Absorption Analysis Of Cadmium, Zinc And Chromium In Lichen Samples

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Abstract

Lichens obtain nutrients from the atmosphere and can absorb heavy metals, holding high potential as bioindicators for metals. Examining heavy metals in lichen can help us better understand their ability to serve as pollution indicators.

By utilizing X-ray fluorescence, the elemental composition of metals in the lichen samples can be examined through spectroscopy. Lichen samples collected in Lemont, IL at Sagawau Nature Preserve were exposed for a two week period to a solution of 0.1M cadmium chloride, zinc nitrate or potassium chromate, specifically lichen species: Lepraria finkii, Candelaria concolor, and Flavoparmelia caperata.

The resulting chemical state of the metals will be studied using XANES, EXAFS, or both. Results for each species of lichen will be compared to further understand the absorption ability of each species.

Purpose

The purpose of this experiment is to identify which lichen species absorbs the highest amount of a selection of heavy metals out of liquid concentrates within a given time frame. The methodology to do so was selected to mimic extreme environmental exposure to common heavy metals .

Hypothesis

The Lepraria Finkii will likely be the most absorbent as previous studies* have shown that Crustose lichen have been most effective in absorption. The metal that will have the highest absorption rate will be chromium as it is the lightest of the metals we will be testing. Utilizing equipment at Argonne, we expect to view heavy amount of chromium within the sample of Lepraria finkii.

Results

The results from all three species were rather unique. While our initial hypothesis was proven invalid, rather large traces of Zinc was identified within the Candelaria Concolor species. In fact, the species nearly absorbed 14757% more Zinc than compared to the high for Lepraria Finkii. We also observed a slight increase in traces of Strontium, a metal that we did not account for, within the Lepraria Finkii species when compared to the other two observed. And finally, there were no traces of Cadmium within all the species tested.

Materials and Methods

Using the ionic compounds Zinc Nitrate, Potassium Chromate, and Chromium Nitrate, the different species were able to be exposed in a contained heavy metal environment over the span of two weeks. The three species were combined in four different containers each with a different compound (as exampled in the image to the right).

To have accurate and valid results, other variables were kept constant, including temperature and light exposure. The compound solutions did evaporate at different rates however, and they were refilled respectively when there was little to none of the solution remaining in the sample.

After exposure, the samples were mounted for X-Ray observation. The DND-CAT Synchrotron radiation source was used to produce a characteristic X-Ray of each of the samples, and the XANES (X-ray Absorption Near Edge Structure) scans were collected to identify the amount of a metal within the sample.

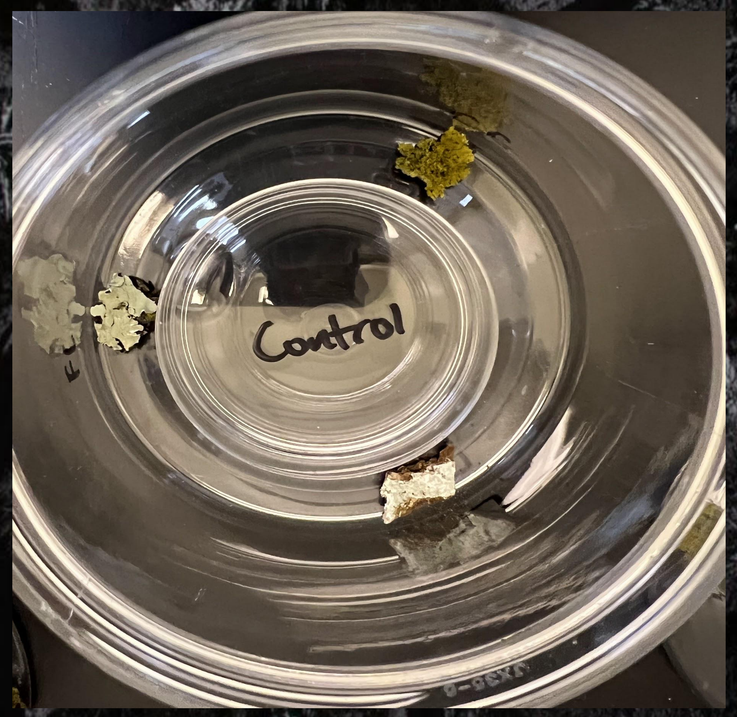

Image shows arrangement of lichen species (control group)

