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Short Communication

Heavy meal decontamination of polluted soils using *Bryophyllum pinnatum*

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Phytoremediation was carried out with *Bryophyllum pinnatum* as a means of cleaning up soils contaminated with heavy metals. Maximum levels of metals accumulated were Ni (11.91 mg/kg), Pb (399.90 mg/kg), Cr (32.48 mg/kg), V (5.81 mg/kg) and Cd (3.12 mg/kg) and this occurred in the 4th month of study. Results of this study indicate that *B. pinnatum* is an efficient metal hyperaccumulator for phytoremediation of metal contaminated soils.

Key words: *Bryophyllum pinnatum*, Soil, phytoremediation, Metal decontamination.

INTRODUCTION

Soils are often heavily contaminated with heavy metals especially in areas of high mineral intoxications. Sources of metal enrichment of soil include municipal wastes (incinerators), fertilizers, urban compost, car exhausts, cement factories, residues from mining and smelting industries, sludge and sewage (Adhikari et al., 2004; Grispen et al., 2006). Contamination of agricultural soil by heavy metals has become a major global and environmental concern. The extent of soil pollution with heavy metals and subsequent uptake by crops depend upon several factors such as source of heavy metal, soil type, organic metal content, seasonal variations, major and minor nutrients and heavy metal load (Adhikari et al., 2004). Heavy metal pollution deteriorates soil fertility and crops produced. Moreover, heavy metals have the tendency to bioaccumulate and biomagnify from one trophic level to another.

Remediation of heavy metal contamination on soils is not easy. One of the conventional techniques used for remediation of metal-polluted soils has been to excavate contaminated soil and remove it to a landfill. This method merely moves the contamination elsewhere. It is costly and environmentally disruptive (Grispen et al., 2006). Moreover, availability of unpolluted replacement soil for backfilling may be limited.

Bioremediation techniques have been reported to be more economical than the traditional methods, and involve on-the-site treatment of pollutants, thus reducing exposure risks for clean-up personnel, or potentially wider exposure as a result of transportation accidents (Vidali, 2001). An alternative bioremediation technology available for cleaning up metal-contaminated soils is phytoremediation which uses plants to extract metals from soils (Raskin and Ensley, 2000; Grispen et al., 2006; Salt et al., 1998; Eddy and Ekop, 2007). It has been suggested that ideal plants for phytoremediation should possess properties such as fast growing, high biomass, deep roots, be easy to harvest and should tolerate and accumulate a range of heavy metals in their aerial and harvestable parts (Grispen et al., 2006; Clemence et al., 2002). Hyperacumulator plants are able to tolerate high concentrations of toxic metals by producing molecules (phytochelatins) that bind metals into complexes that can be compartmentalized, thus preventing encroachment on sensitive plant tissues that may kill the plant (Dzantor, 2000).

In this study, phytoremediation was carried out with *Bryophyllum pinnatum* as a means of cleaning up soils contaminated with heavy metals.

MATERIALS AND METHODS

Collection of samples

Polluted soil samples were collected from a landfill in the industrial site of the defunct Sunshine batteries Industry, Ukana in Akwa Ibom State of Nigeria. The soil has been confirmed to be highly polluted (Obot, 2006). *Bryophyllun pinnatum* was collected from the botanic

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Table 1. Concentration (mg/kg) of heavy metals absorbed by *Bryophyllum pinnatum*.

Period		Ni	Pb	Cr	V	Cd
1/2 Month	P	3.02±0.01	4.11±0.06	4.76±0.03	0.09±0.001	0.08±0.02
	S	10.69±0.01	38.72±2.30	30.57±1.23	3.52±1.22	3.14±1.02
	C	0.28±0.10	0.106±0.01	0.16±0.01	0.03±0.001	0.03±0.001
	P	3.72±0.01	4.19±0.05	5.68±2.00	1.09±0.02	0.12±0.00 2
1 Month	S	92.10±1.36	48.01±0.06	23.67±1.23	12.31±1.02	4.31±0.81
	C	0.31±0.01	0.09±0.00	0.24±0.01	0.09±0.002	0.03±0.011
	P	3.91±0.10	30.08±3.42	9.17±1.12	4.17±1.07	0.05±0.002
2 Months	S	10.81±1.00	420.07±5.23	14.61±1.56	10.10±2.01	4.01±0.01
	C	0.36±0.02	0.07±0.01	0.63±0.01	0.41±0.01	0.01±0.001
	P	6.82±0.02	28.10±1.26	9.83±0.98	5.29±1.02	2.31±1.02
3 Months	S	10.10±1.05	310.14±3.42	14.89±2.02	10.47±2.03	3.21±1.01
	C	0.68±0.02	0.91±0.01	0.66±0.01	0.51±0.02	0.72±0.002
	P	11.91±2.32	399.90±4.32	32.48±3.21	5.81±0.08	3.12±1.03
4 Months	S	9.90±1.36	306.70±5.33	45.84±3.11	8.03±0.09	3.01±0.01
	C	1.20±0.01	1.30±0.01	0.71±0.02	0.72±0.02	1.04±0.41
	P	10.24±2.45	223.40±4.53	5.93±1.56	4.23±1.08	2.08±0.14
5 Months	S	10.27±3.27	356.10±6.22	43.59±1.88	7.00±0.12	3.40±1.30
	C	1.00±0.01	0.63±0.01	0.14±0.001	0.605±0.11	0.61±0.002
Y		74.12	870.31	131.13	59.98	12.44

Y = Initial concentrations of heavy metals.
P = Concentration of metal in *B. pinnatum* at the relevant time interval.
S = Concentration of metal in soil at the relevant time interval.
C = Phytoextraction coefficient.

garden of Akwa Ibom State Polytechnic, Ikot Osurua, Nigeria.

