International Journal of Current Research in Applied Chemistry & Chemical Engineering
Vol. 4, Issue 1 – 2020
ISSN: 2581-5385

Comparative Evaluation of Phytoremediation Potential of *Laportea Aestunans* L. and *Tithonia Diversifolia* for Cadmium Metal Remediation

Bisi-Omotosho Ademola[1]

[1]*Federal University of Technology Akure.*

Correspondence E-mail Id: *editor@eurekajournals.com*

Abstract

In this study, the phytoremediation potential *of Laportea aestunans* L. and *Tithonia diversifolia* (sunflower) in a cadmium contaminated soils were investigated. Soil was collected within the Federal University of Technology Akure premises at the afforestation farm, the soil samples were air dried, picked for obvious gravel, and sieved through 2mm mesh. The physicochemical properties of the soil samples were determined using standard methods. The soil samples were spiked with different concentration of cadmium. Virgin and spiked soil samples were extracted using aqua regia and extracted solution analysed with Atomic Absorption Spectrophotometer (AAS) for cadmium metal. Seeds of both *Tithonia diversifolia* and *Laportea aestuans* were planted in untreated (control) and treated soil samples in triplicates; experiment was terminated after 8 weeks. From the experiment, the leaf of both plants accumulated more of the metal followed by the stem and the root. The bioaccumulation factor for both plant in all samples were all found to be less than one which confirms both plants to be excluders, however, *Tithonia diversifolia* is closer to one which indicates a better phytoremediator. This implies that Tithonia *diversifoliais* more suitable for phytoremediation of cadmium metal*than Laportea aestuans*.

Keywords: *Laportea Aestunans, Tithonia Diversifolia*, Sunflower, Phytoremediation, Cadmium.

Introduction

As a result of technological advancement in industrial activities and continuous growth of population has led to the increase in the heavy metals concentration in the environment, which has consequently led to environmental negative issues such as negative effect on growth of plants at high concentration (1) and human health problems at global level (2). Heavy metals are not biodegradable which is the major reason they pose a critical concern to living organisms and the environment through their action as carcinogenic and mutagenic compounds (3). Because they are not biodegradable, remediation processes are not just necessary but compulsory to sustain safe and healthy environment.

Different remediation technologies have been applied for treating heavy metals contaminated soils which are divided into three major classes namely, physical (e.g vitrification technologies and soil replacement) (4, 5), chemical, (stabilization/ solidification, encapsulation, and soil washing technologies) (6, 7) and biological (majorly biosorption and microorganisms) (8).

However, the remediation technologies are with disadvantages and limitation which includes expensive, need high labour and may some produce other contaminants to the environment (9, 10).All these limitation needs to be eliminated by a remediation method that is less expensive and also environmental friendly. Phytoremediation is an excellent method that have these features. It uses plant to remove heavy metal from heavy metals contaminated sites (11,12). This technique is cost effective, simple and environmentally friendly with minimal environmental negativite contribution. Accumulation heavy metals by plants differs in capacity with different plants(13); This implies that a plant used for phytoremediation must be heavy- metal tolerant, fast growth with a high biomass yield and good metal-accumulating ability in the aboveground parts (14).

Among the heavy metals is cadmium (Cd), cadmium has no known biological function in higher organisms, a cadmium-dependent carbonicanhydrase has been found in marine diatoms (15). Cadmium is highly toxic so it should be used and handled with great caution. As an implication of anthropogenic activities which include metal ore combustion and waste burning, cadmium has found its self in the environment and transfer of cadmium compounds can happen through leaking sewage sludge to agricultural soil which may enter the food chain when absorbed by plants and accumulate in various human organs when such plants are consumed. Also, the other great source of cadmium exposure is cigarette smoke (16).

