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COMPARATIVE STUDIES ON UPTAKE OF LEAD (Pb) AND CHROMIUM (Cr) BY *AMARANTHUS CAUDATUS*

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ABSTRACT

Soil pollution with heavy metals due to discharge of untreated urban and industrial waste water is a major threat to ecological and human well being. This research was carried out to determine and compare the level of heavy metal uptake (Cr and Pb) of *Amaranthuscaudatus* planted on contaminated soil. A 6kg of soil was contaminated with 20g of $Pb(NO_3)_2$ which contains 12.51g of Pb and 20g of $K_2Cr_2O_7$ which contains 7.07g of Cr. *Amaranthuscaudatus* was planted on this contaminated soil. Germination begins after 2 days of plantation but for Cr there was no germination. In soil contaminated with Pb, growth continuous for 50 days under. A similar trend was carried out for the uncontaminated soil which also germinates after 2 days of plantation. The result shows that Cr was toxic to germination and it affects the germination process of *Amaranthuscaudatus* which did not germinate entirely. The level of heavy metals in the soil and vegetable was determined using Atomic Absorption Spectrophotometer (AAS) analysis. Transfer Factor (TF) from the soil to the plant was also determined. This result shows a large percentage of the heavy metals absorbed by the plant from the soil. The result also shows that *Amaranthuscaudatus* has the ability to phytoremediate to a very small extent.

INTRODUCTION

Heavy metals pollution is a global concern and also hazardous to human health. However dietary exposure to trace of heavy metals is highly variable. Different metals show toxicity at different concentration and are potentially toxic at sufficient high concentration, on the other hand certain metals exhibit toxicity at low concentration.

Heavy metals are ubiquitous in the environment, as a result of national and anthropogenic activities, and humans are exposed to them through various pathways. Wastewater irrigation, social waste disposal and sludge application are the major sources of soil contamination with heavy metals, and increase metal uptake by vegetable grown on such contaminated soil is often observed (Sajjad *et al.*, 2009).

These heavy metals have been given considerable concern due to their toxicity and accumulative behavior. For example the major source of lead (Pb) in human diet is from post-harvest processing of food (Bolger *et al.,* 1996). For chromium (Cr), however, the principal exposure route for the general population is through uptake from the soil by food plants (Lopez–Artiguez *et al.*, 1993). Consequently, government have imposed limit on the maximum concentration of selected metals in food product intended for human consumption (Commission Regulation, 2001). Where metal concentration exceeds this limit, it may be possible to use this product in animal feeds, in order to minimize the effect upon the human diet. However, animals feed on heavy metals enriched diet may have elevated concentration of these metals in their tissues and milk (Baars *et al.,* 1992, Crews *et al.,* 1992). The greatest degree of metals accumulation occurs mostly in livers and kidneys (Beresford *et al.,* 1999). Regular consumption of metal enriched animal products may also lead to adverse health effect in human (Reilly, 1991). Heavy metals are natural component of the earth crust. They cannot be degraded or destroyed, to a small extend they enter our bodies via food, drinking water and air (heavy metals Lenntech). Heavy metals and metalloids are of environmental concern. In very small amount many of these heavy metals are useful to support life. However in large amount they may build up in biological system and becomes hazardous to health. Heavy metals make significant contribution to environmental pollution as a result of anthropogenic activities such as mining, energy and fuel production, power transmission, intensive agricultural practice, sludge and industrial effluent, dumping and military operations (Salt *et al.,* 1998). In general, wastewater contains substantial amount of beneficial nutrients and toxic heavy metals which are creating opportunities and problems for Agricultural production (Sajjad*et al.*, 2009). *Amaranthuscaudatus* is a species of annual flowering plant. It goes by common names such as love – lies bleeding pendant, Amaranth tassel flower, velvet flower, foxtail amaranth and quilete. Many parts of the plants, including the leaves and the seeds, are edible and are frequently used as a source of food. This species, as with many others of the amaranths, are originally from the American tropic. The exact origin is unknown. The red color of the inflorescence is due to a high content of β-cyanins, as is the relate species known as "Hopi red dye" amaranth. In terms of cultivation, it can grow anywhere from 3 to 8 feet in height, and grows best in full sun (Wikipedia, 2015). As such these edible vegetable (*Amaranthuscaudatus*) was put under observation for 50 days and the level of uptake of these heavy metals was compared and their accumulation was also determined.

