ESRP: Root Uptake of Cobalt in Common Plants and Vegetables

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Abstract

The presence of cobalt in soil samples from North Wales, Cuba, Northwest Spain, and the Copperbelt of Africa drew the attention of the Federal Food and Drug Administration Agency as well as the World Health Organization, due to the toxicity associated with this element. Last year the Lemont High School Exemplary Student Research Program student researchers participated in testing, observation, and analysis of plant uptake of cobalt to determine the long-term impacts of element toxicity and its relation to plant vitality. This year the experiment was continued with a different beam line. It is essential to understand the toxicity of cobalt in ground-rooted plants.

Motivation

- In recent years, cobalt in soil numbers have been increasing.
- There are small levels of cobalt already present within the environment which can provide many health benefits High levels of cobalt is toxic to humans and can have severe short term and long term effects
- High cobalt exposure can cause in morphology and the chlorophyll in plants.

Methods

Onions, peas, carrots, lettuce, and arabidopsis seeds will be planted in agarose gels. After one week the plants were harvested, mounted for XRF scanning and evaluated using Leica microscope located Beamline 2-ID-E. After the initial scan to find baseline elements, in the roots of the plants were put in a cobalt solution for 1 hour, x-ray absorption spectra were measured to examine the chemical state of cobalt upon uptake by various plants.

2021 vs 2022 Experiments

- 2021 (Beamline 9MB)
  - Beam size of 500 x 300 nm
  - Arabidopsis, Carrot, Lettuce, Onion, Tomato and Peas
  - results show insignificant amount of cobalt uptake
- 2022 (Beamline 2-ID-E)
  - Beam size of 50 x 50 microns
  - Arabidopsis, Carrot, Lettuce, Tomato and Peas
  - Results show significant uptake findings (Cobalt uptake from greatest to least: carrot, pea, tomato, arabidopsis, lettuce)

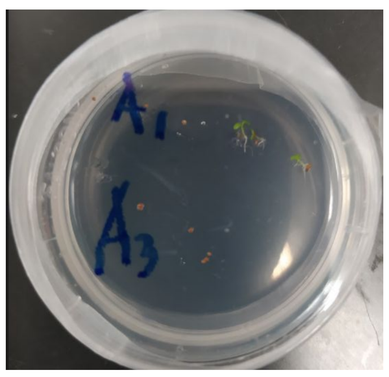
Plant Growth Information

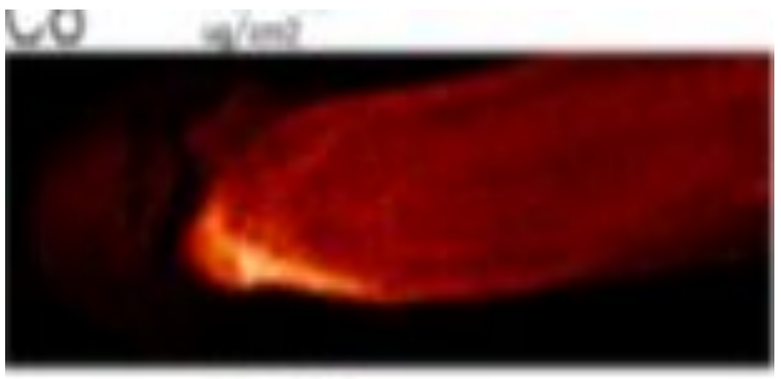
Plant	Root length (mm)	Root diameter (mm)	Growth gel volume (ml)
Arabidopsis(A)	7-10	0.1	5
Carrot (C)	25-30	0.3	5
Lettuce (L)	40	0.3-0.5	5
Pea	25	3	20
Tomato	20	0.3	10

