Bima Journal of Science and Technology, Vol. 7 (2) June, 2023 ISSN: 2536-6041

DOI: 10.56892/bima.v7i2.442

PHYTOREMEDIATION OF CONTAMINATED SOIL ALONG REFUSE DUMPSITES OF DOUBELI BYE-PASS IN YOLA NORTH, ADAMAWA STATE

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ABSTRACT

Improper disposal and mismanagement of solid wastes cause ground and surface water contamination. Hence the aim of this study was to determine the phytoremediation capability of heavy metals from Doubeli contaminated site by sun flower and to ascertain the plants tissue that accumulated most of these metals. The sunflower seeds were planted directly in the contaminated soil in greenhouse and monitored for two months. The concentrations of heavy metals were recorded using Atomic Absorption Spectroscopy. The results showed that the root accumulated more heavy metals followed by leaf and stem. (Roots > leaf > stems). The plant was able to removed 44.4% of Cr, 67.1% of Cd. 73.0% of Cu, 31.1% of Pb and 32.0% of Mn. This shows the potential of sunflower for the treatment of contaminated soil by heavy metals in Doubeli refuse dumpsites of Yola North, Adamawa State.

Keywords: Phytoremediation, Heavy Metal, Solid Waste

INTRODUCTION

Indiscriminate disposal of solid waste in the environment and lack of clear waste management policy are the major factors militating against effective solid waste management. In Jimeta-Yola, solid wastes are dumped in undeveloped plots of lands, street or access roads, burrow pits, drainage system and uncompleted building (Edan, Ono, & Sarkinzango, 2015). Doubeli bye-pass is characterize by uncontrolled and unattended disposal of refuse which litter and pollute the surrounding environment. The area encountered various environmental challenges among which soil pollution is of great concern. This is because heavy metals can be mobilized in the soil and transported into the soil sub-layer which can affect ground water resources. This leads to both surface and ground water pollution.

Metals are generally classified as heavy metal when their density exceed 5g cm^3 (Shagal, Maina, Donatus, & Tadzabia, 2012) They include Copper, Lead, Mercury, Chromium, Manganese, Aluminum, Zinc etc. They represent a serious threat to both fauna and flora in the surrounding environment because they are toxic, non-biodegradable and have the tendency to bioaccumulate and biomagnify in living organisms (Kahlon et al., 2018) (Ali & Khan, 2018) (Ayangbenro & Babalola, 2017). Being water soluble, they can be easily absorbed and accumulated in human body via the food chain (Malik, Bashir, Qureashi, & Pandith, 2019). This causes damages to some organs and nervous system, and in some extreme cases lead to death.

The strategies involved in remediating heavy metals include, physical (soil isolation, soil replacement and verification), chemical (stabilization/solidification, encapsulation and soil washing) and biological (biosorption and

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metal uptake by microorganisms) (Alaboudi, Ahmed, & Brodie, 2018). Most of these strategies are expensive, inappropriate for *in situ* application and may generate secondary pollutants in the surrounding environment (Marques, Oliveira, Rangel, & Castro, 2008) (Haque, Peralta-Videa, Jones, Gill, & Gardea-Torresdey, 2008). However, phytoremediation is less expensive, appropriate for *in situ* remediation and can remove contaminants with minimal environmental damages. But the choice of the plant that can withstand the stressful condition of the polluting environment is a major challenge.

Recently, Sun flower (*Helianthus annuus L.*) of the family *Asteraceae*, has attracted the attention of many researchers in phytoremediation due its unique features. It is an ornamental plant which grows very fast with high amount of biomass under stressful conditions (Marathe, 2019). Hence it is considered as an agent in various environmental clean-up. This study therefore investigated the use of sun flower (*Helianthus annuus* L.) in the removal of heavy metals in the dumpsite of Doubeli bye-pass in Yola North, Adamawa and also to ascertain the parts of the plants that accumulate more heavy metals.

