Heavy Metal Uptake in Garden Vegetables

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Introduction and Background

- Urban farming has become an efficient, and effective way to use abandoned urban properties.
- Certain concerns with the contaminants associated with urban society (storm water).
- Reconsideration of urban farm localities.
- Other agricultural communities affected by stormwater runoff.

Introduction and Background

- Cornell and New York Department of Health (2010).
  - Cadmium: electric car batteries, acts as a carcinogen.
  - Copper: automotive brakes, motors, radiators, bearings, etc., causes liver damage.
  - Lead: legacy lead, wheel balance weights, spark plugs, detrimental to a child's health, also poisonous to adults.
- EPA Reference Doses.
  - Cadmium: .001 ppm (ATSDR, 2008).
  - Copper: 1.3 ppm maximum ground-level concentration (EPA, 2018).
  - Lead: .300-.600 ppm (Basta, 2010).
- Garden Vegetables
  - Spinach, Radish, Arugula .

Questions Posed

- Is it viable to grow radishes, spinach and arugula microgreens in soils contaminated with selected concentrations of Pb, Cd, and Cu, and if so what is the amount of contaminant uptake each type of plant exhibits?
- Is there a specific selected heavy metal that is more or less prone to being absorbed into the selected plants?
- What is the effect and connection between rainwater runoff from urban settings into planting soil and heavy metal uptake in plants that are exposed to those contaminants?
- Is there threshold limit to the amount of heavy metals that a particular plant can absorb and, if so, what is it?

The Analog

- Significant storm event every 4.5 days.
- Average rainfall during 2018 summer months: 3.6 in / month.
- Every storm event aquated to 0.4 inches of rain over surface area of plant pot.
- Storm water runoff concentrations:

Metal	Control	Conc. 1	Conc. 2	Conc. 3	Conc. 4
Cu	0 ppm	10 ppm	100 ppm	250 ppm	500 ppm
Pb	0 ppm	1 ppm	10 ppm	100 ppm	250 ppm
Cd	0 ppm	1 ppm	10 ppm	100 ppm	250 ppm

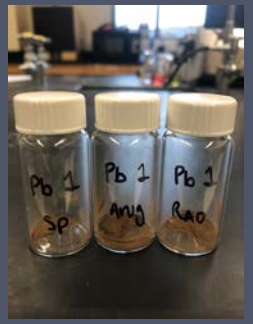
Methods: Growing and Watering Procedure

6x

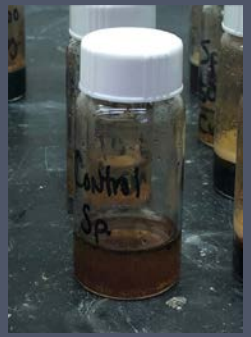
Methods: Digestion Procedure

Preparation for drying

Drying for 20 hours

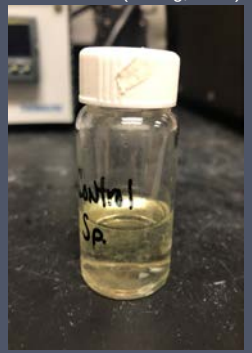


Ground samples after Drying



Addition of 5 mL of Nitric Acid

(Huang, 2004)



After 96 hours of digestion, and addition of 4 mL of water and 1 mL of Hydrogen peroxide

