Communication in Physical Science 2020, 6(2):869-874

Phytoextraction Potentials of *Hyptis suaveolens* and *Euphorbia hirta* Weeds for Cd^{2+} and Co^{2+}

Hauwa, I. Muhammad* **and Victoria Adedoyin**

Received 22 October 2020/Accepted 27 December 2020/Published online: 30 December 2020

Abstract: *Cleanup of contaminated soils to get rid of heavy metals using environmental friendly methods is of great significance. Phytoremediation is a biological on-site clean up approach that makes use of plant with high metal uptake ability. In this study, Hyptis suaveolens and Euphorbia hirta were grown on soils that were contaminated by* Cu^{2+}, Cd^{2+}, Ni^{2+} *and* Co^{2+} *while the uncontaminated soil served as a control. The dried leaves, stems and roots of the harvested weeds were analyzed using Atomic Absorption Spectrophotometer (AAS). Both plants showed highest phytoextraction coefficients with respect to the root. Euphorbia hirta showed accumulating capacity for cadmium (i.e 37.75 µg/g) than cobalt (i.e 15.35 µg/g). Hyptis suaveolens also followed similar trend accumulating 45.85 and 23.95 (µg/g of cadmium and cobalt ions respectively.*

Keywords: *Heavy metal, contamination, soil, phytoextraction, Hyptis suaveolens, Hyptis suaveolens*

Hauwa, I. Muhammad*
Department of Chemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria
Email: hauwalarai2010@gmail.com
Orcid id: 0000-0002-0426-7269

Victoria Adedoyin
Department of Chemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria
Email: adedoyintunrayo52@gmail.com

1.0 Introduction

The presence of heavy metals in the soil is of serious environmental concern because of its tendency to affect primary production capacity of plants, which will ultimately affect the entire ecosystem through the food chain and surface run off (Tangahu *et al.*, 2011). Studies have shown that much attention have been directed towards the contamination of water than those of the land and the air environment (Ashraf *et al.*, 2017). Plants can absorb heavy metal into their cells through foliar absorption process (Eddy and Ekop, 2007). Since plants are primary producers to both man and animal, consumption of such plants can lead to bioaccumulation of such heavy metal ions in their tissues, hence manifestation of toxic impart depending on the type of the heavy metal ions, the nature of the plant, soil and climatic conditions (Jadia and Fulekar, 2009). Some of the options that have been reportedly used to remediate soil contamination by heavy metal ions are excavation of the soil, stabilization of the soil (through addition of chemicals to the soil), etc ((Cho-Ruk, *et al.*, 2006; Hinchman *et al.*, 1998). However, phytoremediation has been found to be one of the best options because it is nonselective, environmentally friendly and cost effective. According to Eddy and Ekop (2007), phytoremediation involves the use of the growing plant to remove the metal ions from the soil. Tangahu *et al.* (2011) also stated that phytoremediation can be achieved through phytostabilization, rhizofiltration and phytoextraction. Consequently, some weeds of Nigerian origin have been found to exhibit strong phytoextraction potentials (Ashraf *et al.*, 2017; Rakhshaee, *et al.*, 2009). For example, Ekwemegbo *at al.* (2013) found that

Bryophyllum Pinnatum is very effectice in the extraction of several heavy metals from contaminated soil. Eddy and Ekop (2007) reported very high extraction efficiency of *Phyllanthus amarus (chanca piedra*), *chromoloena odorate (awolowos weed), Stachytarpheta indica (gervao), Bryophyllum pinnatum* (life leaf) and *Murraya koenigii* (curry leaf) for Pb^{2+}, Zn^{2+}, Cd^{2+}, Cu^{2+} and Ni^{2+}. Other weeds have also been reported as effective for phytoextraction of heavy metal from the soil (Goland-Goldhirsh, 2006; Dasgupta *et al.,* 2011; Quainoo *et al.,* 2015).

Weeds are unwanted plants and are found in soils that they have not significant economic benefit. Most of them can withstand harsh environmental conditions and some are found to exhibit strong phytoremediation potentials because of the nature of their leaves, stems and other organs (Sunil *et al.,* 2010). In view of their wide spread and great potentials for the removal of heavy metal ions from contaminated soils. This study seeks to apply *Hyptis suaveolens* and *Euphorbia hirta* for the remediation of soils contaminated by Cu^{2+}, Cd^{2+}, Ni^{2+} and Co^{2+}.

2.0 Materials and Methods

2.1 Sample collection and preparation

Soil samples used for planting were gathered at 5 cm below the earth surface within the premises of Ibrahim Badamasi Babangida University Lapai, Niger State Nigeria. Soil samples were put in polyethylene pots (measuring 49.3 cm by 32.9 cm) and transferred to the school garden where the transplanting will take place. Each of the polyethylene pots containing the soil were watered for three days so as to soften the soil and prepare it for transplanting. The taxonomical classification identifies the soil as loamy sand with a pH of 6.20.

