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EFFICIENCY OF FLUTED PUMPKIN PLANT (*TELFAIRIA OCCIDENTALIS*) IN THE PHYTOREMEDIATION OF WASTEWATER EFFLUENT FROM SHARADA INDUSTRIAL AREA, KANO STATE, NIGERIA

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ABSTRACT

Heavy metals tend to accumulate in the environment thereby contaminating the food chain, and as such pose risks to health. In this study the use of fluted pumpkin plant in phytoremediation of heavy metals from soil polluted with heavy metals from Sharada Industrial Area of Kano state Nigeria has been examined. The seeds of the plant were planted in four different planting pots, with one set of pots watered with the effluent collected from the Sharada Industrial Area, and the other set (the control) watered with clean unpolluted water. Prior to planting, the physicochemical parameters of the soil to be used were analyzed, with the pH, the electrical conductivity and the concentrations of the heavy metals all determined. After germination both the samples and controls were subjected to ashing (for the plants) and digestion (for the waste water) and were later subjected to AAS. The results show high concentration (in mg/L) of heavy metals in the plant sample watered with effluent, that is Cd (2.30); Pb (6.20); Cr (0.70); Zn (3.70); Cu (2.90) and Fe (7.13), while the concentrations (in mg/L) of these heavy metals were also found to be very high in the Sharada industrial effluent (the waste water sample), that is Cd (2.210); Pb (3.300); Cr (0.500); Zn (5.080); Cu (3.900) and Fe (2.520). In all the cases the concentrations in the controls were found to be below or within their permissible limits.

Keywords: Effluents, heavy metal, phytoremediation, *Telfairia occidentalis.*

INTRODUCTION

Environmental pollution by heavy metals has become a serious problem in the world. The mobilization of heavy metals through extraction from ores and subsequent processing for different applications has led to the release of these elements into the environment Hazrat *et al.,* (2013). The problem of heavy metals' pollution is becoming more and more serious with increasing industrialization and disturbance of natural biogeochemical cycles. Unlike organic substances, heavy metals are essentially non-biodegradable and therefore accumulate in the environment (Khan *et al.,* 2010).

The loading of ecosystems with heavy metals may be due to excessive fertilizer and pesticide use, irrigation, atmospheric deposition, and pollution by waste materials (Aydinalp and Marinova, 2003). The source of heavy metals in plants is the environment in which they grow and the soil from which heavy metals are taken up by roots or foliage (Okonkwo *et al.,* 2005). Plants grown in polluted environments can accumulate heavy metals in high concentration causing serious risk to human health when consumed. Heavy metals are toxic because they tend to bio-accumulate in plants and animals, bio-concentrate in the food chain and attack specific organs in the body (Chatterjee and Chatterjee, 2000; Akinola *et al.,* 2008). Living organisms require trace amounts of some heavy metals (Fe, Mn, Zn and Cu,) for proper growth and development, however at excessive levels they can pose a health risk to humans and have environmental effects on aquatic organisms (Kisamo, 2003).

As reported by Govindasamy *et al.,* (2011) the concentrations of heavy metals in the environment is increasing year by year. Therefore, the clean-up of soils contaminated with heavy metal is utmost necessary so as to minimize their impact on the ecosystems. So far different physical, chemical and biological clean-up techniques have been employed, with the most conventional remediation methods including the in situ vitrification, soil washing and flushing, solidification, soil incineration, and stabilization of electro-kinetic systems (Sheoran *et al.,* 2011; Wuana and Okieimen, 2011). Generally, the physical and chemical methods have many limitations ranging from like high cost, intensive labor, and irreversible changes in soil properties to other pollution problems Hazrat *et al.,* (2013). Therefore, there is a need for research to develop a much more cost effective, efficient and environment friendly remediation techniques for the removal of heavy metals from soils, and one such novel approach is phytoremediation.

Phytoremediation refers to the use of plants and other associated soil microbes to reduce or remove the concentrations or toxic effects of contaminants like heavy metals in the environments (Greipsson, 2011). It is a novel, efficient, cost-effective, environment-friendly and in situ applicable remediation technique (Chehregani and Malayeri, 2007; Kawahigashi, 2009; Saier and Trevors, 2010; Sarma, 2011; Singh and Prasad, 2011; Vithanage *et al.,* 2012). Plants generally handle the contaminants without affecting topsoil, thus conserving its utility and fertility, in fact they may tend to improve soil fertility with inputs of organic matter (Mench *et al.,* 2009). Phytoremediation is aesthetically pleasant and has good public acceptance, and is suitable for application at very large fields where other remediation methods are not cost effective or practicable (Garbisu and Alkorta, 2003).

