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Phytoremediation Effects Of Chochorus Olitorus On Selected Soil Metals

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Abstract: ***This study examined the phytoremediation effects of corchorus olitorius plants on soil metals through uptake of these potentially toxic metals by the tissues of the plant. The study was carried out in a screen house at The Polytechnic, Ibadan, Saki Campus, Oyo State in South Western Nigeria. The soils for were taken from Abata Ogun valley bottom in Saki, Nigeria. The selected metals for analyses are cadmium (Cd), chromium (Cr), lead (Pb) and zinc (Zn). Analyses were carried out on a Flame Atomic Absorption Spectrometer fitted with a hollow Cathode Lamp using an air-acetylene flame after digestion.***

The concentrations of these metals were found to be decreasing in the soil while the plant tissues were taking up some quantities of the metals. The bioavailability of the metals from soil to plant based on the transfer factor was observed to increase in the order Cd, Cr, Pb and Zn. Generally, it was observed that planting of the vegetable plant caused a change in the concentrations of the soil metals thus giving rise to a phytoremediation effect on the soil. It is therefore recommended that the method should be encouraged and improved on through further researches such as using different types of plants and even expanding the scope of metals and other pollutants to be tested.

Keywords: Phytoremediation, effect, Corchorus Olitorius, soil, metals

I. INTRODUCTION

A major environmental concern due to dispersal of industrial and urban wastes generated by human activities is the contamination of soil. Controlled and uncontrolled disposal of wastes, accidental and process spillage, mining and smelting of metalliferous ores, sewage sludge application to agricultural soils are responsible for the migration of contaminants into non-contaminated sites as dust or leachate and contribute towards contamination of our ecosystem. A wide range of inorganic and organic compounds cause contamination, these include heavy metals, combustible and putrescible substances, hazardous wastes, explosives and petroleum products. Major component of inorganic contaminates are heavy metals (Adriano, 1986; Alloway, 1990), they present a different problem than organic contaminants. Soil microbes can degrade organic contaminants while heavy metals need immobilization or physical removal. Although many metals are essential, all metals are toxic at higher concentrations, because they cause oxidative stress by formation of free radicals. Another reason why metals may be toxic is that they can replace essential metals in pigments or enzymes disrupting their functions (Henry, 2000).

Potentially toxic metals contamination in soil are widespread and contamination could be from geological or anthropogenic sources. The sources of these metals (e.g cadmium, Cd, chromium, Cr, lead, Pb and zinc, Zn) include soil parent materials, volcanic eruptions, fertilizers, pesticides, sewage sludge, power station, automobiles, incineration of wastes, metal smelting plants, mines et c. (Ruley et al., 2006). The contamination of these toxic metals in agricultural land is a major concern. Potentially toxic metals in soil can bioaccumulate in plants and are transferred to the food chain where they raise human and animal health concern. Once they are taken up by plants, they can enter the food chain and may be taken up by humans and animals leading to adverse health effect. Cd, Cr and Pb are of concern because they are toxic to plants and animals even in small concentrations (Wolnik, et al., 1983). At high concentrations, these metals exhibit chronic toxicity or carcinogenicity as well as fatality (Wolnik et al., 1983; Blaylock and Huang, 2000; Monni et al., 2000;Reeves & Baker, 2000).

One of the key aspects to the acceptance of phytoremediation pertains to the measurement of its performance, ultimate utilization of by-products and its overall economic viability. To date, commercial phytoremediation has been constrained by the expectation that site remediation should be achieved in a time comparable to other clean-up technologies. So far, most of the phytoremediation experiments have taken place in the lab scale where plants grown hydroponic setting are fed heavy metal diets. While these results are promising, scientists are ready to admit that solution culture is quite different from that of soil. In real soils, many metals are tied up in soluble forms and they are less available and that is the biggest problem (Kochian, 1996).

The future of phytoremediation is still in research and development phase, and there are many technical barriers which need to be addressed. Examples include optimization of the process, proper understanding of plant heavy metal uptake and proper disposal of biomass produced is still needed.

Broadly, the objective of this study is to examine the phytoremediation effects of corchorus olitorius on soils polluted with heavy metals. The specific objectives include:

- ✓ Investigating the rate of absorption of these metals by the plant.
- ✓ Investigating the extent of soil metals absorption by the plant and reduction in the soil.

II. MATERIALS AND METHODS

STUDY SITE DESCRIPTION

The study was carried out in a screen house at The Polytechnic, Ibadan, Saki Campus, Oyo State in South Western Nigeria. The soils samples were taken from Abata Ogun valley bottom in Saki, Nigeria. The study area is situated at $7^0 24^I$N $3^0 53^I$E. The vegetation is a derived savannah with a mean annual rainfall of about 1289.2mm. Surface soil samples from 0-15cm depth were randomly collected from the valley bottom for analysis and planting.

