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Heavy metal pollution of dumpsite soil of Kogi State University, Ayangba

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ABSTRACT

The research aims to assess the local addition of selected heavy metals (Pb, Cd, and Cu) when dumpsite soil is used as a soil amendment and the ability of Amaranth (NH536–1) to phytoremediate the soil. It was a pot experiment conducted at Kogi State University's Faculty of Agriculture in Ayangba. The soil samples were collected from a dumpsite and arable soil. The dumpsite soil application to the arable soil was at different rates:10kg Arable soil (Treatment 1, control), 8kg Arable soil+ 2kg Dumpsite soil (Treatment 2), 6kg Arable soil+ 4kg Dumpsite soil (Treatment 3), 4kg Arable soil + 6kg Dumpsite soil (Treatment 4), 2kg Arable soil+ 8kg Dumpsite soil (Treatment 5) and 10kg Dumpsite soil (Treatment 6). The result shows that the concentration of heavy metals: Lead (Pd), Cadmium (Cd), and Copper (Cu) increased significantly as the concentration of dumpsite soil increased. Lead (Pb) has the highest concentration, while copper (Cu) has the lowest concentration. The result also shows that the plant's metal concentration depends on their concentration in the habitual soil environment. Thus, the Amaranth was able to show phytoremediation potential on soil heavy metals content. The trend of Amaranth potential phytoremediation heavy metals from the soil is in the sequence Lead Pb> Copper (Cu) >Cadmium (Cd).

1.0. Introduction

Sustainable agriculture is the integrated agricultural production system with a site-specific application that will, over a long period, satisfy human food and fiber needs. It also enhances environmental quality and natural resources in which the agricultural ecosystem depends, makes efficient use of the non-renewable resources, and integrates, where appropriate, natural biological cycle and control (Gold, 2009). Organic farming holds a special place under sustainable agriculture. Hue *et al.* (2000) emphasize that sustainable agriculture involves using organic material as a soil amendment and a source of plant nutrients. According to Davis and Whiting (2013), soil amendment is any material added to the soil to improve its physical properties such as water retention, permeability, water filtration, drainage, aeration, and structure. Soil leached out its essential and necessary element during long-term plantation and crop production (Abbott and Muruphy, 2007). Farmers can use several artificial or synthetic fertilizers to cultivate a field entirely in a few periods or enhance soil fertility. However, Partha *et al*. (2011) noted that inorganic fertilizers are water-soluble and can be leached or washed away if there is rainfall shortly after they are applied, which could pollute stream, pond, and other body of water which in extreme cases leads to the death of plant and animal life growing in the polluted water. Due to the high cost of chemical/ inorganic fertilizer, it is now standard practice for farmers to search for soil rich in organic manure. Such soils are easily obtained from the dumpsite and used for planting vegetables and food crops.

Dumpsite soil can be used to amend the effect of inorganic fertilizer on the soil. The dumpsite soils, which are a good source of organic material, improve soil's physical properties that allow profitable crop production. Cathy (2012) reported that organic fertilizer enhances soil by improving soil structure, aeration, and moisture retention. It decomposes slowly, preventing run-off or leaching into water bodies, and causes little or no salt build-up. Organic fertilizer includes plant and animal by-products (fish emulsion and hydrolyzed liquid fish, bone meal, cottonseed meal, alfalfa meal, blood meal, feather meal), rock phosphate, seaweed, inoculants, compost, and manure (Jessica, 2014). Small farmers and co-operative farmers produce vegetable crops in old garbage dumpsite in small and large cities worldwide where improper management of municipal waste exists to their manure source (Hemore and Ratta, 1995). Anikwe *et al*. (1999) reported that dumpsite soil within some limits could enhance soil fertility and improve its physical property.

Despite the low industrial and commercial activities in developing countries, their solid waste is not devoid of hazardous substances. Furthermore, excessive input of unsorted municipal/household wastes or use of dumpsite soil in crop production may likely lead to the loading of nitrate and heavy metals in soil and groundwater and may harm soil, crop, and human health. Anikwe *et al*. (2002) also posited that continual disposal of municipal waste in the soil might also increase the concentration of heavy metals in the soil.

Municipal waste in the form of garbage and waste from household and food processing plants has been incinerated or dumped (Amusan *et al*., 1999). These dumps decomposed over time to form organic soil rich in nutrients and used by farmers to cultivate fruits and vegetables without regard to the risk of absorption of toxic heavy metal in the soil. Heavy metal may harm soil, crop, or human health (Smith *et al*., 1996). Based on these facts, this work seeks to determine if dumpsite soil in Ayangba contributes to soil's heavy metal pollution. This study's objectives were to determine the presence and quantity of heavy metals in dumpsite soil used as an organic amendment and determine if Amaranth can be used to phytoremediate heavy metal polluted soil.