Several species of aquatic macrophytes such as smallwater fern (*Azolla* sp.), water lettuce (*Pistia* sp.), water hyacinth (*Eichhornia* sp.) and duckweeds (*Lemna* sp., *Spirodella* sp.), have been used for the removal of heavy metals from wastewater (Okunowo and Ogunkanmi 2010; Suhag *et al.,* 2011; Rai 2008; Gupta *et al.,* 2012; Ajibade *et al.,* 2013; Saha *et al.* 2015). Many researchers have also used different plant species like duckweed *(Water Lemna)* (Mkandawire and Dudel 2007), Bulrush *(Typha)* (Mashauri, *et al.,* 2000)), Vetiver Grass (*Chrysopogon zizanioides)* (Baskar *et al.,* 2009).

This research work is aimed at evaluating the potentials of fluted pumpkin plant (*Telfairia occidentalis*) for use in phytoremediation of heavy metals from soil polluted with wastewater effluent from Sharada Industrial Area, Kano State, Nigeria.

MATERIALS AND METHOD

All reagents/chemicals used in this work were of analytical grade. All glass ware and plastic containers used were thoroughly washed with detergent and then rinsed with tap water and finally with distilled water.

Determination of the Physicochemical Parameters of the Soil

The soil was obtained from the premises of Yusuf Maitama Sule University, Kano Main Campus. The soil sample was crushed and sieved through a 2 mm sieve and then subjected to laboratory analyses using standard procedures. The pH was determined using the 1:2.5 soil-distilled water ratio using EL model 720 pH meter, while the electrical conductivity (EC) was determined using 1:2.5 soil-distilled water ratio using Beckman Conductivity Bridge as described by Dawaki *et al.,* (2013). Double acid digestion technique as described by Anderson (1974) was used for the total heavy metal determination. All analyses were run in triplicates and the concentrations of the metals were determined using Atomic Absorption Spectrophotometer.

Sample Collection and Preparation

The wastewater sample from the Sharada Industrial Area was collected in a 50 L clean jerry can, prewashed with detergent and distilled water, and then thoroughly rinsed with ethanol. Fluted pumpkin seeds used for the experiment were purchased from retail outlets at Sabon Gari market of Kano metropolis, Kano state. The fluted pumpkin seeds were planted in four separate pots. Two of the pots were regularly watered with waste water collected from Sharada Industrial Area. This served as the test experiment, while the other two pots were regularly watered with water collected from the local tap. This serves as the control experiment. After about 8 days the seeds from both pots germinated. Watering continued until the plants were ripe enough for the analysis. The leaves from both pots were detached and thoroughly rinsed with deionized water and cut into smaller sizes using a stainless steel knife which had been rinsed with distilled water and air dried.

Digestion of the Water Sample

Water sample of 100 mL was measured in a measuring cylinder, and then poured in the 100 ml beaker. The beaker and its content were heated on a hot plate at a temperature of 300 ^oC with the volume reduced to 20 ml, 5.0 ml of concentrated nitric acid was added and the beaker heated again on a hot plate. It was cooled to room temperature and finally 30 ml of distilled water was added (Radulescu *et al.,* 2014; Anna *et al.,* 2019). The procedure was repeated in triplicates.

Ashing of the Plants Sample

Both the control and test samples were dried and grounded to powdery form using mortar and pestle. One gram (1g) each of the dried *T. occidentalis* samples (both control and test) was placed in a crucible and ashed in a muffle furnace at 550^OC for 5 hours. The ashed plant samples were placed in a 50 ml beaker. Exactly 0.17g of the sample was weighed into a 50 ml beaker and 5 ml of concentrated nitric acid was added and heated on a hot plate. Then 5 ml of concentrated perchloric acid was also added and then boiled again for few minutes after which 15.0 ml of deionised water was added and allowed to cool to room temperature. The whole mixture was then transferred to a 100 ml volumetric flask and made up to the mark with deionised water. These solutions were placed in storage container used for the analysis (Okunowo and Ogunkanmi 2010; Radulescu *et al.,* 2014; Anna *et al.,* 2019).

Atomic absorption spectrophotometry (AAS) was used in determining the heavy metals Fe, Zn, Cu, Cd, Cr,and Pb in both the plant samples and the waste water samples.

RESULTS AND DISCUSSION

The result for the physicochemical parameter of the soil used in for the research is presented in Table 1, while the concentration of heavy metals determined in Sharada wastewater and the fluted pumpkin are presented in Tables 2 and Table 3 respectively. All the values reported are the mean values for the replicate measurements.

Table 1.0: Mean Values for the Physicochemical Parameters of the Soil

Parameter	pH	EC (mS/m)	Org. Carbon (g/Kg)	Cu (mg/Kg)	Cr (mg/Kg)	Ni (mg/Kg)	Zn (mg/Kg)	Pb (mg/Kg)
Sample	7.43	0.69	8.07	4.95	65.66	27.03	49.03	68.12
WHO (1996)	6.5-8.5	1.00	12-18	36	100	35	50	85

Table 2.0: **Mean Values for the Concentration (mg/L) of Heavy Metals in Sharada Waste Water**

Heavy Metals	Cd	Pb	Cr	Zn	Cu	Fe
Waste Water	2.210	3.300	0.500	5.080	3.900	2.520
Unpolluted Water	0.003	0.010	0.030	0.050	0.090	0.110
WHO (Water)	0.005	2.013	0.050	0.200	0.200	0.300
USEPA (Water)	0.005	2.015	0.100	2.000	1.300	0.300

