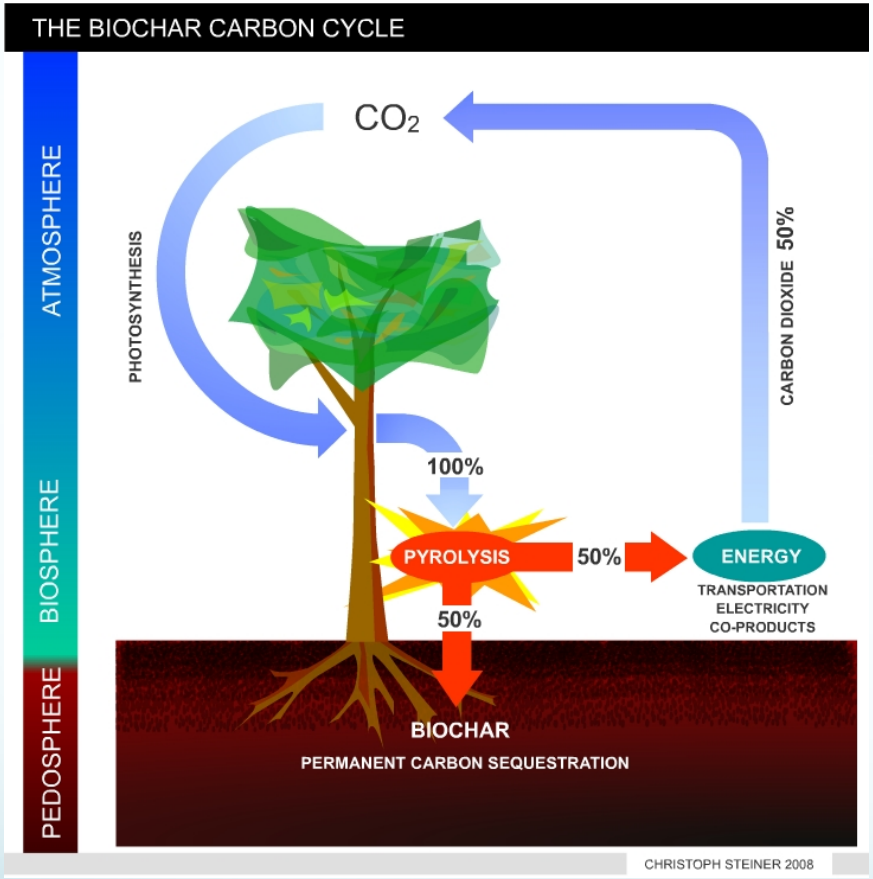
The Effect of Biochar on Heavy Metal Sorption:

Nickel, Copper, Lead, and Cadmium

Allie Jefferson
2010 Kearney Undergraduate Fellowship Report
Department of Land, Air and Water Resources
The University of California, Davis

What is Biochar?



Biochar is a form of charcoal produced by the pyrolysis of biomass.

Biochar is a biproduct in the production of biofuels

Background

- Studies suggest biochar application to soils:
  - improve crop production
  - Increase carbon sequestration and reduce greenhouse gases
- Preliminary data collected in the Parikh Lab show high sorption capacity of DOC from water to walnut shell biochar, while wood feedstock biochar shows low sorption capacity.
- Previous studies show decrease of heavy metals with application of different types of biochar and biosolids

Research Goal

To study the effect of biochar soil amendment on the transport of heavy metals and organics in soil ecosystems, focusing on heavy metal sorption.

Specific Objectives

To measure the sorption of

I. Nickel, copper, lead and cadmium independently

II. Nickel, copper, lead and cadmium in competition

III. Nickel, copper, lead and cadmium in competition with the addition of biosolids

Method

Part I: Individual Metal Experiments

- Added 0.48g Kaolanite, Activated Carbon, Walnut and Wood Feedstock Biochar to 15 mm tubes in a 5mm NaCl solution at pH 7
- Put on shaker for 48 hours
- Added 0-200 ppm of Nickel to each tube
- Put on shaker for 24 hours
- Centrifuged, Filtered, Acidified
- Analyzed using Atomic Absorption
- Repeated for each metal individually (Copper, Lead, and Cadmium)

…Method

Part II: Combined Metal Experiments

- Added 0.48g Kaolanite, Activated Carbon, Walnut and Wood Feedstock Biochar to 15 mm tubes in a 5mm NaCl solution at pH 7
- Put on shaker for 48 hours
- Added 0-200 ppm of all metals, combined, to each tube
- Put on shaker for 24 hours
- Centrifuged, Filtered, Acidified
- Analyzed using Atomic Absorption

…Method

Part III: Combined Metal and Biosolid Experiment

- Added 0.48g Kaolanite, Activated Carbon, Walnut and Wood Feedstock Biochar to 15 mm tubes in a 5mm NaCl solution at pH 7
- Put on shaker for 48 hours
- Added 0.48g of biosolids, then 0-200 ppm of metal to each tube
- Put on shaker for 24 hours
- Centrifuged, Filtered, Acidified
- Analyzed using Atomic Absorption

