Measurement of Iron Uptake in Garlic Plants for the Purpose of Soil Phytoremediation

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Abstract:
Though iron is a necessary nutrient in soil, in large quantities it can be harmful to human health. Symptoms of iron toxicity in humans can be caused by ingestion of 20 mg Fe per kg body weight. Severe cases of toxicity often occur at levels of 60 mg/kg.[1] Mining and industrial wastes have caused heavy metals such as iron to deposit in soil. This iron can be taken up by plants in agricultural soil and consumed by humans in excess quantities. The effects of ingesting large quantities of iron include lung inflammation and damage to the circulatory system.[2] The broader goal of this research is to develop a method to remove excess iron from contaminated soil through phytoremediation. The specific goal of these experiments is to develop a method for measuring iron uptake in garlic plants and to determine if garlic would be suitable for use in phytoremediation. Plants will be grown in soil in an attempt to accumulate the contaminant and remediate the soil. ICP-MS and spectrophotometry will be used to analyze the content of iron in contaminated soil with garlic growing in it. These results will be compared to the analysis of soil without garlic.

Aims:
1. The first aim was to develop a method for soil digestion and analysis of iron content using spectrophotometry.
2. The second aim was to introduce iron into the soil and plant garlic cloves in attempt to induce iron uptake into the garlic plant.
3. The third aim was to compare iron content in two types of soils with and without plants in order to make comparisons to control samples.

What is Phytoremediation?
Phytoremediation uses plants to extract nutrients from the soil. Plants can accumulate metals and then be harvested, removing the contaminants from the soil.[2] Phytoremediation is not costly and is potentially very effective, because plants are capable of spreading a large area and extracting contaminants deeper in soil via root systems. Hyper-accumulators are the plants typically used for phytoremediation because they are able to extract the largest amount of contaminant from the soil. A hyper-accumulator of Fe is capable of accumulating 10000 mg/kg in its dry plant matter.[3]

