Biochar amendments influence the microbial community in mine soils

BIOCHars Agricultural Research Service

Viola Manning and Claire Phillips, ARS, Corvallis, OR
Kate Hall, UMN, St. Paul MN
Hannah Rushmiller, Tillman Meyers, E. Brooke Hayword and Don Watts, ARS, Florence, SC

Amending metal contaminated soil with biochar to facilitate soil remediation through phytostabilization

USDA

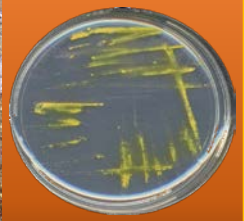
United States Environmental Protection Agency

Kristin Trippe, ARS, Corvallis, OR
Kurt Spokas, ARS, St. Paul MN
Mark G. Johnson, EPA , Corvallis, OR
Jim Ippolito, Colorado State University, Ft. Collins, CO
Jeff Novak, Gilbert Sigua, and Tom Ducey, ARS, Florence, SC

Amending metal contaminated soil with biochar to facilitate soil remediation through phytostabilization

- 30,000 mines in the western US
- 12,000 miles of rivers and streams and 180,000 acres of lakes and reservoirs are adversely affected by contaminated water draining from abandoned mines
- Low pH and concentrated metals, typically with little or no organic matter
- Very few pathways to remediate mines and mine tailings

Microbial communities at abandoned mine lands are dominated by autotrophic bacteria that interact with the mineralogy and perpetuate acidic soil conditions.



Abiotic : $FeS_2 + H_2O + 3.5O_2 \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+$

Biotic: $14 \quad + 3.5O_2 + 14H^+ \rightarrow 14Fe^{3+} + 7H_2O$

Abiotic : $FeS_2 + H_2O +$ $\rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$

Sulfuric acid decreases soil pH creating favorable conditions for acidophiles which drive the abiotic reactions that create sulfuric acid.

As pH decreases other metals are dissolved into the water, creating a toxic mileau that threatens ecosystems.

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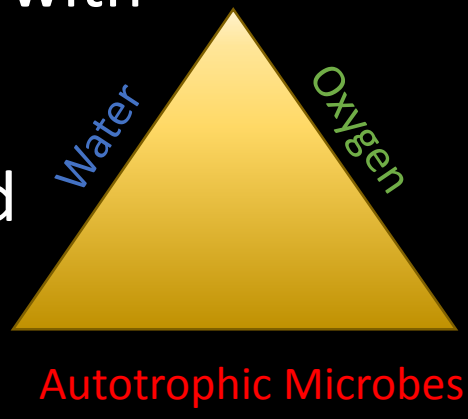
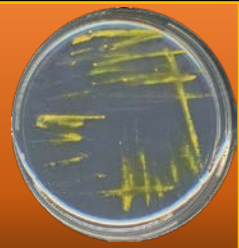


Phytostabilization of the Formosa Mine in Southern Oregon

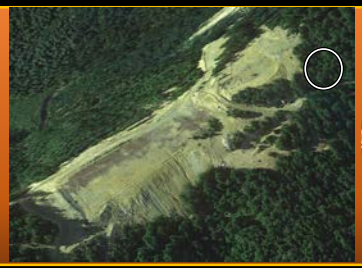


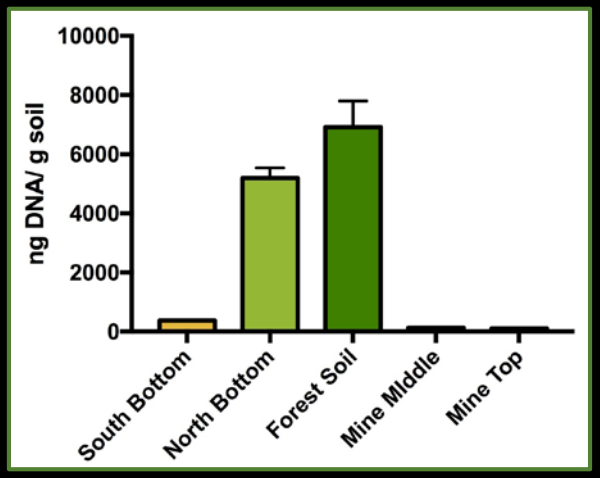
76-acre site historically mined for Cu and Zn from 1926-1937 and 1990-1993

