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Phytoremediation Potentials of Some Nigerian Weeds

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The potentials of *Phyllanthus amarus* (chanca piedra), *chromolaena odorate* (awolowos weed), *Stachytarpheta indica* (gervao), *Bryophyllum pinnatum* (life leaf) and *Murraya koenigii* (curry leaf) to absorbed, Pb, Zn, Cd, Cu and Ni from contaminated soil. The plants were allowed to germinate in a pre-analyzed natural soil (within 2 weeks) after which they were transplanted to contaminated soil. After 5 weeks exposure, the plants were removed and the soil and the plants were analysed for their heavy metals content. The absorption capacity of these plants for Pb, Zn, Cd, Cr, Cu and Ni shows that *Stachytarpheta indica, Phyllanthus amarus, Murraya koenigii, Phyllanthus amarus, Phyllanthus amarus, Phyllanthus amarus* and *Phyllanthus amarus* have the potentials of absorbing heavy metals from contaminated soil.

Key Words: Some Nigerian weeds, Phytoremediation potentials.

INTRODUCTION

Phytoremediation is the use of plants to remove contaminants from soil and water. It is a slow but environmentally friendly way to remove toxins[1]. Plant materials such as fungi, lichens, tree bark, tree rings and leaves of higher plants have been used for many years to detect the deposition, accumulation and distribution of heavy metals pollutants[2]. Lower plants especially moss and lichens have been widely used due to their capacity for metal accumulation[3]. Some higher plants have also been used for biomonitoring of heavy metals[2]. Al Shayeh *et al.*[4] have reported the use of the date palm (*Phoenix dactylifera* L.) for the biomonitoring of lead. Aksoy and Sahin[2] adopted *Elaeagnus ongustifolia L.* for the biomonitoring of heavy metal pollution in Kaysedi (Central Anatolia of Turkey). Aksoy and Ozturk[5] used date palm leaves to monitor the distribution of Pb, Cd, Zn and Cu in the city of Antalya while Joseph[6] uses *Trifolium pretense* (red clover) and *Medicago sativa* (alfalfa) on his studies on phytoremediation of tin from commercially contaminated soil samples.

According to Eddy[1] plants that can accumulate metals (hyperaccumulators) have a large potential for use in cleaning up land contaminated with heavy metals because these plants can extract the metal from the soil and when harvested, the metal-rich shoots and leaves would remove the metal from the site. Heavy metals includes the toxic heavy metals (such as Pb, Cd, Se, Ni, *etc.*) the non-toxic and essential heavy metals (such as Zn, Mn, *etc.*)[1,3,7]. The environmental roles play by most heavy metals is therefore remarkable because of the toxicity of heavy metals to the land, water, plant and animals[8].

One of the most common and effective methods of cleaning up heavy metal polluted soil is the use of acid to leach the soil. However, this method is very costly and makes the resultant soil barren[7].

In view of this, the present work is designed to evaluate the potential of *Phyllanthus amarus, Chromolaena odorate, Stachytarpheta indica, Bryophyllum pinnatum* and *Murraya koenigii* in the remediation of soil polluted by heavy metals.

EXPERIMENTAL

Samples of *Phyllanthus amarus* (chanca piedra), *Chromolaena odorate* (awolowo), *Stachytarpheta indica* (gervao), *Bryophyllum pinnatum* (life) and *Murraya koenigii* (curry) were carefully uprooted from some farmlands and homes located within Ikot Ekpene metropolis and transported to the study site located within the Botanical garden of the Akwa Ibom State polytechnic, Ikot Osurua. The heavy metals content of the representative samples of these plants were determined according to the method recommended by AOAC[9]. The heavy metals content of the soil samples from the study site was also determined.

