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Assessment of Plants Growing on Bitumen and Gypsum Mine Soils, in Southwestern, Nigeria for Mine Reclamation

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Authors' contributions

This work was carried out in collaboration among all authors. Author AOF designed the study and wrote the first draft of the manuscript and author FSO wrote the protocol and managed the analyses of the study. Author SAA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Human activities increase the concentration of heavy metals in the environment from year to year. Therefore, decontamination is very important for the ecological restoration. This study investigated the phytoremediation potential of *Platycerium coronarium* (Fern),*Vernonia amigdalina (*Bitter Leaf), *Chromolenaodorata*, *Talinumfruticosum (*Water Leaf) for the removal of Ni, Cd, Cr, Zn and Cu in the goldmine tailings.Bioaccumulation factor of all element are lower than one which indicated accumulator. Translocation factor of Cd, Ni and Cr more than one and hence, *Platycerium coronarium* and *Chromolenaodorata* could be considered as potentially useful for remedying Cd, Ni and Cr contaminated soil.

Keywords: Heavy metal; decontamination; ecological restoration; bioaccumulation; translocation.

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1. INTRODUCTION

Phytoremediation is considered as innovative, eco-friendly, novel, economical, green technology for the removal of heavy metals from contaminated soil. Phytoremediation takes the lead advantage in the unique and selective uptake capabilities of plant root systems, together with the translocation, bioaccumulation, and contaminant degradation abilities of the entire plant body and thereby decontaminate and purify the affected area [1,2].

One of phytoremediation categories which is phytoextractioncan be used to remove heavy metals from soil using its ability to uptake metals which are essential for plant growth (Fe, Mn, Zn, Cu, Mg, Mo, and Ni). Mining activities for mineral resources over the years have resulted in major soil damage. Due the removal process of desired mineral materials, soil textures have been destroyed, various nutrient cycles have been disturbed and microbial communities have been altered, a_ecting vegetation and leading to the destruction of wide areas of land in many countries [3-6].

An appropriate plant for phytoremediation should ideally have high and fast biomass production, and ability of translocation of contaminants into the plant shoot (Cunningham and Ow, 1996). Plant communities that are tolerant to imposed stress conditions can fulfill the objectives of stabilization, pollution control, visualimprovement and removal of threats to mankind.The constraints related to plant establishment and amendment of the physical and chemical properties of the toxic metalliferous soils depend upon the choice of appropriate plant species that will be able to grow in such a hostile environment. Thus, the plant community tolerant to toxic trace elements plays a major role inremediation of degraded mine soils. Plants tolerant to toxic levels of trace elements respond by exclusion, indication or accumulation of metals [7].

Many species of plants have been successful in absorbing contaminants such as lead, cadmium, chromium, arsenic and various radionuclides from soils.

Heavy metals are useful micro nutrients for plants, human and animal but become toxic when their concentrations exceed a limit [8]. Heavy metals are widespread pollutants of great environmental concern because they are toxic and non degradable. Heavy metals are naturally present in the environment; their occurrence however, has gradually been increasing with the increase of industrialization. Cd, Pb and Zn are among the most abundant heavy metals in the agricultural soil as majority of them are found as contaminants in plant and herbal materials [8].

Heavy metals may originate from various types of anthropogenic sources such as petroleum, diesel and coal combustion, as well as industrial and mining activities [9,10] and natural geochemical processes such as weathering [11].

Mining activities leave behind vast amount of mine spoils and mine tailings, which will become the sources of metal contamination and pollution in the environment. The direct effects of these processes will be the degradation of cultivated, forest or grazing land with concomitant reduction in production [12] and there is need to preserve and decontaminate the ecosystem.

The present study was to investigate phytoremediation, bioaccumulation and trans-location characteristics of Ni, Cd, Cr, Zn and Cu in the tailings and plants around Itagunmodi Mining Site, Nigeria.