2.0. Materials and methods

The research work was conducted between July and September 2015 at the Faculty of Agriculture, Kogi State University, Ayangba. The area location is on longitude 7^0 6' N and latitude 6^0 43' E of the equator, within the southern guinea savanna agro-ecology of Nigeria (Kowal and Knabe, 1992). It is between the warm, humid climate belt zone of Nigeria with a distinctively dry and wet season and in between the wet and dry season is the harmattan (cold) season due to North-East Trade Wind which brings in the harmattan. The topsoil of 0 – 15cm depth was collected from two different locations in Ayangba. One was collected from a dumpsite located opposite covenant lodge off Kogi State University stadium road. It is a significant dumpsite that has been in use for over ten years. The dumpsite is mainly composed of household materials like polythene bags, plastic, body spray can, bottles, food ruminants, used batteries, leaves, metals, paper, old clothes, etc. The second sample (arable soil) was collected beside the National Space Research and Development Agency (NASRDA) proposed complex center for Low Atmospheric Studies near the Faculty of Agriculture, Kogi State University, Ayangba. Amaranth species (NH536-1) sourced from Nigeria Horticulture Research Institute, NIHORT, Ibadan were used in the research work. The treatment consists of two soil sources, the Arable soils (AS) and Dumpsite soils (DS). The soil samples were air dry at room temperature and gently crushed to pass through a 2mm mesh sieve. The experiment was conducted in a plastic pot under open field conditions. Each pot was filled with 5kg of the soil of different treatments. There were six (6) treatments as follow:

Treatment 1 = 100%AS. (Control)
Treatment 2 = 20%AS + 80%DS.
Treatment 3 = 40%AS + 60%DS.
Treatment 4 = 60%AS + 40%DS.
Treatment 5 = 80%AS + 20%DS.
Treatment 6 = 100%DS.

Each treatment was replicated four (4) times in a completely randomized design (C.R.D.) to give a total of twenty-four (24) pots. Seeds were planted and later thinned to two plants per pot two weeks after planting.

Pre-cropping soil samples were collected from both arable and dumpsite soil. At four and eight weeks after planting, soils were collected from all the pots. The soils were analyzed by weighing 5g of each soil sample, and 0.5 ml hydrochloric acid (HCI) was used to extract 50ml and filtered with Whatman paper. After which, the soil extract was analyzed for Lead (Pb), Copper (Cu), and Cadmium (Cd) by Atomic Absorption Spectrophotometer (A.A.S.). The experiment was conducted within eight weeks. At maturity, the plants were harvested and analyzed for heavy metals Cadmium (Cd), Copper (Cu), and Lead (Pb) after washing with water thoroughly such that they were free of soil particles and oven-dried at the temperature of 70^0C. The leaves, stem, and root were ground with ceramic pestle and mortar. 0.5g was weighed in a crucible and put in a muffle furnace at 550^0C for 3 hours. It was removed and allowed to cool at room temperature. Ten percentage (10%) of HF–HNO3–HClO was used to digest the sample and make it up to 500ml with distilled water and filtered with Whatman paper. The supernatant samples (soils and Amaranth) were analyzed for total Pb, Cd, and Cu by an inductively coupled plasma-mass spectrometer (ICP-MS, Agilent 7500a, U.S.A).

2..1 Data Analysis

The data generated were subjected to Analysis of Variance (ANOVA). The statistical software package used was SPSS. The means were separated using the least significance difference (L.S.D.) at $p \leq 0.05$ confidence level.

3.0. Results and Discusion

3.1.Heavy Metal Concentration in Soil at Four (4) and Eight (8) Weeks after Planting Amaranth

This study was carried out to investigate the presence and quantity of heavy metal in dumpsite soil. Table 1 shows the concentration of heavy metals investigated in the pre-cropping soil sample in mg/kg. Lead has the highest concentration, followed by cadmium above the European Union (E.U.) Standard (Appendix 1) of the permissive level of heavy metals in agricultural soil, while copper with the minor concentration is below the permissive level.

3.2 The concentration of Heavy Metal in Soil at Four (4) Weeks After Planting

The result in Table 2 shows the concentration of heavy metal Cadmium (Cd), Lead (Pb), and Copper (Cu) after four weeks of planting. Lead concentration was affected significantly, with T6 having the highest concentration ($P \leq 0.05$) than the rest of the treatments. The lead concentration increases significantly across the treatment from T1 to T6. Cadmium and copper also follow the same trend. The cadmium result shows no significant difference in T2 and T3, T3, and T4, but there is a significant difference ($P \leq 0.05$) between T2 and T4.

