American Journal of Chemistry 2015, 5(1): 40-48
DOI: 10.5923/j.chemistry.20150501.06

Concentration of Heavy Metals in Root, Stem and Leaves of *Acalypha indica* and *Panicum maximum jacq* from Three Major Dumpsites in Ibadan Metropolis, South West Nigeria

Rasaq A. Olowu[1,*], Gregory O. Adewuyi[2], Olumayowa J. Onipede[3], Oladipo A. Lawal[1], Owolabi M. Sunday[1]

[1]Department of Chemistry, Lagos State University, LASU Post Office, Lagos, Nigeria
[2]Department of Chemistry, University of Ibadan, Ibadan
[3]Department of Chemical sciences Bell, University of Technology Ota, Ogun State, Nigeria

Abstract The research was conducted to investigate the levels of some heavy metals Iron, Copper, Zinc, Chromium, Cadmium, Lead and Nickel in the roots, leaves. and stems of *Acalypha indica* and *Panicum maximum jacq* plants growing naturally at Liberty road, Orita-Aperin, and Apata dumpsites in Ibadan metropolis. The analysis was carried out with atomic absorption spectrophotometry to compare trace metal capacity in various parts of the plants and to ascertain the region of accumulation. The obtained result revealed that iron was the most accumulated ranging from 40.1±45 mg/kg to 374±85.3 mg/kg which was followed by zinc with a value range of 27.7±11.8 mg/kg to 100.2±60.3 mg/kg. The level of copper concentration in the plant parts studied was found to between 7.5±5.6 mg/kg and 30±26 mg/kg, Lead and Cadmium were found in only one root of all the samples with a value of 800.5 mg/kg and 7.95 mg/kg respectively. Nickel and Chromium were not detected in any of the plant analyzed. The result showed that the leaves parts of the plants exhibited highest concentrations value compared to the roots and stems However, *Panicum maximum jacq* from liberty had highest concentration in stem >leave> root also *Acalypha indica* in Orita-Aperin had the highest concentration in leave followed by root and then stem. This result shows that leaves consumed by herbivores for a reasonable length of time in a polluted area may be a link to exposure in humans which may pose a health risk.

Keywords Heavy metals Acalpha indica, Bioaccumulation, Dumpsites, Antioxidant, Phytotoxicity

1. Introduction

There have been concerns on uptake of trace metals by plants, leading to bioaccumulation of these metals in plant. Trace metal accumulation may result from mining, smelting, fertilizer, pesticide, atmospheric deposition, municipal and industrial dumpsite, since waste disposal and management has been a bane of most economy of the developed and the developing nations of the world. One of the ways of management of waste include deposit of waste at designated dumpsite. Some of these wastes include metals from electronic materials and other forms of metal containing materials thus leading to accumulation of metals in the dumpsite but they have a long half-life in the environment [1]. Removal of contaminants in soil is a popular practice called phyto-remediation which is the process that utilizes plant to extract and detoxify pollutant in soil and surface water, phyto-remediation involves phyto-filteration, phyto-extraction and phyto-stabilization of heavy metals [2]. Many plants have been found to accumulate trace metals, which are of particular problem for remediation because of the long residence time. At high concentration, some metals have strong toxic effect and are referred to as environmental pollutant [3, 4]. Trace metals like lead, cadmium, manganese and zinc have been classified as neurotoxic metals to children [5], Chromium phytotoxicity has been said to inhibit seed germination, pigment degradation, disturbances in nutrient balance and generation of reactive oxygen species which induces oxidative stress and alteration in antioxidant enzyme activities [6] Lead is the most dangerous heavy metal because of its elevated level in the environment in certain areas [7]. Trace metals are potentially toxic for plant, phytotoxicity may result in plant chlorosis, weak plant growth, yield depression, and they could also result in

* Corresponding author:
raadeolowu@gmail.com (Rasaq A. Olowu)
Published online at http://journal.sapub.org/chemistry

reduced nutrient uptake and disorder in plant metabolism [8]. The sludge time bomb hypothesis states that a slow mineralization of organic in sludge releases metals into more soluble form [9, 10].

Many research articles concerning toxicity of trace metals have paid attention to animals and lower plants such as bacteria but there seems to be insufficient data on impact of toxicity in higher plants. The accumulation of metals in higher plant contributes in no small measure to human exposure [11]. Since plants take up and process metals in soil and in so doing transfer the bioaccumulated metal to herbivores, diseases such as spongiform encephalopathy or prion disease which affect herbivores has been associated with trace metals accumulated in food chain [12]. Trace metals like zinc, copper, are essential for plant growth and human and animal nutrition but can result in phytotoxicity and zootoxicity concerns when accumulated in excess in soil and in plant others such as cadmium, arsenic, mercury, and lead are not essential for either plant or human and animal and pose risk when they enter the food chain [13, 14]. Conversely, effect of polluted soil on crop is significantly different from other species; though the growth of these plants may not be inhibited yet agricultural product harvested from polluted soil have a potential risk to humans due to the concentration of the contaminants exceeding the food sanitation standard or relative environmental quality standard [15]. Hence, to determine the health risk associated with metal contamination in soil we need to predict metal phyto-availability, many of the research done are from plant species which grow from the wild and this research is not an exception, because most of them have excellent capability of accumulating metals [16-18].

