Detroit Urban Farming and Phytoremediation of Copper in *Allium satvium*

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Abstract

Throughout the world, especially in urban environments, metal and waste contamination is a prominent issue. One of the numerous metal contaminants commonly found throughout urban areas is copper. Exposure to high levels of copper has a myriad of detrimental health effects. In order to improve the health of urban residents, and increase the general quality of life of the populace, phytoremediation techniques can potentially remove excess copper waste. Phytoremediation focuses on using plants and their natural ability to uptake metals and other soil contaminants and use them in their metabolic pathways. This uptake removes and reduces the contaminants in the soil and can potentially benefit the plant. Given the large variety of metabolic pathways in plants it is easy to conclude that certain plants would behave as stronger hyper-accumulators for different contaminants than others. In this experiment the hyper accumulation abilities of *Allium sativum* , commonly known as garlic, were tested using a copper analyte contaminant. To measure the extent of the accumulated copper the ppm concentration of copper in the soil and plant before and after treatment was analyzed using XRF and ICP-MS instruments. This research proved significant because it showcased the potential hyper accumulation ability of *Allium sativum* and its future use as a potent phytoremediation agent for copper waste. This research has been carried out as a part of the BUILD Research Coordination Network CHM 1150 Detroit Urban Farming and Phytoremediation Research course.

Background and Significance of Phytoremediation

What is phytoremediation?

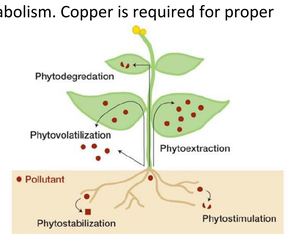
Phytoremediation is the process of utilizing plants to uptake and or reduce soil contaminates to a safe level. Phytoremediation operates of the concept that plants require a diverse array of nutrients for proper cellular metabolism. With this principal in mind plants then readily absorb and utilize what would normally be toxic contaminates from the soil for their own metabolic processes thus decontaminating the soil. These plants can then be harvested and transported away from the area of interest, and subsequently disposed of or treated at a hazardous waste facility.

What are hyper-accumulators?

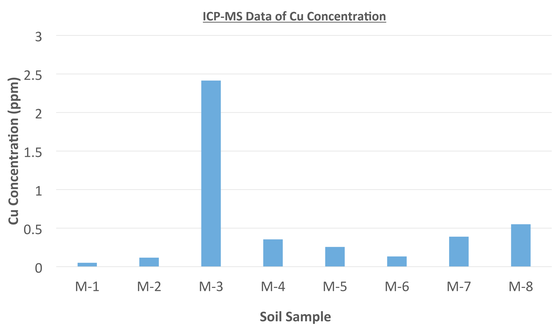
Most scientist refer to plant species as hyper-accumulators if they are able to uptake and store a specific contaminant to a concentration equal too or greater than 1,000 micrograms of contaminant per gram of leaf or plant tissue. Despite the ease that a strict quantitative value provides for differentiation between hyper-accumulators and non-hyper-accumulators there is plenty of contention between weather or not this strict value should be encompassing for of all contaminants[1].

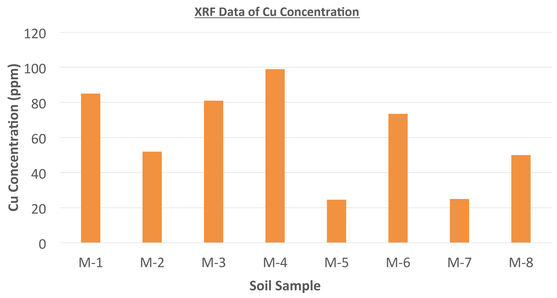
What is coppers role in plant metabolism?

Copper is a vital micronutrient necessary for proper plant metabolism. Copper is required for proper plant development and consequently plant seeds are often saturated with copper in order to facilitate proper growth and development. Copper is also necessary in daily plant metabolism as it helps to guide the formation of metalloproteins. However, excess copper levels can be toxic to plants and as a result copper uptake in plants is strictly regulated.



Data Charts: ICP-MS vs XRF





Methodology

The research experiment involved two methods of analyses in order to measure Cu levels in soil samples. The first process used was ***Inductively-Coupled mass spectrometry***, also known as ICP-MS.

~ 2g of each soil sample was weighed out. → Samples were appropriately labelled with their corresponding contents. → Each sample was ran through the ICP-MS → Cu Concentration Data was received and analyzed

The second method of analyses was through an X-Ray Fluorescence instrument, also known as XRF.

