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Assessment of lead and zinc phytoaccumulation potential of some selected ornamental plants

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Abstract

Lead and Zinc phytoaccumulation potential of eight ornamental plants *Begonia sarmentacea* Brilmayer, *Bidens sulphurea* Sch. Bip., *Episcia cupreata* Hanst., *Impatiens walleriana* Hook.f., *Kalanchoe blossfeldiana* Poelln, *Tagetes erecta* L., *Tradescantia spathacea* Sw. and *Turnera subulata* Sm. were analyzed using atomic absorption spectrophotometry. It was found that, among the selected plants *Begonia sarmentacea* Brilmayer accumulated the highest amount of Lead and *Episcia cupreata* Hanst. accumulated the highest amount of Zinc. Concentration of Lead in acid dissolved dry plant material of *Begonia sarmentacea* was 16.61mg/kg and that of Zinc in *Episcia cupreata* was 36.72mg/kg. The study revealed that *B.sarmentacea* and *E.cupreata* were capable of removing the heavy metal contaminants, Lead and Zinc respectively from polluted soil, suggesting their potential for the reclamation of lands contaminated with these heavy metals.

Keywords: phytoremediation, heavy metals, ornamental plants, atomic absorption spectrophotometry

Introduction

Soil is an imperative component of the natural environment. It is as important as flora and fauna, rocks, landforms and rivers. Soil always responds to changes in ecological factors, including influences of man and land use. Soil pollutants reduce productivity of soil and they have harmful effects on the physical chemical and biological properties of the soil. The decline in the productivity of soil due to soil pollution forms a great threat to natural and agricultural ecosystems. (Mishra *et al.*, 2016) [5].

Mining operations, use of sewage sludge in farm land, dumping of waste, and spillage are responsible for the migration of pollutants into non-polluted areas and contribute towards pollution of our ecosystem. Each type of pollution has its own detrimental effects to microbes, plants, animals and eventually to human health, however heavy metal pollution in soil and water definitely requires greater concern due to their carcinogenicity and persistent nature. Heavy metal pollutants cannot be destroyed by using living organisms, but some living organisms can change heavy metal pollutants from one oxidation state or organic compound to a new oxidation state or organic compound (Garbisu and Alkorta, 2001; Gisbert *et al.*, 2003) [2, 3]. Higher concentrations of heavy metals in soil can negatively affect crop growth, as these metals interfere with metabolic functions in plants, including physiological and biochemical processes, inhibition of photosynthesis and respiration, disintegration of most important cell organelles and may even cause death of the plants (Garbisu and Alkorta, 2001) [2]. Hence, heavy metal contamination causes great menace to the environment and human health. The most dangerous heavy metals are Pb, Hg, As, Cd, Cr, Zn and Cu. Among these, Cd and Pb are the most hazardous metals affecting human health (Sekara *et al.*, 2005) [10]. During their normal physiological processes, plants pump large amounts of water and solutes in to plant body. This pumping action can be exploited to improve degraded environments by stabilizing, removing or breaking down contaminants in the substrates, that is, plants can be used for bioremediation. Plant based bioremediation is known as phytoremediation. (Robinson *et al.*, 2003) [7].

Phytoextraction or phytoaccumulation, is a phytoremediation technology which refers to the use of plants to absorb, translocate, and store toxic contaminants from soil, sediments or sludge in the tissues of root and shoot (Salt *et al.*, 1998; Garbisu and Alkorta, 2001) [9, 2]. It is the most accepted and practical phytoremediation procedure for the removal of toxic heavy metals from contaminated environments. Phytoextraction requires growing and harvesting of the plants, as well as secure disposal of toxin accumulated plant materials. The cost involved in phytoextraction, when compared with those of conventional soil remediation techniques, is tenfold lower. Hence phytoextraction is a cost-effective technique (Salt *et al.*, 1995) [8].

Plants with a short life cycle and having ornamental value are ideal for phytoremediation application. Use of ornamental plants in phytoremediation enhances the environment's aesthetics in addition to removing pollutants from the environment and may help in generating additional income, including additional employment opportunities. Hence the utilization of ornamental plants in phytoremediation will add new facet to the field of removing pollutants from aquatic and terrestrial environments (Nakbanpote *et al.*, 2016) [6]. Considering all this, in the present study some common non edible ornamental plants were evaluated for their potential in phytoremediation. Being non edible, the risk of contaminants entering the food chain was reduced. Present experiments were conducted in this context and an effort was made to investigate the Lead and Zinc phytoaccumulation potential of eight non edible ornamental plants.

Materials and methods

Eight common ornamental plants were chosen for the present study. They were *Begonia sarmentacea* Brilmayer, *Bidens sulphurea* Sch.Bip, *Episcia cupreata* Hanst, *Impatiens walleriana* Hook.f., *Kalanchoe blossfeldiana* Poelln, *Tagetes erecta* L., *Tradescantia spathacea* Sw., *Turnera subulata* Sm. Thirty numbers of each plant species used for the study were collected from Kuruvattur, Kozhikode district and acclimatized in the Botanical Garden of St. Joseph's college, Devagiri for two weeks.