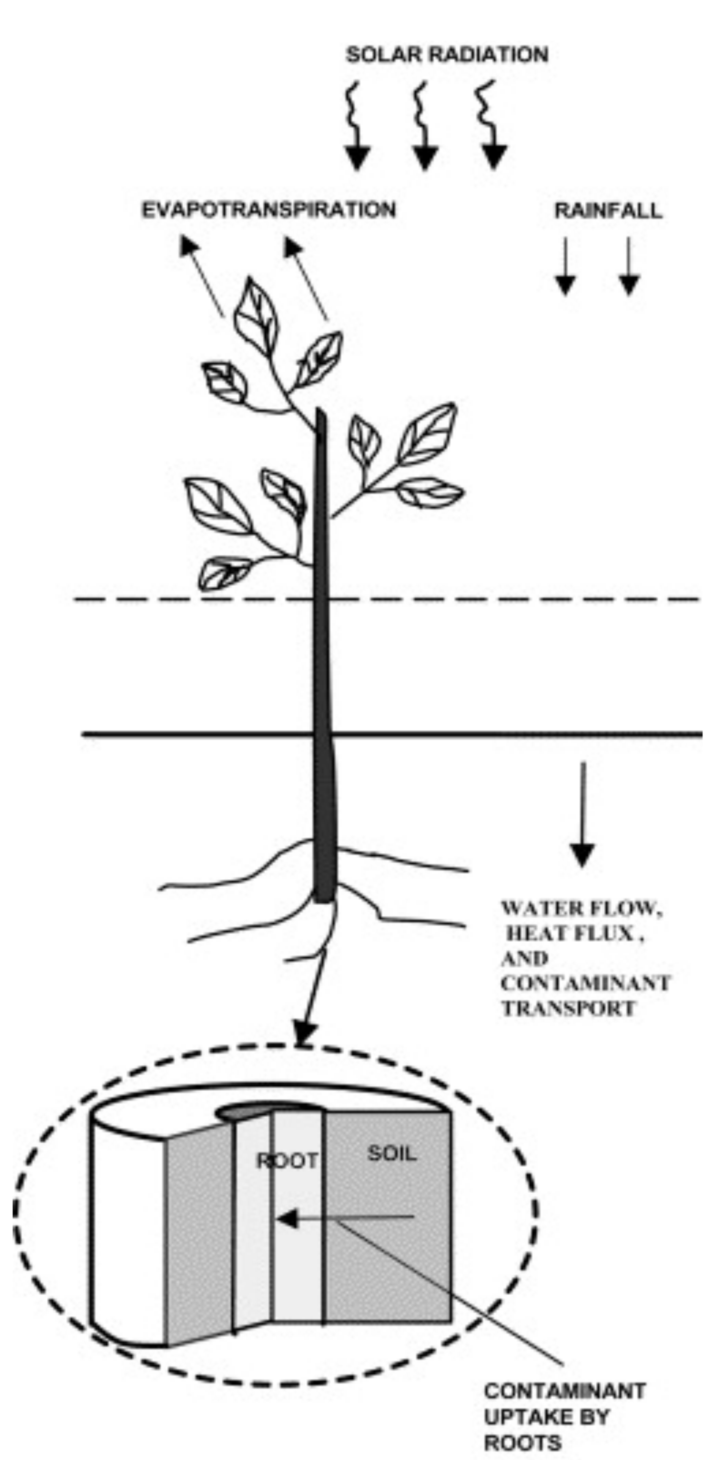

Figure 1. Illustration of Phytoremediation[4]
Contaminants are released into the soil directly or into the air and transported to the soil. The excess contaminants are then taken up by roots along with water and nutrients.

Figure 2. Phytoremediation Attempt
Garlic plants were planted in soil samples in an attempted to remove excess iron from the soil.

Methodology:

Plant
- Pots were labeled, mass of each soil sample recorded
- Samples treated as indicated in Table 1
- Samples left in controlled conditions for several weeks

Extract
- Approximately 2 g of each sample extracted from pot
- Samples digested in HCl
- Samples filtered and diluted with HCl

Analyze
- **Spectrophotometry** (at UDM)
- Standard curve generated
- Solutions reacted with buffer, and diluted
- Extract solutions analyzed with spectrophotometer
- Concentrations determined from standard curve
- **ICP-MS** (at Wayne State)

Table 1. Soil Sample Treatment

Soil Sample	1 (Generic)	2 (Generic)	3 (Generic)	4 (Generic)	5 (Marygrove)	6 (Marygrove)	7 (Marygrove)	8 (Marygrove)
Group	No plant	No plant	Plant	Plant	No plant	No plant	Plant	Plant
Fe Concentration (ppm)	0	10	0	10	0	10	0	10

Figure 3. Analysis by Spectrophotometry
Spectrophotometry was used to analyze the absorbance of each sample and determine iron concentration in solution.