AAS analysis

Qualitative Results

Lead

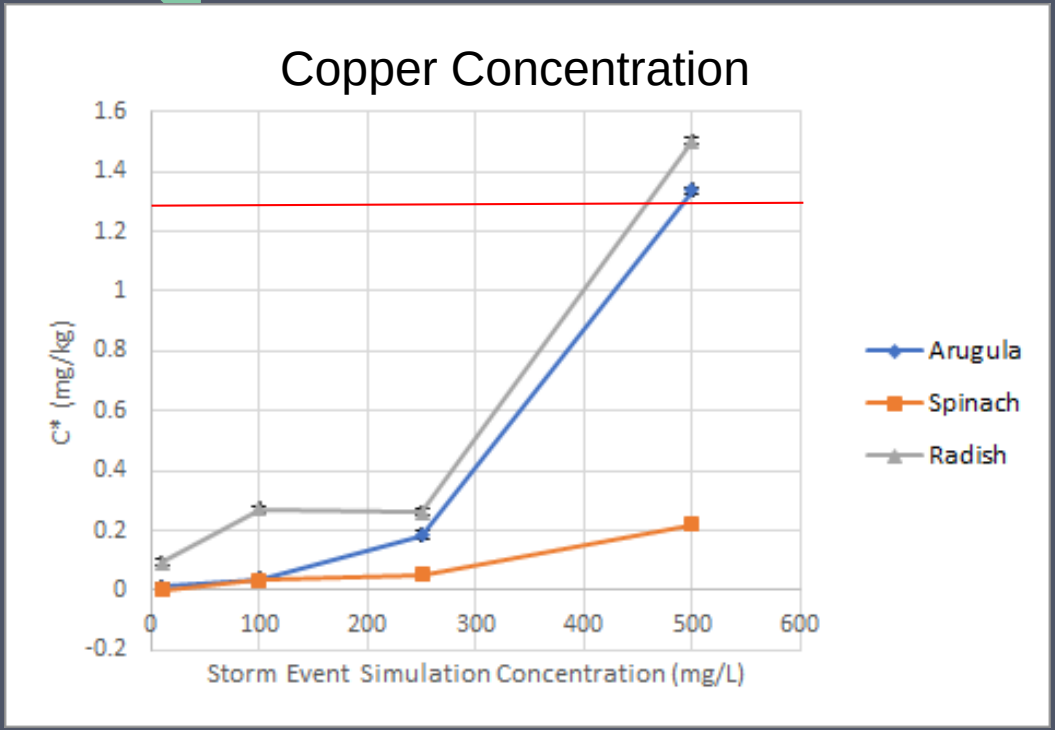
Cadmium

Copper

Low Concentration

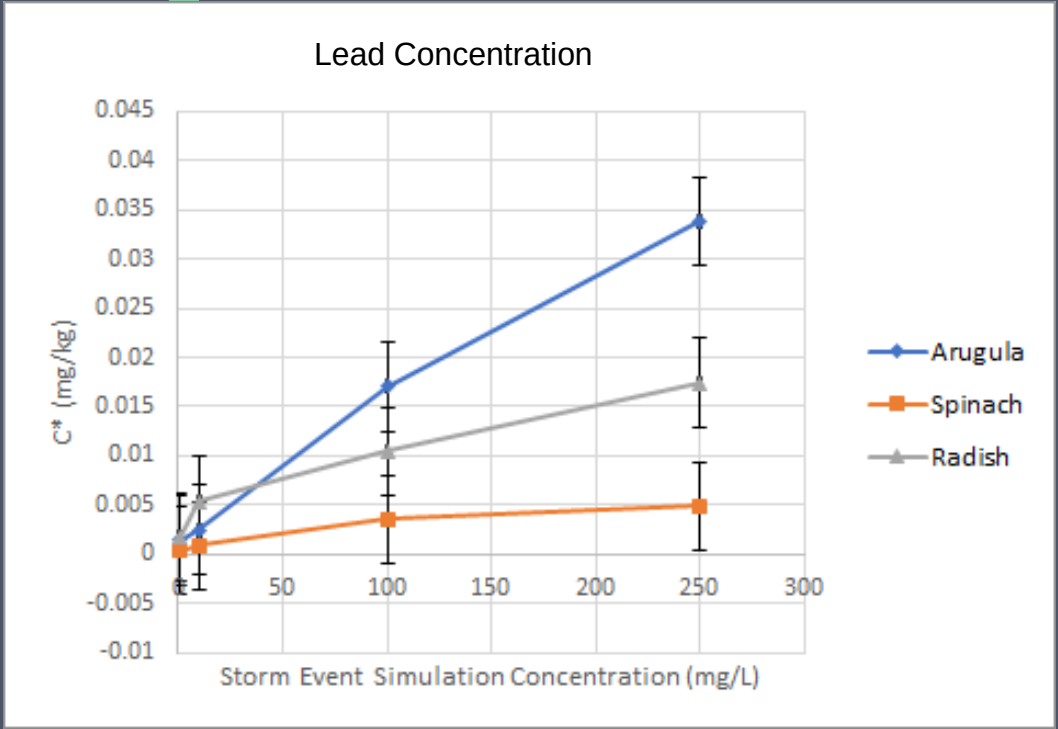
High Concentration