Table 3.0: Mean Values for the Concentration (mg/L) of Heavy Metals in the Fluted Pumpkin after Remediation

Heavy Metals	Cd	Pb	Cr	Zn	Cu	Fe
Sample	2.30	6.20	0.70	3.70	2.90	7.13
Control	0.03	0.04	0.07	0.30	1.27	0.30
FAO (Vegetable)	0.01	5.00	0.05	2.00	0.20	5.00

From Table 1, it can be said that all the physicochemical parameters of the soil used in the research were within the WHO (1996) recommended limits. The pH of the soil (7.43) which is slightly tilted to the alkaline range, and the EC value (0.67 mS/m) all agree with similar report by Dawaki *et al.,* (2013). The heavy metals contents of the soil reveal values that are all within the WHO recommended permissible limits.

Table 2, presenting the concentration of the heavy metals in the Sharada waste water reveals high concentration of all the heavy metals analyzed. Zinc, copper and lead recorded the highest concentrations of 5.080 mg/L, 3.900 mg/L and 3.300 mg/L respectively, while iron, cadmium and chromium recorded lesser concentration, but still all the concentrations were found to be far above the WHO (2008) maximum permissible limits, as well as the United State Environmental Protection (USEPA) permissible limits. The finding from this research is in agreement with similar researches conducted and reported by Abioye *et al.,* (2018); Bulus *et al.,* (2018); Islam *et al.,* (2013); Yakubu *et al.,* (2018).

The fluted pumpkin sample was found to contain a cadmium concentration of 2.30 mg/L as shown in Table 3. This was found to be far above FAO permissible limit of 0.01 mg/L. The results obtained from this study agreed with what was reported by Faruruwa *et al.,* (2014) who reported a high uptake of cadmium by fluted pumpkin. Also Jamali *et al.* (2007) reported high concentration of cadmium in vegetables grown and cultivated using wastewater.

The level of lead in the sample plant (fluted pumpkin) was found to be 6.20 mg/L as shown in Table 2. This result is found to agree with that reported by Friday *et al.* (2013) who also reported a high concentration of lead in fluted pumpkin planted in contaminated area. The concentration is higher than the permissible limit of lead (5.00 mg/L) set by FAO (1985). This means the wastewater should not be used for irrigation, as lead is highly toxic (Bigdeli and Seilsepour, 2008).

The chromium concentration in this study was found to be 0.70 mg/L, and this result is higher than permissibility level set by FAO (1985) which is 0.05 mg/L as shown in Table 2. In a similar study Friday *et al.* (2013) reported a high concentration of lead in fluted pumpkin planted in contaminated area. Similar result was also reported by Faruruwa *et al.,* (2014).

Result for the zinc concentration shows that it is higher in the plant sample studied (3.70 mg/L) and this way above the permissible limit of 2.0 mg/L set by FAO (1985). The concentration of zinc in this study was found to agree with the result reported by Faruruwa *et al.,* (2014) who reported a high uptake of zinc by fluted pumpkin. Also Jamali *et al.,* (2007) reported high concentration of zinc in vegetables grown and cultivated using wastewater.

The fluted pumpkin sample used in this research was found to contain a very high concentration of copper (2.90 mg/L) as shown in Table 2. This was found to be far above FAO permissible limit of 0.20 mg/L. The results obtained from this study compared with what was reported by Faruruwa *et al.,* (2014) who reported a high uptake of copper by fluted pumpkin, and also Jamali *et al.* (2007) who reported similar high concentration of zinc in vegetables grown and cultivated using wastewater.

Lastly, the iron concentration was found to be higher than the FAO (1985) permissible limit of 5.00 mg/L. The result reveals a concentration of 7.13 mg/L and this is in agreement to that reported by Adepoju-Bello *et al.,* (2013) and Luc *et al.,* (2015) who reported a high concentration of iron in fluted pumpkin samples.

The results obtained for the control sample are all within the WHO recommended permissible limits and this result is in full agreement with similar report by Lami *et al.,* (2015) who analyzed and reported the heavy metals concentrations of fluted pumpkin leaves cultivated on the south bank of River Benue, Nigeria.

CONCLUSION

Heavy metals remain one of the most critical threats to the soil and water resources, as well as to human and animal health. The concentrations of heavy metals in the environment have been in the increase, as a result their menace and effects are ever increasing. Phytoremediation is a new cleanup technique that involves the use of plants to clean, stabilize and safe-guard contaminated environments. Phytoremediation of heavy metals is the most effective plant-based method to remove pollutants from contaminated areas, it is cost effective, environmentally friendly and efficient. Some specific plants ranging from herbs to woody species have been proven to have noticeable potential to absorb toxic metals, and remove them from the soil. One plant that is believed to be capable of serving that purpose is the fluted pumpkin. This work has demonstrated, to some extent, the possibility of using fluted pumpkin plant for phytoremediation of heavy metals.

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