MATERIALS AND METHODS

Sample Collection

The soil samples used in the study were collected from Doubeli-bypass dump site located along Mubi Road before Jimeta main bridge. The samples were collected at a depth of 0-20 cm, sealed immediately in a plastic container to maintain its moisture and transported to the laboratory. The soil was stored in the greenhouse of the Chevron Biotech Center of Modibbo Adama University and maintained at room temperature.

Experimental Setup

The plastic pots use in this experiment have a surface area of 900 cm^2, 500 cm^3. The contaminated soil samples were added to each of the pot and five seeds of the sun flower were planted directly into the contaminated soil. After seeds germination and the seedling attained a height of 20cm, the plants were thinned to one per pot. The plants were then allowed to grow for the period of two months while the soil moisture content was maintained at 80% of water holding capacity (Adejube, Anteyi, Garba, Oyekunle, & Kudaisi, 2017). The plants were then harvested at the end of the two months and dried for four days in an oven at 60^oC for further analysis. The experiment was conducted in triplicate.

Analytical Methods

Qualitative and quantitative analysis of heavy metals in the control, soil and plants parts (root, stem and root) were determined using atomic absorption spectrophotometry (AAS) according to the protocol reported in (AOAC, 2016). The percentage of removal was calculated as reported in (Idi, Ibrahim, Mohamad, & Majid, 2015).

RESULTS AND DISCUSSION

Determination of Heavy Metal Removal in the Study Area

The results obtained from this study showed that the sun flower was able to removed 44.4% of Cr, 67.1% of Cd. 73.0% of Cu, 31.1% of Pb and 32.0% of Mn. This reduction followed the order Cu>Cd>Cr>Mn>Pb. The order of heavy metal reduction is determined by the plant species used in the phytoremediation and the concentrations of heavy metals in the contaminated site. For instance, during the phytoremediation of heavy metals in sewage treatment unit at the university of Basrah in Iraq using *Utricularia* *vulgaris L.* (Bladderwort) and *Lemna minor L.* (Duckweed), heavy metals concentrations were reduced by more than 68% in the following order by both plants species Pb>Mn>Cu>Zn (AZEEZ, 2021). Furthermore, When the accumulation of two plants (*T. angustifolia* and *C. esculentus*) were compared, different patterns were observed from the same aqueous solution of heavy metals. While *T. angustifolia* showed the pattern: Fe>Mn>Zn>Cr>Pb>Cu> Ni>Cd, *C. esculentus* showed the following pattern: Fe>Mn>Zn>Pb>Ni>Cu>Cr>Cd (Chandra & Yadav, 2011)

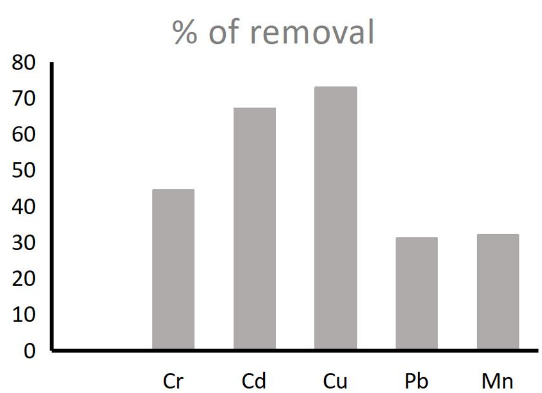

Figure 1: Percentage of heavy metals removal using sun flower.

Phytoremediation of Lead

Even though the phytoremediation of lead is reported to only be economically feasible when high amount of biomass is accumulated in the shoot (Huang, Chen, Berti, & Cunningham, 1997), the results of the phytoremediation of lead in Doubeli bye pass showed that the root accumulated more lead followed by the steam and leaves as described in Figure 2. However, since sunflower cultivation and harvesting are inexpensive, phytoextration of lead in Doubeli bye pass still provide an alternative for the clean-up of the contaminated soil. Furthermore, this study was conducted within 2 months, which is in line with the goal of phytoextraction of lead, which is to reduce lead within a reasonable amount of time frame (Huang et al., 1997). The timing is significant and is related to species, initial concentration of lead among other factors.