Sunflower(H. annuus) is an annual plant belonging to the family of Asteraceae and it grows in a wide range of soil types. The stem of the flower can grow as high as3m tall, with the flower head reaching up to 30 cm in diameter with the “large” seeds. its suitable for constipation, stomach pains, indigestion, sore throat, liver ains and to treat malaria. Reports claim that it has been used as anti-inflammatory, analgesic, antimalarial, antiviral, antidiabetic, antidiarrhoeal, antimicrobial, antispasmodic, vasorelaxant and cancer-chemopreventive (17). *Laportea aestuansL* belong to family Urticaceae. An erect, annual herb up to 1.5 m high, with long, stiff, sometimes stinging hairs that reproduces from seeds.It is a common weed of bush regrowths, cultivated fields and waste areas in West Africa, sometimes eaten as a pot herb and widely used in African traditional medicine. The pulped whole plant is eaten or the plant sap is drunk as an anthelmintic and for the treatment of hernia (18,19).

The aim of this research work is to investigate the phytoremediation potential of *laportea aestunans l and Tithonia diversifolia* (sunflower) to remediate cadmium contaminated soils of different cadmium concentrations.

Method and Materials

Collection of Materials

The soil used for this experiment was taken from a plain land with short trees and shrubs, with no record of any farming activities. The area located on longitude N 07^{o}18’26.6” and latitude of E 005^{o} 07’34.4” and at an elevation of 1252 m. Soil samples were collected at depth 0-15 cm (ploughable soil) and air dried for 3 weeks, sieved through 2 mm stainless mesh (British Standard), the physicochemical characteristics of the soil were determined. The physiochemical characteristics include pH, particles size distribution, Organic matter (O.M), Total nitrogen and phosphorus, Total cadmium concentration. Seeds of *Larpotea aestuans and Tithonia diversifolia* were collected from Crop Soil and Pest departmental research farm of the Federal University of Technology, Akure at uncontaminated sites and were treated and washed.

Preparation of Heavy Metals Stock Solutions

A high purity analytical grade of Cd standard solutions. A single stock standard solution of 1000 mg/L $CdCl_2.1H_2O$ (MERCK) was prepared by dissolving 2.0306g of cadmium chloride in 250 ml deionised water and diluted to 1 litre in a volumetric flask were used as the source of the Cd stock solutions and was used to contaminate the soil with Cd at different concentrations of 100, 200, 300, 400 and 500mg kg^{-1}. All the required solutions were prepared with analytical reagents and double-distilled water.

Pot Experiments, Plant Harvest, Preparation and Analysis

Eight seeds were planted per pot. The plant was irrigated with deionised water every two days and weeding was done by hand picking. The experiment was terminated after eight (8) weeks of planting and the plants were harvested. Harvesting was carried out by hand up-rooting. The roots were rinsed with tap water and then distilled water. Soil samples from the immediate root vicinity of the plants were collected in nylon bags. The roots of the plants were then rinsed thoroughly in water to remove soil particles before been separated from the shoot with a knife.

The plant samples were dried at 75^{o}C for 48 h and reweighed. Each sample was ground with a mill, 0.3 g of the milled samples was acid digested with 10 ml of *aqua regia* and heated until a clear solution was obtained. The soil sample (0.5 g) was taken before planting and after harvesting, it was digested and extracted using 15 ml of aqua regia. All solutions were

International Journal of Current Research in Applied Chemistry & Chemical Engineering
Vol. 4, Issue 1 – 2020
ISSN: 2581-5385

filtered with an analytical grade filter paper and diluted to 50 ml with deionised water. The concentrations of Cd in the digested and extracted solutions were determined using atomic absorption spectrometry (AAS).

Heavy Metals Accumulations and Translocations Factor

Bioaccumulation factor and transfer factor of Cd was measured. (19), Shoot-root Translocation Factor (TF) was also examined to determine the phytoremediation potential (20).

