PHYTOREMEDIATION OF IRON CONTAMINATED SOIL BY WATERLEAF (*Talinum triangulare* (Jacq) Willd) IN JOS, PLATEAU STATE, NIGERIA

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ABSTRACT

Phytoremediation is an environmentally friendly approach which involves plants for removal of contaminants from polluted soil. The objective of this study therefore was to evaluate the effectiveness of water leaf (*Talinum triangulare*) in extraction of iron (Fe) from contaminated soil. The research consisted of the following treatments: 0, 26, 52, 78, 104, 130 and 156 Fe mg/kg of soil. Iron nitrate was used as the source of iron. The plant data collected were leaf and flower count, plant height, stem diameter, number of branches, shoot weight, the root weight and iron concentration in the shoot. These were analyzed using analysis of variance and the Fisher's pairwise comparisons. The result showed that there was no significant effect of treatments on growth parameters except for leaf count. Plants that received 130 (Fe mg/kg) had significantly higher leaf count probably due to higher amount of nitrogen supplied by iron nitrate. There was significance difference in iron concentration in the shoots of water leaf plants among the various treatments when compared to the control. Mean maximum extraction of iron was 5815 mg/kg with a standard deviation of 16.51. Lower leaf count and amounts of iron extracted at higher concentration of iron in the soils are probably due to unset of iron toxicity in the water leaf plants. This indicates that water leaf plants possess great potential in phyto-extraction of iron and other heavy metals from contaminated soil.

Keywords: Phytoremediation, Iron, Water leaf.

INTRODUCTION

Iron as a heavy metal is naturally present in the soil however anthropogenic activities have led to increased concentration of this element to amounts that are harmful to both plants and animals. Indiscriminate disposal of urban and industrial waste generated by human activities is the major source of pollution of soil with heavy metals (Jolly et al., 2013 and Bamuwamye et al., 2017). Though majority of heavy metals are phytotoxic even at low concentrations (Ekwumemgbo et al., 2013) some studies have indicated that certain types of plants could accumulate high levels of heavy metals from the soil while continuing to grow and proliferate normally (Udosen et al., 2006 and Bhagure et al., 2010). This ability of some plants to survive in contaminated environments has been exploited to remove contaminants from the soil (Ebah et al., 2016).

Furthermore, phytoextraction, a type of phytoremediation which is the use of vegetative species for in-situ treatment of areas polluted by variety of hazardous substances relies upon the plant's natural ability to absorb certain substances such as heavy metals from the environment and sequester them in their cell until the plant can be harvested (Bentjen et al., 2017). Similarly, Phytoremediation is an environmentally friendly method which uses plants to accumulate the contaminants from the soil and stores it within tissues of the plant thereby making soil reusable. This approach is suitable for environmental conservation as there are no risks, side effects or hazards incurred in the process of mitigation or reversal of the effects of human activity on the environment.

Various research on the effectiveness of phytoremediation abilities of plants did not attempt to control heavy metal contents in soils before carrying out the experiments. For example, Mathew (2005) only used soil from contaminated sites in their experiments and heavy metal contents in the soil were not varied to observe plant response at various concentrations. Similar approaches were performed by Farrag et al., (2013), Anyalogbu (2017) and Orwa (2013). In contrast, Ochonogor and Atagana (2014) were able to use a novel approach to control heavy metal contents and concentration while monitoring plant response. Similar methods have been adopted by Lina et al., (2018) and Mahmud et al., 2013. Following this approach, therefore, the objective of this study is to determine the effect of iron contaminated soil on growth of *Talinum triangulare* to investigate the effectiveness of *Talinum triangulare* in phyto-extraction of iron from contaminated soil.

MATERIALS AND METHODS

Study Area

The study area is located within on the Jos Plateau. The Jos Plateau lies between latitude 8^0 50^1N and 10^0 10^1N and longitude 8^0 22^1E and 9^0 30^1E (Kareem, 2007). It has an average elevation of about 1250m above sea level and stands at a height of about 600m above the surrounding plain (Olowolafe, 2002). The average temperature in Jos ranges between 21^{o}C – 25^{o}C. The climate of Jos is cool due to the high altitude. The mean annual rainfall is 1260mm, while the relative humidity increases from May to August and decreases gradually from September to April. The characteristics of soil used for the study was earlier determined by Owonubi and Abimiku (2021) presented in Table 1. The soils have loamy texture and are moderately acidic. Organic matter and available phosphorus are at moderate levels, but the fertility of the soils is generally low.

Table 1: Characteristics of soil used for the study

Soil property	Value	Units
Sand	88.8	%
Silt	8.4	
Clay	2.8	
pH	5.69	
N	0.065	
Available P	12	Mg/kg
Available S	2.4	
Ca	1.48	Cmol/kg
Mg	0.084	
Na	0.0022	
K	0.13	
Exchangeable acidity	1.57	
CEC	3.68	

Source: Owonubi and Abimiku (2021)

Phyto extraction Treatments and Growth Parameters Analysis

Topsoil sample was collected from an uncontaminated site, the soil sample was air dried and then sieved through a 2mm mesh sieve. The soil was properly mixed, and all lumps broken before the sieving process. Three kilograms of the soil was weighed into plastic pots. The waterleaf seed was broadcasted on the soil and covered with a light soil layer. After germination, the plant was thinned to one plant per pot.