Diversion system failed in 1997, killing all aquatic life in Middle Creek

Strongly acidic drainage that contains levels of metals which exceeds acceptable standards by several orders of magnitude

Status of the microbial community at the Formosa mine





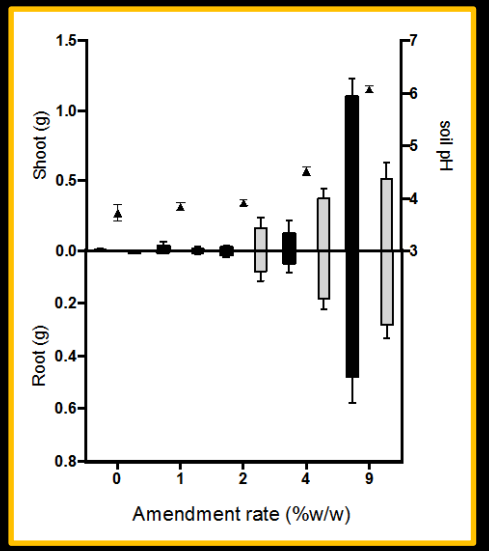
Can biochar improve infiltration, pH, soil structure, to encourage plant growth and increase microbial diversity?

Can biochar amendments promote phytostabilization?

Biochar amendments made from wood or seed screenings facilitate the growth of wheat in mine tailings from the Formosa Mine

What is the mechanism that confers this ability?

Does the carbon from the roots and the biochar support a heterotrophic microbial community?



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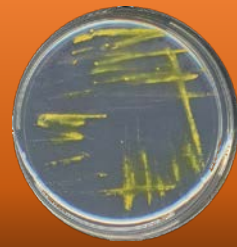
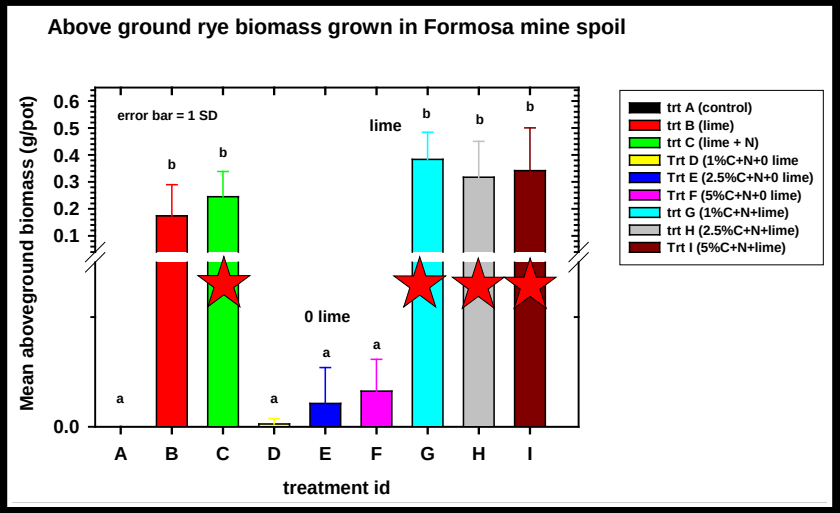
Formosa Soils Experimental Design



Goal: Can biochar amendments support the growth of native plant species in Formosa mine tailings?