AAS Results: Copper



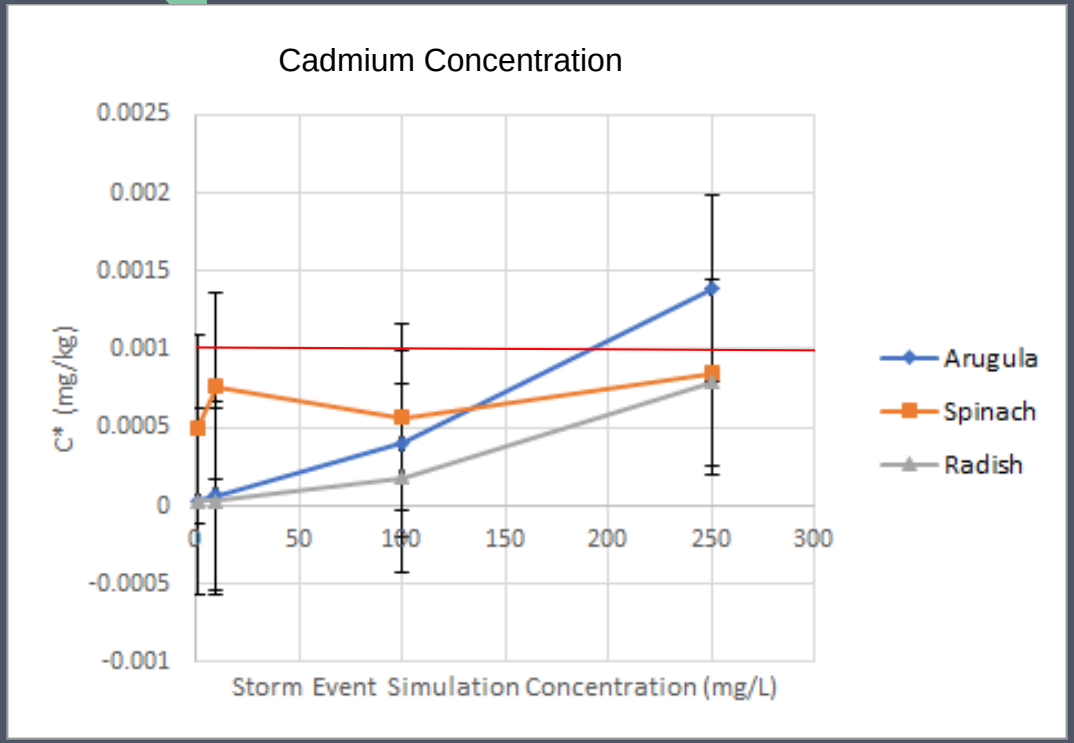
- Reference Dose: 1.3 ppm.
- Radish and Arugula surpass threshold only for 450-500 ppm runoff.
- Spinach threshold at ~1300 ppm runoff.