3.3 The concentration of Heavy Metals in Soil at eight (8) Weeks After Planting

At week eight, after planting, as shown in Table 3, heavy metal concentrations were also significant ($P \leq 0.05$), following the same trend as Table 2. Lead concentration shows that Treatment 6 had the highest significant concentration (372.88) than the rest of the treatment. Cadmium and copper also follow the same trend, but there is no statistical difference between T3 and T4 in cadmium at a 5 percent significant level (P≤0.05).

Tables 2 and 3 further prove a reduction in heavy metal concentration when compared. However, the concentration varies with treatment from T1-T6, respectively. T6 had the highest concentration in both tables. There is also a reduction in the concentration of heavy metals at the end of the eight (8) weeks of cultivation compared with the pre-sample concentration of 513.00 mg/kg, 104.04 mg/kg, and 17.50 mg/kg for Lead (Pb), Copper (Cu) and Cadmium (Cd) respectively which is above the European Union Standard permissive level of heavy metals in agricultural soil. The reduction in concentration could be a result of plant uptake or leaching. Furthermore, there exists a relationship between the three heavy metals. It was observed from the study that there was a direct relationship among the three heavy metals in the soil as they tend to increase proportionately with an increase in dumpsite soil from T1-T6, and they are all significant (P≤0.05)

Table 1: Pre-cropping Soil Sample (Dumpsite soil)

Elements	Concentration in mg/kg
Lead (Pb)	513.00
Cadmium (Cd)	104.05
Copper (Cu)	17.50

Table 2. Analysis of Concentration of Heavy Metals in the Soil at Four (4) Weeks of Planting

Treatment	Heavy metal (mgkg^{-1})		
	Pd	Cd	Cu
T1	118.12	1.65	16.55
T2	231.00	2.08	34.63
T3	294.25	2.24	44.19
T4	345.08	2.51	56.21
T5	391.38	3.63	83.06
T6	448.00	4.72	93.63
L.S.D ($p \leq 0.05$)	14.95	0.34	3.14

Pb-Lead, Cd-Cadmium, Cu-Copper, AS-Arable soil, and DS-Dumpsite soil

Table 3: Analysis of Concentration of Heavy Metals in the Soil after Eight (8) Weeks of Planting

Treatment	Heavy metal (mgkg^{-1})		
	Pd	Cd	Cu
T1	102.75	0.33	9.26
T2	144.75	1.28	15.56
T3	235.25	1.70	21.83
T4	295.38	1.87	27.83
T5	330.25	2.49	32.06
T6	372.88	3.43	54.89
L.S.D ($p \leq 0.05$)	9.21	0.38	3.15

Pb-Lead, Cd-Cadmium, Cu-Copper, AS-Arable soil, and DS-dumpsite soil

3.4 Heavy Metals Concentration in Plant at Harvest

Table four (4) below presented the concentration of heavy metals accumulated by Amaranth (NH536-1) after eight planting weeks. Generally, concentrations of heavy metal in plants cultivated on dumpsite soils from T2 to T6 were statistically significant and also higher in concentration with an increasing amount of dumpsite soil at a 5 percent level of probability (P≤0.05). T6 was having the highest significant concentration while T1 had the lowest level of probability. It connotes a direct relationship between the concentration of heavy metals accumulated and the concentration of dumpsite soil. Lead and cadmium increase across the treatment (T1 to T6), while in copper, T4 has the highest effective mean, followed by T6 and T5. However, T5 and T6 were not statistically different in lead accumulation; there is no statistical difference between T1 and T2, T2, T3 and T4, T3, T4, and T5.

Nevertheless, there is a statistical difference between T1 and T3, T4, T5, and T2 and T5 in cadmium. The result also shows that there is no significant difference between T1-T5 in copper. The change in the concentration of copper could result from the plant's inability to accumulate more heavy metals. Table 4.4 also showed that Amaranth could phytoremediate heavy metal in soil contaminated with heavy metals. Rehman *et al*. (2013) reported that certain plants (sunflower and Indian mustard seed) could extract/absorb heavy metals from soil.

From the above result, Amaranth was observed to absorb heavy metals (Pb, Cd, and Cu) in the flowing order; Lead>Copper> Cadmium.

4.0 Conclusion

Heavy metal has gained considerable attention as a potent pollutant due to growing anthropogenic pressure on the environment. This study's results reveal the toxic level of the heavy metals analyzed in dumpsite soil used for agronomic

Table 4: Analysis of Concentration of Heavy Metals in Plant after Eight (8) Weeks of Planting

Treatment	Heavy metal (mgkg^{-1})		
	Pd	Cd	Cu
T1	11.06	0.33	0.50
T2	92.63	0.26	9.09
T3	122.14	0.49	9.10
T4	136.62	0.50	10.46
T5	150.88	0.64	9.36
T6	155.60	1.51	10.24
L.S.D ($p \leq 0.05$)	9.44	0.40	1.91

Pb-Lead, Cd-Cadmium, Cu-Copper, AS-Arable soil, and DS-Dumpsite soil

practice(s). According to European Union Standard, the heavy metal concentration of the dumpsite soil used as soil amendment was above the permissive standard for agricultural practice. As such, a farmer in the study area should be discouraged from considering such soil as a source of organic amendment if nothing can be done to remove the soil's heavy metal. The research work also revealed that Amaranth (NH536-1) could phytoremediate heavy metal polluted soil.

