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Research Article

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Assessment of phytoremediation potential of *Telfaira occidentalis* in the removal of Cu, Cd, and Pb in contaminated soil along River Salanta

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ABSTRACT

A Field study was carried out to examine the phytoremediation potential of some plants metals (Cd, Cu and Pb) in contaminated soils along Sallanta river, Kano. A total of one hundred and eighty (100) samples comprising of 40 (soils), 20 (effluents), and 40 (plant parts) of T. 0ccidentalis were analyzed. 0.50g of the plant tissue and 1.0g of soil sample and 50mL of the effluent sample were digested using triacid digestion method and the levels of the metals were determined by the use of atomic absorption spectrophotometry. The mean levels of the metals in plants and soils from contaminated and control sites were found to be in the sequence of Cu (27.08±3.15)> Cd (24.57±8.25)>Pb (3.00±0.52) and Cu (10.10±2.50)> Cd (2.80±0.05)>Pb (2.00±0.63) respectively. The contamination factor (CF) of all the metals in the plants were found to be in the sequence of Cd (8.35±1.53)> Cu (2.52±1.20)>Pb (1.50±0.21). The results showed that these plants can be used for the phytoextraction of the metals from contaminated soils. The values of bioaccumulation and translocation factors were also found to be more than one in almost all cases. From these results it could be recommended that the three plants investigated would be ideal for phytoremediation in multi-metal contaminated soils.

KEYWORDS: Phytoremediation, contamination factor, bioaccumulation factor, translocation factor, heavy metals, contaminated soils

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INTRODUCTION

Heavy metals are the most dangerous substances in the environment due to their high undegrading nature and toxicity to the biota [1]. The idea that plants can be used for environmental remediation is an old technique and cannot be linked to any particular source; however, dogged research approach led to the development of this idea into a promising environmental technology called Phytoremediation [2].

Soil is the basic environmental element constituting ecosystem, and the important material basis for human survival and development on the planet earth. Rapid industrialization and urbanization coupled with the zeal of attaining rapid growth in technology, jeopardize the environmental safety of soil throughout the world. This causes serious contamination of soil with heavy metals [3]. Heavy metals contamination is the introduction or release of heavy metals into environment in quantities that adversely affect the living conditions of the flora and fauna in the environment. Heavy metals contaminating soil is a serious concern in most countries. Ecological rehabilitation of the contaminated soils in the industrial, agricultural, and urban territories is a great challenge in recent decades due to anthropogenic activities [4-7].

Hyper accumulators are plants that can absorb high levels of contaminants concentrated either in their roots, shoots and/or leaves [8]. Accumulation of selected metals varied greatly among plants species and uptake of an element by a plant is primarily dependent on the plant species, its inherent the soil quality [9].Numerous factors control metal accumulation and bioavailability associated with soil and climatic conditions, plant genotype and agronomic management [10]. Metal solubility in soils is predominantly controlled by pH and oxidation state of the system [11].

In the Western region of the continent, cultivation of food crops on contaminated soil is common, as small scale farmers cultivate food crops at dumpsites to maximize yields due to the seemingly high organic contents of waste dumpsite soils. Odai

et al., 2008 reported high levels of Pb, Cd, Cu and Zn in soils used for vegetable cultivation at Kumasi waste dumpsites in Ghana. Similarly, in the North Western part of Nigeria, alarming concentrations of Pb, Cd and Cr were recorded in tomatoes grown in the Western region of the continent, cultivation of food crops on contaminated soil is common, as small scale farmers cultivate food crops at dumpsites to maximize yields due to the seemingly high organic contents of waste dumpsite soils [12,13].

MATERIAL AND METHODS

Study Area

The study area is located within Kano Metropolis in Kumbotso Local Government Area. It lies within Latitude 11°56' 30' ' to 11° 58' 30' ' N and Longitude 8° 29' 30' ' to 8° 31' 30' ' E along river Salanta across Sharada industrial estate. The industrial area is within the southern part of Kano metropolis, at an altitude of 485m. The industries in the area are mostly tannery, textile, fertilizer, chemical, food, plastic, and drug. The effluents discharged from these industries are drained into tributaries of Challawa and Salanta Rivers that supply water to hectares of irrigated farmlands across the state.

Cleaning of Glass Wares

Glass wares, plastic containers, crucibles, pestle and mortar were washed with liquid detergent, rinsed with distilled de-ionized water and then soaked in 10% HNO_3 solution for 24 hours [14]. They were then washed with distilled water and dried in an oven at 80°C for 3 hours. Other chemicals and reagents used in this study were of analytical grade obtained from BDH and Sigma-Aldrich. Distilled water was also used for dissolution of metals salts used in the analysis. Procedural and reagent blanks were used and a clean laboratory environment was ensured during the analysis and preparation of solutions. The Atomic Absorption Spectrophotometer (Buck Scientific AAS Model 210VGP) was calibrated with multi-element standard solution (MESS) and the calibration standards were analyzed after 10 sample runs to ensure that the instrument remained calibrated [15].

Samples Collection

A total of one hundred and eighty (180) samples comprising of eighty (80) soils, twenty (20) of effluents and eighty (80) of leaves, stems and roots of *Telfairia occidentalis* were collected from the sites and transported to the laboratory. The control samples were collected at Minjibir Local Government area. The samples were air-dried separately at room temperature in the laboratory.