MATERIALS AND METHOD

Reagents

The entire reagents used are of analytical grade: Nitric acid (HNO_3), Sulphuric acid (H_2SO_4), Perchloric acid ($HClO_4$), Distilled water, $Pb(NO_3)_2$ and $K_2Cr_2O_7$ were all used and they are obtained from the university chemical store.

AREA OF STUDY

The soil sample was collected from ATBU Bauchi. This soil sample was contaminated with Cr and Pb. The vegetable (*Amaranthuscaudatus*) was then planted in separate plastic container containing different heavy metal, watering morning and evening with tap water for the period of 50 days was carried out.

Planting of the Selected Plant

The soil collected from the sampling site was contaminated with the heavy metal Cr and Pb. 20g of $K_2Cr_2O_7$ (7.07g of Cr) was used to contaminate the 6kg soil into 3 separate containers each. *Amaranthuscaudatus* was planted on them for the period of 50 days. This means each container contains 1.178g/kg of both soil and the heavy metal. Also 20g of $Pb(NO_3)_2$ (12.51g of Pb) was used in contamination of 6kg soil into 3 separate containers. *AmaranthusCaudatus* was planted on them for the period of 50 days before harvesting. This also means that each container contains 2.085g/kg of both soil and the heavy metal. A 6kg of non-contaminated soil was also used to plant the vegetable into 3 containers, for the period of 50 days; all the plantations were watered morning and evening throughout the period with tap water.

Germination and Growth

For containers with Cr there was no germination. The concentration of the heavy metal was reduced from 20g to 15g, 10g, 5g and 2g respectively, but still there was no germination. For containers with Pb germination begins after 2days and growth continuous throughout the 50 days period. All changes were observed and recorded after every 5 days.

For the control germination also begins after 2 days with growth throughout the period. All changes were observed and recorded after every 5 days.

Harvesting of the Selected Plant

The sample was harvested after 50 days. The entire vegetable (*Amaranthuscaudatus*) was uprooted and used for the research.

SAMPLE COLLECTIONS

Soil Sampling

Soil used for the plantation was collected. It was collected by digging 5-10cm depth, homogenized and dried under the sun. The sample was then crushed using mortar and pestle and passed through 2mm mesh size sieve and stored at ambient temperature before digestion.

Plant Sampling

The vegetables crop (*Amaranthuscaudatus*) planted after 50 day was harvested. The entire vegetable was collected. The sample was taken to the laboratory and washed with clean tap water to remove the soil particles adhered to the sample of the vegetable. The sample was dried under shed, crushed and sieve with 2mm mesh size sieve and weighed until a constant weight was achieved. The sample was stored at ambient temperature before digested.

ASHING OF THE SAMPLE

The determination of ash content was made by incinerating the sample until all the organic matters are consumed by the heat.

Determination of Ash Content

5.0g of dried grinded sample was place in a crucible. It was then ignited in muffle furnace at 650°C until a white ash appears. The ash was allowed to cool in a desiccator and weighed. The percentage ash content was obtained from the expression below.

$$\% \, \mathbf{ash} = (\mathbf{weight\ of\ ash} / \mathbf{weight\ of\ sample}) \times \mathbf{100}$$

DIGESTION OF PLANT AND SOIL SAMPLE

Plant and soil (2g for soil and 1.5g for plant each) was digested with 30ml of tri acid mixture (HNO_3, H_2SO_4& $HClO_4$ in 5:1:1 ratio) at 80°c until transparent solution was obtained (Allen *et al.,* 1986). The solution was then cooled and filtered using what Mann filter paper no 42 and the filtrate was maintained to 100ml with distilled water.

AAS ANALYSIS

The concentration of Pb in the filtrate of digested plant and soil samples was estimated by using an atomic absorption spectrophotometer (AAS). The instrument was calibrated manually to prepare standard solution of respective heavy metals and the blank and also give accurate concentrations of the heavy metals in the plant and soil sample respectively.