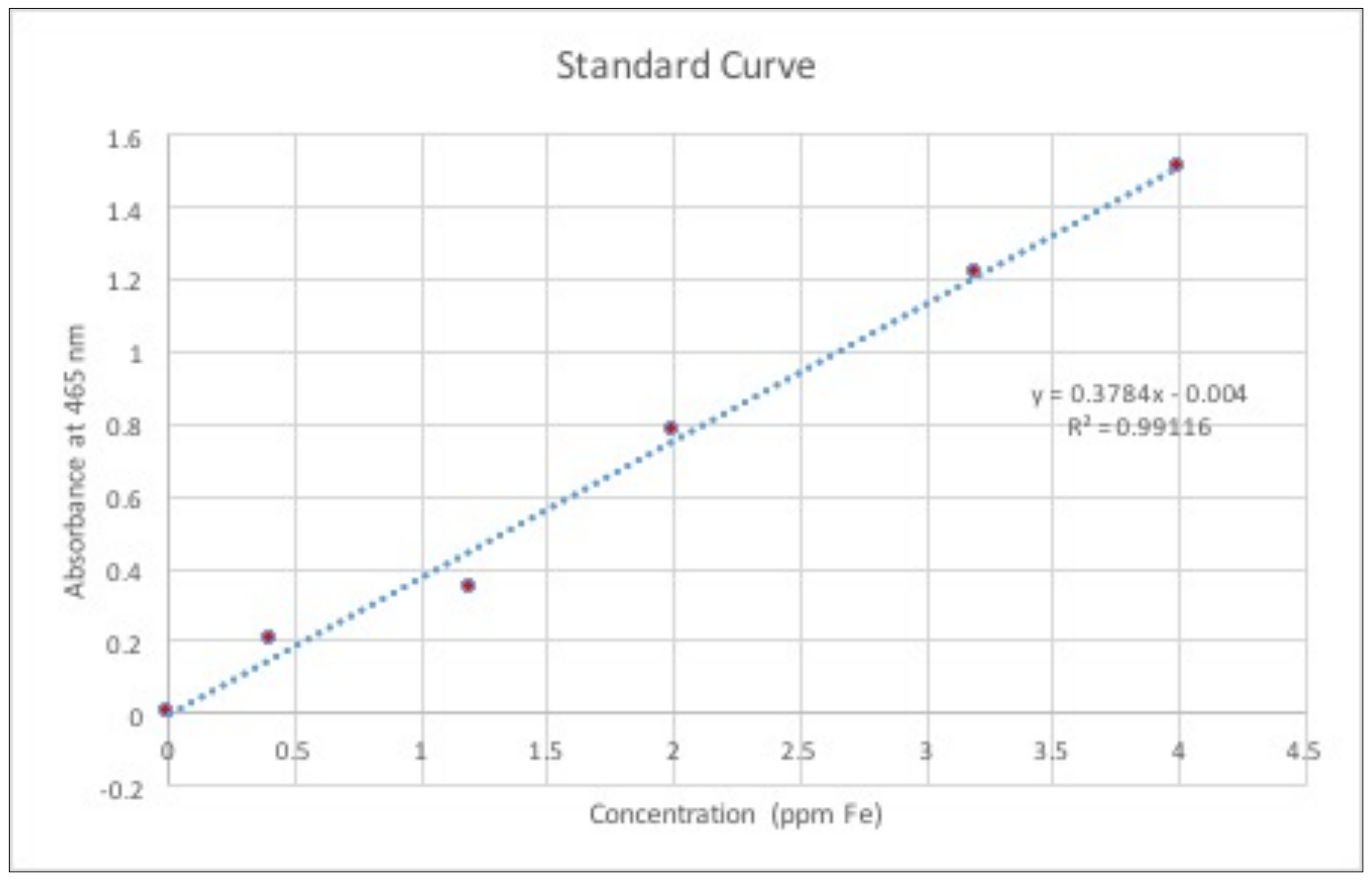

Figure 4. Standard Curve (Absorbance vs. Fe Concentration)
A stock 40 ppm Fe solution was used to prepare Fe solutions of known concentrations which were analyzed using spectrophotometry. The absorbance versus concentration was graphed and a line of best fit determined.

Results:
Spectrophotometry results indicated that samples with Marygrove soil were remediated by garlic plants. Samples 6 and 8 were treated with iron salt and only sample 8 had garlic planted in an attempt to remediate iron. The results in Table 2 show that Sample 8 did have a lower iron soil concentration (148 ppm) than Sample 6 (172 ppm). The generic soil samples resulted in the opposite indication. Samples 2 and 4 were both treated with iron salt and garlic was grown only in sample 4. However, the results show that sample 4 had a higher iron soil concentration (184 ppm) than sample 2 (120 ppm). The ICP-MS results in Table 3 indicate higher concentrations of Fe in soil for each sample. Figure 5 displays a comparison of spectrophotometry and ICP-MS results.

