Journal of Physical Sciences and Innovation *Volume 4, December 2012*

www.cenresinpub.org
ISSN 2277-0119

PHYTOREMEDIATION OF COPPER, ZINC, LEAD AND MANGANES FROM CONTAMINATED SOIL USING *HIBISCUS SABDARIFA* PLANT

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ABSTRACT

Bioaccumulation of heavy metals was studied using *Hibiscus sabdarifa* plant in a green house to investigate the absorption of copper (Cu), Lead (Pb) Zinc (Zn) and manganese (Mn) on a contaminated soil. Garden healthy soil samples were contaminated with various concentrations of these metals and *H.Sabdarifa* plant were grown on it in a pot for a period of 60 days. The roots and shoots organ of the plants were harvested and the samples were prepared and analyzed using Atomic Absorption spectrophotometer (AAS) in order to find out their phytoremediation potential. Result showed that heavy metal content in the plant tissue; roots stem and leaves were as follows: Cu1.00, 0.70, 0.60, (mg/kg), Zn, 5.2, 4.2, 2.00 (mg/kg),Pb 0.9,0.6, 0.5, (mg/kg),and Mn 1.50, 0.20 0.10 (mg/kg) respectively. All the metals tend to accumulate mostly on the roots, stems and leaves and therefore decrease transfer probability to secondary consumers. Also the concentrations of heavy metals in the control samples were analyzed and compared. The results suggest that *H. Sabdarifa* plant could be used for the phytoremediation of copper, zinc, lead and manganese.

Keywords: *Hibiscus sabdarifa*,heavy metals,bioaccumulation phytoremediation

INTRODUCTION:

The global problem concerning contamination of the environment as a consequence of human and natural activities is increasing .Most of the environmental contaminants are by products of industrial processes, agrochemicals and heavy metals such as lead (Pb).Heavy metals released into the environment makes its way into the air, soil and water. These heavy metal pollutants migrate into non-polluted sites as dust or leachate through the soil (khan *et al*., 2000).This contributes to a variety of health effects such as decline in mental, cognitive and physical health of the individual.(Paz-Alberto, *et al.,* 2007). Most of these pollutants are inevitable consequences of human socio-economic and developmental activities such as agricultural fertilizers and pesticides applications, metal smelting, electroplating, sludge dumping, municipal waste generation and gas exhausts etc, but unfortunately, they do not decay and so end up polluting the environment (Onwurah, 2003).

The concentration of heavy metals in the soil is increasingly becoming an issue of global concern at all levels, as the soil constitutes a crucial component of rural and urban environment(Victor,*et a*l.,2006).Soils are being polluted with chemicals and wastes from human activities. These chemicals and wastes causes substantial alteration in the chemical composition and pH of soil and consequently affect plant growth and microbial population(Lenntech,2005,Abdulsalam *et al*,.2011,Osun &Okereke,2010).The remediation of these soils posses a lot of difficulties to individuals and government agencies .For instance in the United State of America ,billions of dollars are been spent each year on the remediation of polluted soils which is an economic liability as well as a technical challenge (APHA,1980).

In Nigeria this problem of environmental pollution has assumed an unprecedented proportion and the rate of environmental pollution has reached a frightening scale in recent years especially in the Niger-Delta region, the largest part in Africa and the third largest in the world where most of the crude oil in the country is found (Erakhrumen and Agbontain 2007). This problem may be owing to the interplay of demographic and socio-economic force coupled with the various activities that revolve round the exploration or an exploitation of large amount of crude oil do covered in the Niger-Delta region and some part of the world. (Erakhrumen and Agbontain 2007). The remediation of these contaminants could be carried out by physical removal of the contaminated soils ,followed by treatment technologies such as soil washing ,solidification and stabilization, chemical treatment, vitrification, thermal desorption, electrokinetics and incineration but that these cleanup methods are very expensive and render the land useless as a medium for plants growth ,remove all biological activities including useful microbes such as nitrogen fixing bacteria and mycorrhizal fungi, as fauna (Musgrove,1991;Tuin and Tels,1991;Khan *et al*.,2008,Uwumaronge *et al* .,2008,).This physical and chemical methods of cleaning up contaminated sites are very expensive and harmful. An alternative way of reducing heavy metal concentration from the soil is through phytoremediation. Phytoremediation is a method that uses plants to clean up a contaminated area.However; the plant species being used must grow well in toxic levels of heavy metal conditions and can produce high biomass. This is a complimentary technology that can be used by plants species to extract, sequester and or detoxify pollutants, through physical, chemical and biological processes (Yan-de *et al.,* 2007). It is an emerging cleanup technology for contaminated soils, ground water, and waste water and is both low-tech and lower cost. It is an engineered used of green plants including grasses forbs and woody species to remove pollutants or rendered harmless such environmental contaminants as heavy metals, trace element, organic compounds and radioactive compound in soil or water (Lasat 2000).