Various concentrations of Cu^{2+}, Cd^{2+}, Ni^{2+} and Co^{2+} were prepared from $CuSO_4$, Cd $(NO_3)_2$, $NiSO_4.6H_2O$ and $CoSO_4.7H_2O$ respectively and stored for further use.

The weeds used for the study, (*Hyptis suaveolens* and *Euphorbia hirta*) were collected from the botanical garden in our institution. They were planted in different pre-prepaid polythene bags, whose soil contents were properly irrigated with the respective metal ion solution in order to enhance absorption. The plants were cultivated in the respective soils after three months. Each soil sample was irrigated daily with distilled water that contained various concentrations of the respective heavy metal ions. The experimental design was randomized completely block designed. The soil sample that was not contaminated with any heavy metal ion was marked as the control.

At the end of two months, each plant sample was uprooted and the respective soil samples were taken for heavy metal analysis using atomic absorption spectrophotometer (AA-6300 model). However, the leaves stems and root of both plants were separated and analyzed Acid digestion of the samples was carried out according to the method described by Kabta-Pendias and Pendias, (1984); Yusuf *et al.,* (2003).

2.1 Determination of Translocation Factor

$$BF = \frac{C_{plant}(\mu g/g)}{C_{soil}\,(\mu g/g)} \qquad (1)$$

where C_{plant} is the mean concentration of metal ions in plants, C_{soil} is mean concentration of metal ions in soil, BF is bioconcentration factor. Translocation factor (TF) was calculated using the formula of *Yadav et al.* (2009);

$$1 \times TF = C_{aerial} \times \frac{1}{C_{root}} \qquad (2)$$

Where, C_{aerial} is the concentration of the metal ion in the aerial part of the plant while C_{root} is the concentration in the root

3.0 Results and Discussion

Table 1. Show the concentrations of Cd and Co in the soil before contamination. The results reveal that the concentrations of cadmium and

cobalt ions are 1.60 and 10.55 µg/gTherefore, the background concentration of these metal ions in the soil is within recommended safety limits.

Table 1: Concentration of metals in soil used for planting

Element	C(µg/g)	± SD
Cadmium	1.60	0.01
Cobalt	10.55	0.07
Nickel	0.00	0.00

Contamination from industrial and other anthropogenic activities are responsible for most heavy metal pollution (WHO, 1996). Concentrations of cadmium and cobalt ions in the weed samples that were used for phytoextraction ate presented in Tables 2 and 3.

Contamination from industrial and other anthropogenic activities are responsible for most heavy metal pollution (WHO, 1996). Concentrations of cadmium and cobalt ions in the weed samples that were used for phytoextraction ate presented in Tables 2 and 3.

Table 2: Concentration of metals in *Hyptis suaveolens* (µg/g)

	Leaves	Stem	Root	Total
Cd (Control)	0.00	0.00	1.40±0.01	1.40
Cd (extracted)	2.65±0.01	11.50±0.01	31.70±0.01	45.85
Co (control)	2.23±0.01	1.32±0.01	5.55±0.01	9.10
Co (extracted)	7.00±0.06	6.45±0.01	10.50±0.06	23.95

Table 3: Concentration of metals in *Euphorbia hirta* (µg/g)

	Leaves	Stem	Root	Total
Cd (Control)	0.00	0.10±0.01	1.05±0.02	1.15
Cd extracted	7.75±0.01	9.45±0.03	20.55±0.04	37.75
Co (control)	0.10±0.01	1.75±0.01	3.70±0.01	75.55
Co extracted	4.35±0.06	5.05±0.01	5.95±0.02	15.35

Table 4. Translocation factor of the weed plants

Element	*Hyptis suaveolens*	*Euphorbia hirta*
Cd (control)	------	0.10
Cd (extracted)	0.45	0.84
Co (control)	0.64	0.50
Co (extracted)	1.28	1.58

The results presented in Table 2 reveal that *H. suaveolens* showed best extraction capacity for Cd^{2+} (45.85 µg/g) compared to Co^{2+}. However, the roots alone extracted (31.70 µg/g) while the remaining 11.50 µg/g) and the lowest accumulation was found in the leaves (2.65 µg/g). Out of the total cadmium concentration accumulated by the plant, 14.15 µg/g was able to translocate effectively to the stem and leaf while 31.70 µg/g remains at the root. According to WHO (1996), the permissible limit of cadmium in plant is 0.02 µg/g and *H. suaveole* was able to mop up substantial concentrations of Cd in the roots compared to the aerial parts. However, Cd accumulated by *Hytis suaveolens* is considered beyond the permissible limit without any deformity or alteration in the plant growth. Therefore, *Hytis* *suaveolens* is a good phytoextractor for cadmium (Sumiahadi and Acar, 2018).

