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Phytoremediation potential of *Alocasia microrrhiza* grown on soil collected from selected dumpsites in Ekiti State, Nigeria

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Abstract. This study investigates the effect of enhanced phytoextraction on the accumulation of heavy metals by *Alocasia microrrhiza* cultivated on soil collected from selected dumpsites in Ekiti State, Nigeria. The application of 1g/kg EDTA decreased the heights of plants relative to control, but significantly increased the concentration of heavy metals in various tissues of the plant. Notably, concentration of Pb and Cu were greater than the threshold value of 100mg/kg, indicative of the fact that *Alocasia microrrhiza* could be a good candidate for Pb and Cu-phytoextraction. BF, TF and RR values (1.1-1.6), (4.3-4.8) and (1.4-2.3) revealed the effectiveness of the plant to translocate Pb and Cu to their harvestable portion. RRs values greater than one also indicated the efficiency of plant under chelate-induced phytoextraction. However, the concentration of heavy metals did not vary significantly at $p < 0.05$ (LSD test) in all dumpsites investigated.

Key words: Phytoremediation, *Alocasia,* dumpsites, lead, copper accumulation

Introduction

Heavy metals are not biodegradable and tend to accumulate in biological systems (Uwumarongie *et al*., 2008). The environment has been found to absorb pollutants or clean up itself by natural biological/biochemical activities, hence the increasing use of plants, plankton and other biota to remediate the environment (Agunbiade and Fawale, 2009). Plants can accumulate and magnify trace pollutants like heavy metals to a level that is toxic to lives (Madejon *et al.,* 2006).

Phytoremediation is the use of plants, including trees and grasses, to remove, destroy or sequester toxic contaminants from soil, water and air (Zhou and Song, 2004). Compared with other remediating technologies, such as soil flushing, Pneumatic fracturing, vitrification and electrokinetics, it is cost-effective and does not adversely alter the soil matrix (Envangelou *et al*., 2006). The method is comprised of phytoextraction, phytostabilization, phytovolatilization, phytodegradation and phytofiltration. However, only phytoextaction that can effectively remove contaminants from contaminated soils by hyperaccumulators is the most promising for commercial application.

The success of the phytoextraction process, whereby pollutants are effectively removed from soil, is dependent on an adequate yield of plants and/or the efficient transfer of contaminants from the roots of the plants into their aerial parts (Luo *et al*., 2005; Evangelou *et al*., 2007). It was shown that chelating agents such as EDTA and Ethylene glycol-bis (2-aminoethylether)-N,N,N',N'- tetraacetic acid (EGTA) had positive effects on the enhancement of the bioavailability of heavy metals in soils, thereby increasing the amount of metals accumulated in the plants (Lai and Chen,2005; Luo *et al*., 2005). According to Marques *et al*. (2008), the addition of EDTA promoted an increase in the concentration of Zn accumulated by *Solanum nigrum*, up to 231% in the leaves, 93% in the stems and 81% in the roots. However, further research is needed to determine the most appropriate plant species and best method of application before the chelate-assisted phytoextraction technique can be carried out in the field (Luo *et al*., 2005). The objective of the research was to investigate the ability of EDTA to enhance the phytoremediation of some heavy metals using

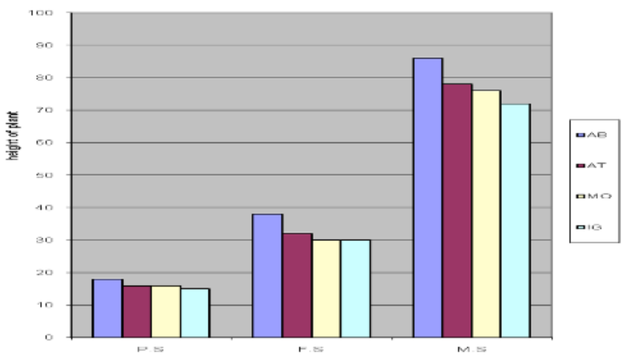

Fig. 1. Height of *Alocasia microrrhiza* at different germination stages with EDTA treatment.

