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# ASSESSMENT OF THE PHYTOREMEDIATION POTENTIALS OF *Jatropha curcas* IN THE REMOVAL OF HEAVY METALS FROM CONTAMINATED SOILS OF THE CHALLAWA INDUSTRIAL ESTATE KANO, NIGERIA

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**ABSTRACT**
***The concentrations of Zinc (Zn), Copper (Cu) and Cadmium (Cd) in soil samples and different plant organs of a native wild plant specie Jatropha curcas collected from Challawa industrial zone in Kano City, Nigeria were investigated using Atomic Absorption Spectroscopy (AAS). The aim was to establish the plant's metal accumulating potential, and as well as which of the plant's organ exhibit the greatest accumulation and to evaluate whether the specie is suitable for phytoremediation programs. The bioaccumulation and transfer of metals from roots to shoots and from soil to roots was evaluated in terms of translocation factor (TF) and bioconcentration factor (BCF). Results showed that the concentrations of heavy metals in the plants have the sequence of (Zn >Cu> Cd). Generally, the shoot region of the studied specie accumulated more heavy metals than the corresponding roots. Based on BCFs and TFs values, the studied plant specie has potential for both phytostabilization and phytoextraction depending on the metal of interest.***
***Key words: AAS, Cadmium, Contamination, Kano metropolis Phytoextraction, Phytostabilization,***

## INTRODUCTION

Heavy metals are the most dangerous substances in the environment due to their high un-degrading nature and toxicity to the biota (Alkorta *et al*, 2004). 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 (Raskin *et al*., 1997).

Hyperaccumulators are plants that can absorb high levels of contaminants concentrated either in their roots, shoots and/or leaves (Cunningham and Ow, 1996). 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 controls and the soil quality (Nadia *et al*, 2012).Numerous factors control metal accumulation and bioavailability associated with soil and climatic conditions, plant genotype and agronomic management (Kabata-Pendias and Pendias, 2001). Metal solubility in soils is predominantly controlled by pH and oxidation state of the system (Ghosh and Singh, 2005). However, despite the advantages offered by phytoremediation, it has not been widely used in affected industrial areas and surrounding environment inhabited by residents of the city of Kano, in a developing country such as Nigeria. This is because of the lack of an action plan by the government and its various agencies to tackle such challenges. Therefore, this paper seeks to investigate/evaluate the effectiveness of *Jatropha curcas* in phytoremediation of heavy metals in soil obtained from Challawa industrial area, Kano, Nigeria.

## MATERIALS AND METHODS

### Study Area

Kano is situated at 12°3'N, 8°32'E and 473m (15570 ft) which has subtropical steppe/low latitude and a semi-arid hot climate. The average annual temperature is 26.4ºC. Kano is an important trade center of Nigeria since its pre-independence days and is the biggest city of the country.

There are many manufacturing and agro-based industries in Kano, which resulted into the rapid growth in the employment sector of Nigeria (Fig 1).

**Sample Location and Collection**

The area is located in Kumbotso local government of Kano state. Sampling was done at Yandanko village in Challawa industrial area, located between latitudes 11°52´49.37" and 11°52´48.81" and along longitudes 8°28´18.03" and 8°28´17.25" (Fig 1).