5.0 Recommendation

Efforts should be made to discourage the indiscriminate use of dumpsite soil as a soil organic amendment. Future research should pinpoint that all dumpsite soil in the study area should be analyzed for heavy metal pollution. It will further buttress the seriousness or otherwise of soil heavy metal pollution through the use of dumpsite soil in the study area.

References

Abbot, I. K., and Muruphy, D. V. (2007). What is soil biological fertility? Soil biological fertility – A key to sustainable land use in agriculture. Springer, pp 1 – 15, ISEN 9781 – 40206619.1.

Amusan, A. A., Ige, P.V., and Olawale, R. (1999). Preliminary investigations on the municipal waste dump for farming: Paper presented at 25th annual conference of Nigeria's soil science society held November 21 – 25, 1999, Benin City, Nigeria.

Anikwe, M. A. N., Okwonkwo, U., and Aneikwe, N. L. (1999). Effect of changing land on selected soil property in Abakaliki, Nigeria. Boi resource technology 74(1999) pp169-173.

Anikwe, M. A. N., and Nwobodo K. C. A. (2002). Long-term effect of municipal and productivity of site used for urban agriculture in Abakaliki, Nigeria. Bioresource technology 83(2002) pp241- 250.

Cathy, C. (2012). Organic and inorganic fertilizers. Issue: May 2012. Pp112. Phoenic home and garden © 2007 Cities West Inc. 15169n. Scottsdale road suite C310 Scottdale AZ85254.

Chiroma T.M., Ebelewe, R.O., and Hymore, F.K. (2014). Comparative Assessment of Heavy Metal Level in Soil Vegetable and Urban Grey Waste Water used for Irrigation in Yola and kano. International Refereed Journal of Engineering and Science (IRJES). ISSN (online) 2319-183x,(print) 2319-1821. Volume3, Issue (2 February 2014), PP01-19.

Davis, J.G., and Whiting, D. (2013). Choosing a soil amendment. Colorado state university. Extension soil specialist, soil, and crop science. Extension specialist 6/00 ISSN245373 Issue 2. pp5-11

Gold, M. V. (2009). Sustainable agriculture and terms: National Agriculture Library U.S Department of Agriculture 10301 Baltimore Avenue Bestvilles: M O2075 -2351. Special reference brief serial no 94 – 05

Hue, N.V, and Silva J. A. (2000). Organic soil amendment for sustainable agriculture. Plant nutrient management in Hawaii soil. Approach for tropical and subtropical agriculture. Uchida.eds.college of tropical agriculture and human resource. The University of Hawaii. Vol: 3. pp3-10

Hemore, K., and Ratta, A. (1995). The surprising yield of urban agriculture change. The human development magazine of UNDP 4 (1) 123-134.

Jessica, W. (2014). Ten natural fertilizers to improve crop production. CMP (Colorado master gardener program/ yard and garden publication /CMG Garden Note#234© 2013. Colorado State University. Revised Oct 2014.

Kowal, J.M., and Knabe, D.T. (1992). An agro climatology atlas of the northern state of Nigeria. A.B.U press Zaria.

Lacatusu, R. (2000). Appraising Level of Soil Contamination and Pollution with Heavy Metals In Land Information System for Planning Sustainable use of Land Resource. European Soil Bureau Research Report No 4. Office of Official Publication of the European Communities, Luxembourg. Pp 393-402.

Partha, V., Murtha, N.N., and Saxena P. R. (2011). Assessment of heavy metals around hazardous waste disposal site in Hyderabad city (India): natural and anthropogenic implications E3J Environ. Res. Mange., volume 2, issue 2, page 027 – 034.

Rehman, M. M., Kibria, M G., Islam, M., and Osman, K. T. (2013). Enhance accumulation of copper and lead in Amaranth (*Amarantus piniculatus*), Indian mustard (*Brassica juncea*), and *Helianthus annuus*. PM10. 23667546 [PubMed index for MEDLINEN] PMCID 3648544 pp7-18.

Smith, C.J., Hipman, P., and Cook, F.J. (1996). Accumulation of Cr, Pb, Cu, Ni, Zn, and Cd in soil following untreated effluent in Australia. Environ poll.1996:94 (3); pg 317-323