SOIL SAMPLES PREPARATION, DIGESTION AND ANALYSES

Surface soils (0 -15cm) were collected from the study site in Abata Ogun valley bottom in Saki, Nigeria. The sampling was done randomly from 10 points on the field before being bulked together, samples were then taken to the laboratory for analysis. The samples were air dried and sieved to pass through a 2mm stainless steel sieve. The pH of the soil in $CaCl_2$ was determined according BS ISO 10390 (1995), using a Mettler Toledo pH meter.

The selected metals for analyses are cadmium (Cd), chromium (Cr), lead (Pb) and zinc (Zn). Analyses were carried out on a Flame Atomic Absorption Spectrometer fitted with a hollow Cathode Lamp using an air-acetylene flame after digestion. The total metal concentrations of Cd, Cr, Pb and Zn in the soils before and after planting were determined.

PLANTING OF VEGETABLES

Seeds of corchorus olitorius plants were purchased from a local market and grown in plastic pots so as not to have a further metallic reaction between the soils and the pots. The seeds were grown in 1kg of soils in the pots and were watered three times a week with clean freshwater. The plants were allowed to grow for eight weeks but were analysed regularly at 4weeks interval.

PLANT DIGESTION AND ANALYSES

The uprooted vegetable samples was weighed and digested with 10ml of concentrated trioxonitrate (V) acid (HNO_3). The digestion was carried for 2hours after which it was allowed to evaporate to near dryness and the residue was taken up in 1M HNO3 and allowed to cool. After cooling, the sample was filtered with Whatman filter paper (11cm) into a 25ml volumetric flask and made up to mark. Analyses for the metals were also carried out on a Flame Atomic Absorption Spectrometer.

MOBILITY OF METALS BY THE PLANTS

The mobility of these metals by the test crop tissues can be determined by calculating the transfer factor (Sauerback, 1991; Gray et al., 1999; Cui et al., 2004; Chojnacka et al., 2005; Intawongse & Dean, 2006).

Transfer Factor (TF) = $C_{plant} / C_{total\text{-}soil}$

where C_{plant} is the concentration of a metal in the plant material (dry weight basis) and $C_{total\text{-}soil}$ is the total concentration of the same metal in the soil (dry weight basis) where the plant was grown.

III. RESULTS AND DISCUSSIONS

METALS CONCENTRATIONS IN THE SOIL SAMPLES

The initial concentrations of selected metals in the soil samples are presented in Table 1. The pH of the soils was found to be in the range of 6.1 to 6.7 with a mean value of 6.4 which revealed that the samples were slightly acidic. The initial concentrations of selected metals were found to range from 52.50mg/kg to 55.60 mg/kg with a mean value of 53.85 mg/kg for chromium (Cr), 21.90 mg/kg to 33.86 mg/kg with a mean value of 29.51 mg/kg for lead (Pb), 13.81 mg/kg to 26.45 mg/kg with a mean value of 19.73 mg/kg for zinc (Zn) while cadmium (Cd) was not detected in any of the samples.

At four weeks after planting (4 WAP) of the test crop (corchorus olitorius), the concentrations of the metals are as presented in Table 2.the concentrations of the metals were observed to be in the range of 41.00 mg/kg to 46.50 mg/kg with a mean value of 43.83 mg/kg for Cr, 21.10 mg/kg to 27.40 mg/kg with a mean value of 24.92 mg/kg for Pb and

9.50 mg/kg to 11.00 mg/kg with a mean value of 9.67 mg/kg for Zn. At this time of the study, was still not detected in the soil samples.

The results for the concentrations of the metals in the soil samples at eight weeks after planting (8 WAP) follow the same trends of decreasing as with four weeks after planting (Table 3). The concentrations ranged from 18.00 mg/kg to39.00 mg/kg with a mean value of 33.00 mg/kg for Cr, 19.60mg/kg to 24.40 mg/kg with a mean value of 21.73 mg/kg for Pb and 3.85 mg/kg to 9.50 mg/kg with a mean value of 6.62mg/kg for Zn. Cadmium was not also detected in the soil samples at eight weeks after planting.

Soil Sample	pH	Cr	Cd	Pb	Zn
A	6.7	52.50	0.00	21.90	13.81
B	6.4	53.45	0.00	32.76	18.93
C	6.1	55.60	0.00	33.86	26.45
Mean	6.4	53.85	0.00	29.51	19.73

All parameters in mgl^{-1} except otherwise stated

Table 1: The initial concentrations of selected metals in the soil samples

Soil Sample	Cr	Cd	Pb	Zn
A	41.00	0.00	21.10	9.50
B	44.00	0.00	26.25	8.50
C	46.50	0.00	27.40	11.00
Mean	43.83	0.00	24.92	9.67

All parameters in mgl^{-1} except otherwise stated

Table 2: The concentrations of the metals at 4 WAP

Soil Sample	Cr	Cd	Pb	Zn
A	18.00	0.00	19.60	3.85
B	37.00	0.00	21.20	6.50
C	44.00	0.00	24.40	9.50
Mean	33.00	0.00	21.73	6.62

All parameters in mgl^{-1} except otherwise stated.

