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PHYTOEXTRACTION OF WEED PLANTS BY SURVEY AND ANALYSIS IN RESPONSE TO LEAD ACCUMULATION

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ABSTRACT: Field experiments were conducted on lead contaminated spoil dump. Plants growing on spoiled dump were collected for phytoremediation (phytoextraction) studies in order to determine whether the plants would thrive in contaminated soil and undergo phytoremediation. Lead accumulation level in soil was 164 mg/kg. Pb in plants was determined by atomic absorption spectrophotometer. Lead (Pb) accumulation levels in dry weight (DW) of plant samples were *Bidens pilosa* (90.53±8.86 mg/kg), *Parthenium histocarpus* (81.53±3.37 mg/kg), *Spermococa pusilla* (74.9±7.21 mg/kg), *Tinospora cordifolia* (74.53±3.31 mg/kg), *Hemidesmus indicus* (74.73±6.80 mg/kg), *Atropa belladonna* (73.26±5.88 mg/kg), *Cyperus flavidus* (51.33±4.71 mg/kg), *Jatropha gossypifolia* (55.2±5.55 mg/kg),*Typha angustata* (57.1±2.96 mg/kg), *Holoptela integrefolia* (70.4±6.78 mg/kg), *Crotolaria verrucosa* (43.53±2.43 mg/kg), *Senna occidentalis* (27.4±2.07 mg/kg), *Alternanthera ficoidea* (36.66±5.41 mg/kg), *Amaranthus spinosus* (66.13±1.10 mg/kg), *Sansevieria roxburghiana* (84.1±1.02 mg/kg), *Achnatherum hymenoides* (70±3.01 mg/kg), *Eichorniafasculata* (10± 0.97 mg/kg), *Anisomilus molabarica* (29± 3.69 mg/kg), *Ipomea purpurea* (72±4.34 mg/kg), *Bromustectorum* (77±4.48 mg/kg) and *Calotropisprocera* (90±2.55 mg/kg). It was found that all the plants were able to accumulate in Pb contaminated site. Among all the plants taken, *Bidens pilosa, Calotropisprocera* and *Sansevieria roxburghiana* showed highest lead accumulation and *Eichornia fasculata* showed lowest accumulation. Based on the atomic absorption spectrometric determination of the plant samples, it was confirmed that these suitable plant species are having potential for lead phytoremediation.

Keywords: Atomic absorption, thrive, lead phytoremediation

INTRODUCTION

Phytoextraction is a green in situ technology which aims to diminish the concentration of the chemical element(s) (often synonymous with heavy metals) of contaminated soils to such a level that the soil can be used without danger for agriculture, horticulture, forestry or amenity. (Ernst *et al.,* 2005). It has been demonstrated that the success of phytoextraction depends on the degree of soil contamination and on the number of metals in surplus at the site, the metal-resistance of the plant species.

In mine tailings and other metal-contaminated soils the distribution of the heavy metals is not homogenous. Heavy metal contamination of soil is widespread and there is a risk of transfer of toxic and available metals to humans, animals, and agricultural crops. If they are phytoavailable, some toxic metals are potentially accumulated in some plants and may pose a threat to humans and grazing animals. Heavy metal contamination of soil varies horizontally with soil depth (Whiting *et al.,* 2000; Haines, 2002; Podar *et al.,* 2004; Chehregani *et al*., 2009). Heterogeneity in plants modifies growth pattern of roots and root morphology, resulting in ecotype-specific root production in soils with heterogeneously distributed heavy metals (Hodge, 2009).

For present study, the major source of heavy metal contamination is lead which is possibly emitted from industrial area. These emissions transported by air, sewage water and industrial sewage effluents have been considered to be responsible for the increased heavy metal concentrations found in the soils of the central studied area. Lead concentration up to 164 mg /kg was found in most pollutant area. Concerning the health risk of the population bioavailability and mobility of heavy metals seems to be of major importance, based on the soil properties found in the study area. In order to recuperate the affected lead contaminated site by employing plants capable of accumulating high levels of contaminants. Periodical field surveys have been made to identify the metal-tolerant species that are spontaneously growing in the polluted soils, and are able to uptake lead.

The objective of this study is to carry out a preliminary assessment of lead accumulation in weed plants potentially growing in Pb contaminated site.

MATERIALS AND METHODS

Study Site

The experiment was conducted in lead contaminated area near Tirupati. All the experimental weed plants were grown under natural conditions; neither agricultural practices nor irrigation were carried out. The plants used for these experiments were similar in size.

Soil sampling

A total of 6 soil samples were collected from of the lead contaminated area. Another six samples of references were also collected from an area of 20 kilometers away from the industrial complex. Soil samples were collected from the surface of the soil (0-20 cm deep) and preserved. From each sampling points, five Soil samples were gathered and mixed properly to obtain a composite sample mixture. The soil sampling spots were cleared of debris before sampling. Each composite soil samples were placed in cellophane bags labeled and were taken to the laboratory for pre-treatment and analysis. In the laboratory, bulk soil samples were spread on trays and were air dried at ambient conditions for two weeks. The samples were then grounded by mortar and pestle, sieved through a 2 mm mesh, and oven-dried at 50°C for about 48 hours. The samples were then stored in polyethylene bags and re-homogenized before being used (USEPA, 2010).