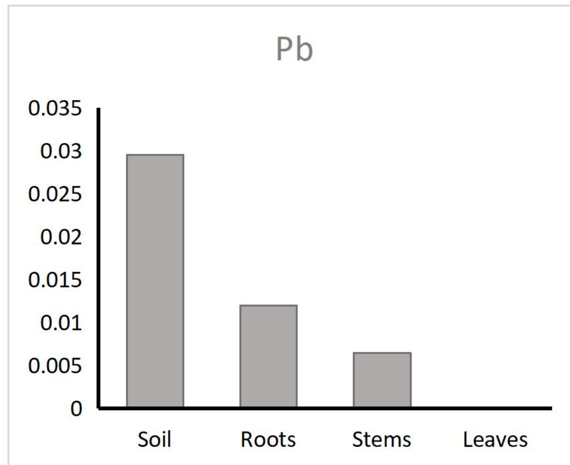

Figure 2: Accumulation of lead based on plants parts (tissue).

Phytoremediation of Manganese

While the concertation of Mn in roots, stems leaves, and shoots remained remarkably similar during the removal of lead by *Phytolacca americana* and *Polygonum hydropiper*), this study showed that leaves accumulated more Mn followed by root and stems. This is in conformity with the study of (Li et al., 2020) using the plants, *Polygonum hydropiper L.* and *Polygonum lapathifolium L.*, while the plants exhibit an excellent capability of removing Mn and Cd. The removal ability was enhanced by the inoculation of *Enterobacter sp. FM-1* and the highest concentration of heavy metals was obtained in the leaves of both plants (Li et al., 2020). But when the ability of *Sorghum biocilor* L. to remove nickel and manganese from a polluted soil was studied, it was found out that the plant was not suitable for

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phytoremediation of manganese and nickel but played a significant role in the stabilization of these metals in the soil (Naeini & Yousefi Rad, 2018).

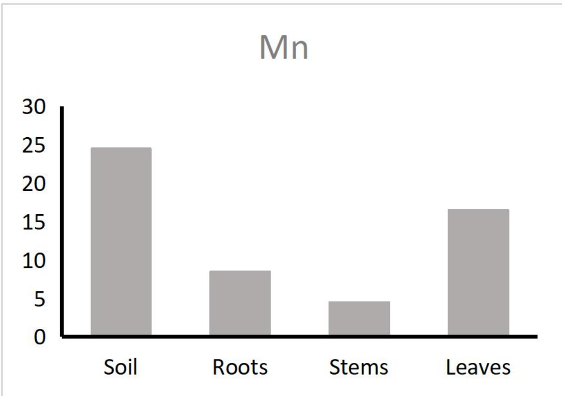

Figure 3: Accumulation of Mn based on plants parts (tissue).

Phytoremediation of Cadmium

During the removal Cd, the root has the highest bioaccumulation followed by leaves then, the stem. Highest accumulation of Cd in the root was also reported by (Alaboudi et al., 2018) using the same plants in contaminated soil amended with 20 mg kg^{-1}. Similarly, when three plants *P. cummunis, T. angustifolia* and *C. esculentus* were studied for their phytoremediation of heavy metals. *P. cummunis* was found to be a shoot accumulator for Cr, Fe, Mn, Ni, Pb, and Zn. *T. angustifolia* was observed to be a root accumulator for Cd, Cr, Cu, Fe, Ni and Pb. while *C. esculentus* also accumulated the heavy metals in the roots. However, Mn and Fe were translocated up to leaves (Chandra & Yadav, 2011).

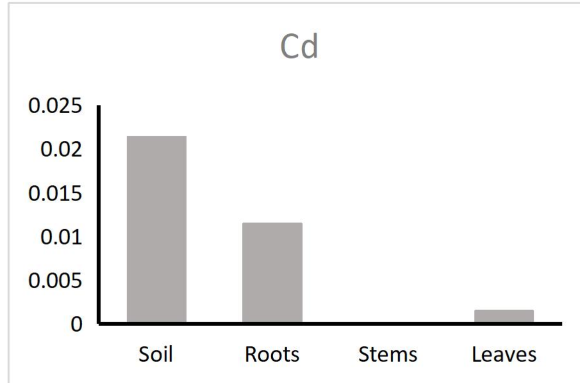

Figure 4: Accumulation of Cd based on plants parts (tissue).

