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Assessment of cadmium and lead phytoextraction potential of selected weed plants

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Abstract
The phytoextraction potential of eight weed plants *Ageratum conyzoides* L., *Alternanthera sessilis*(L.)DC., *Centrosema molle* Mart. Ex Benth., *Chromolaena odorata* (L.) R. M. King & H. Rob, *Mimosa pudica* L., *Synedrella nodiflora* Gaertn. *Tridax procumbens* L. and *Typhonium trilobatum* (L.) Schott. Were assessed using atomic absorption spectrophotometry. Among the selected plants, *Ageratum conyzoides* L. accumulated the highest concentration of cadmium and *Chromolaena odorata* (L.) R.M.King & H.Rob. Accumulated the highest concentration of lead. Concentration of cadmium in acid dissolved dry plant material of *A. conyzoides* was 34.05 mg/kg and that of lead in *C. odorata* was 14.1 mg/kg. The study revealed that *Ageratum conyzoides* L. and *Chromolaena odorata* (L.) R. M. King & H.Rob. Were capable of removing the heavy metal contaminants, cadmium and lead respectively from polluted soil, suggesting their potential for the reclamation of lands contaminated with these heavy metals.

Keywords: phytoremediation, phytoaccumulation, atomic absorption spectrophotometry, heavy metals

1. Introduction

Heavy metals are serious pollutants in various environmental areas. Along with certain natural processes, several human activities also result in the release of heavy metals to the environment. When these contaminants migrate into unpolluted areas in the form of dust or by leaching through the soil, or by the spreading of sewage sludge that contain heavy metals, etc. they result in the contamination of the ecosystems (Gaur and Adholeya, 2004) [8].

Lead is one of the amplest heavy metals. It has no physiological function in the organisms. The common sources of lead contamination include smelting works, incorporation of sludge produced from waste water treatment to soil, transportation, rain etc. A number of studies have reported the increased concentration of lead in air, soil, vegetation near street and highways (Cannon *et al*., 1962) [3] (Daines *et al*., 1970) [6] (Lagerwerff *et al*., 1970) [11]. The toxic effects of lead cause environmental and health problems due to its stability in the polluted sites and the complexity of mechanisms in biological toxicity. The presence of lead in abnormally high concentrations in the body fluid can lead to mental retardation especially in children. (Tiwari *et al*., 2013) [16].

Cadmium is one of the three heavy metal poisons along with mercury and lead. It is not known to have any essential biological function. The substitution of Zn by Cd may cause the malfunctioning of metabolic processes that can cause Cd toxicity. Cadmium is used in nickel-cadmium batteries, as secondary power sources exhibiting extended life, increased output, low maintenance, and improved tolerance to physical and electrical stress. Other uses of cadmium are as pigments, stabilizers for polyvinyl chloride, in alloys, and electronic compounds. Several products like phosphate fertilizers, petroleum products that are refined and detergents contain cadmium as an impurity. In addition, acid rain which causes the acidification of surface waters and soil increases the geochemical mobility of Cd, and as a result, its surface-water concentrations tend to increase as lake water pH decreases (Campbell, 2006) [2]. Even though cadmium has a smaller number of toxicological functions, it is highly persistent in organisms. As a result, once it is absorbed, it remains in the body of organisms for several years.

There are several methods that are used to remove these kinds of pollutants from the environment but many of these methods are expensive and do not perform in a perfect manner. Chemical technologies produce large amounts of sludge and thereby increase the cost of the environment clean up. (Rakhshaee *et al*., 2009) [13]. at present, phytoremediation has become effective as well as an affordable technological remedy to extract or remove inactive metals and metal pollutants from polluted soil.

Phytoremediation, which is also called as botanoremediation, green remediation or vegetative remediation, is an on-site remediation technology which makes use of plants and associated microbiota, soil amendments, and agronomic techniques to eliminate, contain, or make environmental pollutants harmless (Cunningham and Ow, 1996) [4] (Helmisaari *et al*., 2007) [9]. This strategy is eco-friendly and cost effective. Hyperaccumulator plants are those plants with high metal accumulating capacity. There are reports on the success of many species of plants in absorbing pollutants like lead, cadmium, chromium, arsenic, and many radionuclides from contaminated soils. Phytoextraction, which is a phytoremediation strategy, is used to remove heavy metals from soil using the ability of plants to absorb metals which are necessary for plant growth (Fe, Mn, Zn, Cu, Mg, Mo, and Ni). Some metals whose biological functions are unknown (Cd, Cr, Pb, Co, Ag, Se, Hg) can also be absorbed and accumulated (Ruk *et al*., 2006) [14].

Phytoremediation has various advantages compared to classical remediation methods. The advantages are that it is cost-effective, less disruptive to the environment, aesthetically pleasing, reduces the risk of spreading of the contaminants, and also can be used to remediate sites contaminated with more than one type of pollutant. The disadvantages are that the efficiency of clean-up is dependent on the growing conditions required by the plant, tolerance of a plant to the contaminant, problem of leaching to the deeper layers if soil amendments are used to increase the solubility of the contaminant, etc. Phytoextraction (phytoaccumulation), phytostabilization, and phytofiltration are useful phytoremediation strategies for the reclamation of heavy metal contaminated soils (Garbisu and Alkorta, 2001) [7].

The effectiveness of phytoremediation depends on various factors like availability of pollutants to the roots of the plants and the processes of absorption, translocation and accumulation of contaminants by plants. Studies revealed that the transformation of pollutants in the soil is a dynamic process and that the bioavailability of metals varies with time (Calace *et al.*, 2006) [1]. Reports on more than 400 species of plants are available that possess the ability for soil and water reclamation. (Lone *et al.*, 2008) [12]. A phytoaccumulation study on the common weed plants *Ipomoea cornea* and *Jatropha curcas* revealed that these plants could accumulate cadmium in higher concentrations (Kadirvel and Jegadeesan, 2014) [10]. The present work was an investigation of the phytoaccumulation potential of some common weed plants. Weed plants were selected for remediation as they do not require any special care and grow invasively.

