Lead Concentration and Placement in Terminal Root Sections of Brassica juncea

NICHOLAS BONANNO[1], CLARE LOHRMANN[1], GRACE NOVACEK[1], ELIZABETH EVANS[1], JUSTINE HUNG[1], EMMA MCDONNELL[1], MANTAS KISIELIUS[1], ADRIAN GARCIA BADARACCO[1], KEITH DVORKIN[1], DR. BRYANT C. SCHARENBROCH[2], DR. LYDIA FINNEY[3], EVAN MAXEY[3]

[1]Downers Grove North High School 4436 Main Street Downers Grove IL 60515

[2]Urban Soil Scientist, The Morton Arboretum, Lisle, IL 60532, USA

[3]X-ray Science Division, Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439, USA

Motivation

To determine whether or not Brassica juncea roots are able to absorb lead from soil. Plant species able to remove contaminants such as lead could be potential tools to combat pollution. Soil contamination has been attributed to lead-paint chipping (Traunfeld and Clement, 2001), industrial waste, battery manufacturing, smelting, roadside car pollution (E.P.A., 1998), and many others.

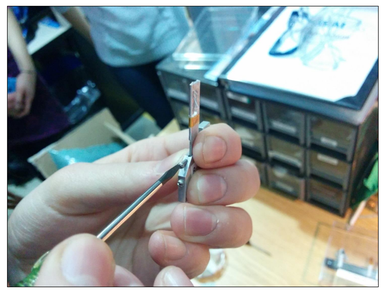
Goals

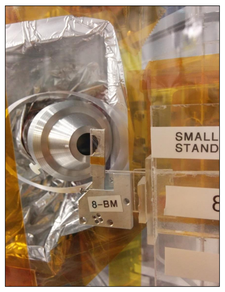
• Determine whether or not Brassica juncea roots have the capability to absorb excess lead from soil.

• Identify the specific locations of the root in which this lead was concentrated, in order to help understand the possible mechanisms of absorption utilized by the plant.

•As high school students, another major goal of the ESRP program is to provide us with an opportunity to carry out our own research so that we can experience what a career in science field holds for prospective students.

Sample Preparation and Experiment





Plant Sample Prep

1) Roots were gathered from the Morton Arboretum, grown in simulated contaminated soil with 100 ppm lead contamination. These were prepared by Dr. Bryant Scharenbroch.
2) 5 cm terminal root sections were collected from 4 plants. 2 of which were grown in 100 ppm Pb concentrated soil, and the other 2 were grown in a control soil with 0 ppm Pb.
3) These roots were then fixed in a 3:1 Ethanol - Acetic Acid solution for 30 minutes in glass vials. The vials were drained. Then 10 ml of 70% ethanol was added to each and set for another 30 minutes. They were drained again and were finally replaced with more 70% ethanol. After this preparation, the samples were stored at 4 degrees Celsius for several months.

Beam Sample Prep

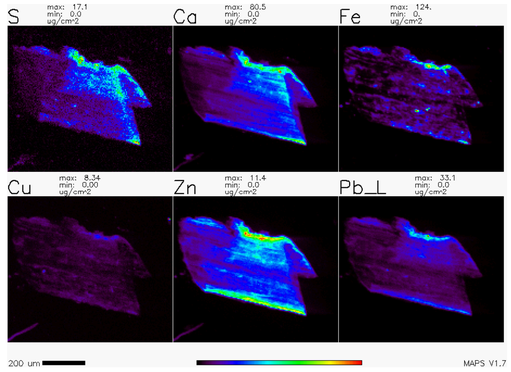
1) Hand microtomes were used to get samples to the thickness necessary for observation on the beam line.
2) Sections of roots were embedded in paraffin wax and then cross sections were sliced to a thickness between 100 and 400 microns.
3) These root sections were removed from the wax and transferred to substrates specially designed by beamline specialist Evan Maxey.
4) These substrates suspended the root sections in a ultralene window that allowed them to have unobstructed examination in the beam line.
5) These samples were transferred to holders that attached to beamline 8-BM.