The pre-analyzed soil samples were polluted with Pb, Zn, Cd, Cu, Cr, Mn and Ni by watering the soil with the solution of the salt of these metals. The polluted soil samples were analyzed for their heavy metals content and used for the cultivation of these plants. A total of ten plants samples (for each set of polluted soil) were cultivated in heavy metals polluted soil while the remaining ten samples were cultivated in the control soil samples (Unpolluted by heavy metals). These plants were exposed to normal atmospheric conditions for 39 d after which there were uprooted, treated and analyzed along with the soil samples for their heavy metal content. The amount of heavy metals absorbed was calculated by comparing the results obtained for plant and soil samples.

RESULTS AND DISCUSSION

The concentrations of lead absorbed by *Phyllanthus amarus*, *Chromolaena odorate*, *Stachytarpheta indica*, *Bryophyllum pinnatum* and *Murraya koenigii* were 0.20, 1.35, 5.40, 2.70 and 1.05 mg/kg, respectively.

Phyllanthus amarus, *Chromolaena odorate*, *Stachytarpheta indica*, *Bryophyllum pinnatum* and *Murraya koenigii* absorbed 263.42, 103.95, 129.10, 138.70 and 190.10 mg/kg of zinc, respectively.

Phyllanthus amarus, *Chromolaena odorate*, *Stachytarpheta indica*, *Bryophyllum pinnatum* and *Murraya koenigii* absorbed 0.071, 0.60, 0.85, 0.55 and 1.40 mg/kg of cadmium, respectively.

Phyllanthus amarus, *Chromolaena odorate*, *Stachytarpheta indica*, *Bryophyllum pinnatum* and *Murraya koenigii* absorbed 25.21, 9.40, 14.85, 14.20 and 10.85 mg/kg of chromium, respectively.

Phyllanthus amarus, *Chromolaena odorate*, *Stachytarpheta indica*, *Bryophyllum pinnatum* and *Murraya koenigii* absorbed 29.42, 16.15, 18.70, 13.15 and 19.15 mg/kg of copper, respectively.

Phyllanthus amarus, *Chromolaena odorate*, *Stachytarpheta indica*, *Bryophyllum pinnatum* and *Murraya koenigii* absorbed 113.28, 84.55, 113.9, 73.45 and 82.55 mg/kg of manganese, respectively.

Phyllanthus amarus, *Chromolaena odorate*, *Stachytarpheta indica*, *Bryophyllum pinnatum* and *Murraya koenigii* absorbed 79.00, 23.55, 33.60, 16.15 and 23.15 mg/kg of nickel, respectively.

The concentrations of lead, zinc, cadmium, chromium, copper, manganese and nickel in soil were found to be 749.25, 168.80, 52.47, 175.90, 295.50, 204.175 and 207.00 mg/kg, respectively.

There was a significant difference between the concentrations of the respective heavy metals in plants and in the soil samples ($p < 0.05$).

The highest amount of lead, zinc, cadmium, chromium, copper, manganese and nickel absorbed was exhibited by *Stachytarpheta indica*, *Phyllanthus amarus, Murraya koenigii, Phyllanthus amarus, Phyllanthus amarus, Phyllanthus amarus and Phyllanthus amarus,* respectively implying that *Phyllanthus amarus* has a strong absorption capacity for the essential heavy metals (Zn, Cr, Cu, Ni and Mn). The graphical demonstration of these trend are shown in Figs. 1-7.

According to Dara[10] at low and moderate concentration, Zn, Cr, Cu and Mn have been found to be essential elements needed by the soil and plants for their biochemical roles. For this reason, *Phyllanthus amarus* plant is normally considered as unwanted weeds by farmers because the plant depletes the essential elements components of the soil. However, the medicinal role of this plant has been recommended and confirmed by their phytochemical composition shown in Table-1.