Result and Discussion

Physiochemical Properties

Table 1.0 shows the result of the physico-chemical properties of the soil sample. The pH of the soil was found to be 6.6. According to (21), most soils within higher pH in t h e range of 7.0-9.0 have metals that are not always in the free form and bio available. The metals in the studied soil are likely be available for the uptake of the plant. pH plays significant role in solute concentration, sorption and desorption of contaminants in soil (22).The soil organic of the soil was found to be 3.8%. According to the sustainable agriculture research and education, 2% organic matter in a soil with highest percentage of sandy soil such as this is very fertile. The soil showed appreciable content of nitrogen and phosphorus necessary for the proper growth of the plants used for the phyto-remediation (Nitrogen-3.51%, Phosphorus-4.71%). Nitrogen assists plants root and leaf growth of leafy vegetables. Another function of nitrogen is that It encourages the uptake and utilization of other nutrients including potassium of plant (23). Similarly, phosphorus(P) is a vital nutrient that affect growth parameters such as plant height and also has function in cell division and cell enlargement (24). Texture of the soil contributes positively to plant development and also influences the physical parameters of the soil (25), The studied soil has very low silt content and high percentage of sand content indicating that it belongs to class of sandyclay.

Metal Analysis in Soil

Table 2.0 shows the result of Cadmium concentration in the soil before planting and after harvest. The result showed that the metals (cadmium) spiked were indeed available in the soil which indicates that the plants will have metals to absorb. The result after harvest indicates decrease a concentration at all sample field which indicates that there is possibility that metals have been lost through bioaccumulation in plants.

International Journal of Current Research in Applied Chemistry & Chemical Engineering
Vol. 4, Issue 1 – 2020
ISSN: 2581-5385

Table 1.

Parameters	Result
pH	6.6 ± 0.00
%Sand	51.68 ± 0.00
%Clay	33.92 ± 0.00
%Silt	14.4 ± 0.00
Organic matter	3.8 ± 0.02
% Nitrogen	3.50 ± 0.00
% Phosphorus	4.71 ± 0.00

Values are mean ± S.D

Table 2.

Cadmium introduced (mg/Kg)	Cadmium Before planting	Cadmium after harvest
Blank	00.00	00.00
100	91.06 ± 0.40	74.75 ± 0.42
200	195.23 ± 0.27	119.09 ± 0.28
300	296.07 ± 0.97	12.39 ± 0.26
400	396.09 ± 0.43	83.16 ± 0.10
500	493.36 ± 0.68	9.86 ± 0.45

Values are mean ± S.D

Cadmium Concentration in the Plants

The cadmium concentration in leaf, stem and root of the plants are presented in Table 3.0, 4.0 and 5.0 respectively. Comparing the level of absorbed concentrations, Tithonia show higher Phyto remediation potential than the laportea plant. The difference in their potentials indicted that Tithonia leaf absorbs more than twice as absorbed by the laportea leaf. This was observed throughout the field samples which suggests and explains that the higher Phyto-remediating potential of Tithonia leaf over the laportea leaf is not affected by the level of metal concentration in the soil.

The concentration of metals in the plants stem were found to be lower than the metals in the leaf Although the difference in the concentrations are not as wide as observed in the leaf. A similar observation was reported by (26) in a research on the potential of sunflower for phytoremediation of Nickle (Ni) and lead (Pb), it was observed that the metal concentration in the stem were lower than the concentration observed in the leaf. Another similar trend is that sunflower show higher potential to accumulate more heavy metals in the shoot than the laportea plant. This still further proves that sunflower potential for phytoremediation is higher than the laporteaplant.

The metal concentration at the root of the two plants were found to be the lowest among the three part (Leaf, Stem and root) studied. Having lowest concentration at the root agrees with previous studies on phytore mediation especially with the use of sunflower (27). This suggests a positive transfer factor from the root to the other part of the plants.