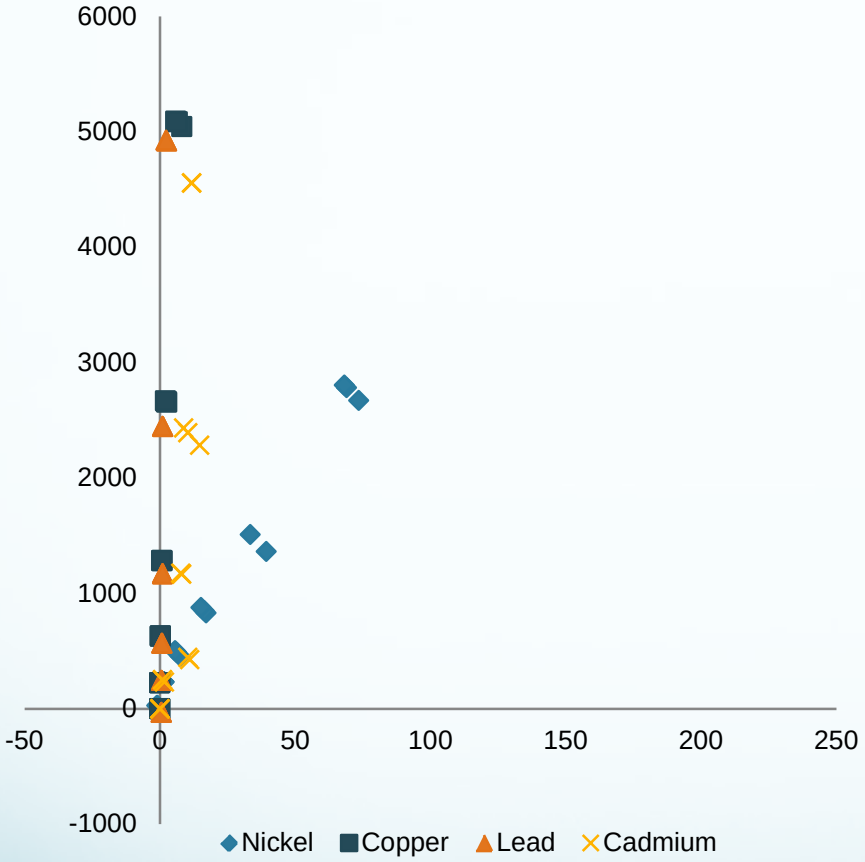
Results

I. Walnut Biochar and Activated Carbon sorbed the highest amount of metals

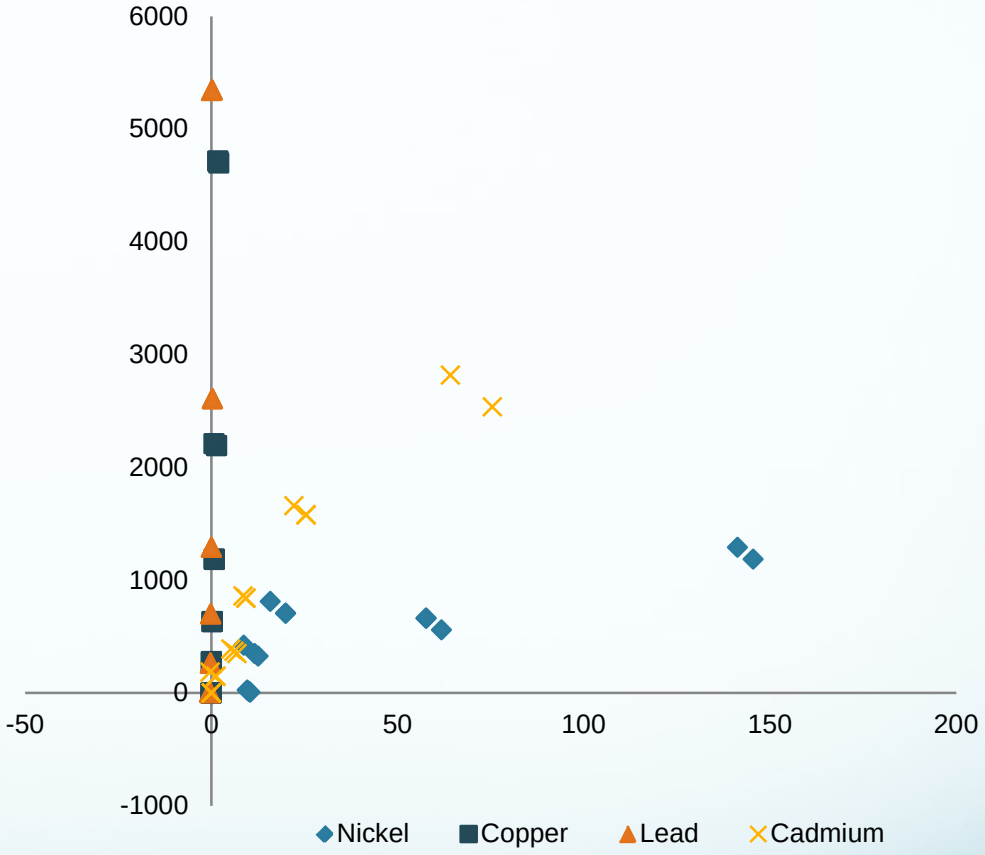
- Walnut Biochar sorbed high amounts of Copper, Lead, and Cadmium
- Activated Carbon sorbed high amounts of Copper and Lead