Many accumulate them on the root and transport them to the aerial tissues, Dichlorodiphenyldichloroethylene (**DDE**), dioxin and furan have been quantitatively determined in stem leaves and fruits of plants [19]. Studies have also shown that the younger plant but not the older rarely absorb and translocate trace metals [10]. Thus, this research examine the concentration of Iron, Copper, Zinc, Chromium, Cadmium, Lead, and Nickel in leaves stem and root of indigenous plant in three selected dumpsite in Ibadan, Nigeria situated at Liberty, Orita_Aperin and Apata respectively. The study aim at comparing these trace elements capacity in various parts of the plant (root, stem, and leave) so as to determine the region of high metal accumulation within the plant for better prediction concerning food chain contamination and the remediation capacity of the selected plant species.

2. Materials and Methods

Sampling

Liberty dumpsite is located between latitude 7^o, 21-29N and longitude 3^{o}35-41E, Orita-Aperin dumpsite is located between latitude 7^o, 21-24N and longitude 3^{o}31-56E, while Apata dumpsite is located between latitude 7^o, 02-10N and longitude 3^{o}18-33E. The samples were collected randomly from each of the sample sites. The sampling were conducted during the raining season from the month of May to July since water makes nutrient available to plant and research have found that concentration of metals in plant depends on the pH of the soil as well as other physiochemical properties within the surroundings of the plants [10].

Chemicals

Analytical grade reagents and metal stock standards (1000 mg/L) were purchased from Sigma-Aldrich chemical.

Instrumentation

The determination of metals was done with the Buck Scientific 210-211VGP Atomic Absoption Spectrophotometer. The manufacturer's fuel specification, lamp specification, settings and other operational condition strictly was adhered to and the calibration of instrument was done with the analytical grade standard stock solution. The plant samples namely *acalypha indica* and *Panicum maximum jacq* were collected in May 2012 at different points on each of the sample site the plants were identified at the herbarium of the Department of Botany, University of Ibadan and they were stored in different polythene bags before they were transferred to the laboratory the dirt were removed and were air dried.

Sample preparation

Root stem and leave were rinsed twice with tap water to remove dirt and then with de-ionized water and were then air dry until they were dry completely, the samples were chopped into pieces, a representative sample were taken from leaves stem and root and the dry weight were taken. Each of the samples were digested in 3 ml of concentrated 1:1 nitric: perchloric acid until a clear solution was obtained and was made up to 20 mL volume with de-ionized water. The concentrations of heavy metal (Cu, Pb, Zn, Cr, Fe, Cd, and Ni.) in the digested solution were determined with atomic absorption spectroscopy. The average of quadruplets for each treatment and standard deviation were calculated using SPSS [14, 20]. All determination was done in quadruplets and a spike sample was used to verify the accuracy of the procedure.

3. Result and Discussion

Liberty Dumpsite

See Table (1) and Chart (1)

Table 1. Showing the concentration of Zinc in different dry weight parts of *Panicum maximum jacq*

Part	mg/kg	mg/kg	mg/kg	mg/kg	Average	SD
Root	46.8	36.5	98.1	10.9	48.1	3.4
Leave	60	18.6	40.3	49.8	42.2	1.7
Stem	43.9	42.2	210	13.9	77.5	1.9