Results obtained for the absorption of cobalt by *H. suaveolens* revealed that the root absorbed most (10.50 µg/g) while 6.45 and 7.00 µg/g were absorbed by the leaf and stem respectively. Therefore, the leaf has better capacity to store cobalt than the stem and the translocation trending from the root to the stem was very low compared to that of the stem to leaf. Therefore, retention of cobalt ion by the stem is less likely but most likely for the metal ion to be transferred to the leaf. The total concentration of cobalt extracted by *H. suaveolens* for the period of 30 days was 23.95 µg/g. 56.16 % of cobalt was translocated to the above ground part that is 29.23 % for the leaves and 26.93 % for the stem, where as 43.84 % remains at the ground level (root). Hence, *H. suaveolens* can bioaccumulate considerably high concentration of cobalt.

Accumulation of nickel in *Hytis suaveolens*: no traces of nickel were found in the root, stem or leaves (fig.4) as the concentration of nickel in the plant was below the detection limit of the instrument. Therefore *H. suaveolens* shows no accumulation potential for nickel.

The amount of cadmium ions extracted by *Euphorbia hirta*; root was 20.55 µg/g after 30 days of remediation. However, 9.45 µg/g and 7.75 µg/g were absorbed by the stems and leaves respectively. Therefore, the root of this plant has higher extraction efficiency than the stem or leaf. This is because the initial mechanism of absorption of heavy metals by plants is through the root before it is gradually shifted to the stem and leaf. The translocation trending from the stem to the leaves was high compared to the trend from the root to the stem. The total concentrations of Cd^{2+} extracted from the soil was 37.75 µg/g.. Also, in *Euphorbia hirta*, 5.95 µg/g of Co^{2+} was accumulated in the root while 5.05 µg/g and 4.35 µg/g were extracted into the stem and leaves respectively (Table 3). These showed a low trend of cobalt accumulation in *E. hirta*. Only 5.89 % of cobalt was accumulated in this weed plant. WHO 1996 permissible limit of cobalt in plant is 10.0 µg/g. *Euphorbia hirta* exceeded the permissible limit. This result thereby predicts *E. hirta* not possessing a mechanism of high cobalt accumulation. According to Huang and Cunningham (1996) and Blaylock *et al*., (1997) plants can remove between 180 and 530 kg/ha of metals per year, which suggests that the amount of heavy metal ions accumulated by this plant is not strange. This rule may however fail in cases where some plants have very high tendency to tolerate high concentrations of heavy metal ions in their tissues.

Translocation factor (TF) can be used to characterize the ability of phytoremediation (Baker, 1981; Usman and Mohamed, 2009; Yoon *et al*., 2006). It is defined as the ratio of the metal concentration in the shoots to that in the roots. Plants with TF values > 1 are categorized as high efficiency plants for translocation of metals from roots to shoots (Ma, *et al*., 2001). Therefore, the high extraction efficiency of *H. suaveolens* and *E. hirta* leaves is justified since their TF values (1.28 and 1.58) are greater than unity.

4.0 Conclusion

From the results and findings of the present study, the following conclusions are drawn

(i) Roots, stems and leaves of *H. suaveolens* and *E. hirta* plants have strong tendency to accumulate heavy metal ion and are suitable phytoextractors.
(ii) The root can accumulate heavy metal ions more than the stem and the leaf because the mechanism of absorption of heavy metal ions from the soil occurs through the root before it is transported to other parts of the plants
(iii) The two phytoextractors have better extracting capacity for Cd^{2+} than Co^{2+}
(iv) *H. suaveolens* and *E. hirta* plants can be used as a phytoextractor for

the removal of Cd^{2+} and Co^{2+} from the soil.

5.0 References

Ashraf, M.A.; Hussain, I.; Rasheed, R.; Iqbal, M.; Riaz, M. & Arif, M.S. (2017). Advances in microbe-assisted reclamation of heavy metal contaminated soils over the last decade: A review. J. Environ. Manag., 198, 132–143.

Baker, A. J. M. (1981). Accumulators and excluder-strategies in the response of plants to heavy metals. *Journal of Plant Nutrition*, 3, pp. 643–654.

Blaylock, M. J. Salt, D. E. Dushenkov, S., Zakharova, O., Gussman, C., Ensley, B. D. & Raskin, I. (1997). Enhanced accumulation of Pb in Indian mustard by soil-applied chelating agents, *Environmental Science and Technology*, 31(3), pp. 860–865.

Cho-Ruk, K., Kurukote, J., Supprung, P. & Vetayasuporn, S. (2006). Perennial plants in the phytoremediation of lead contaminated soils," *Journal of Biotechnology*, 5(1), pp. 1–4.