~ 2g of each soil sample were weighed out. → Samples were covered with a plastic cover and placed into XRF beam. → The manual button was held down for ~ 60 seconds. → The results were recorded and analyzed

Using two methods to evaluate Copper levels in the soil ensures that the results stay both accurate and consistent, and allows comparisons to be made.

Photos of Garlic Plants & Titration Setup throughout the experimentation period

Results and Data

M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8
Generic Soil No Plant 0 ppm Cu	Generic Soil No Plant 10 ppm Cu	Generic Soil Plant 0 ppm Cu	Generic Soil Plant 10 ppm Cu	Urban Soil No Plant 0 ppm Cu	Urban Soil No Plant 10 ppm Cu	Urban Soil Plant 0 ppm Cu	Urban Soil Plant 10 ppm Cu
0.052 ppm	0.117 ppm	2.413 ppm	0.353 ppm	0.255 ppm	0.132 ppm	0.389 ppm	0.549 ppm

Table 1.
Represented above is the Copper concentration in the soil samples after 6 weeks of growth, retrieved from the ICP-MS experimentation method.

M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8
Generic Soil No Plant 0 ppm Cu	Generic Soil No Plant 10 ppm Cu	Generic Soil Plant 0 ppm Cu	Generic Soil Plant 10 ppm Cu	Urban Soil No Plant 0 ppm Cu	Urban Soil No Plant 10 ppm Cu	Urban Soil Plant 0 ppm Cu	Urban Soil Plant 10 ppm Cu
85 ppm	52 ppm	81 ppm	99 ppm	24.5 ppm	73.5 ppm	25 ppm	50 ppm

Table 2.
Represented above is the Copper concentration in the soil samples after 6 weeks of growth, retrieved from the XRF instrument.

Soil Enrichment Process

Table 1. Mass of Cu added to each Soil Sample	
Sample ID	Mass Cu (g)
M-1	**0 g**
M-2	**0.00724 g**
M-3	**0 g**
M-4	**0.006167 g**
M-5	**0 g**
M-6	**0.02432 g**
M-7	**0 g**
M-8	**0.0250 g**

1. Eight pots were labeled and filled with soil with the mass determined.
2. Pots 1-4 were made with generic store soil and pots 5-8 were prepared with Detroit Urban Farm soil.
3. Amount of salt added to the soil was calculated, ~ 10 ppm, then mixed into soil.
4. Four garlic cloves were placed underneath the soil
5. Pots were in growth carts under light for ~ 6 weeks.

Future Research Plans in Phytoremediation

Phytoremediation is becoming an increasingly popular and cost-effective method of toxin removal from soil, so evidently, research in this field is also increasing. Experimenting with different metals, and a variety of hyper-accumulators, will allow researches to understand and identify the best methods when approaching phytoremediation. Some future plans in the research field of phytoremediation include:

Analyzing alternative metals, including those associated with a higher toxicity, such as lead, mercury, etc.

Doing another trial of this particular experiment again, while taking into account any Copper that was previously existing in the garlic clove.

Analyzing the phytoremediation efforts of other types of plants.

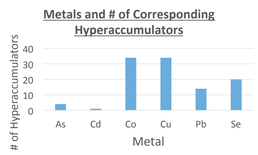


Table 3.
As shown above, there is a wide variety of hyper-accumulators for different metals, and there is plenty of research to be done in the field of phytoremediation.

Conclusion

After testing the hyper accumulation abilities of *Allium sativum* it can be seen that some hyper accumulation did occur, however not as much as was expected. Once the soil samples had undergone the ICP MS analysis the results showed that the soil contained very low concentrations of copper which conflicted against those shown from the XRF analysis. In comparison to the ICP MS results the XRF results showed to have a much larger copper concentration. There are many reasons as to why this may have occurred, the main one being that the concentration of copper found within the garlic cloves themselves wasn't taken into consideration. During the period in which the garlic plants were grown weeds appeared in the pots as well which could have potentially hyper accumulated the copper analyte along with the garlic. Apart from that, any copper concentration within the soil itself were not measured out before the garlic was planted. Any one of these factors or a combination of either could have been the reason for the skewed data. Considering the limited research being done on the use of garlic as a hyper accumulator there is a large potential for undergoing further research on the topic.

Acknowledgements

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Sources

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