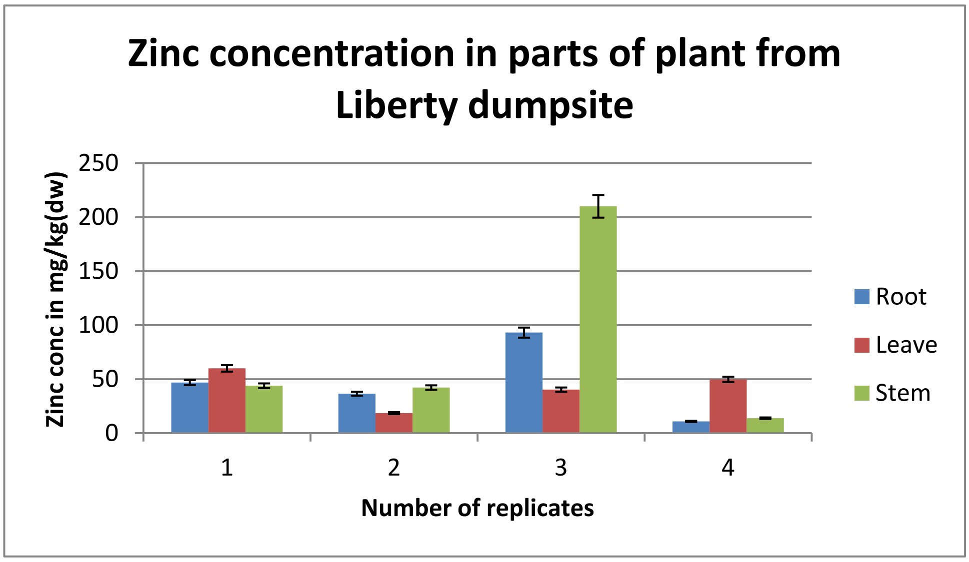

Chart (1). Zinc concentration in parts of plant from Liberty dumpsite

Apata Dumpsite

See Table 2 and Chart (2)

Table 2. Showing the concentration of Zinc in different dry weight parts of *acalypha indica*

Part	mg/kg	mg/kg	mg/kg	mg/kg	Average	SD
Root	41.3	33.3	ND	37.2	37.3	4.0
Leave	64.5	65.9	24.2	31.9	46.6	2.1
Stem	16.7	19.1	33.8	41.3	27.7	1.2

Key: dw; dry weight. ND; not detected

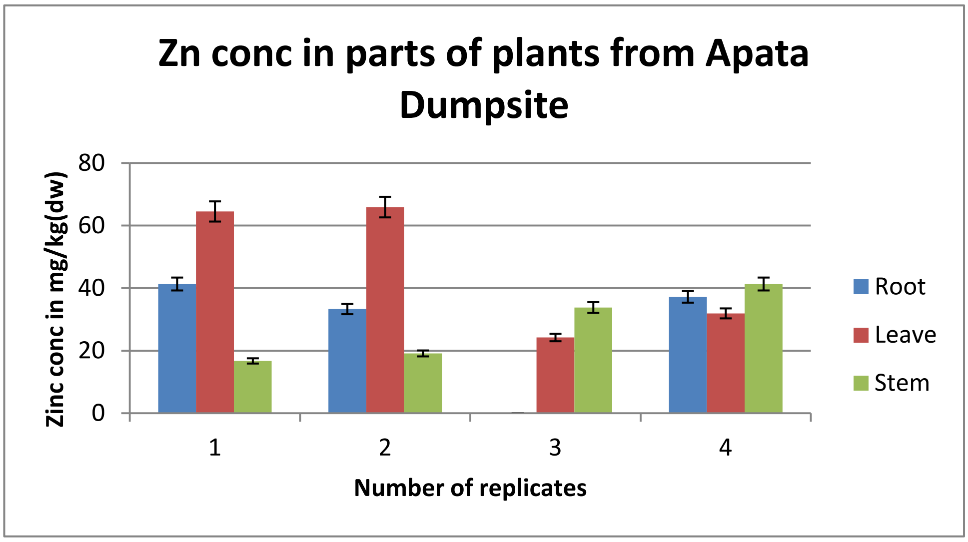

Chart (2). Zinc concentration in parts of plant from Apata dumpsite

Orita-Aperin Dumpsite

Table 3. Showing the concentration of zinc in different dry weight parts of *acalypha indica*

Part	mg/kg(dw)	mg/kg(dw)	mg/kg(dw)	mg/kg(dw)	Average	SD
Root	46.5	39.1	65.3	52.2	50.8	1.1
Leave	55.2	41.3	156.1	148.2	100.2	2.2
Stem	ND	57.6	ND	33.5	45.5	1.7

Key: ND; not detected, ; dw; dry weight.

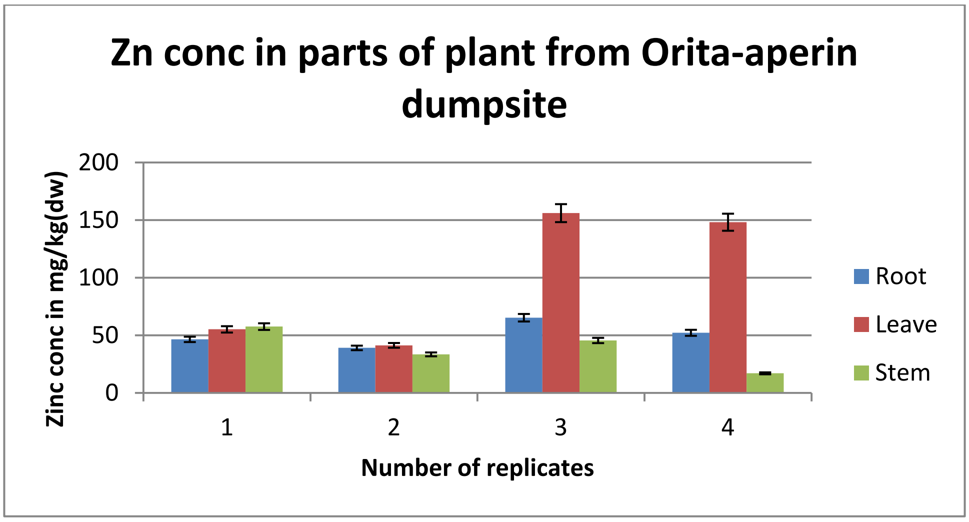

Chart (3). Zinc concentration in parts of plant from Oita Aperin dumpsite

Liberty Dumpsite

See Table 4 and Chart (4)