Table 3.Cadmium concentration in Leaf of the plants

Cadmium introduced (mg/Kg)	Cadmium in *Tithonia diversifolia*	Cadmium in *Laportea aestuans*
Blank	0.00±0.00	0.00±0.00
100	46.28±0.64	20.39±0.57
200	100.83±0.59	45.54±0.57
300	155.22±1.15	62.75±5.39
400	200.80±0.58	87.88±0.87
500	258.71±0.79	108.15±1.43

Values are mean ± S.D

Table 4.Cadmium concentration in stem of plants

Cadmium introduced (mg/Kg)	Cadmium in *Laportea aestuans*	Cadmium in *Tithonia diversifolia*
Blank	0.00	0.00
100	16.57±0.21	37.19±0.82
200	42.50±0.50	75.60±0.39
300	45.94±0.74	118.90±0.82
400	64.80±0.28	157.72±0.87
500	80.16±0.07	197.16±0.57

Values are mean ± S.D

Table 5.Cadmium concentration in root of plants

Cadmium introduced (mg/Kg)	Cadmium in *Tithoniadiversifolia*	Cadmium in *Laportea aestuans*
Blank	0.00±0.00	0.00±0.00
100	3.96±0.29	3.08±0.24
200	7.74±0.19	6.51±0.26
300	11.35±0.60	8.88±0.48
400	15.23±0.73	12.43±0.16
500	19.19±0.70	15.57±0.46

Values are mean ± S.D

Bioaccumulation Factor

The result is shown in Table 6.0 shows that all the plants studied were excluders because they all have bioaccumulation factor lesser than 1. This result agrees with (28) on the bioaccumulation factor he reported for *Tithonia diversifolia*. However, the bioaccumulation of the sunflower for the cadmium was close to 1 and it indicated that *Tithonia diversifolia* can be use for the remediation process of cadmium polluted soil. The highest bioaccumulation result was at Sample Field spiked with 500 mg/Kg of cadmium and followed by 300mg/Kg of cadmium and followed by 400mg/Kg for cadmium in sunflower. Similarly, the *Laportea* *aestuans* plant had its highest cadmium bioaccumulation factor in the manner sample 400 mg/Kg, 300mg mg/Kg and 500mg/Kg respectively. This implies that even though the concentration of bioavailable metal in the soil may influence bioaccumulation, the bioaccumulation factor for the plant is not directly proportional with the concentration of metal in the soil. This could have been caused by different factors, although the rate of metal uptake by crop plants could be influenced by factors such as metal species, plants species, plant age and plantpart.

Table 6.Bioaccumulation factor result

Cadmium introduced (mg/Kg)	**Cadmium in *Tithoniadiversifolia***	**Cadmium in *Laportea aestuans***
Blank	0	0
100	0.73	0.09
200	0.88	0.25
300	0.91	0.54
400	0.89	0.90
500	0.91	0.37

Transfer Factor

The result of the transfer factor is presented in Table 7.0 TF > 1 indicates that there is a positive transfer of metals from the root which is connected or enriched from the soil to other part of the plants (29). All the result shows were greater than 1. That is, both plant indicates that there was cadmium transfer from the root to the leaf and stem. This agrees with earlier results in Table 3.0 – Table 5.0 which proves the reason for the highest concentration of metal in leaf followed by the stem and lowest in the root. Like the bioaccumulation factor, the transfer factor result shows that it is not directly proportional to the soil metal concentration but rather the transfer factor is influenced is also influenced by other factors such as soil pH and bioavailability of metals.