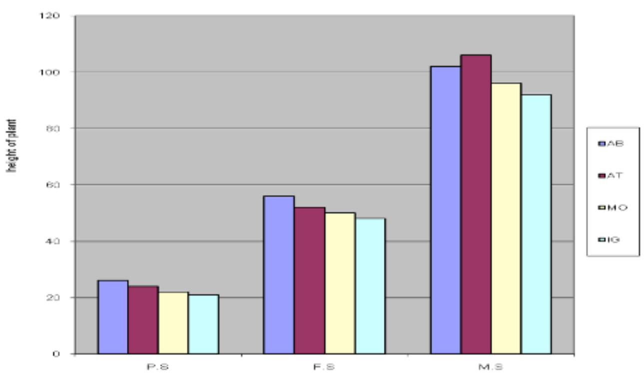

Fig. 2. Height of *Alocasia microrrhiza* at different germination stages without EDTA treatment.

Alocasia microrrhiza planted on soil collected from selected dumpsites.

Materials and Methods

Soil preparation and experimental procedure

Top soil (0-15cm) was collected from four dumpsites namely: Aba Egbira (70 371N), Atikankan (50131E) at Ado Ekiti and Igbehin street (60301N), Moshood road (80 361E) at Ikere Ekiti, Ekiti State, Nigeria. The soil were thoroughly mixed by a mechanical mixer and passed through a 4mm sieve to remove fibre and non soil particulate in the sample. Parameters like pH (range 5.3- 5.8), organic matter content (range 6.02-6.31%) and heavy metals concentration were determined prior to planting.

Plastics pots of 15 cm in heights and 20 cm in diameter were filled with 5kg of soil that passed through a 4mm sieve. The tubbers of *Alocasia microrrhiza* obtained from a farm in Ado Ekiti were planted on each pot marked experiment (with EDTA) and control (without EDTA). The experiment was spiked with 1.0g/kg of EDTA at 22, 40 and 90 days after transplantation according to Sun *et al*. (2009). The plants were cultivated in green house and no fertilizer was added. Loss of water was made up using tap water. The pots were placed in individual trays to prevent loss of amendments from leaching, and the soil was irrigated to the field capacity on daily basis. The tissues were harvested after a 120-day of cultivation.

Plant analysis

The plants were immersed in 0.01M HCl solution to remove any external heavy metals (Aldrich *et al*., 2003) and rinsed with deionized water for 1 min. Subsequently, the plants were separated into parts: roots/tuber, stem and leaf. After that, they were dried at 100oC for 10 min, then at 70oC in an oven until completely dry. The plants and soil samples were digested with a solution of 3:1 HNO3:HCLO4 (v/v). The concentration of heavy metals was determined using atomic absorption spectrophotometer (Perkin Elmer, model 306).

Data analysis

Significant difference was observed between multiple treatments by LSD test. Bioaccumulation factor (BF), the ratio of chemical composition in plant to soil; Translocation Factor (TF), the quotient of contaminant concentration in shoot to roots; and Remediation Ratio (RR) were calculated.

$$RR\ (\%) = \frac{M_{shoot} \times W_{shoot}}{M_{soil} \times W_{soil}} \times 100\%$$

Where Mshoot is the metal concentration in shoots of the plants (mg/kg), Wshoot is the plant dry above ground biomass (g); Msoil is the metal concentration in soil (mg/kg) Wsoil is the amount of soil in the pot (g). The RR reflects the amount of metals extracted by a plant from soil, which indicate phytoextraction efficiency under chelate-induced experiments.

Results and Discussion

The role of EDTA on plant growth

The heights of *Alocasia microrrhiza* in the four dumpsites are shown in Figures 1 and 2. There was reduction in the heights of these plants when 1g/kg of EDTA were applied at three stages before maturity. The heights decreased significantly at various stages relative to control. At the same concentration of EDTA, the height were in sequence of mature stage > flowering stage > pre-flowering stage. The ability of the plant to grow healthily with large biomass makes it a good candidate for phytoextraction (Mant *et al*. 2006), because an ideal plant for remediation should be high yielding that can tolerate high concentrations and accumulate target metals/pollutants(Zhou and Song, 2004).