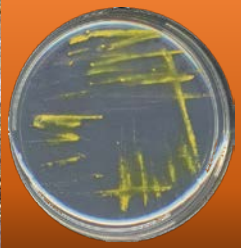
Biochar was produced at 700°C from miscanthus

4 treatments:
Mine soil + lime + N
Mine soil + lime + N + biochar (3 rates: 1%, 2.5%, 5% w/w)



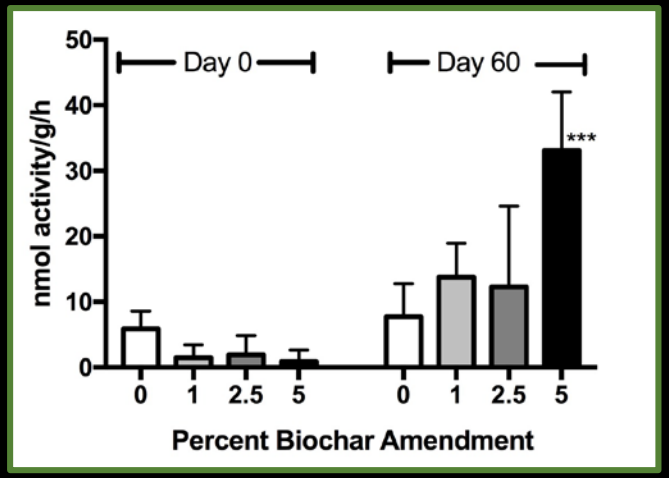
Ash (%)	18.57
Sulfur (%)	<0.001
Carbon (%)	76.73
Hydrogen (%)	1.39
Nitrogen (%)	0.3
Oxygen (%)	3.0
H/C ratio	0.21
O/C ratio	0.03

Does biochar increase microbial populations?

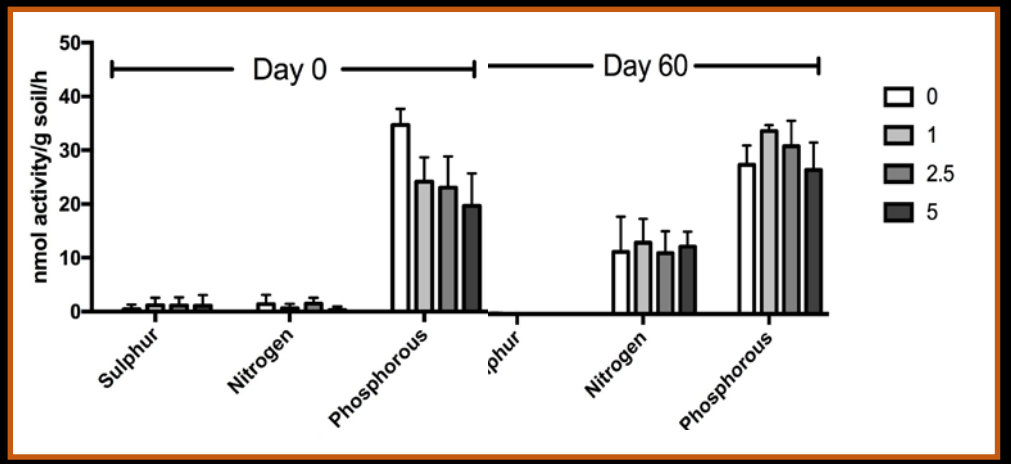


Two measures: Enzyme activity and DNA concentrations

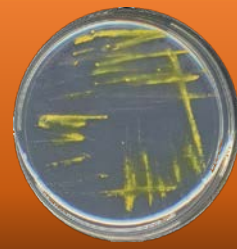
Carbon cycling enzymes (B-glucosidase)