Table 7.Transfer factor result

Cadmium introduced (mg/Kg)	**Cadmium in *Tithonia diversifolia***	**Cadmium in *Laportea aestuans***
Blank	0	0
100	23.50	12.28
200	17.0	12.07
300	22.79	11.37
400	24.15	12.24
500	25.0	12.09

Conclusion

The pH of the soil was found to be slightly acidic. Organic matter, nitrogen and phosphorus content gives us the soil could support healthy growth of the *Tithonia diversifolia* and *Laportea aestuans*. It was found that the two plants accumulate more cadmium in leaf followed by the stem and the root. However, the concentration of metal in soil have a significant influence on the concentration of metal absorbed by the total plant body but does not influence on the pattern by which the plant absorbs the metal into different parts or the concentration that is absorb by each part of the plant. The bioaccumulation result shows that both plant could be regarded to as excluders, because all calculated values are below 1. Even though they were lesser than 1, it was observed that there is potential of sunflower to be an accumulator of cadmium especially at high concentration in the soil. Although, the result show that the bioaccumulation factor of the plant is not directly influenced by the concentration of metal in the soil. As expected, the transfer factor indicated that for the two studied plants, the leaf and stem were metal enriched through the root of the plants. Similarly, the transfer factor is not directly depending on the soil metalconcentration.

References

1. Roy, S., Labelle, S., Mehta, P., (2005). Phytoremediation of heavy metal and PAH contaminated brown field sites. Plant Soil 272, 277–290.
2. Abdelhafez, A.A., Li, J., (2014). Geochemical and statistical evaluation of heavy metal status in the region around Jinxi River, China. Soil Sediment. Contam. 23, 850–868.
3. Wu, W., Wu, P., Yang, F., Sun, D., Zhang, D., Yi, Zhou, 2018. Assessment of heavy metal pollution and human health risks in urban soils around an electronics manufacturing facility. Sci. Total Environ. 630, 53–61.
4. Douay, F., Pruvot, C., Roussel, H., Ciesielski, H., Fourrier, H., Proix, N., Waterlot, C., 2008. Contamination of urban soils in an area of northern France polluted by dust emissions of two smelters. Water Air Soil Pollut. 188, 247–260.
5. Dellisanti, 2016. In-field remediation of tons of heavy metal-rich waste by Joule heating vitrification. Int. J. Miner. Process. 93, 239–245.
6. Ucaroglu, S., Talinli, İ., 2012. Recovery and safer disposal of phosphate coating sludge by solidification/ stabilization. J. Environ. Manage. 105, 131–137.
7. Park, B., Son, Y., 2017. Ultrasonic and mechanical soil washing processes for the removal of heavy metals from soils. Ultrason. Sonochem.
8. Fauziah, S.H., Jayanthi, B., Emenike, C.U., Agamuthu, 2017. Remediation of heavy metal contaminated soil using potential microbes isolated from a closed disposal site. Int. J. Biosci. Biochem. Bioinf. 7, 230-237.
9. Marques, A.P.G.C., Oliveira, R.S., Rangel, A.O.S.S., Castro, P.M.L., 2008. Application of manure and compost to contaminated soils and its effect on zinc accumulation by Solanum nigrum inoculated with arbuscular mycorrhizal fungi. Environ. Pollut. 151, 608-620.

