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Ryley Thomas

University of Nebraska-Lincoln, ryley.thomas@huskers.unl.edu

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Remediation Strategies to Reduce Heavy Metal Uptake in Lettuce Grown in Contaminated Urban Soil

Ryley Thomas

UCARE, College of Agricultural Science and Natural Resources, Environmental Studies, Agronomy



Introduction

- Soils potentially suitable as community gardens in the urban environment of Lincoln, NE can be contaminated with heavy metals.
- This study focused on soil-plant interactions of lead (Pb) and arsenic (As) detected at soil concentrations above EPA guidelines in one potential community garden site.
- Coffee grounds and biochar were tested as soil amendments for their ability to retain Pb and As in the soil and to minimize their plant uptake.
- Biochar was used because of its high surface area, which has been found to increase the reactivity towards pollutants.
- Coffee grounds were used because they are locally available, low cost, and can be similar to biochar reactive towards pollutants.

Materials and Methods

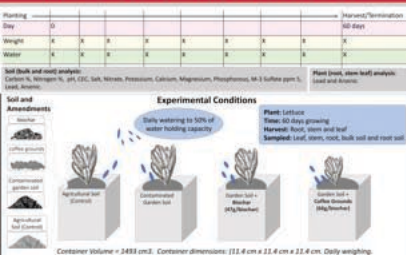


Table 2. Properties of control soil, garden soil, biochar and coffee (n=4)

Treatments	Control soil	Garden soil	Biochar	Coffee
Carbon (%)	2.9 (±0.03)	33.4 (±1.47)	60.2	49.3
Nitrogen (%)	0.26 (±0.01)	0.84 (±0.03)	0.28	2.00
pH	7.18 (±0.05)	6.68 (±0.02)	7.70	5.08
CEC* (cmol/kg)	13 (±0.29)	14 (±0.26)	2	7.8
Nitrate (mg/kg)	13.5 (±1.12)	34.8 (±3.38)	2042	0.90
Potassium (mg/kg)	244 (±14.13)	615 (±6.14)	192	1225
Calcium (mg/kg)	2101.25 (±42.88)	2135 (±46.54)	248	347
Magnesium (mg/kg)	202 (±4.29)	220 (±2.66)	26	333
Phosphorus (mg/kg)	92 (±1.11)	50 (±0.25)	13	63
M-3 Sulfate ppm 5 (mg/kg)	n/a	n/a	3.1	44.6
Artenic (ug/g)	13.5 (±0.78)	34.8 (±3.34)	n/a	n/a
Artenic (ug/g)	8.4 (±0.17)	39 (±1.23)	n/a	n/a

*CEC = cation exchange capacity

Results

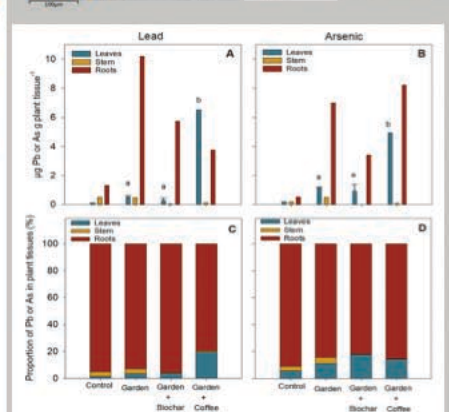
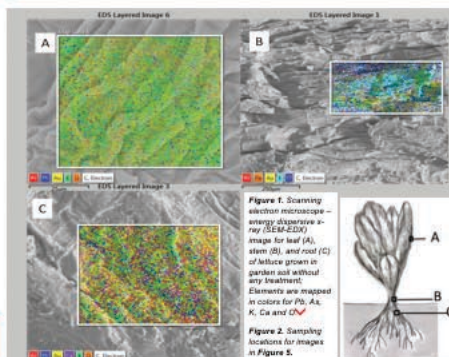


Figure 3. Concentration of (A) Pb, and (B) As in different parts of plants grown in control (uncontaminated agricultural soil), garden (contaminated soil), and treatments of garden soil (biochar and coffee), and proportion of (C) Pb and (D) As mass distributed between the leaf, stem, and root portions of the whole plant tissue in each treatment. Statistical analyses compared Pb or As content among control and garden soil, and biochar/coffee treatments in either leaves, stem, or roots. The same letter indicates non-significant differences.



Figure 4. Leaf spots on a garden + biochar plant on June 4, 2019, 8 weeks and 3 days after planting of the plants one day before harvest, June 10, 2019

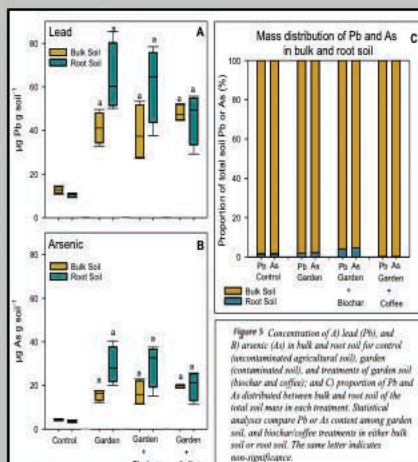


Figure 5. Concentration of (A) lead (Pb), and (B) arsenic (As) in bulk and root soil for control (uncontaminated agricultural soil), garden (contaminated soil), and treatments of garden soil (biochar and coffee), and C) proportion of Pb and As distributed between bulk and root soil of the total soil mass in each treatment. Statistical analyses compared Pb or As content among garden soil, and biochar/coffee treatments in either bulk soil or root soil. The same letter indicates non-significance.

Summary

- Pb was observed to accumulate in some of the crevices of the root, however, all images displayed an absence of a strong pattern of distribution of both As and Pb. (Fig. 1)
- There were not masses of Pb found in the spots on the lettuce leaves. (Fig. 4). The SEM-EDS results suggest the spots were not lead necrosis (Fig. 2)
- The coffee + garden treatment leaves had a significantly higher concentration of Pb and As than garden and garden + biochar treatment leaves. (Fig. 3A, 3B)
- The garden soil had a significantly higher concentration of Pb and As in the root soil than the bulk soil (Fig. 5)
- Pb concentration was significantly higher in the root soil than the whole plant. (Fig. 3, Fig. 5)

Take Aways

- Eating one serving of lettuce grown in the garden soil or the garden soil + coffee grounds would be above EPA regulations for average daily As intake.
- Consumption of one serving of lettuce from the garden soil + coffee grounds would be above the daily recommended limit of Pb for children.
- Based on concentrations found in different parts of the plants, the biochar amendment was the most successful in retaining Pb and As in the soil.
- Additional research for the garden + coffee grounds treatment is needed to clarify Pb and As pathways once entering the root soil so that we can better understand how to keep Pb and As out of the plant.