II. In general, metal sorption decreased with competition, with the exception of Copper and Lead bound to Walnut Shell Biochar.

Walnut Biochar:
Single Metal Solution vs. Combined Metal Solultion



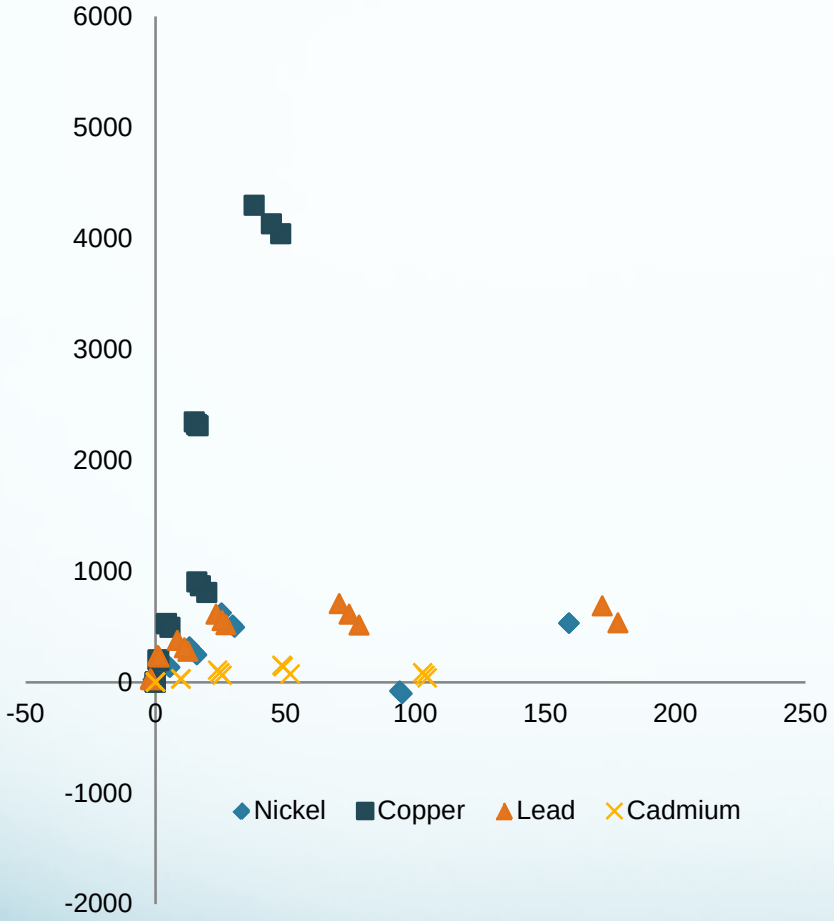
Sorbed concentration in mg nickel, copper, lead and cadmium per kg of solid vs. equilibrium concentration. **Single metal solutions** were used.



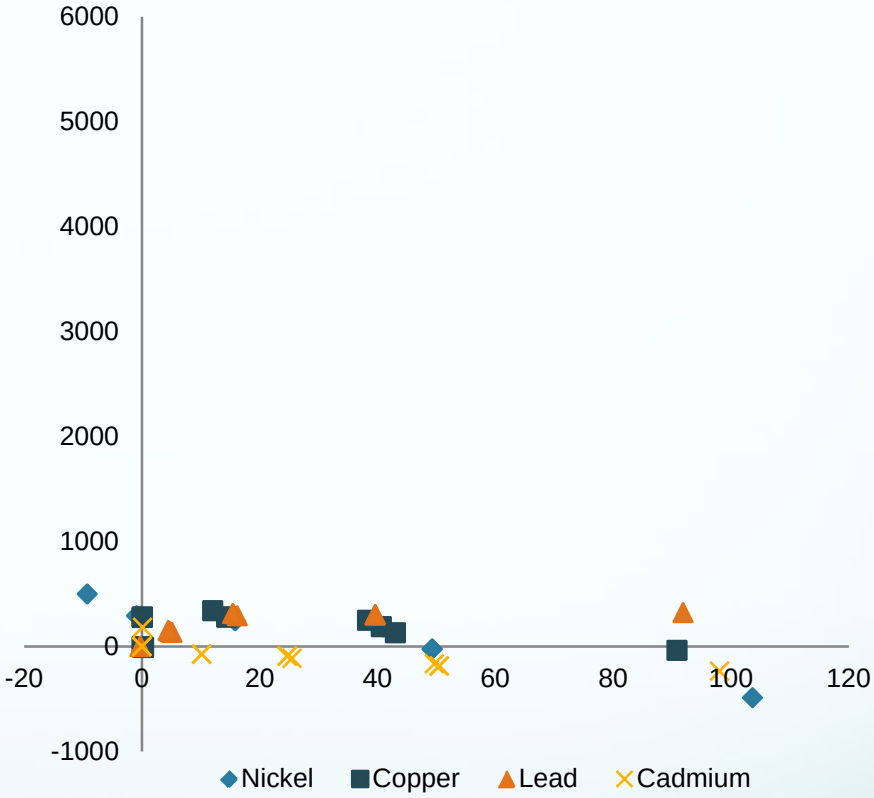
Sorbed concentration in mg nickel, copper, lead and cadmium per kg of walnut biochar vs. equilibrium concentration. A single solution of the **combined metals** was used.