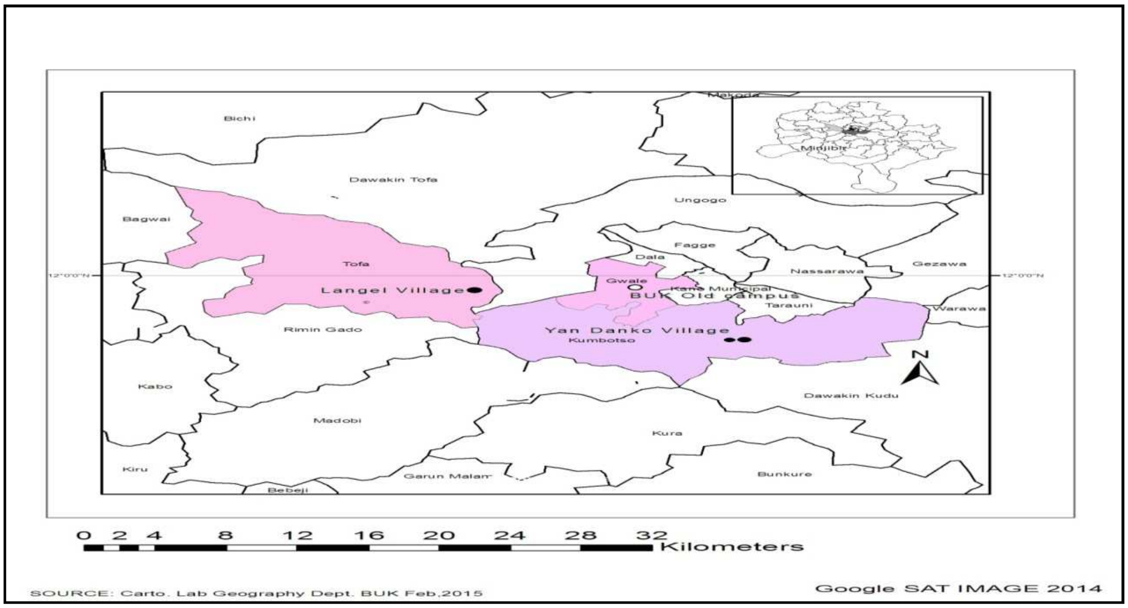


**Fig 1:** Map of kumbotso and Tofa LGA Showing Sampling sites.

**Sampling**

Nine sampling points from three locations were systematically established after every 100m distance. The plant was collected for analysis with at least three plants per sampling point. Identification of the collected plant was done at the Plant Biology Department of Bayero University, Kano. The samples were labeled, placed in polythene and air-dried. Three soil samples were also collected at each sampling point and composites obtained. The composite soil samples were air dried and ground into fine powder using pestle and mortar and sieved through 2mm plastic mesh and stored in labeled polythene bags.

**Description of Sampling Sites and Samples**

Collected samples were abbreviated as follows using the following codes: JC1denotes *J.curcas* and associated soil obtained from location 1, JC2 for *J. curcas* and associated soil obtained from location 2 and JC3 denotes *J. curcas* and associated soil obtained from location 3.

**Plants Tissue Analysis**

The root and shoot samples were thoroughly washed using distilled water to remove all adhering soil particles and then oven dried to constant weights at 105°C. Each dried sample was ground to fine powder. 0.5 gram of each sample was placed in a crucible, transferred to the muffle furnace and ashed at 450°C. The ash was then dissolved in 0.1M nitric acid, filtered and made up to the 100cm$^3$ mark in a volumetric flask. The metal levels of the extract were subsequently determined by AAS (IITA, 1979).

**Soil Analysis**

1gram of the soil sample was weighed and mixed with 20cm$^3$ of Nitric acid ($HNO_3$) (70% w/v, S.G 1.42g/cm$^3$) and allowed to stand for 1hour. 15cm$^3$ of Perchloric acid ($H_3PO_4$) (70% w/v, S.G 1.67g/cm$^3$) was then added. The mixture was placed in a sand bath and heated at 55°C until dense white fumes were observed. It was allowed to cool and then diluted with 0.1MHCl, filtered and made up to the 100cm$^3$ mark in a volumetric flask and analyzed for metal concentrations using Atomic Absorption spectrophotometer buck scientific, Model-210VGP (IITA, 1979). The wavelengths used for determination of various heavy metals are as follows: Zn (213.9nm), Cu (324.8nm) and Cd (228.8nm) (IITA, 1979).

**Statistical Analysis**

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

**RESULTS AND DISCUSSION**

The results of the heavy metal concentrations in plant tissues and soil are discussed using the charts and tables where necessary. Their mean concentrations and standard deviations were used to assess their levels in the samples.

**Heavy Metal Concentrations in Plant Tissues and soil**

Fig.2 depicts the levels of zinc in soils, shoots and roots in the plant *J. curcas* under investigation. Statistically a significant difference was observed between the samples. Zinc concentrations in soils in the studied area attained highest values of 123.8±0.28 at location JC1 where *J. curcas* was sampled and lowest values of 64.99±0.49mg/kg in location JC3. Toxicity level of this element is around 300 mg/kg (Nadia *et al.,* 2012). Results demonstrated that roots of *J. curcas* contain more Zinc than in their shoots. The highest Zinc root concentration of 189.7±1.04mg/kg was attained by *J. curcas* in JC1. The result is much higher than the control values. Roots are thought to be important for zinc uptake (Ross, 1994). Previous studies on the accumulation of various metal ions by native plants have shown that the deposition of most metals was higher in roots than the other parts of plants (Huang *et al.*, 1997). This agrees with the findings of the present study. Normal Zn level of plants growing in uncontaminated soils is 100 mg/kg (Yanqun *et al.*, 2005). The results from this study showed that concentrations of Zn in the plant studied were higher than the normal plant.