ESRP

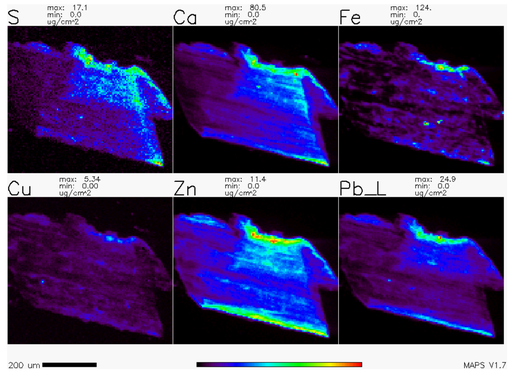
The Exemplary Student Research Program at Argonne allows high school students to collaborate with the research faculty and utilize facilities unique to Argonne. ESRP allows students to apply knowledge from the classroom and gain an understanding of the scientific process at a professional level.

Results

61)



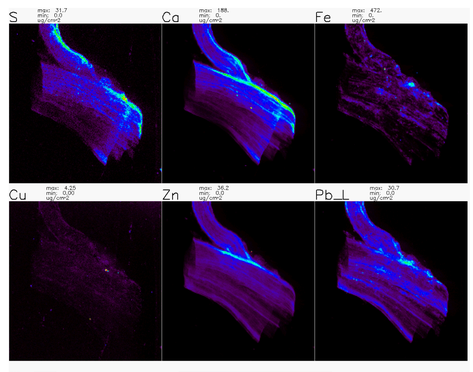
61B)



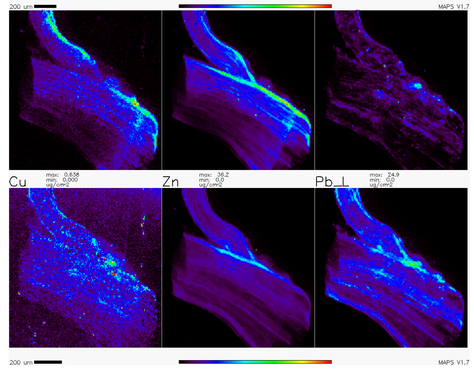
61: Control sample

- Triangle shaped area that indicates traces of lead.
- Lead is most heavily concentrated near the top and the bottom of the sample.
- Traces of calcium, sulfur, zinc, and iron also appear in the same inorganic trapezoid shape, suggesting possible outside contamination.

62)



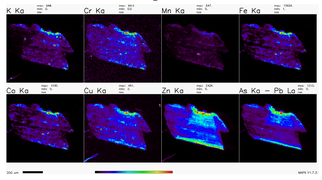
62B)



62: Contaminated sample (soil at 100ppm of lead)

- Traces of lead were found throughout the sample.
- Lead is fairly evenly distributed throughout the sample.

Error Analysis



The same distribution pattern of elements (most notably Zn) observed in 61) and 61B) is also present in the images corresponding to Co and Cr (amongst others); elements which aren't normally found in plants at the concentrations presented in the image. This suggests the sample may have been subject to external contamination, which could also be responsible for the sizable concentration of Pb in sample 61, an anomaly given that the sample was grown in soil with a 0ppm concentration of Pb. The inorganic shape of the distribution, trapezoidal in nature, supports the hypothesis that an outside source is responsible for the contamination of our sample with various elements.

While it is unfeasible to determine the source of the contamination, we believe that lack of proper facilities and equipment may have played a key role.

We are also unable to draw direct conclusions about the location of Pb within the roots, as we were unable to get proper cross sections, and suspect that the images show a longitudinal orientation of the roots rather than cross sections.

Conclusions

Our data was inconclusive. The relative uniform distribution of the metals and lack of a cross-sectional view hindered our ability to make an informed argument. The presence of lead in the contaminated sample is promising, however, the presence of lead in our control is not. The differences in distribution of Pb between control and 100 ppm Pb suggest external contamination of the control. If we were able to continue this research, we would perfect our sample preparation technique. If our samples were better set to have a true cross sectional view and sources of contamination were better controlled, Xray microprobe imaging could confirm uptake of Pb into the volume of Brassica juncea tissue, but presently we cannot.

This research was made possible through the Exemplary Student Research Program, supported by Argonne National Laboratory's Educational Programs (CEPA), and Downers Grove North teacher Keith Dvorkin. Use of the Advanced Photon Source, beamline 8-BM-B, at Argonne National Laboratory was supported by the U. S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357. Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.