This involves growing or encouraging the growth of plant in a contaminated matrix either artificially on a constructed wet land or naturally for a required growth period, to remove contaminants from the soil or facilitate immobilization of pollutant. (Merkel et al., 2005, Ogbo *et al.,* 2009). The success of phytoremediation is greatly dependent upon the choice of plant species to be used. Plant species must adapt to extreme conditions and must be relatively tolerant to high concentration of metals in soils. Phytoremediation takes advantage of the unique and selective uptake capabilities of plant root systems, together with the translocation bioaccumulation, and contaminant storage /degradation abilities of the entire plant body (Angle and Linacre, 2005) Hence the need to develop suitable techniques to remove pollutants from the environment. A plant based technique called phytoremediation has been developed to ensure that the pollutants from the soil, sludge, sediments and waters are managed in an environmentally friendly manner, yet cost effective way (Uwumaronge *et al*., 2008, Oyelola *et al., 2009, Sakthiviel* and Vivekananda, 2009). Hibiscus sabdarifa (Roselle plant) is a perennial plant, which belong to the family malvaceae and is much like the knife but it can be distinguished by the size of the flower and the shape of the seed. Roselle is of two types and the more important one is Hibiscus sabdarifa, an erect sparsely branched annual crop and grows up to 4.6 m high. Generally Roselle is an annual crop and it is easily adapted to varieties of climates and soil condition. It is well grown in the tropical and sub-tropical region. (Cydesal *et al.,* 1979). It is called "sorrel" in English language "*yakuwa* in Hausa language " *isapa* in Yoruba, *Karkade* in Arabic " *Pogabyar"* in Angas and mblanji in Marghi. The flowers of Roselle are generally smaller and are kidney-shaped while those of knife are bigger and triangular shaped (Nweke, *et al.,* 2007). Hibiscus sabdarifa is a multi-useful vegetable, the different parts of the Roselle are the seed leaves and calyces and these have been used for different, purpose as vegetable, source of oil, refreshing drink and food preservation. It is embedded with numerous potentials and ornamental properties which response to rapid growth, produce high amount of biomass and may have the ability to tolerate and accumulate high concentration of metals in shoots, for maximum phytoremediation. The objective of this study is to assess the effectiveness of Hibiscus *sabdarifa* plant as potential phytoremediator of copper, zinc, lead and manganese on contaminated soil.

MATERIALS AND METHODS

Experimental Design

Garden healthy soil sample was collected and uniformly saturated with 3.0g of salts of copper, zinc, manganese and lead and were air dried for 24 hours. Seeds of H.Sabdarifa plant were planted on five pots on the contaminated soil samples and one served as control. The plants were grown on it for the period of sixty days. The *Hibiscus sabdarifa* plant was harvested after 60 days of cultivation and the number of plants per pots was recorded and weighed. The biomass was partitioned into root, stem and leaves and then it was taken to the laboratory.

Sample Preparation

The different parts of the plants including leaves, aerial roots, and bark were rinsed with tap water and then with distilled water in order to remove surface contamination and dried at 55 to 60°C in an electric oven. The dried plant samples were then homogenized using pistil mortar for digestion and analysis.