10. Haque, N., Peralta-Videa, J.R., Jones, G.L., Gill, T.E., Gardea-Torresdey, J.L., 2008. Screening the phytoremediation potential of desert broom (Braccharis sarathroides Gray) growing on mine tailings in Arizona, USA. Environ. Pollut. 153, 362-368.
11. Sharma, S., Singh, B., Manchanda, V.K., 2014. Phytoremediation: role of terrestrial plants and aquatic macrophytes in the remediation of radionuclides and heavy metal contaminated soil and water. Environ. Sci. Pollut. Res. 22, 946-962.
12. Abou-Shanab, R.A.I., 2011. Bioremediation: new approaches and trends. In: Khan, M.S. (Ed.), Biomanagement of Metal-Contaminated Soils, Environmental Pollution. Springer Publications, NY, USA, pp. 65-94.
13. Nouri, J., Khorasani, N., Lorestani, B., Karami, M., Hassani, A.H., Yousefi, N., 2009. Accumulation of heavy metals in soil and uptake by plant species with phytoremediation potential. Environ. Earth Sci. 59, 315-323.
14. Jadia, C. D., and Fulekar, M. H. (2009). Phytoremediation of heavy metals: recent techniques. *African journal of biotechnology*, *8*(6).
15. Nordberg Gunnar F., Koji Nogawa, Monica Nordberg (2015). *Handbook on the Toxicology of Metals (Fourth Edition) Volume II,* Academic Press, 667-716.
16. Templeton, D. M., and Liu, Y. (2010). Multiple roles of cadmium in cell death and survival. *Chemico-biological interactions*, *188*(2), 267-275.
17. Okezie, A., Agyakwa, C. and Ekeleme (2017). *A handbook of West African weeds*. Revised # edition IITA. 381pp
18. Brink, M., 2009. Laportea aestuans (L.) Chew. [Internet] Record from PROTA4U. Brink, M. & Achigan-Dako, E.G. (Editors). PROTA (Plant Resources of Tropical Africa /Ressources végétalesde l'Afrique tropicale), Wageningen, Netherlands. <http://www.prota4u.org/search.asp>. Accessed 11 April 2019.
19. Oloyede, G.K and Ayanbadejo, O.E., 2014. Phytochemical, Toxicity, Antimicrobial and antioxidant Screening of Extracts Obtained from *Laportea aestuans* (Gaud). *Journal of Medical Sciences, 14: 51-59.*
20. Bystrzejewska-Piotrowska, G., Drożdż, A., Stęborowski, R., 2005. Resistance of heather plants (Calluna vulgaris L.) to cesium toxicity. NUKLEONIKA 50, 31.
21. Gupta, S., Nayek, S., Saha, R.N., Satpati, S., 2008. Assessment of heavy metal accumulation in macrophyte, agricultural soil, and crop plants adjacent to discharge zone of sponge iron factory. Environ. Geol. 55, 731-739
22. Adedosu, H. O., Adewuyi, G. O., and Adie, G. U. (2013). Assessment of heavy metals in soil, leachate and underground water samples collected from the vicinity of olusosun landfill in Ojota, Lagos, Nigeria. *Transnational Journal of Science and Technology*, 3(6), 73-86.
23. Yang, J. Y., Yang, X. E., He, Z. L., Li, T. Q., Shentu, J. L., and Stoffella, P. J. (2006). Effects of pH, organic acids, and inorganic ions on lead desorption from soils. *Environmental Pollution*, 143(1), 9-15.
24. Bloom, A. J. (2015). The increasing importance of distinguishing among plant nitrogen sources. *Current opinion in plant biology*, *25*, 10-16.

25. Assuero, S. G., Mollier, A., and Pellerin, S. (2004). The decrease in growth of phosphorus-deficient maize leaves is related to a lower cell production. *Plant, Cell and Environment*, *27*(7), 887-895.
26. Tripathi, A., and Misra, D. R. (2012). A study of physico-chemical properties and heavy metals in contaminated soils of municipal waste dumpsites at Allahabad, India. *International Journal of Environmental Sciences*, *2*(4), 2024.
27. Saima, M. A. I. M. A., Bhatti, H. N., Khalid, M., Haq, M. A. U., and Shahzad, S. M. (2010). Potential of sunflower (Helianthus annuus L.) for phytoremediation of nickel (Ni) and lead (Pb) contaminated water. *Pak J Bot*, *42*(6), 4017-4026.
28. Khalid. A., Ahmed, B., and Brodie, G. (2018). Phytoremediation of Pb and Cd contaminated soils by using sunflower (Helianthus annuus) plant. *Annals of Agricultural Sciences*, *63*(1), 123-127.
29. Baker, A. J. M., Mcgrath, S. P., Reeves, R. D., and Smith, J. A. C. (2000). Metal hyperaccumulator plants: a review of the ecology and physiology of a biological resource for phytoremediation of metal-polluted soils. *Oxford University research Archive.3(2), 5645-5650.*