Table 1. BFs, TFs and remediation ratio of heavy metals in *Alocasia microrrhiza*

	BF		TF		RR			BF		TF		RR	
	EXP	CON	EXP	CON	EXP	CON		EXP	CON	EXP	CON	EXP	CON
Cd AB	0.8	0.3	4.1	4.1	0.9	0.4	Cr	0.2	0.1	3.8	6.6	0.4	0.1
AT	0.7	0.3	4.5	4.2	0.8	0.3		0.2	0.1	3.7	8.2	0.3	0.1
IG	0.7	0.2	4.6	5.1	0.8	0.3		0.2	0.1	3.8	8.6	0.3	0.1
Mo	0.6	0.2	4.8	5.1	0.7	0.3		0.2	0.1	3.7	8.2	0.2	0.1
Fe AB	0.4	0.1	3.5	3.8	0.3	0.1	Mn	0.1	0.05	2.3	1.9	0.2	0.1
AT	0.3	0.1	3.8	4.0	0.2	0.1		0.1	0.05	2.2	1.7	0.1	0.1
IG	0.3	0.1	3.8	3.5	0.2	0.1		0.1	0.05	2.2	1.8	0.1	0.05
Mo	0.2	0.1	3.4	3.5	0.2	0.1		0.1	0.05	2.2	1.7	0.1	0.05
Pb AB	1.2	0.6	4.3	5.0	2.3	0.8	Zn	0.1	0.05	0.8	0.8	0.2	0.06
AT	1.1	0.5	4.4	5.3	2.1	0.7		0.1	0.05	0.8	0.8	0.1	0.05
IG	1.1	0.5	4.4	5.5	2.1	0.6		0.1	0.05	0.8	0.8	0.1	0.05
MO	1.1	0.5	4.4	5.6	1.9	0.7		0.1	0.05	0.8	0.7	0.1	0.05
Ni AB	0.5	0.04	4.3	5.7	0.6	0.05	Cu	1.6	1.0	2.6	2.4	1.7	1.0
AT	0.4	0.05	4.8	6.0	0.6	0.05		1.5	1.0	2.7	2.4	1.6	1.0
IG	0.3	0.05	4.8	6.6	0.5	0.05		1.4	0.9	3.0	3.2	1.5	0.9
MO	0.3	0.05	4.8	6.4	0.5	0.05		1.4	0.9	4.5	4.9	1.4	0.9
Co Ab	0.3	0.02	3.0	3.0	0.3	0.02	Sn	0.1	0.05	0.9	1.5	0.1	0.05
AT	0.3	0.02	3.2	3.9	0.3	0.02		0.1	0.05	1.0	1.5	0.1	0.05
IG	0.2	0.02	3.1	4.1	0.3	0.01		0.1	0.05	1.0	1.3	0.1	0.05
MO	0.2	0.02	3.9	6.0	0.2	0.02		0.1	0.05	1.1	1.4	0.1	0.05

KEY: EXP –Experiment, CON-Control, BF-Bioaccumulation Factor, TF-Translocation Factor and RR-Remediation Ratio

The influence of EDTA on heavy metals uptake and accumulation

Table 1 lists the concentration of heavy metals in tissues of *Alocasia microrrhiza* with and without EDTA treatment in the four dumpsites considered. The results showed that the concentration of heavy metals were greater with addition of EDTA (1g/kg) than without EDTA (control). This similar result was obtained by Yuebing *et al*. (2011). Concentrations of heavy metals (Cd, Cr, Fe, Mn, Pb, Zn, Ni, Cu and Co) were also found to increase in the order leaf > stem > root/tuber in both control and experiments as well as in all dumpsites under consideration. The highest concentration of Sn was found in the root/tuber, this observation will not make Alocasia microrrhiza a good candidate for Sn phytoextraction (Zhou and song, 2004).

The concentrations of Pb and Cu were found to exceed the threshold value in the harvestable parts of *Alocasia Microrrhiza* (100mg/kg) as hyperaccumulators when 1g/kg EDTA was applied (Alkorta *et al*, 2004). Moreover, the results of BF, TF and RR (Table 2) for all the heavy metals showed that for Pb; the experimental values were between 1.1-1.2, 4.3-4.4 and 1.9-2.3 while for Cu; the values were between 1.4- 1.6, 4.3-4.8 and 1.4-1.7, respectively.

These results above further indicated that *Alocasia microrriza* is a good candidate for phytoextraction of Pb and Cu, as these metals are translocated from the roots to stem, and that the concentrations of the heavy metals (compared with control) in the stems and leaves of *Alocasia microrrhiza* were enhanced with the application of 1g/kg EDTA at various stages of plant growth. Figures 1 and 2 revealed that application of 1g/kg EDTA did not have much effect on plant biomass, as the plant only experienced yellowing of leaves after 22 days of EDTA application (Sun *et al*., 2009). The concentration of heavy metals in different tissues of plants in the four dumpsites did vary significantly at $p \leq 0.05$ (LSD test), showing that the plant characteristic varies from dumpsite to dumpsite.

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