Plant sampling

Weed plants were collected from contaminated site near Tirupati, India. The collected plant samples were thoroughly cleaned under running water, then with distilled water, dried and stored. Six replicates of each species were collected, although sometimes an exhaustive sampling was impossible for some species. In addition to that plant samples from an uncontaminated area (Sri Venkateswara University) were also collected as a target set. The collected plant specimens on the site were botanically identified by Dr.K.Madhavachetty, Taxonomist at Sri Venkateswara University, Tirupati, Andhra Pradesh, India.

Plant and soil sample digestion

Plant and soil samples (dried weight) were digested in a HNO_3-$HClO_4$ (3:1,v:v) mixture and Pb concentrations were determined by atomic absorption spectrophotometer (AAnalyst 200, Perkin-Elmer, UK)(Liu *et al.*, 2010).

Statistical analysis

Statistics were analyzed with SPSS version 11.0, and ANOVA was performed, with significance at $p<0.05$. All values were mean of six independent replicates.

RESULTS AND DISCUSSION

Soil characteristics

Table- 1 illustrates the metal concentration in the studied area. The soil used in this investigation had a pH of 5.2 ± 0.08. The analysis of this soil showed the following composition: Texture: sandy loam; organic carbon (0.13±0.05); available N (68±1.20); available P (0.33±0.05); available K (72±0.33).The analysis revealed the contaminated site contain Pb 164.5±2.29 mg /kg in comparison with controls (1.27±0.27).

Table1: Soil characteristics and lead present in contaminated area

S.no	Parameters	Control Soil	Contaminated soil
1	Soil Texture	Sandy loam	Sandy loam
2	Soil p^H	5.7±0.05	5.2±0.08
3	Organic Carbon (gm/kg)	0.23±0.02	0.13±0.05
4	Available N (gm/kg)	55±2.26	68±1.20
5	Available P (gm/kg)	0.41±0.02	0.33±0.05
6	Available K (gm/kg)	65±1.27	72±0.33
7	Total Pb (mg/kg)	1.27 ±0.27	164.5 ±2.29

The following species formed the predominant vegetation in the contaminated area during the collecting time *Bidens pilosa, Calotropis procera, Sansevieria roxburghiana, Parthenium histocarpus, Bromus tectorum, Tinospora cordifolia, Hemidesmus indicus, Spermococa pusilla, Atropa belladonna, Ipomea purpurea, Holoptela integrefolia, Achnatherum hymenoides, Amaranthus spinosus, Typha angustata, Jatropha gossypifolia , Cyperus flavidus, Crotolaria verrucosa, Alternanthera ficoidea, Anisomilus molabarica, Senna occidentalis,* and *Eichornia fasculata.* Plant species belonging to the Asteraceae, Rubiaceae, Menispermaceae, Agavaceae, Amaranthaceae, Poaceae, Fabaceae, Lamiaceae, Convolvulaceae and Asclepiadaceae families are the most frequently found in the contaminated soil.

Pb uptake potential of plants

Among the twenty one collected plant species selected for their ability to grow on the lead contaminated soil, and for their efficiency in accumulating lead, the range of accumulation varied from 10-90 mg/ kg DW (Table 2).

Table 2 Total lead concentrations in the weed plants of contaminated area

S.No	Species	Family	Pb (mg/kg DW)
1.	*Bidens pilosa*	Asteraceae	90.53±8.86
2.	*Parthenium histocarpus*	Asteraceae	81.53±3.37
3.	*Spermococa pusilla*	Rubiaceae	74.9±7.21
4.	*Tinospora cordifolia*	Menispermaceae	74.53±3.31
5.	*Hemidesmus indicus*	Apocynaceae	74.73 ±6.80
6.	*Atropa belladonna*	Solanaceae	73.26±5.88
7.	*Cyperus flavidus*	Cyperaceae	51.33±4.71
8.	*Jatropha gossypifolia*	Euphorbiaceae	55.2±5.55
9.	*Typha angustata*	Typhaceae	57.1±2.96
10.	*Holoptela integrefolia*	Ulmaceae	70.4±6.78
11.	*Crotolaria verrucosa*	Fabaceae	43.53±2.43
12.	*Senna occidentalis*	Caesalpinioideae	27.4±2.07
13.	*Alternanthera ficoidea*	Amaranthaceae	36.66±5.41
14.	*Amaranthus spinosus*	Amaranthaceae	66.13±1.10
15.	*Sansevieria roxburghiana*	Agavaceae	84.1±1.02
16.	*Achnatherum hymenoides*	Poaceae	70±3.01
17.	*Eichornia fasculata*	Fabaceae	10±0.97
18.	*Anisomilus molabaricus*	Lamiaceae	29±3.69
19.	*Ipomea purpurea*	Convolvulaceae	72±4.34
20.	*Bromus tectorum*	Poaceae	77±4.48
21.	*Calotropis procera*	Asclepiadaceae	90±2.55