2. MATERIALS AND METHODS

2.1 Site Description

The samples used for this study were collected from Ode-Irele in Ondo State latitude (06^{o}39'94'') and longitude (04^{o}53'42'') and Ijero–Ekiti, in Ekiti State latitude (07^{o}49'45')'and longitude (05^{o}04'23'') respectively in South Western, Nigeria. The states have an average annual rainfall and temperature of about 1489 mm and 26.5^{o}C respectively. Adebayo et al. [13] observed that crop production is the dominant agricultural enterprise that farmers in South-West Nigeria engage in.

2.2 Sample Collection and Pretreatment

A total of ten tailings and five Plants samples were collected from the mining site. They were air dried, pulverized and sieved through a 0.8mm mesh and stored in clean polythene bags for further analysis.

2.3 Sample Digestion and Analysis

The aqua regia procedure put forth by Nieuwenhuize et al. [14] for metal digestion was

Table 1. Translocation factor

Sample	Ni	Cd	Cr	Zn	Cu
Platycerium coronarium (Fern)	1.265	1.045	0.898	0.932	0.957
Vernonia amigdalina (Bitter Leaf)	0.393	0.161	0.309	0.358	0.345
Chromolena odorata	0.738	0.720	1.280	0.900	0.947
Talinum fruticosum (Water Leaf)	0.200	0.150	0.310	0.364	0.309

Table 2. Bioaccumulation factor

Sample	Ni	Cd	Cr	Zn	Cu
Platycerium coronarium (Fern)	0.032	0.119	0.473	0.634	0.148
Vernonia amigdalina (Bitter Leaf)	0.014	0.047	0.191	0.362	0.098
Chromolena odorata	0.012	0.093	0.244	0.288	0.130
Talinum fruticosum (Water Leaf)	0.014	0.093	0.275	0.401	0.183

followed. Dried and powdered plant sample of 1.0 g was digested with aqua regia (3:1 HCl: HNO_3) in 100 ml conical flask and refluxed gently at 80^0C for 2hrs. After, cooling, the solution was filtered through a moistened Whatman 42 filter paper and diluted to 50 ml volume with distilled water diluted to volume with distilled water. The final solutions were analyzed for their Cr, Cu, Zn, Cd, and Ni concentration using 210VGP (Buck Scientific) atomic absorption spectrometer.

Also, Blank solution was prepared to check forchemical/instrumental interference.

2.4 Translocation Factor (TF)

Translocation from shoot to root was measured by TF which is given in equation (1) below:

$$TF=C_{shoot}/C_{root} \quad (1)$$

Where C_{shoot} and C_{root} are metals concentration in the shoot(mgkg-1) and root of plant (mgkg-1) respectively. TF>1 represent that translocation of metals effectively was made to the shoot from root [15-17].

2.5 Bioaccumulation Factor (BAF)

BAF of heavy metals was calculated using equation (2) by:

$$BAF=C_{shoot}/C_{soil} \quad (2)$$

Cshoot and Csoil are metals concentration in the plant shoot (mgkg-1) and soil (mgkg-1), respectively. BAF was categorized further as hyperaccumulators, accumulator and excluder to those samples which accumulated metals>1 mg kg-1, and < 1, respectively [18,19].

3. RESULTS AND DISCUSSION

The results indicated in Table 1 shows that only the translocation factor of Ni and Cd in *Platycerium coronarium* (Fern) and Cr in *Chromolenaodorata* are greater than 1mg/kg represent that translocation of metals was effectively made to the shoot from root [15-17].

The result indicated on Table 2 shows that the bioaccumulation factor of all the elements analysed in plant samples are less than 1mg/kg which indicated that they are accumulator [18,19].

4. CONCLUSION

Translocation factor values more than one, indicated that *Platyceriumcoronarium*(Fern) and *Chromolenaodorata*is potentially useful for remedying Cd, Ni and Cr-contaminated soil. Bioaccumulation factor value lower than one show that all plants sample are accumulator of Ni, Cd, Cr, Zn and Cu.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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