Table 2. Spectrophotometry Results

Sample	mg Fe/ kg soil
1	85.7
2	120
3	222
4	184
5	279
6	172
7	204
8	148

Table 3. ICP-MS Results

Sample	mg Fe/kg soil
1	97.4
2	144
3	259
4	212
5	444
6	237
7	371
8	309

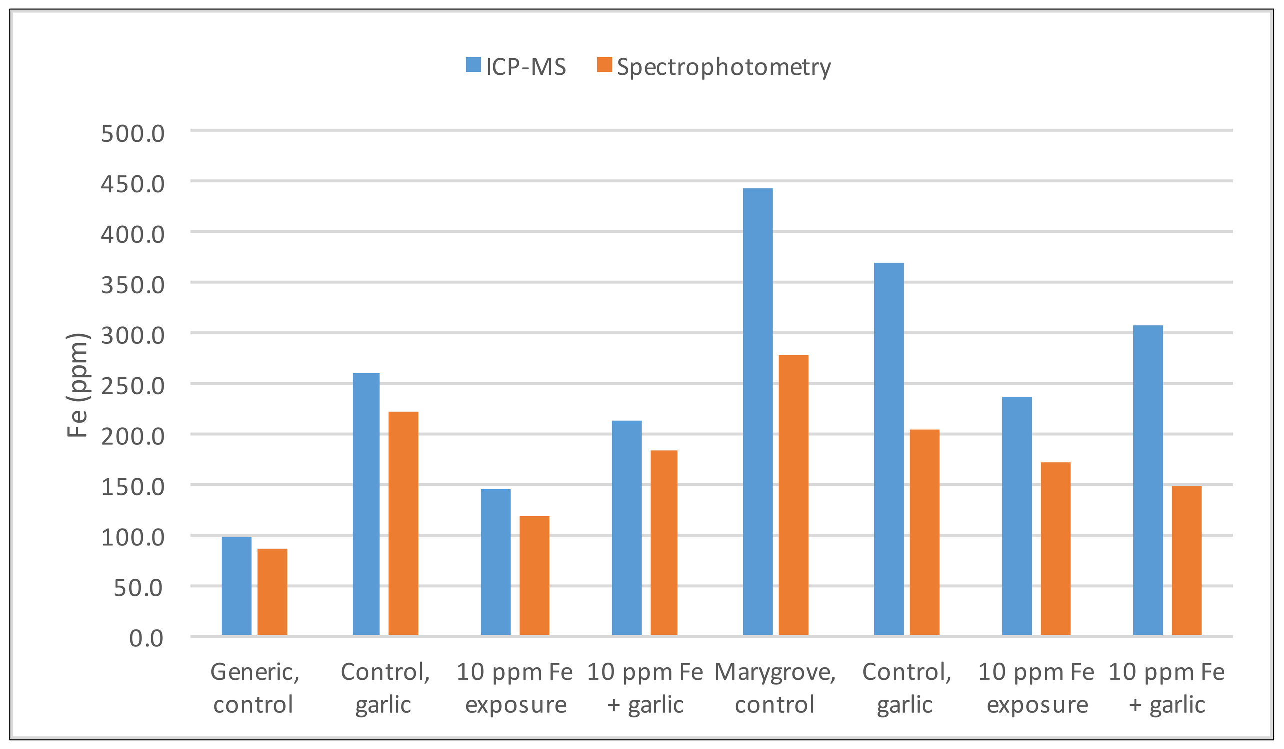

Figure 5. Comparison of ICP-MS and Spectrophotometry
The results of Fe analysis by ICP-MS and spectrophotometry were graphed side by side for each soil sample.

Conclusions:
Though the generic soil samples resulted contrary to expectations, remediation of iron in soil was observed in the results of the Marygrove samples 5 and 6. Further tests should be conducted to ensure that the initial iron concentrations of each sample are the same prior to phytoremediation attempts. In addition, advanced techniques, such as digestion of soil with heated acid, should be used to extract iron from soil samples. Unexpected results also suggest the possibility that garlic cloves introduce additional Fe to the soil, and the Fe content in garlic could be investigated.

References:
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