Dasgupta, S., Satvat, P. S. and Mahinrakar, A. B. (2011). Ability of *Cicer arientinum* (L.) for bioremoval of lead and chromium from soil *IJTES*, 2(3), pp. 338-41.

Eddy, N. O. & Ekop, A. S. (2007). Phytoremediation potentials of some Nigerian weeds. *Asian Journal of Chemistry* 19 (2), pp. :1825-1831

Ekwumemgbo, P. A., Omoniyi, I. K. and Eddy, N. O. (2013). Decontamination of heavy metals in polluted soil by phytoremediation using *Bryophyllum pinnatum* . E3S Web of Conferences, 1, Proceedings of the 16th International Conference on Heavy Metals in the Environment, https://doi.org/10.1051/e3sconf/20130113004

Goland-Goldhirsh A. (2006). Plant tolerance to heavy metals, a risk for food toxicity or a means for food fortification with essential metals: the *Allium schoenoprasum* model *Soil and Water*

Hinchman, R. R., Negri, M. C. & Gatliff, E. G. (1998). Phytoremediation: using green plants to clean up contaminated soil, groundwater, and wastewater, Argonne National Laboratory Hinchman, Applied Natural Sciences, Inc, 1995, http://www.remediation.com/Technical/Phytoremediation.pdf.

Huang, J. W. & Cunningham, S. D. (1996). Lead phytoextraction: species variation in lead uptake and translocation," *New Phytologist*, 134 *1), pp. 75–84.

Jadia, C. D. & Fulekar, M. H. (2008). Phytoremediation of heavy metals: Recent techniques. *African Journal of Biotechnology*, 8(6), pp. 921-928.

Kabta-Pendias, A. & Pendias,H. (1984). *Trace Elements in Soil and Plants*, CRC Press, Boca Raton, Fla, USA.

Ma, L. Q., Komar, K. M. Tu, C., Zhang, W., Cai, Y. & Kennelley, E. D. (2001). "A fern that accumulates arsenic, *Nature*, 409, article 579.

Pollution Monitoring, Protection & Remediation ed I Twardowska, H E Allen and M M Haggblom (Amsterdam: Spinger) pp 479-86

Quainoo, A. K, Konadu A & Kumi M . (2015). The potential of shea nut shells in phytoremediation of heavy metals in contaminated soil using lettuce (*Lactuca sativa*) as a test crop *Journal of Bioremediation and Biodegradation, 6*(1), pp. 1-7

Rakhshaee, R., Giahi, M. & Pourahmad, A. (2009). Studying effect of cell wall's carboxyl- carboxylate ratio change of *Lemna minor* to remove heavy metals from aqueous solution," *Journal of Hazardous Materials*, 163 (1), pp. 165–173.

Sumiahadi, A. & Acar R. (2018). A Review on HeavyMetals (As, Pb, and Hg) Uptake by Plants through Phytoremediation IOP Conf.Series: *Earth and Environmental Science* 142:012023

Sunil, C.M. Shekara, B.G. Kalyanamurthy, K.N. & Shankaralingappa, B.C. (2014). Growth and Yield of Aerobic Rice as Influenced By Integrated Weed Management Practices. Research Gate https://www.researchgate.net/publication/230641893

Tangahu, B.V., Sheikh Abdullah, R.S., Basri, H., Idris, M., Anuar, N. & Mukhlisin M. (2011). A Review on Heavy Metals (As, Pb, and Hg) Uptake by Plants through Phytoremediation. *International Journal of Chemical Engineering*, 2011, pp. 1- 31

Usman A. R. A & Mohamed, H. M. (2009). Effect of microbial inoculation and EDTAon the uptake and translocation of heavy metal by corn and sunflower," *Chemosphere*, 76(7), pp. 893–899.

World Health Organization, (1996). Permissible limit for heavy metals in plants.

Yadav, S. K., Juwarkar, A.A., Kumar, G. P., Thawale, P. R., Singh, S. K. & Chakrabarti, T. (2009). Bioaccumulation and phytotranslocation of arsenic, chromium and zinc by *Jatropha curcas* L.: impact of dairy sludge and biofertilizer, *Bioresource Technology*, 100(20), pp. 4616–4622.

Yoon, J., Cao,X., Zhou, Q. & Ma, L. Q. (2006). Accumulation of Pb, Cu, and Zn in native plants growing on a contaminated Florida site," *Science of the Total Environment*, 368 (2-3), pp. 456– 464.

Yusuf, A. A., Arowolo, T.A. & O. Bamgbose, O. (2003). Cadmium, copper and nickel levels in vegetables from industrial and residential areas of Lagos City, Nigeria. *Food and Chemical Toxicology*, 41 (3), pp. pp. 375–378.

Conflict of Interest

The authors declare no conflict of interest