Mean (range) concentrations of heavy metal lead (mg /kg DW) for the species sampled (n=6)

Accumulation and distribution of heavy metals in plant tissues are important aspects to evaluate the role of plant in remediation of metalliferous soils (Pichtel and Bradway, 2008). Pb increased from the values obtained in the order from maximum to minimum was *Bidens pilosa, Calotropis procera, Sansevieria roxburghiana*, *Parthenium histocarpus*, *Bromus tectorum*, *Tinospora cordifolia*, *Hemidesmus indicus*, *Spermococa pusilla*, *Atropa belladonna*, *Ipomea purpurea*, *Holoptela integrefolia*, *Achnatherum hymenoides*, *Amaranthus spinosus*, *Typha angustata*, *Jatropha gossypifolia*, *Cyperus flavidus*, *Crotolaria verrucosa*, *Alternanthera ficoidea*, *Anisomilus molabarica*, *Senna occidentalis*, *Eichornia fasculata*. Here with phytoextraction technique the risk of pollutant dispersal into the environment is minimized. Moreover, it is noticeable that *Bidens pilosa*, *Calotropis procera, Spermococa pusilla, Tinospora cordifolia* and *Hemidesmus indicus* removal efficiencies are similar, which is indicative of admitting that the absorption of lead into the bodies is constant.

Table: 3 Illustrates the lead accumulation levels of roots, shoots and leaves in all experimental plants

Plant name	Roots	Shoot	Leaves
Bidens pilosa	77.6±1.2	70.4±2.4	123.6±2.0
Parthenium histocarpus	79.2±1.3	80±2.6	85.4±2.8
Spermococa pusilla	Nil	80±2.5	69.8±2.4
Tinospora cordifolia	78±2.2	71.4±1.1	74.2±3.8
Sansevieria roxburghiana	83.8±2.2	Nil	84.4±2.1
Achnatherum hymenoides	43.6±2.5	85.8±2.02	80.6±2.4
Eichornia fasculata	7±0.5	13±0.4	11.5±0.2
Anisomilus molabaricus	27±1.2	29±1.3	32±2.2
Ipomea purpurea	77±3.2	61±3.4	80±3.7
Bromus tectorum	84±2.4	69±3.6	76±3.5
Calotropis procera	90±2.2	87±2.2	92±2.3
Hemidesmus indicus	82.6±3.5	67±3.2	74.6±3.4
Atropa belladonna	65±2.4	69.2±2.2	85.6±2.6
Cyperus flavidus	43.4±1.2	51.8±1.2	58.8±1.3
Jatropha gossypifolia	48.8±1.6	58±1.3	58.8±1.5
Typha angustata	54±1.8	55±1.2	59.2±2.4
Holoptela integrefolia	60.4±2.4	66±1.3	84.8±1.5
Crotolaria verrucosa	66.8±3.2	39.2±2.4	24.6±2.4
Senna occidentalis	Nil	22.4±1.5	32.4±1.4
Alternanthera ficoidea	31±1.1	41.8±1.5	37.2±2.2
Amaranthus spinosus	67.2±1.4	66.2±1.4	65±2.3

Mean ±SD for concentrations of heavy metal lead (mg /kg DW) for the species sampled (n=6).

The heavy metal, lead concentrations in the shoots of the plants collected on polluted soils were significantly higher than those of the roots and leaves. The highest accumulation levels in roots were observed in *Calotropis procera* (90±2.2mg/kg DW), shoots *Achnatherum hymenoides* (85.8±2.02mg/kg DW) and leaves were observed in *Bidens pilosa* (123.6±2.0 mg/kg DW).In the overall plant parts taken the highest lead levels were observed in leaves followed by roots and shoots. Establishing the agronomic management practices to the above-mentioned species allow us to utilize their whole possibilities for cleaning up of contaminated lead.

CONCLUSIONS

The present work verifies the usefulness of collecting and studying plant species on contaminated soils in order to identify and select those plants with high potential to be used in the remediation of the affected area. This investigation showed that the susceptibility of plants to lead was correlated with their growth. Weed plants tolerated Pb at 164 mg/kg at the growth stage of 60 days after germination. Among the 21 different plant species belonging to 17 different families highlight as the most promising lead accumulators to be used in the remediation of the affected area. Based on the above observations, it was inferred that this study allowed us to conclude that the above stated weed plants could be considered potentially feasible to clean up Pb soils. Among them, we found the most effective weed plants for phytoremediation of lead were *Bidens pilosa, Calotropis procera* and *Sansevieria roxburghiana*.

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