Wood Feedstock Biochar:

Single Metal Solution vs. Combined Metal Solultion



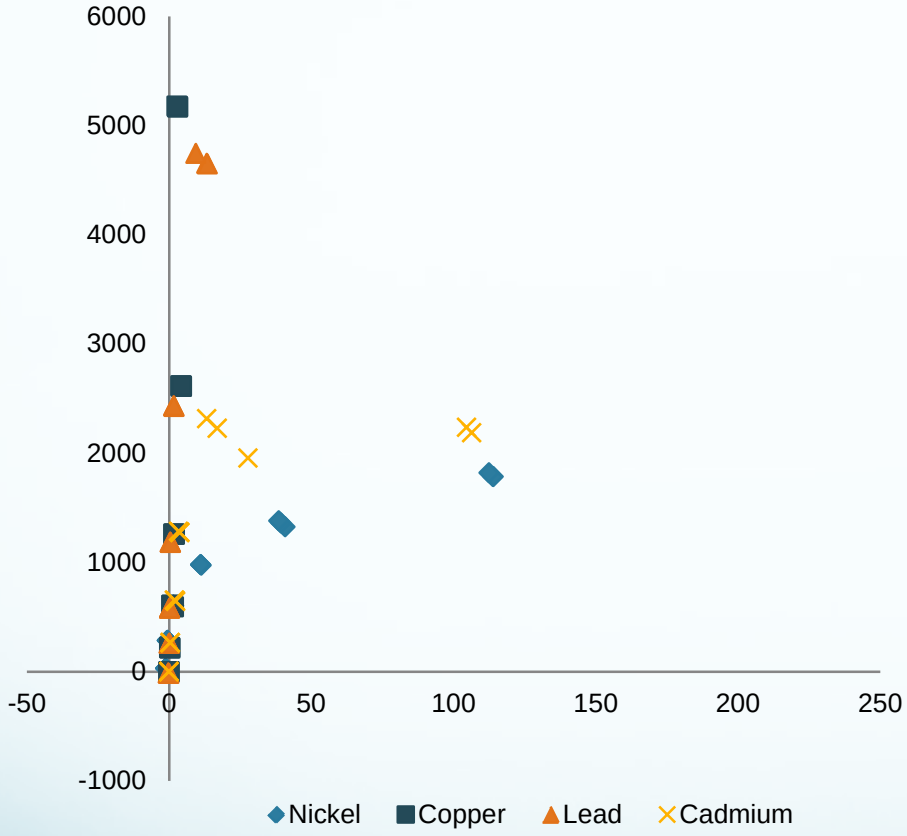
Sorbed concentration in mg nickel, copper, lead and cadmium per kg of solid vs. equilibrium concentration. **Single metal solutions** were used.