Digestion and Analysis of Sample

2.0 g each of the powdered plant samples digested in 6.5 ml of acid solution (HNO_3, HSO_4, $HClO_4$ in ratio of 5:1:0.5). The corresponding solution was heated until white fumes had appeared. The clear solution was diluted upto 50 ml with distilled water and filtered with Watt man filter paper no.1. The standard working solutions of elements of interest were prepared to make the standard calibration curve. Absorption for a sample solution uses the calibration curves to determine the concentration of particular element in that sample. A Bulk Scientific model NO.210 VGP, atomic absorption spectrometer (AAS) was used for the determination of four metals that is, Mn, Zn, Cu and Pb.Cathode lamps used as radiation source. Air acetylene gas was used for all the experiments. This method provides both sensitivity and selectivity since other elements in the sample will not generally absorb the chosen wavelength and thus, will not interfere with the measurement (Sarwoko *et al,.* 2008).

RESULTS AND DISCUSSION

The heavy metal content in the plant tissue (H. Sabdarifa) and the control plant sample, their total concentrations investigated for phytoremediation are presented in Tables 1 and 2. Figures 1 and 2 shows, the relative distribution levels of these heavy metals in the roots, stem and leaves of the plant.

Table 1. Heavy Metal Content (mg/kg) in the H.Sabdarifa plant.

sample	H. Sabdarifa plant (ppm) Cu.	H. Sabdarifa plant (ppm) Zn.	H.Sabdarifa plant. Pb.	H.Sabdarifa plant. Mn.
Leaves	0.60	2.00	0.50	0.10
Stem	0.70	4.20	0.60	0.20
Root	1.00	5.20	0.90	1.50
Total in the whole plant.	**(2.3)**	**(11.40)**	**(2.00)**	**(1.8)**

Results are mean of three determinations
Values in parenthesis' total content in the whole plant.

Table 2. Heavy metal content (mg/kg) in the control H.Sabdarifa plant.

sample	H. Sabdarifa plant (ppm)Zn.	H.Sabdarifa plant. Pb.	H.Sabdarifa plant. Mn.
Leaves	0.10	ND	0.01
Stem	0.02	ND	0.I0
Root	0.20	ND	0.02
Total in the whole plant.	**(0.32)**	**ND**	**(0.13)**

Results are mean of three determinations
Values in parenthesis' total content in the whole plant.