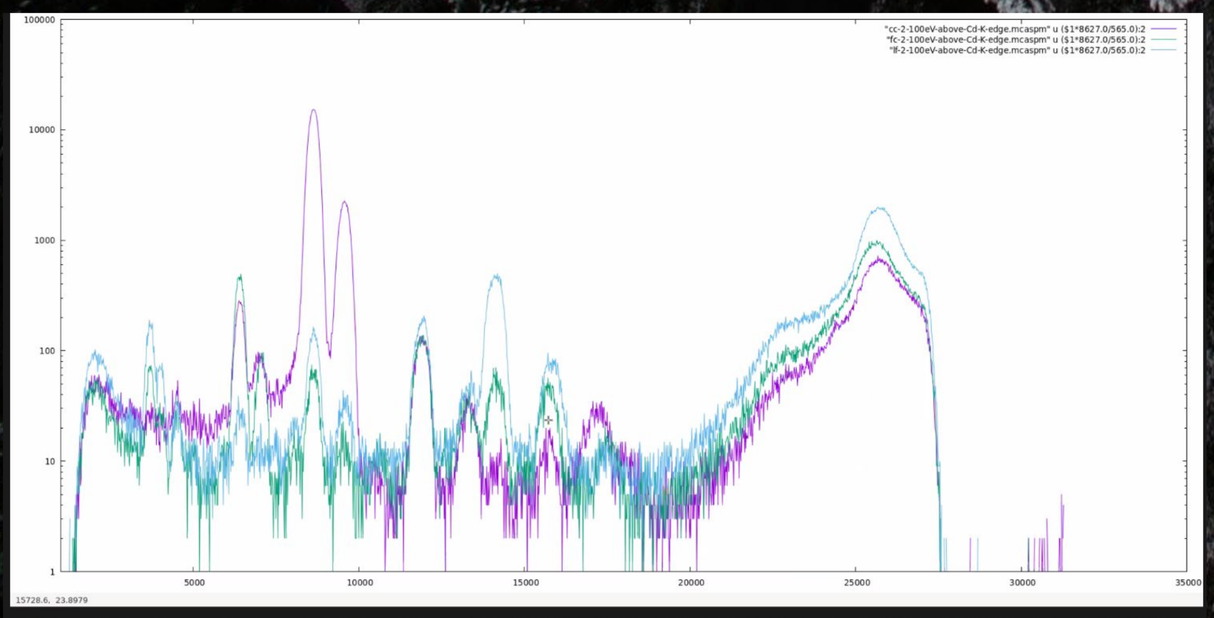

Image shows the edge levels for all three species exposed to Zinc

Sagawau: Sample Collection

Sagawau contains a rich environment with ideal humidity, allowing for Lichen to flourish in growth. Also, this environmental learning center contained many common species of lichen, allowing our findings to be generalized to a larger population. Furthermore, the collection of the samples occurred during winter, a season where lichen can thrive.

Edge	Cd	Cr	Fe	Sr	Zn
Sample	26711	5989	7112	16105	9658
CC-1	0	0.0005	0.3	0.022	0.07
CC-2	0	0.0002	0.16	0.004	10.4
CC-3	0	0.0005	0.28	0.034	0.05
CC-4	0	0.0007	0.35	0.009	0.043
FC-1	0	0.0003	0.2	0.064	0.14
FC-2	0	0.0002	0.18	0.035	0.052
FC-3	0	0.00025	0.13	0.14	0.09
FC-4	0	0.0002	0.16	0.04	0.067
LF-1	0	0	N/A	0.35	0.12
LF-2	0	0	N/A	0.29	0.07
LF-3	0	0.0008	N/A	0.25	0.06
LF-4	0	0	N/A	0.19	0.06

Conclusion

It was believed that due to the lighter mass of Chromium, the samples exposed to Chromium Nitrate would show higher traces of absorption. In support of this idea, previous research and experiments have suggested that Lepraria Finkii would be the most absorbent of the three species.

While this hypothesis was supported by the data, a different metal tested had much more significant results than initially expected. Surprisingly, the Candelaria Concolor species had the highest absorption rate with Zinc. A possible explanation for this result is that the Candelaria Concolor grow best on nutrient rich tree bark. Most trees require large amounts of Zinc to produces chlorophyll, and the species may have adapted to that heavy zinc requirement. Focusing in on our hypothesis however, the Lepraria Finkii did absorb the most Chromium out out of the respective samples exposed. Furthermore, it cannot be concluded that one species in particular is the best at absorbing overall. Each species had high abosrtion rates for particular elements, such as Lepraria Finkii for Strontium (a metal not controlled in this experiment) or Candelaria Concolor for Zinc.

Further Research

Due to the toxicity of certain heavy metals, we weren't able to work with heavy toxins such as mercury or arsenic. As these elements are still present in our environment, it would be ideal to perform another controlled experiment utilizing these elements, to further find species of lichen that can aid in reducing other toxin levels within the environment. Furthermore, our experiment was based in a fixed time interval, yet allowing the lichen to interact with the metals for a longer period might show other key details to lichen absorption.

Application

The information gathered through this experiment will help to further understandings of heavy metal toxicity in lichen and how that it can be useful to predict and manage heavy metal presence in given environments. Additionally, it can provide information on which lichen can best be used to help absorb heavy metals from water and air in order to maintain a clean environment.

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