Lead



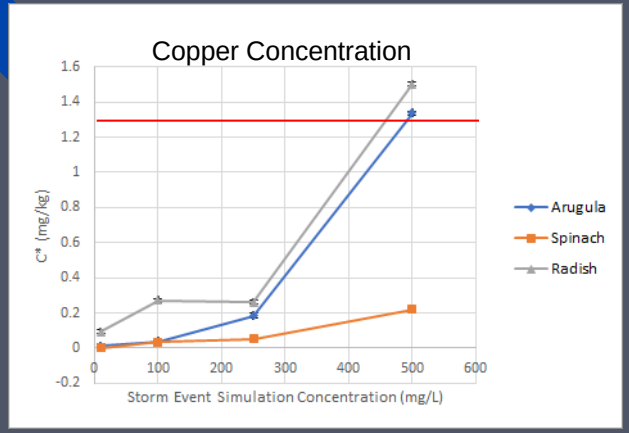
- Reference Dose: 0.300-0.600 ppm.
- No vegetables surpass this threshold.
- Spinach, again, lowest uptake.

Cadmium



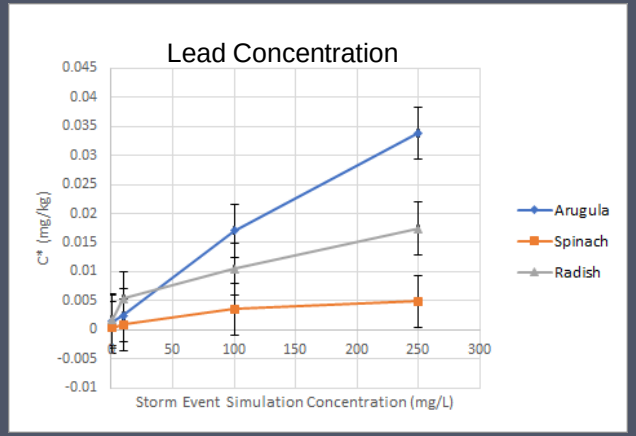
- Reference Dose: 0.001 ppm.
- Arugula surpasses threshold at ~200 ppm runoff.
- Radish had lowest uptake.

Copper



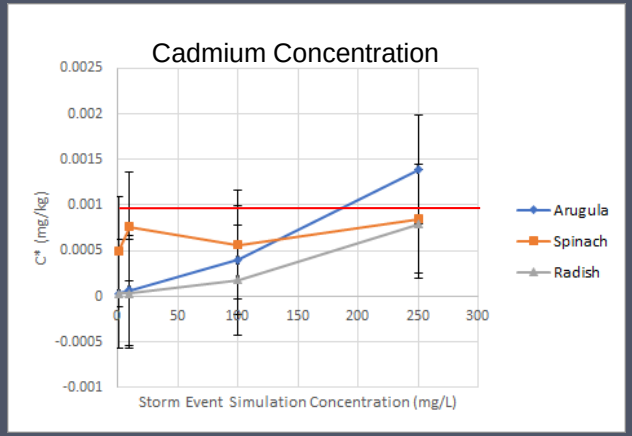
- Safe to grow spinach with <1300ppm Cu runoff.
- Safe to grow radish and arugula with <450ppm Cu runoff.
- Greatest uptake.
- 2nd order polynomial

Lead



- No vegetable reached EPA reference dose threshold.
- Power regression curve (potential uptake limit).
- Safe to grow these vegetables with runoff <14,000 ppm Pb.

Cadmium



- Vegetables more susceptible to Cadmium toxicity.
- Radishes unsafe to eat at >190ppm Cd runoff.
- Cadmium less prominent.
- Lowest uptake.
- 2nd order polynomial

Applications

- We can now determine safe urban farm locations based on EPA guidelines.
- Garden vegetables do not grow well in heavily contaminated conditions (specifically Cu).
- The methodology used in this experiment can be applied to real urban farm operations in order to determine contaminant uptake in garden vegetables.
- Study cost: $15 (repeatable).

Future Work

- Test actual storm water runoff from local parking lots.
- Use longer growth periods and larger range of concentrations.
- Test a variety of urban farm grown vegetables using same methodology of this experiment.
- Take accurate wet and dry weights to investigate if any metal contaminate effects the percentage of water weight in the species, and how that might correlate to the growth.
- Use ICP-OES instrument analysis for less error in the smaller concentrations.

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Works Cited

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AAS Manual

Questions?