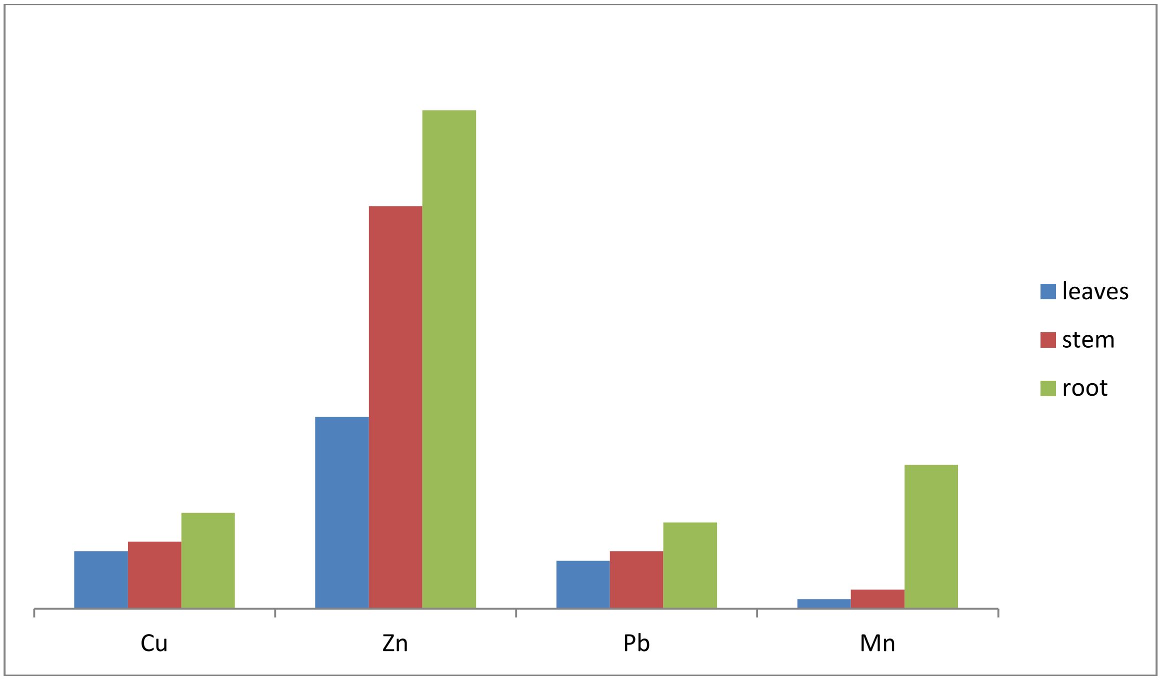

Figure 1. Histograms showing the relative distribution of the heavy metals in the contaminated plants parts.

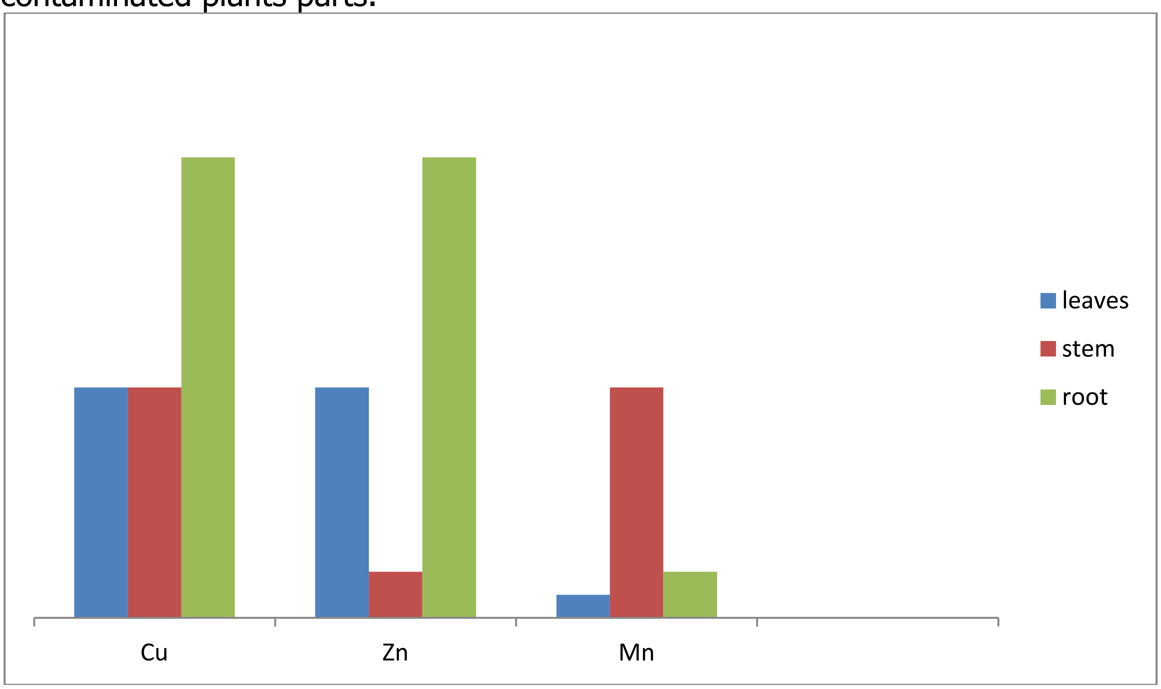

Figure 2. Histogram showing the relative distribution of the heavy metals in the control parts of the plant.