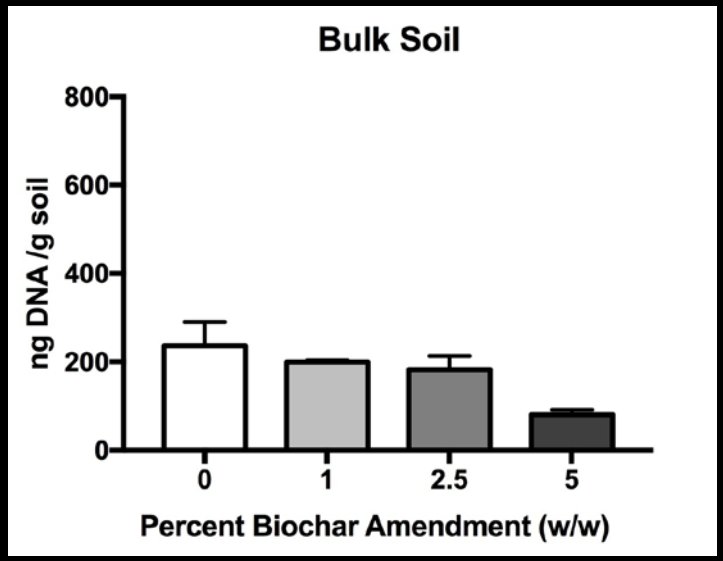


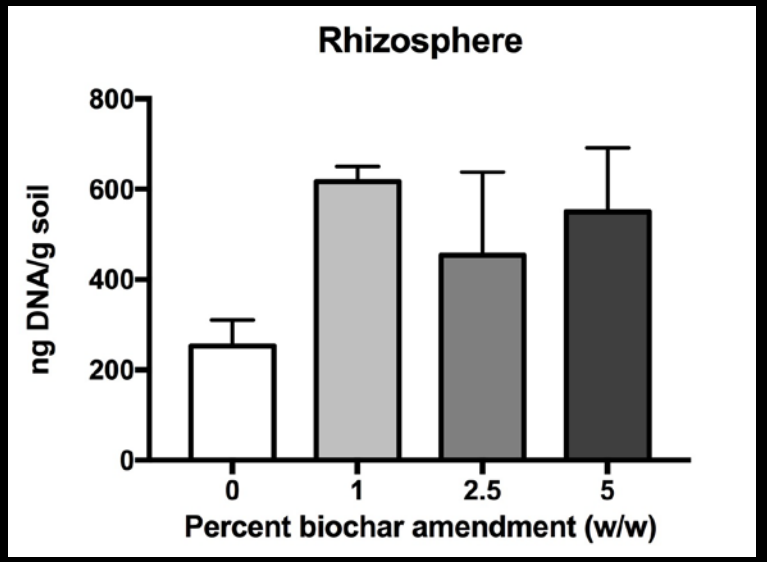
Mineralization enzymes
Arylsulphatase (S)
Phosphatase (P)
N-acetyl-glucosaminidase (N)



Does biochar increase microbial populations?

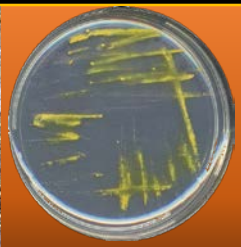






These values are still significantly below total DNA from our reference soil

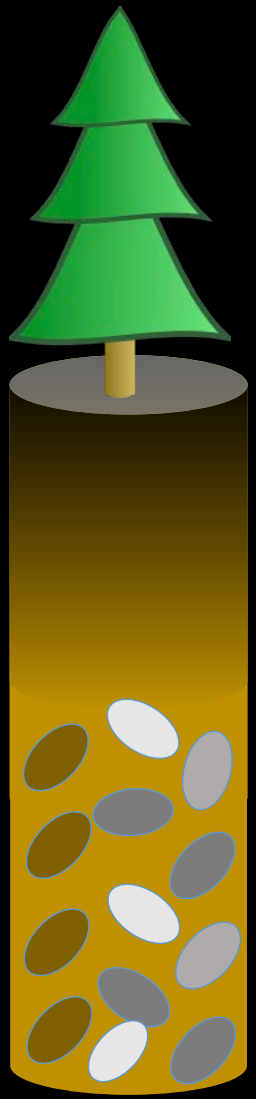
Future directions



Can we inoculate biochar with locally effective microbes?

Resolve data with DDPCR and NGS techniques to determine community level changes

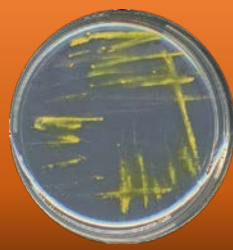
MICROBES → CHAR SOIL MIX



Field experiments at the Formosa mine

Consolidated

Conclusions



Biochar helps establish plant growth in mine-impacted soils

Biochar amended soils have more carbon degrading enzymes

Biochar amended soils have more extractable DNA within the rhizosphere

These results are promising, but will be enhanced with direct inoculation

QUESTIONS?