Table 4. Showing the concentration of Iron in different dry weight parts of *Panicum maximum jacq*

Part	mg/kg	mg/kg	mg/kg	mg/kg	Average	SD
Root	260.5	138.3	ND	ND	199.4	3.6
Leave	811.3	4.5	42.7	ND	286.2	5.5
Stem	ND	ND	37.6	ND	NA	NA

Key: dw; dry weight, nd; not detected, na; not applicable.

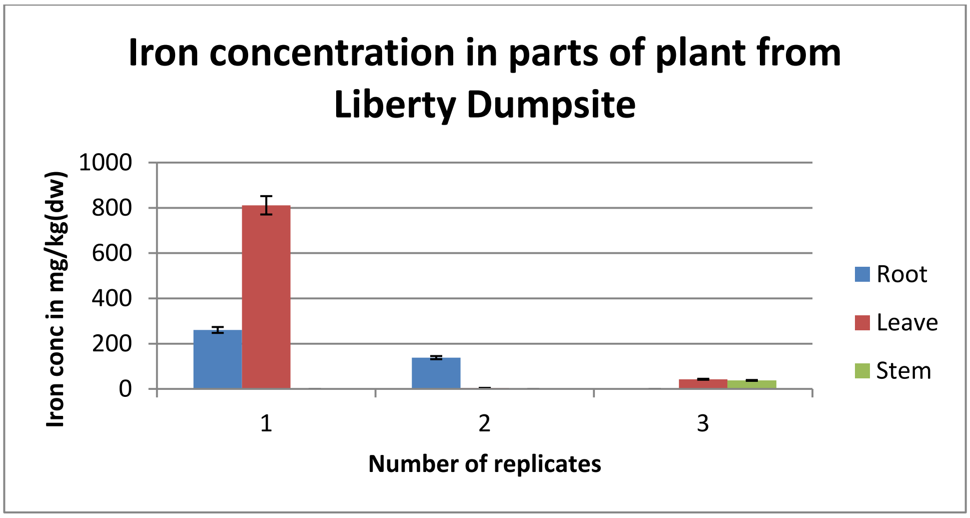

Chart (4). Iron concentration in parts of plant from Liberty dumpsite

Apata Dumpsite

See Table 5 and Chart (5)

Table 5. Showing the concentration of Iron in different dry weight parts of *Acalypha indica*

Part	mg/kg	mg/kg	mg/kg	mg/kg	Average	SD
Root	9.6	91.8	ND	18.9	40.1	4.5
Leave	187	277.8	139.8	213.9	204.6	5.7
Stem	ND	ND	ND	ND	NA	NA

Key: ND; not detected, NA; not applicable, dw; dry weight.

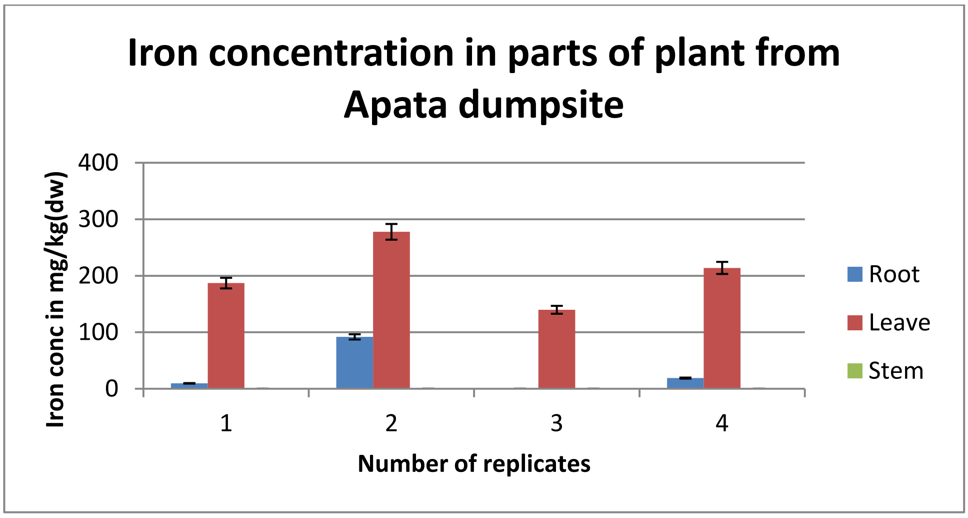

Chart (5). Iron concentration in parts of plant from Apata dumpsite

Orita-Aperin Dumpsite

See Table 6 and Chart (6)

Table 6. Showing the concentration of Iron in different dry weight parts of *acalypha indica*

Part	mg/kg	mg/kg	mg/kg	mg/kg	Average	SD
Root	262	373.2	395.8	468	374.8	8.5
Leave	159.2	221	506.4	535.5	355.5	19.3
Stem	ND	ND	ND	ND	NA	NA

Key: ND; not detected, NA; not applicable, dw; dry weight.