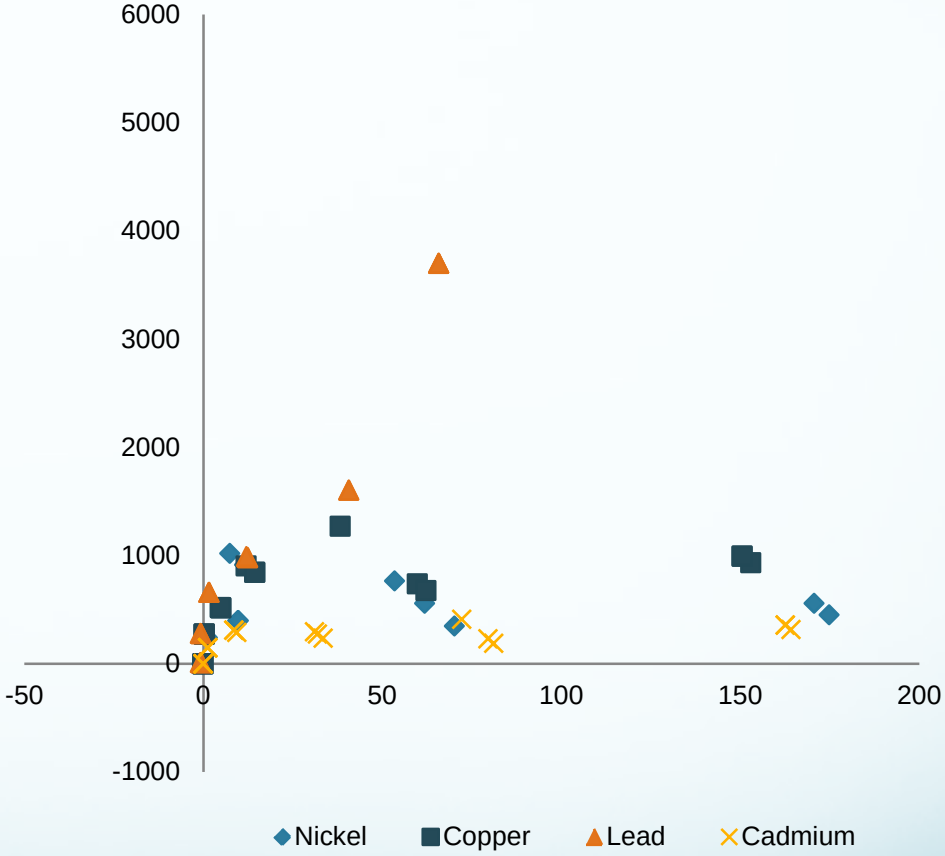
Sorbed concentration in mg nickel, copper, lead and cadmium per kg of wood feedstock biochar vs. equilibrium concentration. A single solution of the **combined metals** was used.

Kaolinite:

Single Metal Solution vs. Combined Metal Solultion



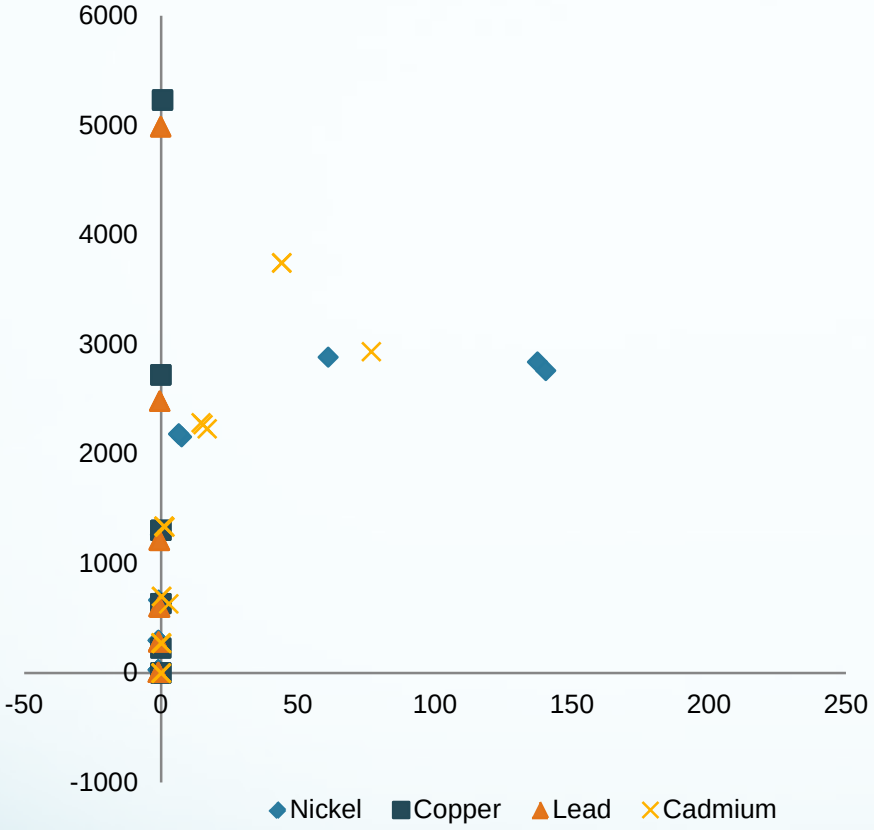
Sorbed concentration in mg nickel, copper, lead and cadmium per kg of solid vs. equilibrium concentration. **Single metal solutions** were used.

