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BIOACCUMULATION OF HEAVY METAL IN SOIL AND DIFFERENT PLANT PARTS OF *ALBIZIA PROCERA* (ROXB.) SEEDLING

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ABSTRACT
An investigation was conducted to study the differential action of heavy metals such as Cd, As and Pb on *Albizia procera*. The study of bioaccumulation of heavy metals such as Cd, As and Pb in soil, root, shoot and leafs of *Albizia procera*. Plants were supplemented with 1mg/L, 5mg/L and 10mg/L concentration of heavy metals per week for a period of four months. The accumulation study showed increase of all metals when the exposure time and concentration were increased. In 10mg/L concentration samples, leaf had higher Cd and As contents than root suggesting that the metal were bound to the leave cells, while in Pb treatment soil had higher content of Pb than leaves, for all concentration, suggesting that metal were bound to the root cells and were partially transported to the leaves.

INTRODUCTION

Environment Pollution is one of the severe problems worlds facing today. Heavy metals are major environmental pollutant, which are discharged into the atmosphere from the burning of fossil fuels, release of industrial wastes and use of agrochemicals. Heavy metals, like As, Cd, Co, Cu, Ni, Zn, and Cr are phytotoxic either at all concentrations or above certain threshold levels. Toxic metals are biologically magnified through the food chain. They infect the environment by affecting soil properties and its fertility, biomass and crop yields and ultimately human health. In recent years interest has been focused on the study of plants as promising candidate for pollutant uptake and biological indicators of heavy metals in ecosystems. Heavy metals are significant environmental pollutants and many of them are toxic even at very low concentrations. Pollution of the biosphere with toxic metals has accelerated dramatically since the beginning of the industrial revolution. The use of plants has been a common practice for biomonitoring. They have also been used frequently to remove suspended solids, heavy metals, toxic organics etc. Living plants can be compared to solar driven pumps which can extract and concentrate several elements from their environment. From soil, plants have the ability to accumulate heavy metals which are essential for their growth and development. Hyperaccumulator plants possess an ability to take up abnormally high amounts of heavy metals in their shoots Chaney *et al.,* (1997) and Shen *et al.,* (1997). Metal hyper accumulator was first used by Brooks *et al.,* (1977) to describe some "strong hyperacumulators" of nickel in 1977. It was defined as those plants containing > 1,000 pg g-'(0.1%) metal in dry materials. The main objective of the work is to find out the accumulation limit of *A. procera* after treatments.

MATERIALS AND METHODS

Species was selected on the basis of survey in different sites/ locations, which are highly affected by industrial effluents. *A. procera* seeds procured from Forest Research Institute, Dehradun, (Uttarakhand), India, were selected for uniformity of colour and size, soaked overnight in distilled water containing bavestine. In this analysis the plants were sown from the seeds planted directly in the media filled pots, after germination the seedling were transferred in to the root trainer. The species were placed in the natural condition of central nursery of Forest Research Institute (FRI), Dehradun. After 3 weeks the plants were grown in polythene bags filled with sand, soil and farmland manure (1:1:1) and were watered daily (for one year).

Heavy metal treatments consisted of $CdCl_{2,}$ As_2O_3 and Pb $(C_2H_3O_2)_2.3H_2O$ with three different concentrations of 1mg/L, 5mg/L, 10mg/L. Three replicates were kept for each treatment along with control. Treatments were given to plant's root environment by watering the plant with doses of three different concentrations of 1mg/L, 5mg/L, and 10mg/L of each heavy metal. After the completion of the doses plants were separated from polythene bags and divided into different plant parts (root, shoot and leaf) and these parts were analyzed for Heavy metals. Heavy metals in soil, root, shoot and leaf of plant species were analyzed by digestion of powdered sample. The digested material was diluted and filtered and then filtrate was analyzed on an inductively coupled plasma mass spectroscopy (ICP-MS).

Bioconcentration factor: The Bioconcentration Factor (BCF) of metals was used to determine the quantity of heavy metals that is absorbed by the plant from the soil. This is an index of the ability of the plant to accumulate a particular metal with respect to its concentration in the soil (Ghosh and Singh, 2005) and is calculated using the formula:

$$BCF = \frac{\text{Metal concentration in plant tissue (whole plant/portal)}}{\text{Initial concentration of metal in substrate (soil)}}$$

The higher the BCF value the more suitable is the plant for phytoextraction (Blaylock *et al.,* 1997). BCF Values > 2 were regarded as high values.

Statistical analysis

The mean of metal concentration was calculated and subjected to analysis of variance (ANOVA) using randomized block design and least significant different methods (RBD) on the "SPSS for windows" program after analysis of the homogeneity of variance according to scheffe test

RESULTS AND DISCUSSION

Heavy metal content

Metals (Cd, As and Pb) were not observed in the control plants at all exposure times. Heavy metal contents in soil, root, shoot and leaf of *A. procera* are shown in Table 1. The metal concentration significantly increased when the concentration were increased ($p < 0.001$). for Cd samples of 1,5 and 10mg/L, the 10 mg/L Cd sample contents showed higher concentration in leafs (0.083mg/g) lower in soil (0.077mg/g), while for 5mg/L Cd samples, maximum concentration was found in shoot(0.038mg/g) and minimum was in root (0.032mg/g). After treatment minimum concentration was found in 1mg/L Cd samples, which was higher in soil (0.0069mg/g) and lower in leaf (0.0044mg/g).