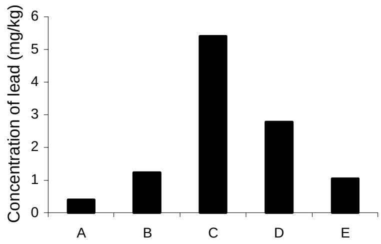

Fig. 1. Absorption of lead

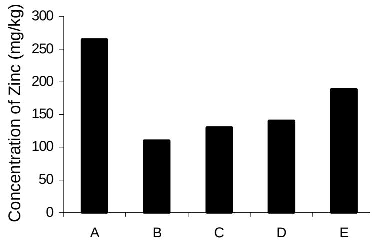

Fig. 2. Absorption of zinc

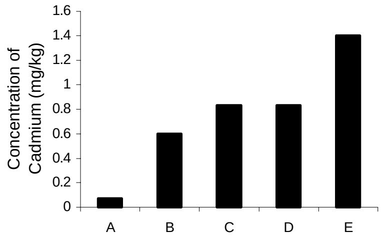

Fig. 3. Absorption of cadmium

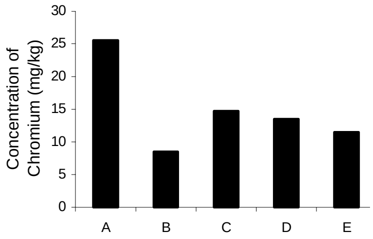

Fig. 4. Absorption of chromium

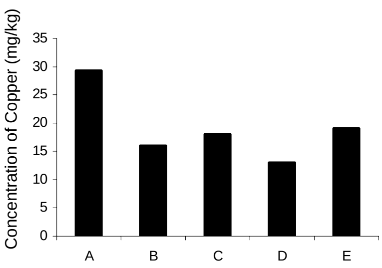

Fig. 5. Absorption of copper

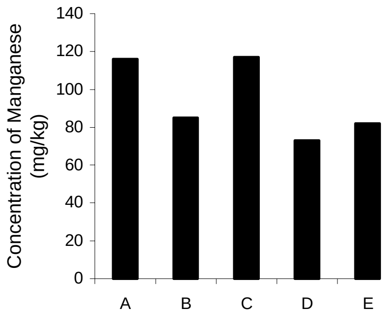

Fig. 6. Absorption of manganese

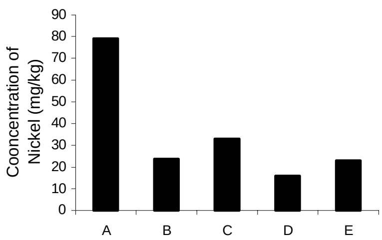

Fig. 7. Absorption of nickel

TABLE-1
CHEMICAL COMPOSITION OF *PHYLLANTHUS AMARUS* [11-13]

Chemical composition	Major forms/examples
Lignanes	Phyllanthine, hypophyllanthine, phyltetralin, lintetralin, niranthin, nirtetralin, nirphylline, nirurin, niruriside.
Terpenes	Cymene, limonene, lupeol and lupeol acetate.
Flavonoids	Quercetin, Quercitrin, Isoquercitrin, astragalin, rutine, physetinglucoside
Lipids	Ricinoleic acid, dotriancontanoic acid, linoleic acid, linolenic acid
Benzenoids	Methylsalicilate
Alkaloids	Norsecurinine, 4 - metoxy - Norsecurinine, entnorsecurinina, nirurine, phyllantin, phyllochrysine
Steroids	Beta-sitosterol
Alcanes	Triacontanal, Triacontanol
Others	Vitamin C, tanines, saponins

From the result of the present study, it is certain that *Phyllanthus amarus* is cultivated in a heavy metal contaminated soil. It is certain that the consumption of such plant for whatever purpose should be discouraged.

The high absorption capacity of *Stachytarpheta indica* for lead and *Murraya koenigii* for cadmium might have been due to the organic matter and lead contents of the plants as well as the absent or low concentration of exchangeable ions in the plant.

Absorption of heavy metals by plants have been found to takes place *via* the root by foliar absorption[7,10]. Ekop and Eddy[14] also stated that the amount of heavy metals absorbed by plant depends on the organic matter contents of the plants, the heavy metals contents of the plant, the presence of exchangeable ions, the pH of the soil and other environmental factors. Therefore, the difference in organic matter contents of the studied plants and the amount of exchangeable ions in the plant soil and other environmental factors might have contributed to the observed trend.