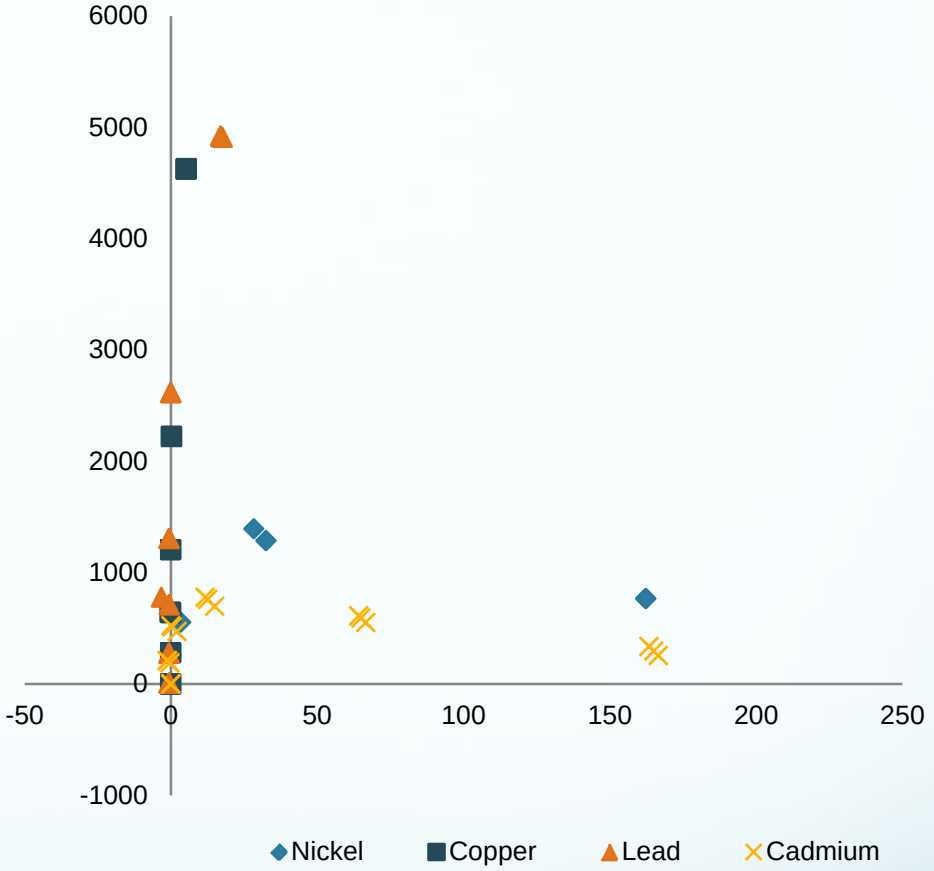


Sorbed concentration in mg nickel, copper, lead and cadmium per kg of kaolinite vs. equilibrium concentration. A single solution of the **combined** metals was used.

Activated Carbon

Single Metal Solution vs. Combined Metal Solultion





Sorbed concentration in mg nickel, copper, lead and cadmium per kg of solid vs. equilibrium concentration. **Single metal solutions** were used.

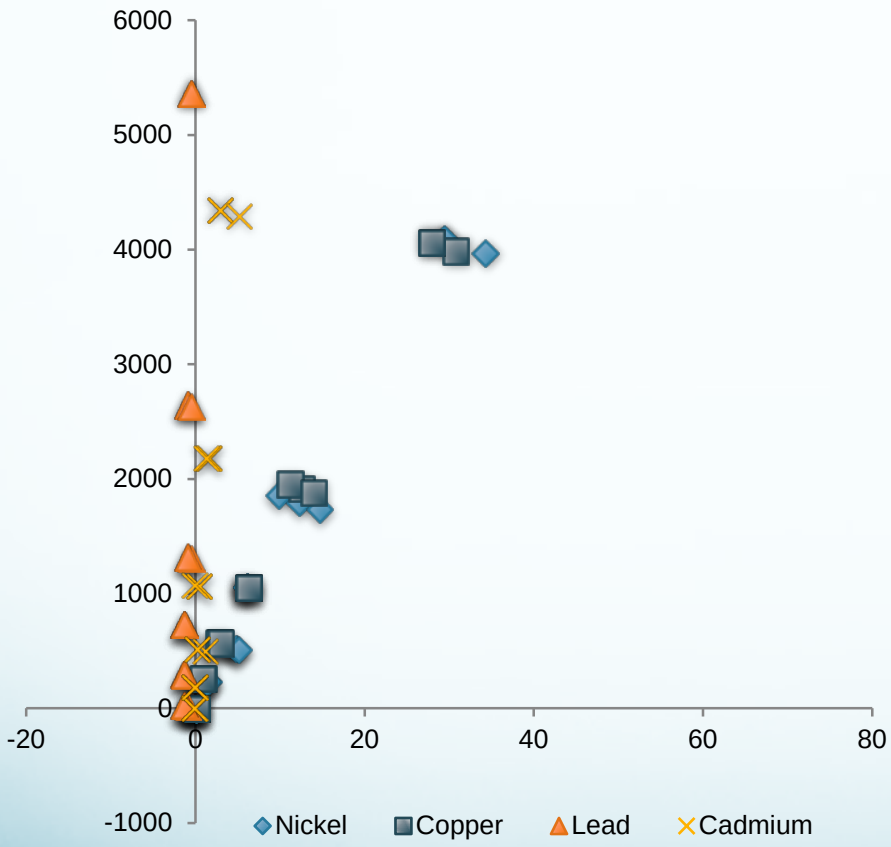
Sorbed concentration in mg nickel, copper, lead and cadmium per kg of activated carbon vs. equilibrium concentration. A single solution of the **combined metals** was used.