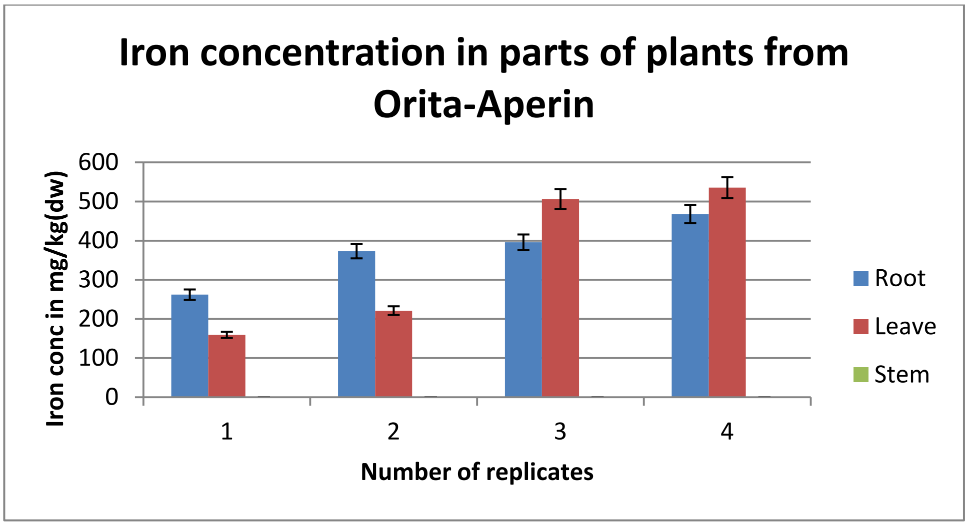

Chart (6). Iron concentration in parts of plants from Orita-Aperin

Liberty Dumpsite See Table 7 and Chart (7)

Table 7. Showing the concentration of Copper in different dry weight parts of *Panicum maximum jacq*

Part	mg/kg	mg/kg	mg/kg	Average	SD
Root	4.0	4.6	14	7.5	0.6
Leave	10.7	ND	18	14.4	1.2
Stem	22.8	ND	ND	NA	NA

Key: ND not detected, NA; not applicable, dw; dry weight.

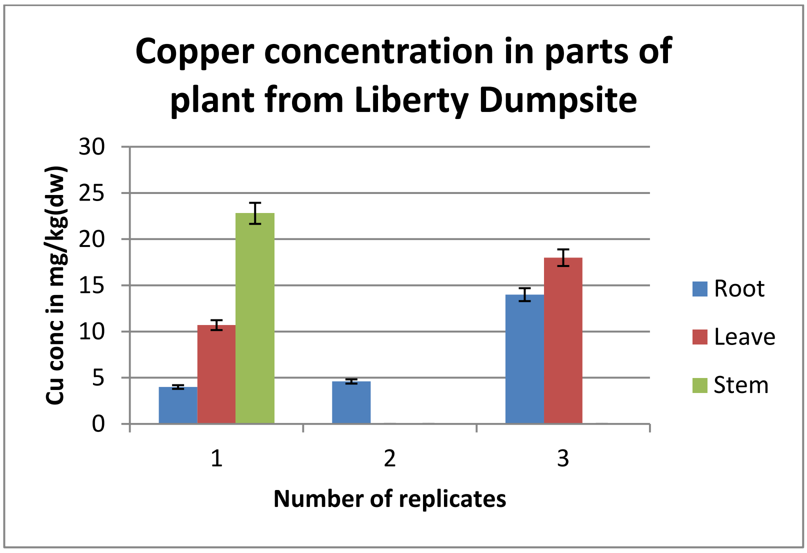

Chart (7). Copper concentration (mg/k) in parts of plant from Liberty Dumpsite

Orita-Aperin Dumpsite
See Table 8 and Chart (8)

Table 8. Showing the concentration of Copper in different dry weight parts of *Acalypha indica*

Part	mg/kg	mg/kg	mg/kg	mg/kg	Average	SD
Root	ND	4.5	ND	25.7	15.1	0.15
Leave	13.1	10.1	66.8	29.8	30	2.6
Stem	ND	ND	ND	ND	NA	NA