Table 3: The concentrations of the metals at 8 WAP

METAL CONTENTS IN THE PLANT TISSUES

Table 4 shows the concentrations of the metals in the uprooted plant tissues at four weeks after planting while the concentrations for eight weeks after planting are presented in Table 5. At 4 WAP, the concentrations of Cr ranged from 4.51 mg/kg to 6.97 mg/kg with a mean value of 5.63mg/kg, that of Pb ranged from 2.32 mg/kg to 4.11 mg/kg with a mean value of 3.38mg/kg while the concentrations of Zn ranged from 0.94 mg/kg to 1.65 mg/kg with a mean value of 1.33 mg/kg. Cd was not found in the analysed plant tissues for both 4 WAP and 8 WAP.

At 8 WAP, Cr concentrations were found to be in the range of 6.00 mg/kg to 8.00 mg/kg with a mean value of 6.92 mg/kg, Pb in the range of 2.54 mg/kg to 7.20 mg/kg with a mean value of 4.64 mg/kg and Zn in the range of 4.25 mg/kg to 12.50 mg/kg with a mean value of 7.42 mg/kg. The mobility of these metals based on the transfer factor at 8WAP for the detected soil metals ranged from 0.13 for Cr to 0.37 for Zn (Figure 1).

PHYTOREMEDIATION EFFECTS OF THE PLANTS

The concentrations of the metals which are potentially toxic in nature found in the soil samples were found to be reduced after eight weeks of planting corchorus olitorius plants on the soil. The concentrations in the plants were found to be increasing over time showing the possibility of uptake of the metals by the plant tissues cultivated on the soil.

Bioaccumulation of these potentially toxic metals in plants from the soil are transferred to the food chain where they raise human and animal health concerns. At high concentrations, these metals exhibit chronic toxicity or carcinogenicity as well as fatality (Wolnik et al., 1983; Blaylock and Huang, 2000; Monni et al., 2000; Reeves & Baker, 2000).

Soil Sample	Cr	Cd	Pb	Zn
A	4.51	0.00	2.32	0.94
B	5.40	0.00	3.71	1.39
C	6.97	0.00	4.11	1.65
Mean	5.63	0.00	3.38	1.33

All parameters in mgl^{-1} except otherwise stated

Table 4: The concentrations of the metals in the plant tissues at 4 WAP

Soil Sample	Cr	Cd	Pb	Zn
A	6.75	0.00	2.54	5.50
B	6.00	0.00	4.17	4.25
C	8.00	0.00	7.20	12.50
Mean	6.92	0.00	4.64	7.42

All parameters in mgl^{-1} except otherwise stated

Table 5: The concentrations of the metals in the plant tissues at 8 WAP

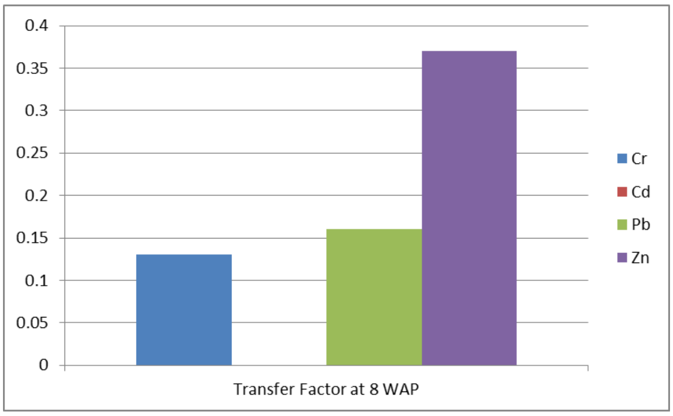

Figure 1: Mobility of soil metals by the plants at 8WAP

IV. CONCLUSIONS AND RECOMMENDATIONS

The phytoremediation effect of corchorus olitorius plants on soil metals through uptake of these potentially toxic metals by the tissues of the plants was investigated in this study. The concentrations of these metals were found to be decreasing in the soil while the plant tissues were taking up some quantities of the metals. The bioavailability of the metals from soil to plant based on the transfer factor was observed to increase in the order Cd, Cr, Pb, Zn.

Generally, it was observed that planting of the vegetable plant caused a change in the concentrations of the soil metals thus giving rise to a phytoremediation effect on the soil. It also revealed that the mobility of these metals based on the transfer factor varies. As earlier mentioned, it has been established that total concentrations of soil metals does not determine its bioavailability (Oyeyiola et al., 2010). The mobility, reactivity and availability for vegetal absorption may be affected by the chemical form of the metals in the soil as well as the physical and chemical characteristics of the environment. For instance, the concentrations of Pb in some cases during this study revealed that environmental conditions such as emissions from exhausts of engines using leaded fuel added to lead concentrations of the soils and plants tissues in conformity with Blokker (1972) and Johansson (2009).

From the outcome of this study, the practice of remediating a metal polluted soil using phytoremediation means is seen to be easy and affordable to carry out. It is therefore recommended that the method should be encouraged and improved on through further researches such as using different types of plants and even expanding the scope of metals and other pollutants to be tested.

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