Experimental protocol and procedure

Thirty plants of each selected plant species were collected and the plants were divided into three sets. First set of ten plants of each species was kept as the control plants. The second set of ten plants of each species was kept for lead treatment. The third set of ten plants of each species was kept for zinc treatment. The heavy metal treatment was carried out for 25 days after the acclimatization period.

Each plant of the control set was given 50ml of water regularly for 25 days. Each plant of the second set was treated with 50ml of lead acetate solution regularly for 25 days. The lead acetate solution was prepared by dissolving 160g of lead acetate in 100L of water.

Each plant of the third set was treated with 50ml of zinc sulphate solution regularly for 25 days. The zinc sulphate solution was prepared by dissolving 160g of zinc sulphate heptahydrate in 100L of water.

After the treatment period, the plants were taken out of the soil, washed with distilled water to remove the soil particles, dried in oven for 48 hours at 80^0 C and were ground into powder.

0.5g ground powder of plants of each set were weighed accurately and digested with 40ml mixture of nitric acid (HNO_3) and perchloric acid ($HClO_4$) taken in the ratio 4:1. The resulting mixtures were evaporated to dryness and were extracted with distilled water. The solutions were heated to boiling and filtered. The volume of the solutions thus obtained was made to 50ml each. The metal ion concentrations in all the samples were analyzed by Flame Atomic Absorption Spectrophotometer at CWRDM (Centre for Water Resources Development and Management), Kozhikode, Kerala, India.

Results and Discussion

Phytoremediation is the use of plants to decontaminate soil or water by inactivating metals or toxic substances in rhizosphere or translocating them in to the aerial parts. This method is considered as a new and highly promising technology for the reclamation of polluted sites. Phytoremediation can be used to remove heavy metals, pesticides, solvents, explosives, crude oil, polyaromatic hydrocarbons, and various other types of pollutants. The plants used for the process can be subsequently harvested, processed and disposed.

1. Phytoaccumulation of Lead

The lead phytoaccumulation potential of the selected plants detected by Flame Atomic Absorption Spectrophotometry revealed that among the control plants, *Bidens sulphurea* Sch.Bip. accumulated the highest amount of lead, the value being 1.48mg/kg (Table 1). The absorption levels of the control plants of *Impatiens walleriana* Hook.f., *Kalanchoe blossfeldiana* and *Turnera subulata* Sm. were below the detection limit. The absorption levels of other plants (*Begonia sarmentacea* Brilmayer, *Episcia cupreata* Hanst., *Tagetes erecta* L. and *Tradescantia spathacea* Sw.) were very low. The study using control plants clearly showed that the level of lead in the soil used for the present study was very low.

All the lead treated plants, except *Turnera subulata* Sm. (0.19mg/kg), showed significant phytoaccumulation levels for lead. *Begonia sarmentacea* Brilmayer showed highest phytoaccumulation level of lead, the value being 16.61mg/kg (Table 1). *Episcia cupreata* Hanst. also showed high level of phytoaccumulation and the value was 15.74mg/kg (Table 1). Thus the results showed that these plants have high lead phytoaccumulation potential.

El-Mahrouk *et al*., (2019) [1] reported that *Salix mucronata* belonging to the family Salicaceae was highly effective in removing lead from contaminated soil. In the present study, *Begonia sarmentacea* Brilmayer belonging to the family Begoniaceae was found to be efficient in removing lead from contaminated soil.

2. Phytoaccumulation of Zinc

The studies on the phytoaccumulation potential of the selected plants for zinc revealed that among the control plants, *Tradescantia spathacea* Sw. accumulated the highest level of Zinc (13.70mg/kg) whereas *Episcia cupreata* Hanst. accumulated the least level of Zinc (2.38mg/kg) (Table 2).

All the zinc treated plants showed sufficiently high levels of absorption and therefore they can be used for the phytoremediation of zinc contaminated soil (Table 2). The highest level of accumulation was seen in *Episcia cupreata*, the value being 36.72mg/kg and the least level of accumulation was shown by *Kalanchoe blossfeldiana* (4.73mg/kg).

Macci and Peruzzi (2016) [4] reported that among the several plants used for phytoremediation *Paulownia tomentosa* belonging to the order Lamiales was the most effective in removal of heavy metals from soil. In the present study also, among the several pants used for the study the plant *Episcia cupreata* Hanst. belonging to order Lamiales was found to be most efficient in removing Zn from contaminated soil.

Conclusions

Phytoremediation is the use of plants to decontaminate soil, air or water. In the present study, among all the eight plants used for the study, *Begonia sarmentacea* Brilmayer showed a substantial amount of accumulation of lead in its tissues and *Episcia cupreata* Hanst. showed the highest amount of accumulation of zinc in its tissues. The results obtained in the experimental study prove that *B.sarmentacea* and *E.cupreata* have the innate capacity for the accumulation of appreciable quantities of heavy metals, lead and zinc respectively. So these plants could be used for removing these heavy metals from heavy metal contaminated soils. Further studies are required to identify various stress signals which can be used for improving phytaccumulation potential of these pants.

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