The significant difference between the heavy metal contents of the plants on the control soil samples and in the plants cultivated in the contaminated soil implies that the uptake of heavy metals by these plants is influenced by the heavy metals content of the plants and soils.

From the above, it is observed that the amount of lead absorbed by the respective plants samples were generally low implying that these plants have low absorption capacity for lead and its absorption is independent of the lead content of the soil. The presence of ions that can exchanged lead in the plant samples might have also contributed to the observed trend. Dara[10] explained that Cd^{2+} and Pb^{2+} can compete for position in living cells if the two are present in the same cell environment. Eddy *et al.*[8] also stated that the ability of most metals to form complexes with ligands is strongly dependent on the present of common ions, exchangeable ions, pH and other environmental factors implying that the low absorption potentials of these plants for lead might have been influenced by these factors.

Zinc is an essential heavy metal and according to Dara[10] the nutritional role of zinc has been recommended for living organism. During the study, it was observed that *Phyllanthus amarus* absorbed maximum zinc, when compare to other weeds. This justifies the medicinal/nutritional role of this plant[11,14,15].

The highest absorption capacity for cadmium exhibited by *Murraya koenigii* and least by *Phyllanthus amarus* might have been due to the fact that Cd^{2+} and Zn^{2+} have closely similar atomic structure and chemical behaviour[10]. This implies that Cd^{2+} and Zn^{2+} can exchanged each other in the living cell depending on the environmental condition of the soil consequently, the highest absorption capacity exhibited by *Phyllanthus amarus* for Zn^{2+} and the least absorption capacity exhibited by *Phyllanthus amarus* for Pb^{2+} shows that *Phyllanthus amarus* has the potential of preferentially absorbing Zn^{2+} instead of Cd^{2+}.

According to Dara[10], plants exposed to cadmium concentration at toxic levels exhibit chlorosis and reduced growth. However, these symptoms of cadmium toxicity were not observed during the study implying that these plants can thrive in soils polluted by heavy metals. This special adaptability shown by these plants confirms the suitability of these plants for use in phytoremediation.

Chromium was highly absorbed by *Phyllanthus amarus* and least by *Chromolaena odorate*. This trend may be due to the organic matter content of these plants. Ademoroti[3], also explained that chromium is more likely to be absorbed by leafy plants than by plant that yield fruits. Similar reason might be responsible for the absorption of manganese from the polluted soil.

Nickel is toxic to plants but not for animals[10]. Nickel concentration of 40 ppm has been reported to leads to the death of most vegetables and other higher plants. However, during the study, none of these plants were dead and their growth rate were not impeded by the high concentration of nickel in the soil implying that these plants can thrive very well in a nickel contaminated soil due to their strong adaptability.

Conclusion

The paper examined the potentials of some Nigerian weeds *e.g.*, (*Phyllanthus amarus* (chanca piedra), *Chromolaena odorate* (awolowo;s weed), *Stachytarpheta indica* (gervao), *Bryophyllum pinnatum* (life leaf) and *Murraya koenigii* (curry leaf) for use in phytoremediation of heavy metals (Pb, Zn, Cd, Cr, Cu and Ni). The study confirms that among these plants, the preferred weeds for phytoremediation for Pb, Zn, Cd, Cr, Cu and Ni are *Stachytarpheta indica*, *Phyllanthus amarus*, *Murraya koenigii*, *Phyllanthus amarus*, *Phyllanthus amarus*, *Phyllanthus amarus* and *Phyllanthus amarus*, respectively. Since most farmers usually consider these plants as weed, the used of these plants for bioremediation can be promising for the removal or the reduction of heavy metals from polluted soil. The strong adaptability of these plants to heavy metal polluted soil, the low cost of acquisition of these weeds, short maturation period and the lack of technicalities in using the weeds for the purpose suggest that these weeds can display a promising role in phytoremediation of heavy metal from polluted soil.

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