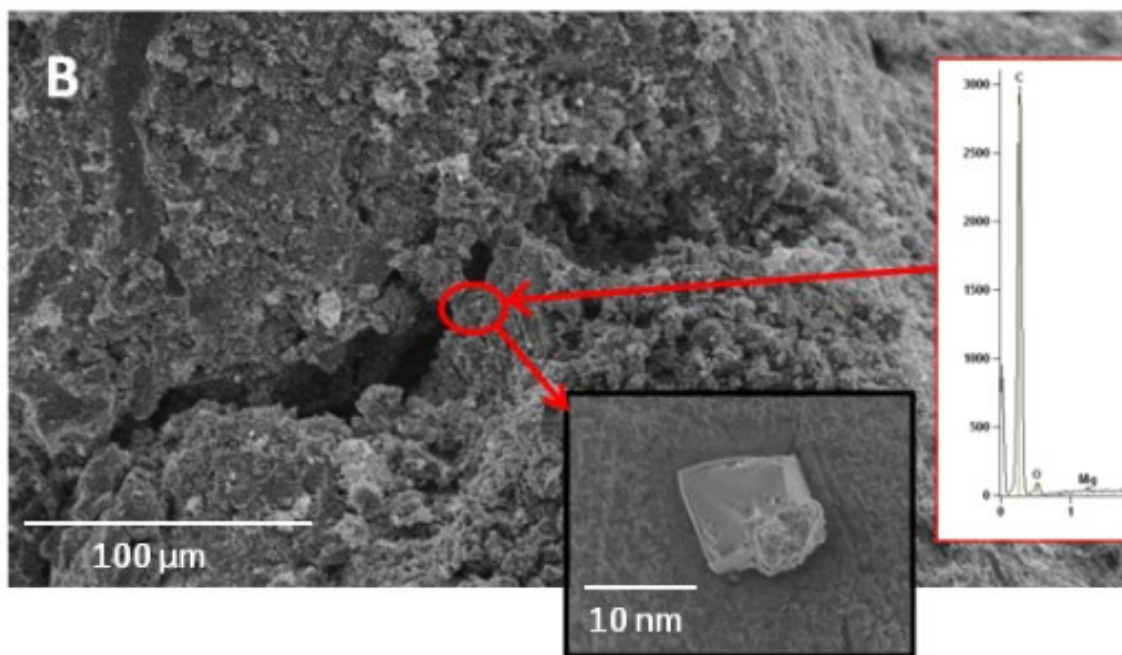
For Phosphorous:

Already know P precipitates in soln with metal cations

PO₄~Ash content may support concept



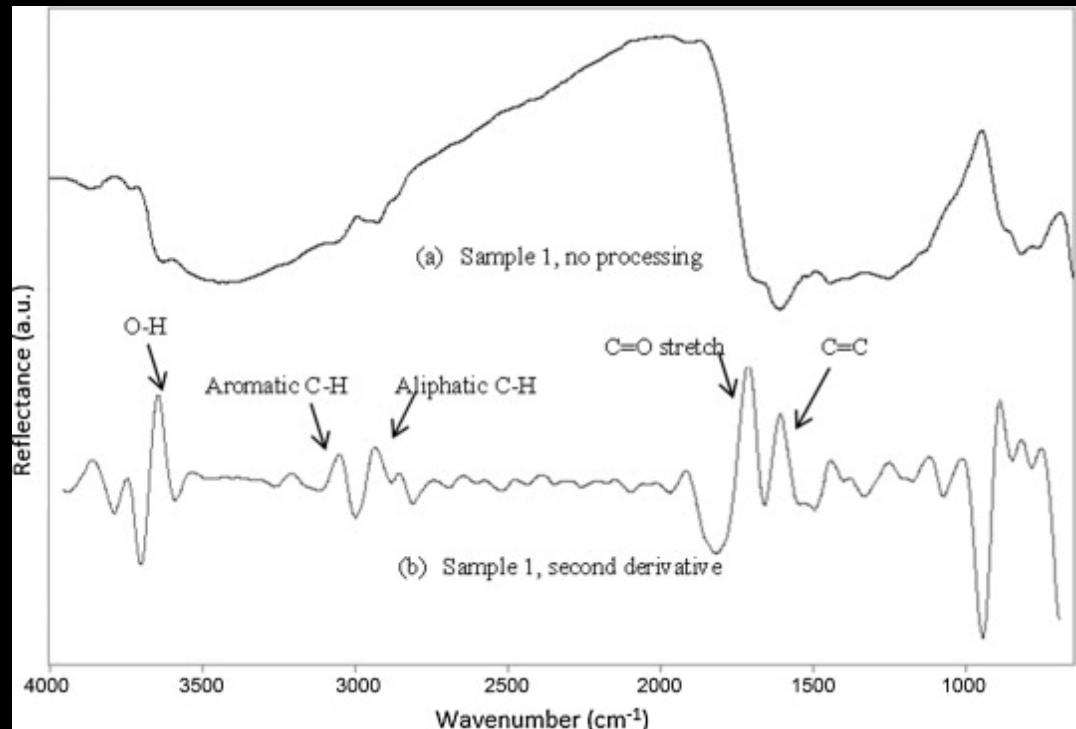
<i>Element</i>	<i>Atom %</i>	<i>Atom % Error</i>
<i>C</i>	21.41	+/- 0.70
<i>O</i>	35.83	+/- 0.47
<i>Na</i>	7.69	+/- 0.23
<i>Mg</i>	3.84	+/- 0.22
<i>Al</i>	2.27	+/- 0.12
<i>P</i>	4.14	+/- 0.16
<i>S</i>	2.01	+/- 0.18
<i>Cl</i>	8.99	+/- 0.30
<i>K</i>	13.82	+/- 0.58
Total	100.00	



<i>Element</i>	<i>Atom %</i>	<i>Atom % Error</i>
<i>C</i>	89.94	+/- 0.63
<i>O</i>	8.20	+/- 0.42
<i>Mg</i>	0.16	+/- 0.02
<i>P</i>	0.57	+/- 0.04
<i>K</i>	1.12	+/- 0.04
Total	100.00	

Future Work

- Surface Area Analysis
- Metal Content Analysis (Ca, Mg)
- pH adjusted sorption experiments (5-8)
- Surficial Chemistry Analysis (FTIR)
- Analysis of the state of sorbed N & P



Conclusion

- Carbon backbone not a primary factor for BC sorbtion interactions
- Environmental factors may play a stronger role than BC properties
- Future work will include examining the surface chemistry and characterizing the state of sorbed N and P

Thank You

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