For As samples maximum concentration was found in 10mg/L treatment that was 0.045mg/g in soil then in root (0.0412mg/g) and minimum in leafs (0.038mg/g). For 5mg/L treatment higher concentration was found in leaf (0.141mg/g) and minimum in soil, while for 1mg/g maximum As concentration was found in shoot (0.0236mg/g) and minimum in root (0.0065mg/g).($p < 0.001$) (Table 1).

For Pb samples concentrations maximum concentration was found in 10mg/L treatment that was 0.0697mg/g in soil then in root and minimum in leafs (0.0441mg/g). For 5mg/L treatment, higher concentration was found in soil (0.0445mg/g) then in root and minimum in leafs (0.0095mg/g), while in 1mg/g maximum Pb concentration was found in soil (0.0168mg/g) and minimum in leaf (0.0081mg/g). (Table 1). The interactions between metals, treatments and metal* treatments were highly significant ($p < 0.001$) (Table 1) in soil, root, shoot and leaf. Only leaf was non-significant with metals.

Bioconcentration factor (BCF): The BCFs of Cd, As and Pb in *A. procera* at different concentrations are shown in Fig. 1. The BCFs of metal Cd and As increased when the concentrations were increased but decreased in Pb. The BCFs of Cd of *A. procera* at 1, 5 and 10mg/L were 0.743, 0.995 and 1.033 respectively. The BCFs of As at different treatments were 1.049, at 1mg/L, 1.964 at 5mg/L and 0.895 at 10mg/L. The BCFs were decrease in metal Pb when concentrations were increase. The BCFs of As of *A. procera* at 1, 5 and 10mg/L were 0.927, 0.751 and 0.600 respectively. The higher value of BCF indicates the ability of plant to concentrate metals in their tissues. Hence, *A. procera* could concentrate Cd and As in their tissues better than Pb. The present study shows that As

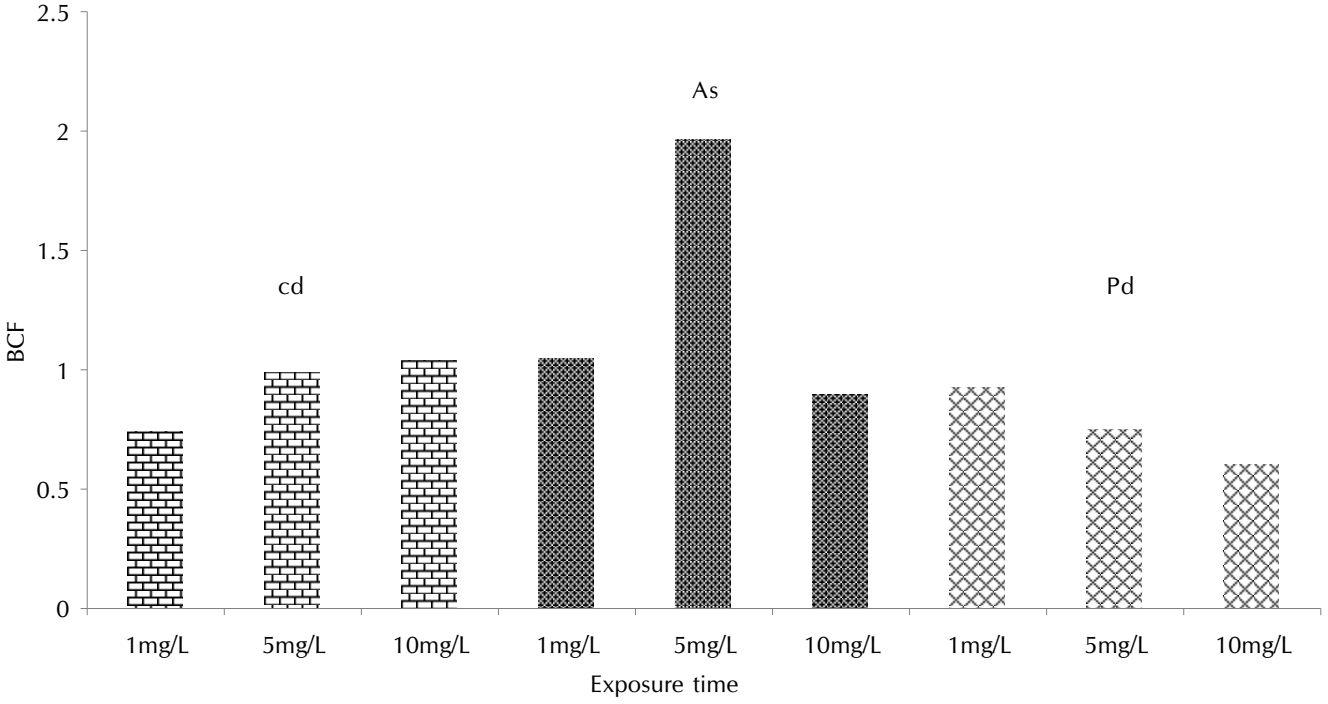

Figure 1: The Bioconcentration factor values of cd, As and Pb in *A. Procera* at different concentrations

