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THE BIOACCUMULATION STUDY OF *ZINNIA ELEGANS* L.: BIOACCUMULATING HIGH CONCENTRATIONS OF LEAD (PB) FROM CONTAMINATED SOILS

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ABSTRACT

With increasing developmental trends in the fields of science and technology, the events of industrial revolution and green revolution in agriculture sector have led to improved life standards but it also has lead to the overall pollution of land, water and air. This study is to assess the ability of Zinnia elegans L. to accumulate Pb from the contaminated soils and thus making the process of reclaiming the contaminated land faster and cheaper. Multiple assessment techniques exists to assess the bioaccumulation capacity of various plant species, the method used in this study is AOAC 1990. By studying the ability of various species it would be easier to find the most suitable species for removing different heavy metals from the soils, in this case Pb. This study was carried out with the sole objective to estimate the bioaccumulation of Pb(Lead) at various concentrations in the soil by *Zinnia elegans* L. The results of this study will aid in the phytoremediation of soils contaminated by Pb and further in reclamation. The outcomes of this study can be utilised by soil scientists, farmers, policy makers etc for the overall well being of the soil health and the subsequent health of the environment.

Keywords: Heavy metals; Effluents; Chemical fertilizers; Bioaccumulation; Phytoremediation.

1. INTRODUCTION

Pollution of the environment with toxic metals has increased dramatically since the onset of the industrial revolution. Because they are rich sources of plant nutrients, sewage effluents and sludge are commonly used (often untreated) by the farmers for irrigating soils around industrial units and metropolitan cities of India at the cost of heavy metal contamination. However, these sewage effluents have the tendency to carry along huge amounts of trace lethal metals [1-3]. Recently, Rattan *et al*. [4] showed that a huge amount of assimilation of Zinc, Copper, Iron, Nickel and Lead in sewage, irrigation etc. leads to a higher assimilation of heavy toxic metals both within the crops and vegetables that are grown with the same water and soil. Disproportionate metal concentration in the soil might result in multiple stressors acting to reduce both growth of good microbes as well as decreased growing capacity and fertility, yield loss [5] and possible contamination of the food chain [6]. It is quite necessary to remediate the soil that is contaminated by these heavy metals but on the other hand it is very expensive and intrusive.

Thus, development of a low cost and environment friendly strategy is required. Recently, the importance of such bioaccumulating plants has been studied very vigorously and has been applied to multiple contaminated soils, [7, 8], giving birth to the field of "phytoextraction" within a broader field of phytoremediation [9]. The alarmingly increasing urbanization and industrialization countrywide is generating enormous amount of inorganic and organic wastes posing to serious problem of safe disposal. Nearly 450 cities in India generate around 1200 tonnes of sewage sludge every day, there exists a potential to produce 4000 tonnes of sludge per day [10]. Sewage sludge contains variable amounts of heavy metals like Pb, Cr (Chromium), Ni (Nickel), Cd (Cadmium) *etc.* as well as essential plant nutrients like Nitrogen, Phosphorous, Potassium, Sulphur and Zinc *etc.* Sewage sludge is generally disposed off or applied in agricultural lands as a source of plant nutrients. Long term application of sewage sludge has been reported to elevate concentrations of heavy metal in soil under peri-urban agriculture around Delhi [11], Calcutta [12] and Ludhiana [13]. These metals once mixed into agricultural soils, do not leach substantially and get accumulated in surface till layer by adsorption or precipitation phenomenon [14, 15].

Development of effective phytoremediation strategy is dependent on an understanding of the coupling of root processes in the rhizosphere zone of hyper-accumulator to microbial activity. Thus before carrying out the phytoremediation processes which can be further used for commercial purposes, the behaviour of hyperaccumulator varieties must be researched and should be perfectly documented. A clear understanding of how the metal is taken up by a certain species and along with it the range of thresholds will help farmers to reduce the toxicity of heavy metals in their crops.

Zinnia elegans L. is annual ornamental plant. This plant belongs to the Asteraceae family. The plant grows upto 30 inches in height. Flowers are solitary daisy like flower-heads on a single, erect stem and the lanceolate leaves are opposite the flower heads. Flower colors vary from white, cream, green, yellow, apricot, orange, red, bronze, crimson, purple and lilac. *Zinnia* plant is easily grown in humus, evenly moist, well drained soils in full sun. This plant was selected due to its ability to grow in various ranges of condition.

This work assesses the capability of *Zinnia elegans* L. to remediate the soils contaminated with Lead. Capability of Lead accumulation by plant parts was also studied.