2. Materials and methods

Eight common weed plants were selected for the present study. They were *Ageratum conyzoides* L., *Alternanthera sessilis* (L.)DC., *Centrosema molle* Mart. Ex Benth., *Chromolaena odorata* (L.) R.M.King & H.Rob., *Mimosa pudica* L., *Synedrella nodiflora* Gaertn, *Tridax procumbens* L. and *Typhonium trilobatum* (L.) Schott. Thirty numbers of each plant species used for the study were collected from St. Joseph's College campus, Devagiri, Kozhikode and acclimatized in the Botanical Garden of the College for two weeks. These 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 cadmium treatment. The third set of ten plants of each species was kept for lead 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 cadmium nitrate solution regularly for 25 days. The cadmium nitrate solution was prepared by dissolving 100g of cadmium nitrate in 100L of water.

Each plant of the third set was treated with 50ml of lead acetate solution regularly for 25 days. The lead acetate solution was prepared by dissolving 100g of lead acetate 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.

1g 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

3. Results and discussion

Pollution of air, water and soil by heavy metals is of immediate concern as it adversely affects animal and human health.

We need cheap and effective technologies to protect our natural resources and lives. Phytoremediation is one such technology. Numerous researches are being done around the world in the direction of identifying the flora capable of hypercumulation of heavy metals (Lone *et al.*, 2008) [12].

Phytoaccumulation of Cadmium

The cadmium phytoextraction potential of selected plants was analysed using flame atomic absorption spectrophotometry. It was found that among the control plants, *Centrosema molle* Mart. Ex Benth. Accumulated the highest level of Cadmium (0.57mg/kg) (Table 1). *Mimosa pudica* and *Tridax procumbens* showed below detection levels of Cd accumulation.

Table 1: Average absorption levels of Cadmium in control and cadmium treated plants.

Serial No.	Name of the Plant	Cadmium Accumulated in Control Plant (mg/kg)	Cadmium Accumulated in Cadmium Treated Plant (mg/kg)
1	*Ageratum conyzoides* L.	0.51	34.05
2	*Alternanthera sessilis* (L.)DC.	0.014	4.14
3	Centrosema molle Mart.ex Benth.	0.57	13.09
4	*Chromolaena odorata* (L.) R. M. King & H.Rob.	0.012	12.06
5	*Mimosa pudica* L.	BDL	7.96
6	Synedrella nodiflora Gaertn.	0.05	10.83
7	*Tridax procumbens* L.	BDL	9.58
8	*Typhonium trilobatum* L.	0.04	5.15

BDL: Below Detection Limit

All the cadmium treated plants showed high levels of Cadmium accumulation.

Ageratum conyzoides showed the highest level of Cd (34.05mg/kg) accumulation.

Efficacy of *Ageratum conyzoides* in remediating heavy metals was reported earlier by Dada *et al.* (2012) [5]. *Alternanthera sessilis* absorbed the least level of cadmium accumulation, the value being 4.14mg/kg (Table 1).

Phytoaccumulation of lead

The studies on the lead phytoextraction potential of the selected plants revealed that among the control plants *Typhonium trilobatum* has absorbed the highest level of lead (0.40mg/kg)

Whereas *Centrosema molle* has accumulated the least level of lead (0.08mg/kg) (Table 2). The concentration of lead was very low in all control plant samples, indicating that the soil used to grow the control plants were not much contaminated with lead.

Table 2: Absorption levels of lead in control and lead treated plants

Serial No.	Name of the Plant	Pb Accumulated in Control Plant	Pb Accumulated in Pb Treated Plant
1	*Ageratum conyzoides* L.	0.37	3.76
2	*Alternanthera sessilis* (L.)DC.	0.09	5.7
3	Centrosema molle Mart.ex Benth.	0.08	1.82
4	*Chromolaena odorata* (L.) R. M.King & H.Rob.	0.36	14.1
5	*Mimosa pudica* L.	0.10	1.77
6	Synedrella nodiflora Gaertn.	0.09	5.11
7	*Tridax procumbens* L.	0.36	6.43
8	*Typhonium trilobatum* L.	0.40	2.49

Among the lead treated plants, *Chromolaena odorata* (14.1mg/kg) has accumulated the highest level of lead and *Mimosa pudica* has accumulated the least level of lead. (1.77mg/kg) (Table 2).Tanhan *et al.* (2007) [15] also reported efficacy of *Chromolaena odorata* (L.) King& Robinson, in phytoremediation of Pb.

4. Conclusion

Phytoremediation is considered as highly promising technology for the reclamation of polluted sites. Phytoremediation can be used to clean up metals, pesticides, solvents, explosives, crude oil, polyaromatic hydrocarbons, and landfill leachates. The plants used for the process can be subsequently harvested, processed and disposed.

In the present study, the results obtained after 25 days of treatment showed that among all the plants used for the study, *Centrosema molle* Mart. Ex Benth. Accumulated the highest level of Cadmium (0.57mg/kg) and *Typhonium trilobatum* has absorbed the highest level of lead (0.40mg/kg). The results obtained in the experimental study proved that *Centrosema molle* Mart. Ex Benth and *Typhonium trilobatum* have the innate capacity for the accumulation of appreciable quantities of heavy metals, Cadmium and lead respectively. So, these plants could be used for removing these heavy metals from heavy metal contaminated soil.

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