Results

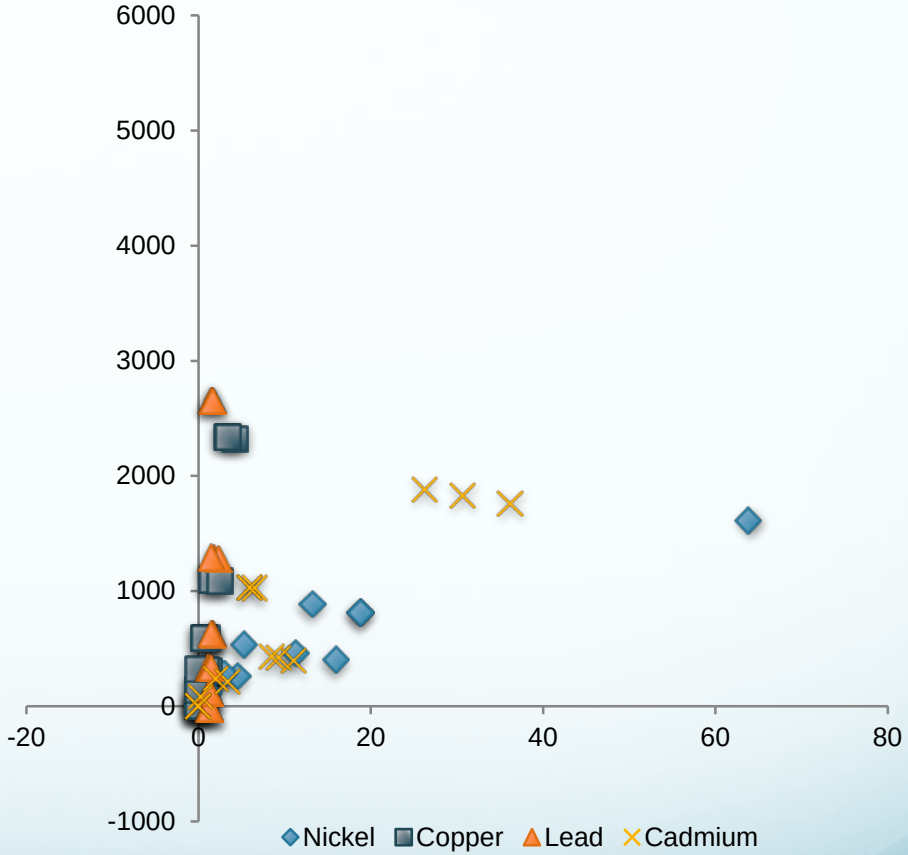
III. Walnut biochar and activated carbon show possible increase in sorption of copper in comparison with sorption to only biosolids

- Difficult to compare because twice the mass was used than in the combined metal experiments resulting in half isotherms
- More research necessary

Combined Metal sorption in Biosolids vs. Biosolids and Walnut Biochar

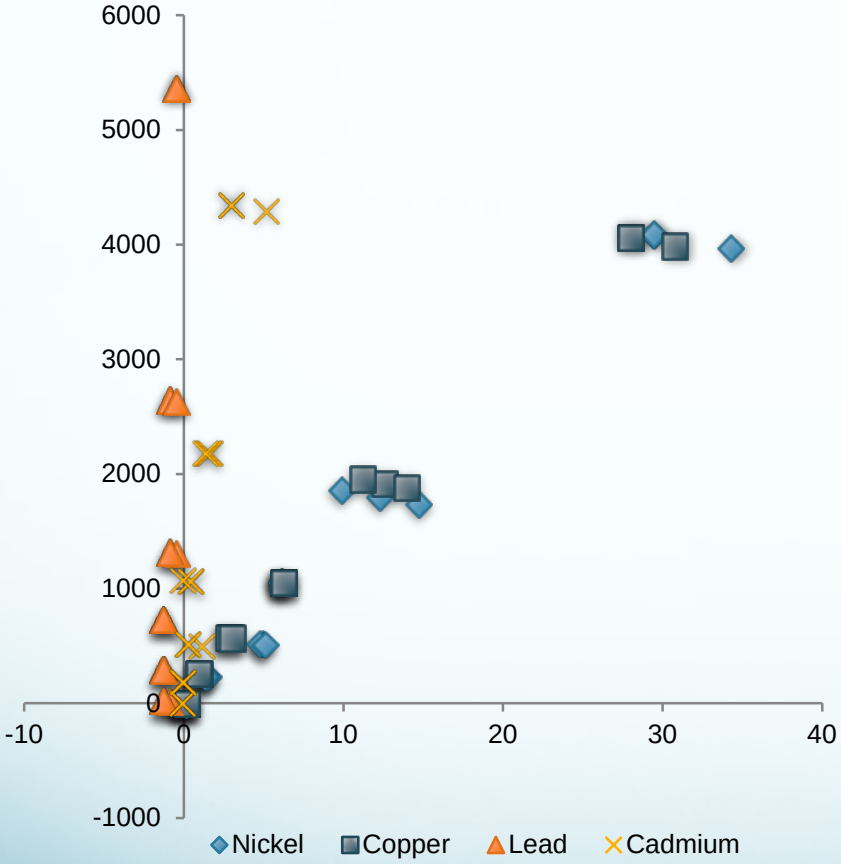


Sorbed concentration in mg nickel, copper, lead and cadmium per kg of biosolids vs. equilibrium concentration. A single solution of the **combined metals** was used.