Table 1: Partitioning of heavy metal in soil and different parts of *A. procera*

A. procera Soil(mg/g)	Cd	As	Pb	Interaction (CD at 5%)
Control	0.00069 ± 0.00019	0.00040 ± 0.00002	0.00013 ± 0.000017	
1mg/L	0.00690 ± 0.0002	0.01460 ± 0.00079	0.01687 ± 0.0011	Metal = 1.339***
5mg/L	0.035358 ± 0.00025	0.015250 ± 0.0000001	0.0445 ± 0.0005	Treatment = 1.546***
10mg/L	0.07789 ± 0.0001	0.04500 ± 0.00100	0.06970 ± 0.0002	Metal*Treatment = 2.678***
Root(mg/g)				
Control	0.00437 ± 0.0066	ND	ND	
1mg/L	0.00510 ± 0.00020	0.00650 ± 0.0001	0.01600 ± 0.0020	Metal = 1.823***
5mg/L	0.03200 ± 0.00100	0.01533 ± 0.00003	0.04450 ± 0.0035	Treatment = 2.105***
10mg/L	0.08200 ± 0.0010	0.04120 ± 0.00010	0.06535 ± 0.00015	Metal*Treatment = 3.645***
Shoot(mg/g)				
Control	ND	ND	ND	
1mg/L	0.00557 ± 0.00015	0.02380 ± 0.03048	0.0180 ± 0.0030	Metal = 2.2504***
5mg/L	0.03800 ± 0.0030	0.02440 ± 0.00001	0.03285 ± 0.00045	Treatment = 2.598***
10mg/L	0.07800 ± 0.0010	0.03970 ± 0.00061	0.01370 ± 0.00070	Metal*Treatment = 4.5008***
Leaf(mg/g)				
Control	ND	ND	ND	
1mg/L	0.00440 ± 0.00020	0.02070 ± 0.02711	0.0081 ± 0.0002	Metal = 0.0253^{ns}
5mg/L	0.03700 ± 0.0010	0.14067 ± 0.1028	0.00955 ± 0.00025	Treatment = 0.0292***
10mg/L	0.08300 ± 0.0020	0.03800 ± 0.0010	0.05360 ± 0.0441	Metal*Treatment = 0.0506***

*** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$), ^{NS} non-significant

are toxic to *A. procera* as shown by the toxicity symptoms such as chlorosis, decreases in the biomass and total chlorophyll contents. Pb is much more toxic than As and Cd at the same concentration in *L. minor* Hosetti (1997), and Zhu *et al.,* (1999).

A. procera possesses the potential to accumulate metal in its tissue. The results revealed that under the experimental conditions, the accumulations of Cd, As and Pb by species were increased when the exposure time and concentration of metal were increased. Similar result was found in *Pistia stratiotes* by Maine *et al.,* (2001) in aquatic plant water lettuce. In plants, metal concentrations were reported to be higher in the roots in most studies Cataldo *et al.,* (1981) In addition; the difference in the ability of plants to accumulate heavy metals has been related to differences in their root morphology Hemphill (1997).

Similar results have been demonstrat-ed by Chandra Sekhar (2005) that Pb mainly accumulated in root and shoot of *H. indicus*. Sharma *et al.,* (2004), Pb accumulated as lead acetate in roots and leaves, although lead sulfate and sulfide were also detected in leaves, whereas lead sulfide was detected in root samples. Lead nitrate in the nutrient solution biotransformed to lead acetate and sulfate in its tissues. Complexation with acetate and sulfate may be a lead detoxification strategy in this plant species *Sesbania drummondii*. Caille *et al.,* (2004) in *P. vittata, P. Cretica P. longifolia* As suitable for phytoremediation in the moderately contaminated soils. *Helianthus annuus* accumulate Pb in the leaf and stem so it could be used in the restoration of abandoned mines and factoriy sites contaminated with elevated Pb levels in the soil Boonyapookana *et al.,* (2005).

Mellem (2006) said that for As, it was found that the plant samples in the soil containing 25 ppm showed no phenotypic changes, however, the samples exposed to 75 and 100 ppm showed toxic changes. The accumulation of As was different in comparison to Cr and Hg, in that the lowest was found in the roots and the highest levels were found in the leaves. Our finding is also approved by Miller *et al.,* (2008), he said that the greater percentage of Pb was sequestered in the roots, Shoot tissue uptake mirrored closely the uptake by roots, indicating that a proportionate amount of Pb was being translocated to the above-ground biomass. Moreover, the tight binding characteristic of Pb to soils and plant materials makes a significant portion of Pb unavailable for root uptake by plants.

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