TRANSFER FACTOR

After undergoing AAS the metal uptake or transfer factor (TF) was determined using Sajjad's (2009) method where:

$$TF = \frac{\text{Concentration of metal in plant}}{\text{Concentration of metal in the soil}}$$

Sajjad *et al*. (2009) defined it as the relative tendency of a metal to be accumulated by a particular species of plant this is dependent on the pH and the nature of the plant itself.

RESULT AND DISCUSSION

During plantation it was observed that the vegetable planted on soil (6kg) contaminated with 20g of $K_2Cr_2O_7$ did not germinate. This is because Cr has toxic effect (when present in certain concentration) on the germination process of *Amaranthuscaudatus*. The concentration of the

compound ($K_2Cr_2O_7$) was then reduced to 15g, 10g, 5g and 2g but still there was no germination. For soil (6kg) contaminated with 20g of $Pb(NO_3)_2$ they was germination and a perfect growth with very green leaves, greener than that planted on uncontaminated soil (control) was observed. The growth was also faster with very tall stem taller than the control also. All these are due to the presence of nitrate in the compound used. The nitrate is a source of nitrogen to the plant, which serves as protein to the plant.
The vegetable planted on the unc ontaminated soil (6kg) also germinate, with normal growth observed. All the plantations were watered morning and evening throughout the period of 50 days before harvested.
Below is the comparative lead (Pb) concentration (mg/kg) in soil samples and the maximum permissible limits in USEPA and some countries as shown in Table 1.

Table 1: Comparative Lead Concentration in Soil Samples with Recommended Permissible Limits

HM	Soil sample (mg/kg) I II III	Great Britain (mg/kg)	USEPA (ppm)	Wu yaoGuo (mg/kg) (2010)
Pb	67.00 57.50 74.50	400	300	216.97

The comparative heavy metal study of soil (mg/kg) presented in Table 1 above showed a significant difference from the one analyzed in this research. The result in this study is less than the permissible limit of metals in the soil of Britain, Japan (Wu Yao Guo, 2010) and USEPA. This toxic heavy metal has to be monitored to prevent further increase which may lead to outbreak of disease. The table also shows that all the concentration in soil I, II and III are less than the permissible limit and this signifies that the soil is good for plantation.

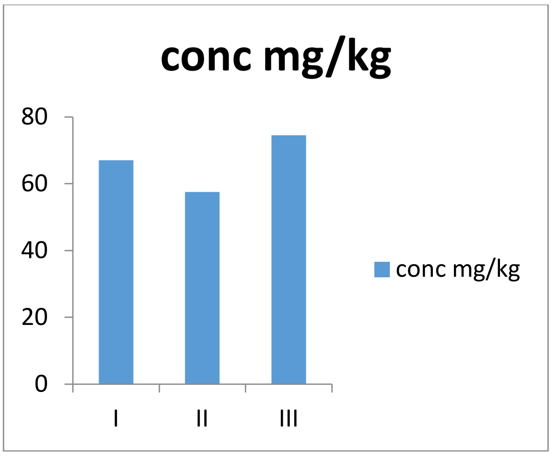

Fig 1: Mean Pb concentration in soil samples
I = represent the Pb concentration in soil I
II = represent the Pb concentration in soil II
III = represent the Pb concentration in soil III

From the chart above we deduce that soil III has the highest concentration of Pb followed by soil I, with soil II having the lowest Pb content. It also shows that there is variation of Pb content in the soil may be due to the uptake of the metal by the soil. Table 2:Bellow is the comparative Pb conc. (mg/kg) in plant sample with maximum permissible limit in some countries and WHO/FAO compared.

Table 2: Comparative Lead Concentration in Soil Samples with Recommended Permissible Limits

HM	Plant sample (mg/kg) I	II	III	Anthony and Balwant (2005) (mg/kg)	WHO/FAO (2011)	Indian standard (mg/kg)
Pb	5.76	12.24	10.08	4.31	5.0	2.5

The result of Pb (above) in plant sample in this work was compared with similar work reported by Anthony and Balwant (2005) as this work was higher than that of the compared results and also higher than the maximum permissible limit of the Indian standard and WHO/FAO. The result shows variation with the one compared. Therefore, it has to be monitored in order to prevent further outbreak of Pb poisoning.