Key: ND; not detected, NA; not applicable. dw; dry weight

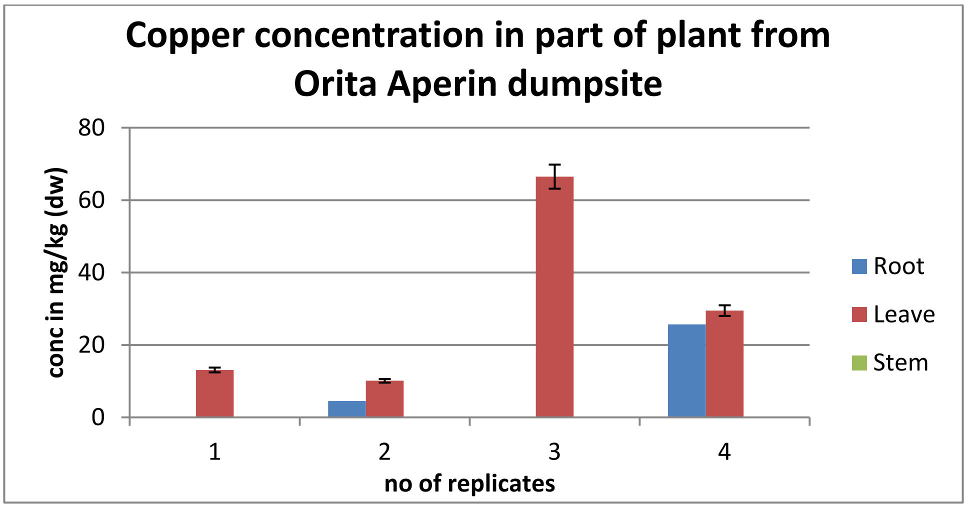

Chart (8). Copper concentration (mg/k) in parts of plant from Orita Aperin dumpsite

Nickel and Chromium were below the detection limit of the atomic absorption spectroscopy (AAS) used to analyzed the samples which was 0.05mg/L and 0.04mg/L respectively. The ability of some plants to accumulate one trace metal may not infer the ability to accumulate the other, since; metals interact competitively during uptake [20]. It has been found that some species of plant can tolerate high concentration of trace elements and they are from the family *caryophyllaceae, brassicaceae, cyperaceae poaceae fabaceae and chenopodiaceae* [21]. These plants which can adapt and survive in contaminated soil containing high concentration of heavy metals have been called excluders examples are *silene vulgaris* and *zea may* have been termed to be nickel excluder while *Hyparrhenia hirta* has been termed copper excluder [22-24]. The knowledge about the ability of different plant species of plant to absorb and transport metals under different condition will provide insight into choosing the these may seems to suggest that *acalypha inidica* do not seems to accumulate nickel and chromium in them.

Iron had the highest concentration in the parts of the plants analyzed, though some were below the detection limit of the instrument, the concentration was between 40.1±45 mg/kg to 374.8±85.3 mg/kg dry weight of the samples. This was more as compared to that obtained by Kamal et al, 2004, on some aquatic plants [25]. Iron concentration seems to concentrate more in the leaves than the stem and root, this could be traced to the fact that iron is a macro nutrient pivotal in plant photosynthesis and its deficiency could produce symptoms such as chlorosis [26]. Zinc has the next highest concentration in plant samples analyzed after iron though some were below the detection limit of the atomic absorption spectroscopy used, it ranges between 27.7±11.8 mg/kg to 100.2±60.3 mg/kg of the dry weight of the samples, and the result is comparable to that obtained by Murray et al 2000 on plants from contaminated site [27]. Zinc is an essential element to plants and studies have shown that total zinc concentration in plant tissues increases as zinc supply increases in both tolerant and non tolerant genotype plant [28]. The mean concentration in stem and leave is about 66 mg/kg [29]. But it could be higher if the soil is contaminated from the result obtained from the plants we could observe that some of them had concentration beyond the aforementioned concentration. Studies have shown that increased cadmium application to zinc deficient plant tends to decrease plant zinc concentration but in plant with adequate zinc supply, zinc concentration are either not affected or increased by cadmium [13].