DISCUSSION:

The concentration of copper in the root, stem and the leaves was found to be 1.00, 0.7 and 0.60 (mg/kg). The accumulation of copper were in the order Root > stem > leaves. It has been observed that the concentration of copper in the stem and leaves is low, showing that the plant has the capacity to extremely tolerant of this metal with high accumulation in the root tissue (Table 1). The concentration of zinc follows a similar pattern in the order root > stem > leaves >. The trend of the heavy metal accumulation from 5.20 to 2.00 mg/kg followed a decreasing order. This would therefore decrease the metal transfer probability to secondary consumers. The accumulation of lead showed similar pattern, only that the levels are low in the order of root > stem > leaves, with the values of 0.90, 0.60 and 0.50 (mg/kg). This could be due to the extent of movement of lead metal ions within the plant which do not only depend on the metal concern, but also on the plant organ and age of plant (Alloway, 1996). The ability of H. sabdarifa plant to absorb manganese indicates that the order decrease thus root > stem > leaves with the values 1.50, 0.20 and 0.10 mg/kg.The accumulation of these metals cu, zn, Pb and Mn showed a similar pattern.

The order of abundance of the metals in the control site were as follows as root > stem > leaves, with the values Cu, 0.20, 0.10, 0.01, Zn, 0.20, 0.20,0.10 and Mn, 0.02, 0.01 (mg/kg). The plant in the control sites accumulated cu, zn and Mn at varying concentrations except lead that were not detected at all in some parts of the plants. This could be attributed to the absent of lead in the soil. The distribution pattern of the metals in this plant showed that zn > cu > Pb > Mn and accumulation were more in the root figures 1 and 2. This shows that the leaves can be prevented from contamination with these metals especially Pb and Mn. From the figures, each Metal exhibited different extent of accumulation from root to leaves. These results are probably related to the differences in their solubility in the medium. So, the low concentration of some of these metals may be attributed to their functions in the plant species, the ability of the plant to bioaccumulation of these metals, the differences in their solubility and availability of the ions of the metals (victor et al,. 2005).

CONCLUSION:

The study reveals that the phytoaccumulation capacity of, Cu, Zn, Pb and Mn using H. Sabdarifa plant decreases in the order of root > stem > leaves and accumulated significantly in the roots. This would therefore decrease the probability to the secondary consumers. Our research has shown that plant-based technologies for removing and detoxifying toxic trace elements from contaminated soil are effective, and more importantly, can be improved substantially using modern scientific approaches. Thus, genetic improvement of plants for phytoremediation has a great potential for improving environmental quality. Hibiscus Sabdarifa plant was able extract different concentration of heavy metal from the soil. In view of this hibiscus Sabdarifa plant can be used to clean up contaminated soil by farmers. This will decrease some of the metal element present in the contaminated soil or dump soil before the soil can be used as compost for agricultural purpose. This technique can also be applied to industrial effluents containing toxic metals or recalcitrant organic pollutants. In all of these approaches, whether upland or wetland, there is clearly an urgent need for research aimed at the fundamental understanding of all the physical, chemical, and biological mechanisms involved. On a final note, more field demonstration projects are also urgently required to optimize phytoremediation approaches and to provide recommendations for the regulators, decision-makers and the general public to convince them of the suitability of the green approach for environmental cleanup. The results of this research work show that hibiscus Sabdarifa plant which is available and relatively cheap, could be beneficial in cleaning of contaminated soil by farmers. This will keep, in check, possible excessive consumption of these metals by man; which if no care is taken may lead to accumulation in man with attendant healthy hazards. It is therefore recommended that contaminated soil or dump soil should not be used for agricultural purpose until after a cleaning process with metal hyper-accumulated plants like hibiscus sabdarifa , which must not be consumed by man or animal after harvesting if grown on a contaminated soil. For conclusive work, we recommend that this work be extended to include studies on phytomediation of other heavy metals and trace element using different plants. Such a study would further assist the phytoremediation of these elements that are likely to cause health hazards. In relation to future prospect, phytoremediation technology for enhanced heavy metal accumulation is still in embryonic stage and needs more attention in gene manipulation area. Moreover, harvesting and recycling tools needs more extensive research. A multidisciplinary research effort that integrates the work of natural sciences, environmental engineers and policy makers is essential for greater success of green technologies as a potent tool of heavy metals management. Deliberate efforts should be made to ensure that local plants with phytoaccumulation potential are planted in and around dumpsites, agricultural farms and landfills to serve as trap for these heavy metals.

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