Samples Preparation

The plant samples were separated into portions of roots, stems and leaves and then cut into small pieces and washed with tap water and then rinsed with distilled de-ionized water. These were placed on card board papers and dried in an open-air in the laboratory for three weeks. The dried samples were ground into fine powder using ceramic pestle and mortar and stored in labeled stoppered plastic bottles. Soil samples were air-dried, ground to fine powder, sieved using a 10 mesh nylon sieve and stored in labeled polythene bags.

Soil pH Determination

The pH of the soil samples were measured using a calibrated SB20 pH meter. The calibration of the pH meter was carried out using two buffer solutions of pH 4 and 10. 20 mL distilled de-ionized water was added to 15 g of the soil sample and allowed to stand for 5minutes. The mixture was stirred vigorously and allowed to stand for another 3 minutes, with occasional stirring. The electrode of the pH meter was inserted into the swirled slurry and three replicate readings taken for each sample [16].

Atomic Absorption Spectrophotometer Analysis

The concentration of heavy metals in the samples were determined using Atomic Absorption Spectrophotometer (Buck 210 VGP Model) equipped with a digital read-out system [17]. Working standards were used, after serial dilution of 1000ppm metal stock solution in each case. Calibration curves were generated by plotting absorbance values versus concentrations. By interpolation, the concentrations of the metals in sample digests were determined as described by Audu and Lawal[18].

Data Analysis

Data was subjected to Bioconcentration Factor (BCF) which indicates the efficiency of a plant species in accumulating a metal into its tissues from the surrounding environment. Hence it is used for determining the efficiency of phytoremediation. It is calculated using equation (1) [19].

$$\text{Bioconcentration Factor BCF} = C_{\text{harvested}} \text{ tissue } C_{\text{soil}} \quad (1)$$

Where: $C_{\text{harvested}}$ tissue is the concentration of the target metal in the plant harvested tissue.

C_{soil} is the concentration of the same metal in the soil where the plant grows.

Data was also subjected to Contamination Factor (CF) which is used to determine the degree of contamination of the heavy metals in the study area. It is calculated as the ratio of heavy metal concentration at each sampling point to metal evaluation criteria. Metal evaluation criteria is the permissible limit of the metal. Thus,

$$\textit{Contamination Factor } CF = \textit{Cicref} \quad (2)$$

Where: C*i* is the metal concentrations at each sampling point. C*ref* is the evaluation criterion of the metal.

The evaluation criteria of Cd, Cu and Pb for soil by WHO (1996) are 1.4, 63and 70 mg/kg respectively.

Table 1: Table showing the mean levels of heavy metals (mg/kg) in the Soils samples analyses in comparison to the maximum allowed concentrations

Metals	Contaminated soils (Mean±SD)	Uncontaminated soils (Control) (Mean±SD)	Uncontaminated soils (Control) (Mean±SD)
Cu	27.08±3.15	10.10±2.50	5.00-20.00
Cd	24.01±8.25	2.80±0.05	6.03-0.30
Pb	3.00±0.52	2.00±0.63	2.00 – 20.00

Table 2: Variation of contamination factor values (cf) (mg/kg) with soil samples

Plant sample	Cd	Cu	Pb
	8.35±1.53	2.52±1.20	1.50±0.21

Table 3: Translocation of metals (mg/kg) from roots to shoots of plant samples in polluted area

Plant sample	Cd	Cu	Pb
	1.28	1.68	1.45

Table 4: Bioaccumulation co-efficient (BAC) values for heavy metals in the tissues of plants

Plant part	Cd	Cu	Pb
Leaves	2.19	1.35	1.75
Stem	1.23	1.70	1.91
Root	2.51	2.01	2.54

CF<1 indicatesnocontamination,CF=1–2suspectedcontamination,CF=2– 3.5slightcontamination,CF=3.5–8moderatecontamination,CF=8– 27severecontamination,CF>27extremecontaminations[20].

Statistical Analysis

The data was statistically analyzed using SPSS package by applying one-way ANOVA to detect any significant differences between samples taken.

RESULTS AND DISCUSSION

The results in Table 1 showed that the soils along Salanta river is contaminated with metals (Cd, Cu and Pb) and their pH was slightly acidic. Lower pH values in soil lead to higher heavy metal solubility.

The contamination factor (Cf) values revealed that the soils are highly contaminated with Cd (8.35±1.53) and Cu is said to have considerably contaminated the soils. Pb is considered to have only moderately contaminated the soils (Table 2).

The results revealed that the translocation factors of all the metals in the plants tissues were greater than one (Table 3).

These values indicated higher availability and distribution of metals in soils contaminated with heavy metals in the three plant species which can be labeled as translocators of Cd, Cu, andPb based on TF>1. Heavy metal tolerance with high TF value have been suggested for phytoaccumulator of contaminated soils [21,22] and therefore these plant species can be used as phytoremediators for multi-metal contaminated soils. Also the results revealed high bioaccumulation factors (BAF) of all the metals examined in the tissues. All the BAF values were greater than one in *T.occidentalis* leaves and stems respectively (Table 4). The bioaccumulation of the metals indicates a great performance of these plant species for metals phytoextraction and could be labeled as accumulator plants [22].

CONCLUSION AND RECOMMENDATIONS

The results obtained showed that *T. occidentalis* can accumulate heavy metals from contaminated soils. The bioaccumulation and translocation factors were found to be greater than one in all cases; indicating that all the three plant parts are potentially useful for remediating heavy metals contaminated soils for these metals (Cd, Cu, and Pb). It is recommended that *T.occidentalis* can be ideal option for the phytoremediation in multi-heavy metal contaminated soils. These plants if massively planted in and around river Salanta would reduce these metals in the soil and would also in the long run help to prevent the ground water contamination by heavy metals in the industrial effluents.

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