Copper was the next in concentration to zinc it was in the range 7.5±5.6 mg/kg to 30±26 mg/kg dry weight of the samples but all the plants analyzed at Apata dumpsite had concentration below the detection limit atomic absorption spectroscopy used, the copper concentration obtained was comparable with that obtained by Wei et al 2005 on some plant excluder [14]. Copper is an essential element to plant but it could be toxic to plant if more than 20 mg/kg in the plant [29]. Most of the samples had low concentration of lead as only one root sample had 800.5 mg/kg Pb of the dry weight of the sample, this buttress the fact that only a small part of lead is taken up by root transported to via the xylem to the above ground part of the plant, as lead has a low permeability in most research conducted on plant, even plants with high water permeability showed less permeability to lead [7]. Metals such as lead and chromium have low solubility in soil and show particularly strong barrier even if they accumulate at the root, they are not usually significantly translocated to the leaves fruits and seed [30]. Lead concentration in uncontaminated fresh water plant is between 6.3-9.9 mg/kg and the concentration that is toxic to plant is 27 mg/kg [30] Lead bound to cell wall of plant and render lead ineffective in acting as a strong metabolic inhibitor, lead may accumulate in root more than leave and stem because of it relatively low mobility [31]. Similar trend was that observed in lead was also noticed cadmium as only one root sample had 8.0 mg/kg cadmium per dry weight of the sample though that was the only sample with cadmium yet the result obtained was higher than that obtained by Nabulo 2011 on tropical vegetable grown on amended sewage sludge [32]. Cadmium is potentially toxic to both plant and animal and has no essential biological function and it excessive concentration is undesirable [33]. Cadmium promotes the production of stress ethylene in different species of plant and also rapidly induce synthesis of phytochelatins in plants [33-34]. The uptake and distribution of trace metal especially cadmium varies from species to species, this may be associated with the differences in ability of plant to control the movement of trace metals from xylem to phloem and via the phloem to other parts of the plant [14]. Cadmium competes with copper for uptake in plant. The detection limit of lead was 0.04mg/L while that of cadmium was 0.01mg/L, cadmium concentration in leaves and stem is about 1.9 mg/kg in a normal plant but the value could be higher in contaminated soil [29], concentration in observed in most plant samples in this study was still in the range of the normal but for the one with 8 mg/kg.

4. Conclusions

The result revealed that the plants studied accumulated more of iron, zinc, copper, and less of lead and cadmium and very less of nickel and chromium. It is also noteworthy to know that in most site and both plant studied, the metals studied accumulated most in leaves, followed by root and then stem which may be an indication that the plants bioaccumulate metals more in the leaves which when consumed for a reasonable length of time by herbivores may accumulate in their body thereby increasing the chances of exposure of humans who is at the end of the food chain.

REFERENCES

[1] Adewuyi, G.O., Okonkwo, J. and Okoli, C.P. (2009). Assessment of some heavy metals in soils and waterleaf (*Talinum triangulare*) in the vicinity of major quarry factory in Ibadan metropolis, Nigeria. *Fresenius Environmental Bulletin 18(12):2396-2401*.

[2] Goel, S., Malik, J.A. and Nayyar, H. (2009). Molecular approach for phyto-remediation of metal contaminated sites. *Archives of Agronomy and Soil Science 55(4):451-475*.

[3] Guala, S.D., Vega, F.A. and Covelo, E.F. (2010). Heavy metal concentration in plants and different harvestable parts; A soil-plant equilibrium model. *Environmental Pollution 158:2659-2663*.

[4] Chehregani, A., Malayeri, B. and Golmohammadi, R. (2005). Effect of heavy metals on the developmental stages of ovules and embryonic sac in Euphorbia cheirandenia. *Pakistan Journal of Biological Sciences 8:622-626*.

[5] Zahran, S., Mielke, H.W., Weiler, S., Hempel, L., Berry, K.J. and Gonzales, C.R. (2012). Associations between standardized school performance tests and mixtures of Pb, Zn, Cd, Ni, Mn, Cu, Cr, Co and V in community soil of New Orleans. *Environmental Pollution 169: 128-135*.

[6] Sharmin, S. A., Alam, I., Kim, K., Kim, Y., Kim, P.J., Bahk, J.D. and Lee, B., (2012). Chromium-induced physiological and proteomic alterations in roots of *Miscanthus sinensis*. *Plant Science 187;113-126*.

[7] Wierzbicka, M. and Obidzinska, J. (1998). The effect of lead on seed imbibition and germination in different plant species. *Plant Science 137:155-171*.

[8] Dan, T., Hale, B., Johnson, D., Conard, B., Stiebel, B. and Veska, E. (2008). Toxicity threshold for oat (*Avena Sativa I*) grown in Ni-impacted agricultural soils near Port Colborne, Ontario Canada. *Canadian Journal of Soil Science 88: 389-398*.

[9] McBride, M.B. (1995). Toxic metal accumulation from agricultural use of sludge are USEPA regulations protective? *J. Environ. Qual. 24:5-18*.

[10] Frost, H.L. and Ketchum Jr, L.H. (2000). Trace metal concentration in durum wheat from application of sewage sludge and commercial fertilizer. *Advances in Environmental Research 4:347-355*.

[11] Baldantoni, D., Alfani, A., Tommasi, P.D., Bartoli, G. and DeSanto, A.V. (2004). Assessment of macro and micro element accumulation capability of two aquatic plants. *Environmental Pollution 130:149-156*.