The completely randomized design was employed for the experiment, the experiment consisted of seven treatments and three replicates. The treatment was mixed with the soil before the commencement of planting. The details of the treatment to be used in the experiment are presented in Table 2. Iron nitrate was applied to supply the treatments presented in Table 2

Table 2: List of treatments used in this study

SN	TREATMENT	Fe (mg/kg)
1	T_0	0
2	T_1	26
3	T_2	52
4	T_3	78
5	T_4	104
6	T_5	130
7	T_7	156

Data collection and statistical Analysis

The following plant data was collected during the growth period:

1. Plant height
2. Leaf count
3. Stem girth
4. Number of branches
5. Number of flowers
6. Shoot weight
7. Root weight

After the growth period, the shoot of the plants was sampled and analyzed for total Iron (Fe). Total Fe in the plant samples were extracted after a mixed acid digestion involving perchloric, nitric and sulphuric acids. Fe was read from the digest using an atomic absorption spectrophotometer. One-way analysis of variance was employed to determine the effect of treatments on growth performance of waterleaf and its efficiency in extracting iron from contaminated soil at 75% level of significance. The Fisher's test of significance was used for mean separations.

RESULTS AND DISCUSSION

Growth Parameters

Data on growth parameters is presented in Table 3. Results obtained from statistical analysis on plant height, stem diameter, number of branches and flower, and shoot and root weight indicated that effects of treatments were not statistically significant. However, treatments had significant ($p < 0.05$) effect on leaf count with lowest values obtained in treatment 1 whereas the highest values were obtained in treatments 5 and 6. Higher values of leaf count in these treatments could be due to increased nitrogen levels in the soil due to application of iron nitrate at higher levels to the soils. Brady and Weil (1999) have shown that optimum soil nitrogen level leads to improved vegetative growth. However, the drop in leaf count values at treatment 7 could be as a result occurrence of iron and or nitrogen toxicity.

More so, iron toxicity has been reported to affect the development of healthy leaves (Nikolic and Pavlovic, 2018). In addition, increased soil nitrogen levels through the application of iron nitrate could also lead to nitrogen toxicity thereby leading to poor leaf, root and fruit development (Brady and Weil, 1999). Lina *et al.,* (2018) in a similar study involving application of lead nitrate to soil also observe poor biomass development. This was however attributed to the effect of lead toxicity on the plants.

Table 3: Number of leaf count at 12 weeks of growth

Treatment	Mean	Standard Deviation	95% CI
1	18.67d	5.13	9.74,27.59
2	30.00^{cd}	2.65	21.07,38.93
3	43.33^{ab}	8.33	34.41,52.26
4	33.67^{bc}	6.66	24,74, 42.57
5	54.67^{a}	4.04	45.74,63.59
6	53.67^{a}	10.02	44.74,63.59
7	4.00^{bc}	10.00	31.07,48.93

Mean that do not share a letter are significantly different, Note: CI = Confidence Interval

Iron Concentration in Water Leaf Plant

Table 4 shows concentration iron (Fe) extracted by water leaf at 12 weeks after planting. There were significant differences in the effect of treatments on concentration of iron in the water leaf plants. Consequently, water leaf plants in treatment 6 had higher concentration of Fe, followed in rank by treatment 3, 4, and 5. These results indicate that water leaf plants were effective in extracting Fe up to a soil concentration of 130 mg/kg but were ineffective at concentrations above 156 mg/kg. This corresponds to observations by Anyalogbu *et al.,* (2017) who reported the efficiency of water leaf plants to extract heavy metals from contaminated soil.

Furthermore, performance of water leaf plants in extraction of Fe (5.8%) in this study was however far lower than that reported by Ochonorgor and Atagana (2014) for *Psorela pinnata* plants (55%). Water leaf plants in treatment 1, 2, and 7 had the least concentration of Fe. The high concentration of iron in treatment 7 could have impeded the efficiency of the water leaf plants in extracting iron from the soil probably due to toxicity effect of the treatment on the plant.

Table 4: Iron concentration in water leaf plant at 12weeks of growth

Treatment	Mean (mg/kg)	Standard Deviation	95% CI
1	2795.0bc	112.1	1054.5,4535.5
2	3020bc	10.36	1280,4761
3	3623abc	9.53	1883,5364
4	4199ab	5.55	2459,5940
5	5218ab	15.98	3477,6958
6	5815a	16.51	40.74,7555
7	1736.6c	76.5	-3.9,3477.1

Mean that do not share a letter are significantly different. Note: CI = Confidence Interval

Similar observations were made by Lina *et al.* (2018) while studying phytoremediation of lead contaminated soils using *Cordyline fruicosa.* Also, Siagian *et al.,* (2018) reported a phytoremediation efficiency of 37 to 48 and 32 to 52 percent for cadmium and copper respectively for vertiver grass depending on the concentration in the soil. Furthermore, the efficiency of Cu uptake from soil by Triticum aestivum was observed to be 1221.57 mg kg^{-1} of total dry weight (Mahmud et al., 2013). These indicates that water leaf performed significantly in the phytoextraction of iron from soil.

CONCLUSION

The growth of water leaf was significantly inhibited at 156 milligram of iron per kilogram of soil. Also, at this concentration the extraction efficiency of iron from soil by water leaf was significantly affected. In contrast, water leaf showed great efficiency in extracting iron from soil at treatment ranges of between 52 to 130 milligram of iron per kilogram of soil.

The study has shown that water leaf plants possess great potential for usage in phyto remediation of iron contaminated soils. Also, further research can be conducted to test the effectiveness of other plants in phyto-extraction of various heavy metals in polluted soils.

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