Green house pot experiments

B. pinnatum was cultivated in five different plastic buckets containing heavy metals polluted soils and nurtured for 5 months. The plants were left in ambient conditions and watered periodically. After the first 2 weeks plant and soil samples were collected and analyzed for heavy metals content. Subsequently plant and soil samples were collected monthly and analyzed for heavy metals for 5 months.

Sample pre-treatment

Soil samples were air-dried, homogenized and passed through a 2-mm sieve prior to analysis. Plant samples were air-dried and ground to fine powder. Both plant and soil samples were placed in different airtight plastic bottles and stored in a refrigerator (4^{o}C) until required for analysis.

Soil and plant analyses

Soil and plant samples were digested in di-acid (HNO_3 : HCl, 3:1) mixture at approximately 125^{o}C. Digests were filtered into 100 ml Erlenmeyer flasks and made up to the mark with distilled and de-ionized water. Total concentrations of Ni, Pb, Cr V and Cd in the prepared samples were determined by atomic absorption spectrophotometry (Unicam 933). All soil and plant analyses were carried out in duplicate with representative samples.

RESULTS AND DISCUSSION

Table 1 shows the concentration of metals absorbed monthly by *B. pinnatum,* the phytoextraction coefficient ([metal in plant]/[metal in soil]) as well as the soil-metal concentration. The amount of each heavy metal absorbed by *B. pinnatum* increased as the period of exposure to the heavy metal increased. Maximum amounts of the metals were absorbed in the 4th month of the study period. Except for Ni, Pb and Cd in the 4th month, soil metal concentrations were generally significantly higher than ($p<0.01$) the concentrations accumulated by *B. pinnatum* throughout the study.

The duration of exposure to heavy metals is a major factor affecting bioaccumulation of heavy metals in plants. On the other hand, factors affecting the level of heavy metals in the soil include soil pH, solubility of the metal in soil solution, the organic matter content, cation exchange capacity and the oxidation state of the metal (Ghosh and Singh, 2005; Eddy and Ekop, 2007). However, soil pH seems to have the greatest effect than any single factor on the solubility and retention of metal in the soil; hence availability of heavy metals for absorption.

The concentrations of Ni, Cr, V and Cd absorbed by *B. pinnatum* increased as the metal concentration in the soil around the plant increased. Conversely as the amount of Pb absorbed by *B. pinnatum* increased soil Pb concentra-

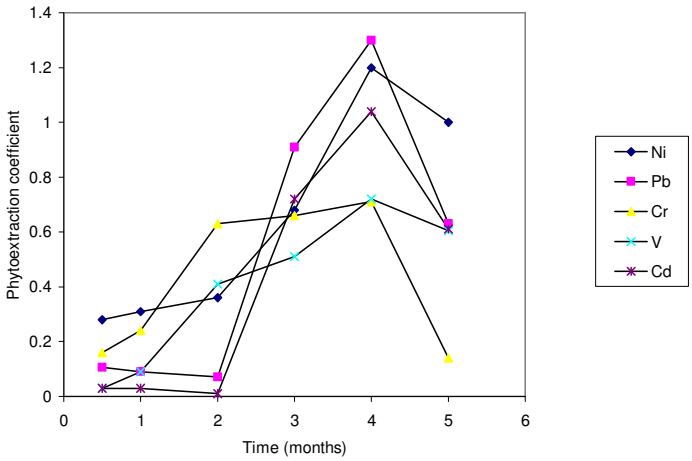

Figure 1. Plot of phytoextraction co-efficient against time during heavy meal decontamination of polluted soils using *Bryophyllum pinnatum*.

tion around the plant also increased up to the 3rd month of study. Thereafter soil Pb concentration decreased as the amount of Pb absorbed increased up to a maximum in the 4th month. The reason for the observed different trends in heavy metals bioaccumulation by *B. pinnatum* is not immediately known. However, it is believed that the absorption of heavy metals by *B. pinnatum* sets up a concentration gradient, which draws up metal ions in soil solution towards the soil/plant roots interface.

Figure 1 shows the plot of phytoextraction coefficient vs. time. The shape of the curve shows that there is a time lag before considerable amounts of the metals could be bioaccumulated. This indicates that the plant needed some time to adjust its internal structures to accumulate high levels of he metals. Within the first month, Ni was the highest absorbed metal followed by Cr while Cd was the least absorbed. On the basis of phytoextraction coefficient, bioaccumulation of metals followed the order: Ni > Cr > Pb ≈ V > Cd in the first month. The trend changed in the second month. The highest absorbed metal in the second month was Cr followed by V and Ni while the least absorbed metals were Pb and Cd, respectively.

Phytoextraction coefficients for all the metals increased remarkably in the 3rd month of study while maximum values were obtained in the 4th month. This indicates that hyperaccumulation of the metals occurred in the 4th month. Lead was the highest absorbed metal in the 4th month followed by Ni, Cd, V and Cr. However, phytoextraction coefficients of all the metals investigated dropped in the 5th month and the concentration of each metal absorbed by *B. pinnatum* also decreased.

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