2. METHODOLOGY

2.1. Experimental work was done step by step as mentioned below:

1. Pot culture experiments: Z*innia elegans* L. was grown in naturally available soil (control) along with in soils that were induced with various concentrations of Pb $(NO_3)_2$.
2. The process of sample collection: samples were taken at an interval of every 15 days to assess the morphological parameters, for the estimation of heavy metal's content; samples were only taken after the complete maturity of the plants at 60 days.
3. Estimation of Lead $Pb(NO_3)_2$ content in plant parts: At the time of the maturity of the plants, sampling plants were uprooted and the estimation of Pb was carried out in the roots, stems, flowers and leaves.

2.2. Initial quantitative estimation of Pb in the experimental soil (Association of official analytical chemists: AOAC, 1990)

It is necessary to estimate the amount of the contaminants already present in the study soils so that they do not affect the end results of the actual estimation of the concentrations of Cd and Pb added later on for the experiments.

The process started with drying the soil samples in the hot air oven at 80°C for atleast 48 hours or until a singular dry weight was obtained. Once the process of drying ended the soil was allowed to cool after which it was grounded and powdered to the required finesse, then finally it was used for analysis.

Table 1: Pb treatments in preliminary seed germination experiments

Sr. No.	Pb Conc. (mg/kg)	$(Pb(NO_3)_2)$added (mg)
1.	500	50
2.	1000	100
3.	1500	150
4.	2000	200
5.	2500	250
6.	3000	300
7.	3500	350
8.	4000	400
9.	4500	450
10.	5000	500
11.	5500	550
12.	6000	600
13.	6500	650
14.	7000	700
15.	7500	750
16.	8000	800
17.	8500	850
18.	9000	900
19.	9500	950
20.	10,000	1000

Table 2: Concentrations of Pb selected for study

Metal	Concentrations (mg/kg)				
Lead (Pb)	500	1000	1500	2000	2500

3. RESULTS AND DISCUSSION

Accumulation potential of *Zinnia elegans* L. was found higher at higher concentrations of Pb whereas at lower concentrations it was comparatively low. At lowest concentration tried, *i.e.,* 500 mg/kg Pb in soil, roots accumulated 551.21 mg/kg of Pb, it was just 1.1 times more than that present in the soil, whereas at highest concentration *i.e.,* 2500 mg/kg, roots accumulated 3237.93 mg/kg Pb, which was 1.3 times more than that was present in the soil. But the highest amount of accumulation with increasing concentrations of Pb was found in the leaves, stem and the flower respectively. At the highest concentration *i.e.* 2500 mg/kg leaves showed an accumulation of 9636.62 mg/kg that was 3.8 times of the Pb present in the soil. The second highest accumulation at 2500 mg/kg was seen in the stem at 5728.49 mg/kg which was 2.3 times higher than that present in the soil. The third highest accumulation was seen in the flowers at 4624.11 mg/kg which was 1.8 times more Pb that was present in the soil. Based upon the above results *Zinnia elegans* L. has been clearly shown to be a great phtyoremediation plant species for higher concentrations of Pb in the soil.

Table 3: Pb accumulation in root, stem, leaves and inflorescence of *Zinnia elegans* L

Pb in Plant Part/ Treatment	Pb in Leaves (mg/kg)	Pb in Stem (mg/kg)	Pb in Root (mg/kg)	Pb in Flower (mg/kg)
Control	81.19±9.63	74.11±5.56	58.08±6.56	40.23±7.23
500mg/kg	929.00±45.63	435.44±35.72	551.21±40.47	492.44±39.88
1000mg/kg	3353.07±63.97	1087.68±63.91	891.96±43.90	1063.70±59.61
1500mg/kg	6638.37±85.64	2378.51±69.07	2037.06±59.39	1459.89±52.40
2000mg/kg	7997.52±101.84	3437.21±78.11	3147.61±65.79	2199.11±70.16
2500mg/kg	9636.62±119.00	5728.49±85.89	3237.93±75.65	4624.11±46.19

4. CONCLUSION

The conclusions that were derived from the results of analysis carried out for the study were as follows:

1. *Zinnia elegans* L. was shown to have been a good accumulator of Pb, thus this plant can be grown on soils that are contaminated by this heavy metal for phytoremediation and land reclamation.
2. Pb accumulation was highest in the leaves followed by the stems, the analysis concluded that the bioaccumulation capacity of Pb by *Zinnia elegans* L. was very high and it kept on increasing with increasing concentrations of Pb in the soils.
3. The analysis of the physical parameters concluded that there was no major change observed in the morphological characteristics of *Zinnia elegans* L. flowers. The higher concentration of Pb in the flowers made them commercially not viable.

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