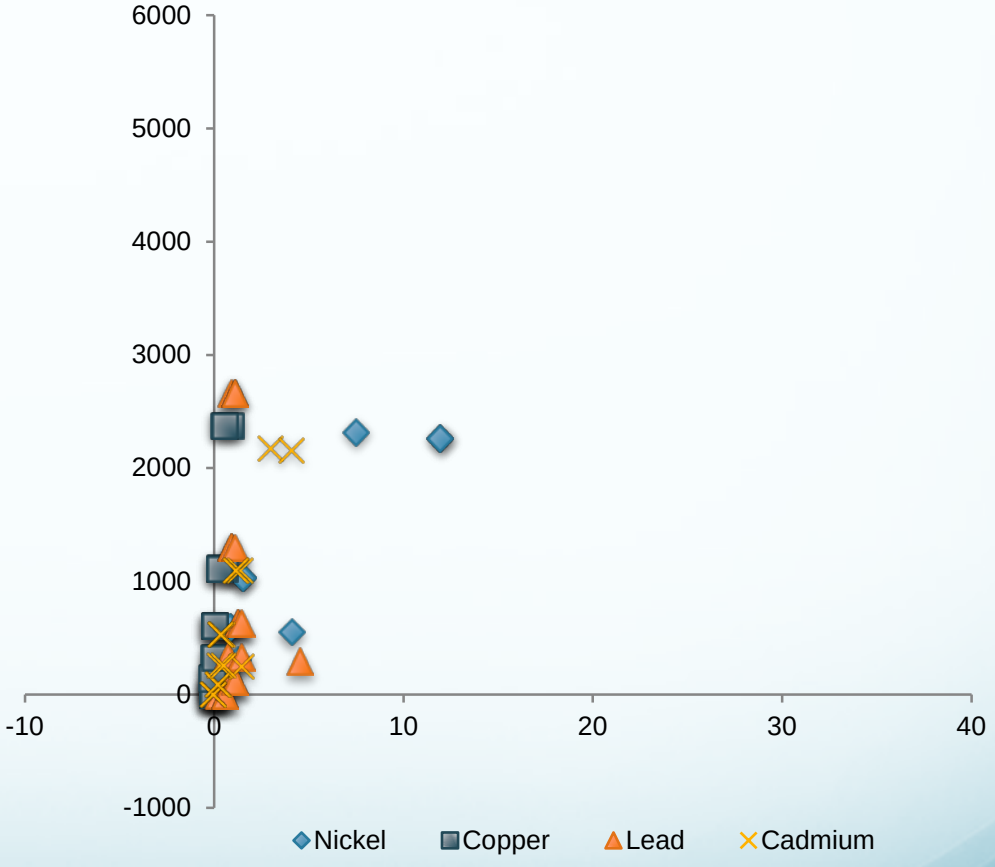


Sorbed concentration in mg nickel, copper, lead and cadmium per kg of biosolids and walnut biochar vs. equilibrium concentration. A single solution of the **combined metals** was used.

Combined Metal sorption in Biosolids vs. Biosolids and Activated Carbon



Sorbed concentration in mg nickel, copper, lead and cadmium per kg of biosolids vs. equilibrium concentration. A single solution of the **combined metals** was used.



Sorbed concentration in mg nickel, copper, lead and cadmium per kg of biosolids vs. equilibrium concentration. A single solution of the **combined metals** was used.

Future Research

- Lower concentrations of lead and cadmium in the biosolids studies needs to be used to determine if there is an increase in sorption when solids (biochar, activated carbon, kaolinite) are added
- Studies to determine where the sorption is occuring between biosolids and solids
- Higher concentration of metals or lower amount of solids in the biosolids experiments to achieve a complete isotherm

Conclusions

- Walnut shell biochar and activated carbon show high sorption of heavy metals especially copper and lead.
- Walnut shell biochar and activated carbon could enhance sorption of heavy metals by biosolids
- Possible applications:
  - Use of walnut shell biochar for remediation of contaminated soils
  - Use of walnut shell biochar to prevent leaching of heavy metals into water supplies
  - Use of walnut shell biochar in wastewater treatment

Acknowledgements

- Sanjai Parikh
- Fungai Mukome, UC Davis
- Kearney Foundation of Soil Science Undergraduate Research Fellowship
- Parikh Soil Chemistry Group, UC Davis