Phytoremediation of Copper

Cupper is an important element in industries, but it presents in large amount in the soil become detrimental to the environment. Hence it removal is significant in environmental clean-up. However, unlike Cadmium and Zinc, Cupper usually demonstrates poor phytoavailabilty, hence its removal by plants is very low (Karczewska, Mocek, Goliński, & Mleczek, 2015). The results from this study showed that the roots accumulated more Cu followed the leaves and stems as described in Figure 5. This result is in agreement with the result obtained by (Chandra & Yadav, 2011) where the plant, *T. angustifolia* was found to be a root accumulator for Cu, Cd, Cr, Fe, Ni and Pb. However, Cu accumulation were reported to be more efficient in submerged tissue compared to floating plants (Maksimović, Lolić, & Kukavica, 2020) (Babović, Drazić, Djordjević, & Mihailović, 2010).

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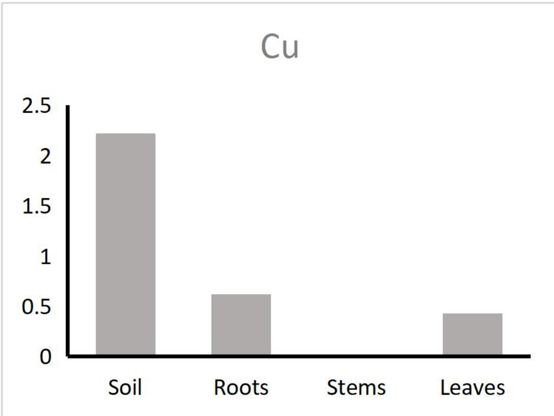

Figure 5: Accumulation of Cu based on plants parts (tissue).

Phytoremediation of Chromium

The concentration of Cr recorded from this study showed that the highest accumulation occurred in the roots followed by stem and the leaves recorded the less Cr accumulation. This in conformity with results obtained by (Abdullahi, Animashaun, Garba, Adamu, & Yisa, 2021) during the phytoremediation of lead and cadmium by the same plants in contaminated soils of IBB university, Lapai, Nigeria, where the roots recorded the highest accumulation rate of both Pb and Cr and leaves recorded the less accumulation rate.

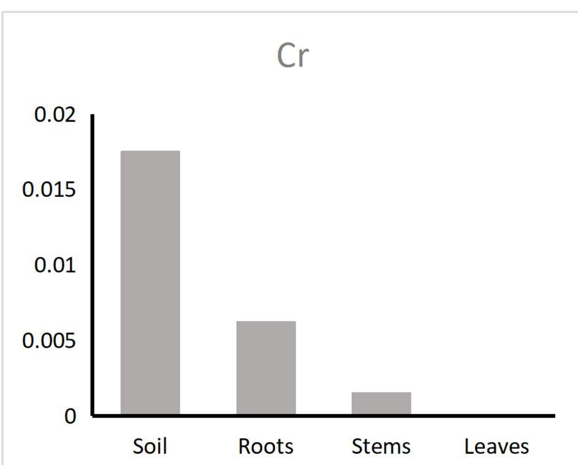

Figure 6: Accumulation of Cr based on plants parts (tissue).

CONCLUSION

The ability of sun flower to remove heavy metals in contaminated soil of Doubeli bye pass of Yola North was investigated. The plant showed a good phytoremediation ability within a short period of time. The plant was able to removed 44.4% of Cr, 67.1% of Cd. 73.0% of Cu, 31.1% of Pb and 32.0% of Mn within 60 days. The root accumulated more heavy metals followed by leaf and stem. (Roots > leaf > stems). Hence sun flower is a good candidate for reducing heavy metals concentration in dump site of Doubeli bye pass of Yola North.

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