Fig 3 presents the levels of copper in soils, shoots and roots in *J. curcas* under consideration. Statistically a significant difference was observed between the samples. Copper is an essential trace metal for plants and animals, and may become toxic to plants at tissue concentrations higher than 20 mg/kg (of dry weight) in the edible parts of plants (Prakash *et al.*, 2007). However, excessive concentrations of this metal are considered to be highly toxic. The distribution of Cu in the soil of studied location (Fig. 3) shows that the highest soil copper concentration of 13.93±0.67mg/kg was recorded in association with JC2 in location 2 while the lowest concentration of Copper, 12.36±0.99mg/kg was recorded in association with JC1 in location 1. Generally, the stem tissues of most of the *J. curcas* attained higher Cu concentrations than root tissue, with maximum value of 43.61±0.44mg/kg attained by JC2 in location 2 while the lowest Cu concentration of 7.43±0.46mg/kg was attained in the leaf in association with JC3 in location 3. These are however higher than the control. However, higher concentrations of Cu in shoots are always in phases of intensive growth and at the luxury Copper supply level (Kabata-Pendias and Pendias, 2001). The normal Cu level of plants growing in uncontaminated soils is 5-25 mg/kg (Yanqun *et al.*, 2005). The results from this study showed that concentration of Cu in the plant was higher than the normal plant an indication of its ability to tolerate this element.

Fig 4 presents the levels of cadmium in soils, shoots and roots in the plant under investigation. Statistically a significant difference was observed between the samples. Cadmium (Cd) is a toxic element and exists along with Zinc in nature. Generally, from the present study, the cadmium concentration in the soils was relatively low. The highest soil Cd concentration of 2.25±0.264mg/kg was recorded in association with JC2 (Location 2) and lowest concentration of 0.49±0.001mg/kg was detected in association with *J. curcas* (Location JC3). The highest Cd uptake of 13.26±0.57mg/kg was attained by *J.curcas* leaf in JC2 while the least Cd concentration of 7.11±0.56mg/kg was noticed in root of *J.curcas* in JC3. Cadmium is one of the increasingly frequent contaminants of agricultural soils. Cadmium contamination in agricultural soils is due to either excessive phosphate fertilization, use of sewage sludge as a fertilizer in agriculture (Varsha *et al.*, 2010).The normal Cd level of plants growing in uncontaminated soils is 1 mg/kg (Yanqun *et al.*, 2005). The results from this study showed that concentrations of Cd in the species studied were higher than the normal plant and this shows that this plant had a strong ability to tolerate this element.