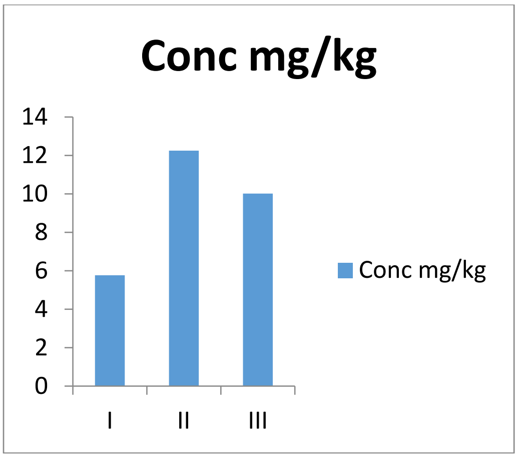

Fig 2: Mean Concentration of Pb in Plant Samples
I = represent the Pb concentration in plant I
II = represent the Pb concentration in plant II
III = represent the Pb concentration in plant III

The chart above shows that plant II has the highest Pb content followed by plant III with plant I having the lowest Pb content. We can conclusively say that plant II has the highest uptake of the metal.

TABLE 3.0 Transfer factor for plant I and soil I.

HM	Conc. In soil (mg/kg)	Conc. In plant (mg/kg)	TF
Pb	67:00	5.76	0.086

TABLE 3.1 Transfer factor for plant II and soil II.

HM	Conc. In soil (mg/kg)	Conc. In plant (mg/kg)	TF
Pb	57.50	12.24	0.213

TABLE 3.2 Transfer factor for plant III and soil III.

HM	Conc. In soil (mg/kg)	Conc. In plant (mg/kg)	TF
Pb	74.50	10.08	0.135

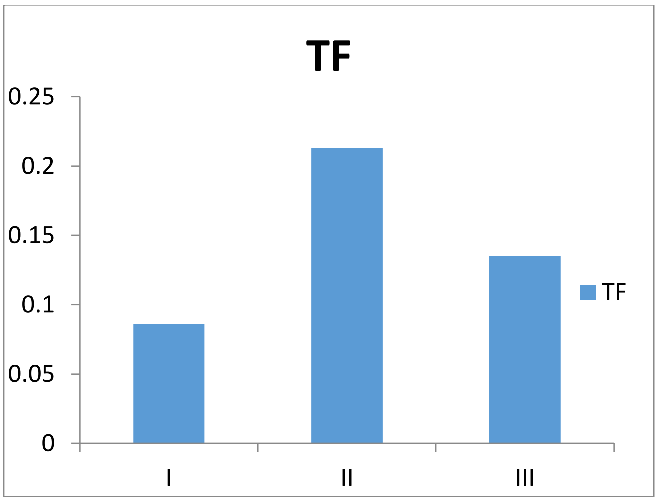

Fig 3: Transfer Factor

I = represent TF from soil I to plant I

II = represent TF from soil II to plant II

III = represent TF from soil III to plant III

From the chart above we can deduce that the transfer factor for II (soil II to plant II) has the highest TF. This means that plant II absorb more Pb than I and III from the soil. It has been found that plant II and soil II has the highest TF value (0.213) in the *Amaranthuscaudatus* with plant I and soil I has the lowest TF value (0.086). The trend of concentration of Pb follows plant II and soil II> plant III and soil III> plant I and soil I. This could be attributed to the high retention of the metal in the soil.

The high TF for heavy metals through leafy vegetables does not present the risk associated with the metals in any form (Sridthara Chary *et al.*, 2008). The availability of a metal species in its different forms to migrate from the soil through the plants part and makes itself available for consumption was represented by the transfer factor as seen in the tables (5.0, 5.1 and 5.2) above. The transfer factor is a function of different factors such as soil, pH, soil organic matter, metal availability and soil particle size.

CONCLUSION

At the end of this research the level at which *Amaranthuscaudatus* absorb heavy metals (Pb) from the soil was known and compared. The transfer factor (TF) of these heavy metals was also calculated. The result also shows that *Amaranthuscaudatus* has the ability to phytoremediate this heavy metal to a small extends.

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