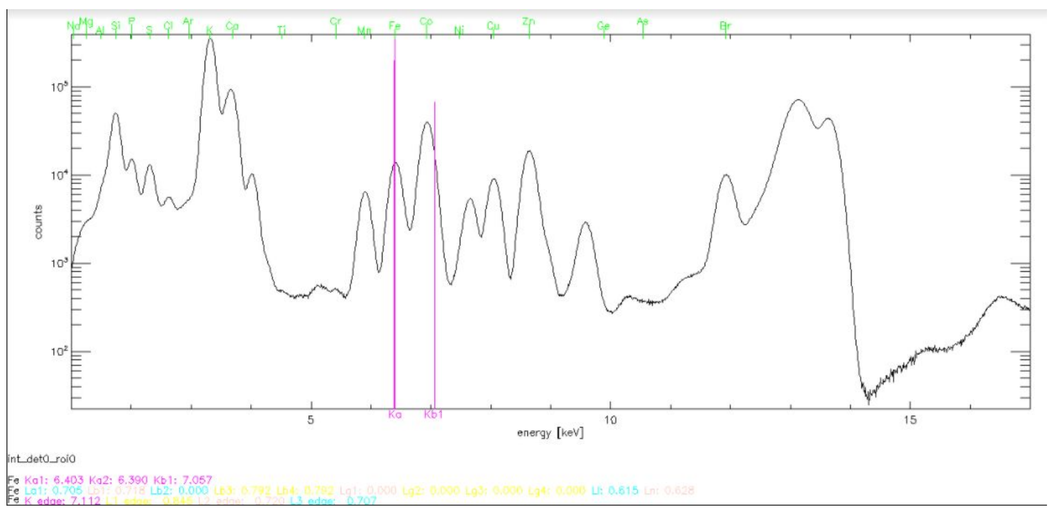
Change in Co:K Ratio

Sample after 1 hour Cobalt	Cobalt Uptake (ug/cm^2)	Change in Co:K Ratio (%)
Arabidopsis	1.0489146	0.01551844937
Lettuce	1.274541527	0.01448646883
Tomato	1.36030558	0.01985540905
Carrot	2.8785706	0.03645105524
Pea Tip	2.661154767	0.03634698729

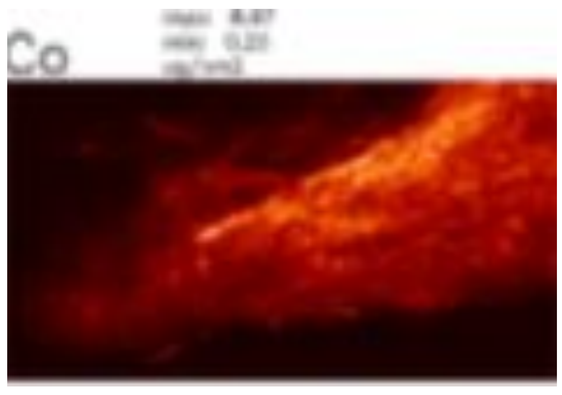
Arabidopsis

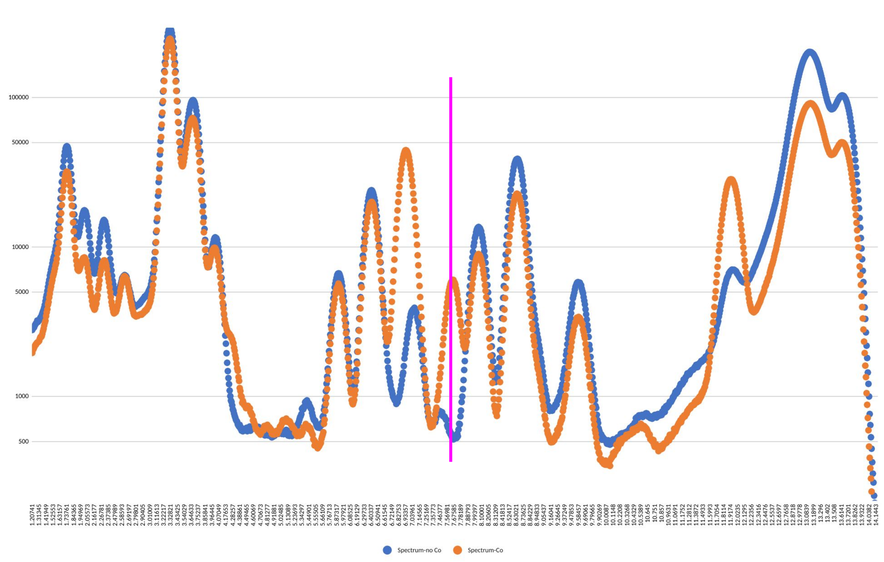






Carrot





CONCLUSIONS

- All trials showed some uptake of cobalt in the leaves and roots of four different plant samples.
- Greater amounts of cobalt were detected than in the 2020-2021 experiment
- The amount absorbed in all of the samples was still insignificant since all samples had cobalt amounts lower than what would cause harm to humans.
- Cobalt uptake from greatest to least: carrot, pea, tomato, arabidopsis, lettuce.

NEXT STEPS

For future research, there are three different avenues to look at:

- Changing the concentration of cobalt chloride and the amount of time it is exposed
- Test different plants that are more prevalent in the areas of the world that have high levels of cobalt soil contamination.
- How are the leave affected from the cobalt uptake?
- Uptake of the plant verses transportation of cobalt
- Cobalt resistant plants

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