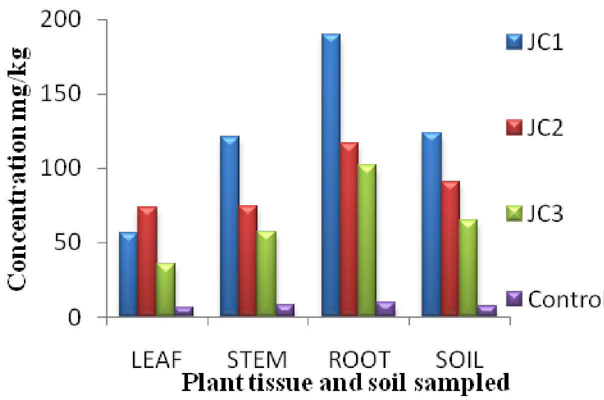


**Fig 2: Concentration of Zinc in tissues and soil of *Jaropha Curcas***

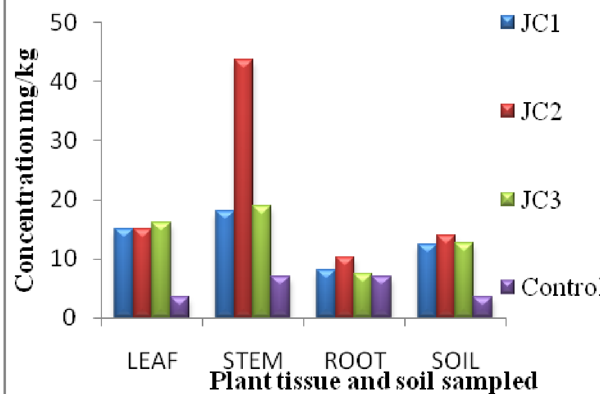


**Fig 3: Copper Concentration in tissues and soil of *Jatropha curcas***

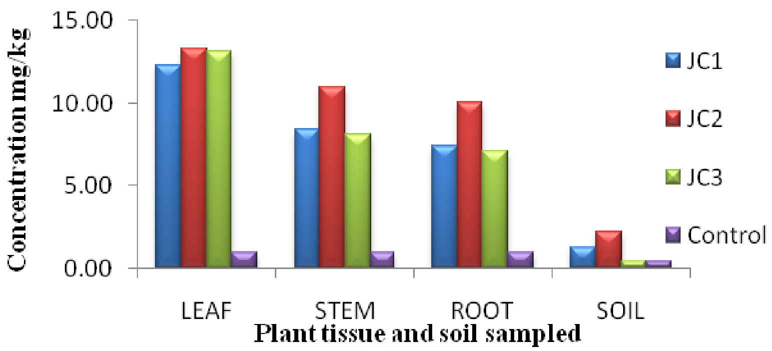


**Fig 4 : Concentration of Cd in plant tissue and soil of *Jatropha curcas***

**Bioaccumulation and Translocation in Plants**

Plants are classified as a hyperaccumulators for heavy metals when they meet the following criteria.(1) TF> 1 (level of heavy metal in the shoot divide by level of heavy metal in the root).(2) Higher levels of heavy metals of 10 – 500 times the levels in normal plants (uncontaminated plants) according to Allen (1989) and Fifield and Haines (2000).(3) More than 1,000mg/kg of copper, lead, nickel, chromium; or more than 100mg/kg of cadmium or more than 10,000mg/kg of zinc (Shen and Liu 1998; Ginocchio and Baker 2004; Yanqun *et al.*, 2004; Boularbah *et al.*, 2006; Rotkittikhun *et al.*, 2006).

Table 1: Translocation factor (TF) and Bio-concentration Factor (BCF) for Zinc, Copper and Cadmium in *J.curcas* Growing in the Industrially Polluted Soil.

| Metals | Zinc | Copper | Cadmium |
|---|---|---|---|
| **TF** | 1 | 4.8 | 2.7 |
| **BCF** | 1.5 | 0.7 | 8.3 |

TF gives an idea whether a native plant is an accumulator, excluder or indicator. Table 1 shows the efficiency of *J. curcas* in translocation of selected heavy metals from roots to shoots with TF values greater than unity for the metals studied. The same table shows BCF values all greater than unity with the exception of Copper. The plant is therefore suitable for phytoextraction since TF>1. Phytostabilization is a process which depends on roots ability to limit the contaminant mobility and bioavailability in the soils which occurs through the sorption, precipitation or complexation (Ghosh and Singh, 2005). Although the concentration of heavy metals remained below 1000 mg/kg, BCF values from this study show that the plant may be suitable candidates for phytostabilization of contaminated soils depending on the metal of interest as the plant retains some metals like Pb in its roots (Cui *et al.,* 2007). Plant species with high TF values were considered suitable for phytoextraction generally requires translocation of heavy metals in easily harvestable plant parts i.e. shoots (Yoon *et al*., 2006).

**CONCLUSION**

The potential for phytoremediation of *Jatropha curcas* against Zinc, Copper and Cadmium was studied. In the course of this study, we have concluded that *J. curcas* is a resistant species with an ability to hold in its tissues amounts of heavy metals that were much higher than those considered toxic for normal plants. Based on the translocation factor (TF) and the bio concentration factor (BCF) values, the study show the suitability of this plant for phytoremediation of contaminated soil with heavy metals using a non-edible plant like Jatropha *curcas* which offers an environmental friendly and cost-effective method for remediating polluted soil.

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