[12] Osundiya M. O., Ayejuyo O. O., R. A. Olowu, Bamgboye O. A. and Ogunlola A. O (2014). Advances in Applied Science Research 5(1), 1-7

[13] McBride, M.B. (2007). Trace metals and sulfur in soil and forage of a chronic wasting disease locus. *Environ. Chem 4;134-139*.

[14] Singh, B.R., Gupta, S.K., Azaizeh, H., Shilev, S., Sundre, D., Song, W.Y., Martinoia, E. and Mench, M. (2011). Safety of food crops on land contaminated with trace elements. *J. Sci-Food Agric. 91: 1349-1366*.

[15] Wei, S., Zhou, Q. and Wang, X. (2005). Identification of weeds of plants excluding the uptake of heavy metal. *Environmental International 31:829-834*.

[16] Neumann, D. and zur Nieden, U. (2001). Silicon and heavy metal tolerance of higher plants. *Phytochemistry 56:685-692*.

[17] Schwartz, C., Gerard, E., Perronnet, J.K. and Morel, J.L. (2001). Measurement of Phytoextraction of zinc by spontaneous metallophytes growing in a former smelter site. *Sci. Total Environ. 279:215-221*.

[18] Peralta-Videa, J.R., De la Rosa, G., Gonzalez, J.L. and Garrdea-Torresdey, J.H. (2004). Effect of growth stage on the heavy metal tolerance of alfalfa plants. *Advances in Environmental Research 8:679-685*.

[19] Mattina, M.J.I., Lannucci-Berger, W., Eitzer, B.D. and White, J.C. (2004). Rhizotron study of cucurbitaceae: Transport of soil bound chlordane and heavy metal contaminants differ with genera. *Environ. Chem.1:86-89*.

[20] Ince, N.J. (1999). Assessment of toxic interaction of heavy metals in binary mixture a statistical approach. *Arch. Environ. Contam. Toxic. 36:365-372*.

[21] Gonzalez, R.C. and Gonzalez-chavez, M.C.A. (2006). Metal accumulation in wild plants surrounding mining wastes. *Environmental Pollution 144:84-92*.

[22] Kabata - Pendias, A. and Pendias, H., 2001. Trace Elements in Soils and Plants, 3rd Edition, CRC Press, Boca Raton, London, 413 p.

[23] Fischerova, Z., Tlustos, P., Szakova, J. and Sichorova, K. (2006). A comparison of phytoremediation capability of selected plant species for given trace elements. *Environmental Pollution 144:93-100*.

[24] Wenzel, W.W., Bunkowski, M., Puschenrerter, M. and Horak, O. (2003). Rhizosphere characteristics of indigenous growing nickel hyperaccumulation and excluder plant on serpentine soil. *Environmental Pollution 123:131-138*.

[25] Poschenrieder, C., Bech, J., Llugany, M., Peace, A., Fences, E. and Barcelo, J. (2001). Copper in plant species in copper gradient in Catalonia (North East Spain) and their potential for phytoremediation. *Plant Soil 230: 247-256*.

[26] Kamal, M., Ghaly, A.E., Mahmoud, N. and Cote, R. (2004). Phytoaccumulation of heavy metals by aquatic plants. *Environmental International 29:1029-1039*.

[27] Kopittke, P.M., Asher, C.J., Blamey, F.P.C. and Menzies, N.W. (2008). Tolerance of two perennial grass to toxic level of Ni^{2+}. *Environmental Chemistry 5:426-434*.

[28] Murray, P., Ge, Y. and Hendershot, W.H. (2000). Evaluating three trace metal contaminated sites: a field and laboratory investigation. *Environmental Pollution 107;127-135*.

[29] Santa-Maria, G.E. and Cogliatti, D.H. (1998). The regulation of zinc uptake in wheat plants. *Plant Science 137;1-12*.

[30] Deng, H., Ye, Z.H. and Wong, M.H. (2004). Accumulation of lead, zinc, copper, and cadmium by 12 wetland plant species thriving in metal-contaminated sites in china. *Environmental Pollution 132:29-40*.

[31] McBride, M.B. (2003). Toxic metal in sewage sludge amended soils has promotion of beneficial use dissented the risk? *Advances in Environment Research 8:5-19*.

[32] Soltan, M.E. and Rashed, M.N. (2003). Laboratory study on the survival of water hyacinth under severe condition of heavy metal concentration. *Advances in Environmental Research 7:321-334*.

[33] Nabulo, G., Black, C.R. and Young, S.D. (2011). Trace metal uptake by tropical vegetable grown on soil amended with urban sewage sludge. *Environmental Pollution 159: 368-376*.

[34] Mohammad, A., Moheman, A. and Seema, A. (2009). The influence of a single and multiple soil contamination of cadmium with lead and zinc on growth, chlorophyll content, uptake and translocation of cadmium in tomato plants. *Archives of Agronomy and Soil Science 55(4):*407-413.