



Mobility and Distribution of Some Selected Trace Metals in Soil from Dumpsite in Lafia, Nasarawa State

Gube-Ibrahim Mercy Ayinya

Department of Chemistry, College of Education
Akwanga, Nasarawa State, Nigeria

Ibrahim Ezekiel Gube

Department of Chemistry, University of Jos,
Plateau State, Nigeria

ABSTRACT

Mobility and distribution of some selected trace metal was carried out using Tessier et al 1979 sequential extraction method and the results obtained shows from dumpsite A, samples taken from 0 – 5cm the result ranges from 0.56 – 21.56%, 0.34 – 40.66%, 1.34 – 29.18%, 0.06 to 45.91% and 0.37 – 12.95% for the exchangeable, Fe – Mn oxide, organic carbonate and residual fractions respectively. For the samples taken from 10 – 15cm at dumpsite A, the results of the fractions are 0.42 – 13.63%, 0.03 – 18.48%, 1.01 – 25.34%, 0.03 – 35.19% and 0.27 – 9.31% for exchangeable, Fe – Mn oxide, organic, carbonate and residual fractions. The results of dumpsite B are 0.48-27.36%, 0.28-40.07%, 2.93-31.15%, 3.87-42.50% and 0.84-30.67% for exchangeable, Fe-Mn oxide, Organic, carbonate and residual fractions for sample taken from 0-5cm while for samples taken from 10 – 15cm the results show 0.32 – 36.38%, 0.23 – 16.49%, 0.53 – 15.83%, 1.53 – 34.88% and 0.04 – 5.27% for exchangeable Fe – Mn oxide, carbonate and residual fractions respectively. The dumpsite C has the concentration of the various fractions ranging from 0.25 – 18.34%, 2.73 to 15.58, 4.02 – 23.28%, 0.07 – 45.25% and 1.57 – 37.43% for exchangeable, Fe – Mn oxide, organic, carbonate and residual for samples taken from 0 – 5cm while for samples taken between 10 – 15cm the concentrations are 0.42 – 12.62% 0.80 – 11.59%, 2.16 – 17.33%, 9.86 – 34.48% and 0.99 – 32.99% respectively.

KEY WORDS: Heavy metals, Mobility, Distribution, Toxicity and Speciation

INTRODUCTION

Over centuries, anthropogenic activities such as mining metallurgical processes, burning of fossil fuels, industrial production and agricultural operations

have resulted in extensive heavy metal contamination which threatens the well-being of the global environment of today. Contamination of heavy metals in the environment has attracted global attention owing to its abundance, persistence and environmental toxicity. Both natural and anthropogenic activities are responsible for the abundance of heavy metals in the environment (Sanchez et al, 2007).

Heavy metals are considerably dangerous due to their toxicity, wide sources, lack of biodegradable properties and accumulative behaviour (mansouri et al, 2012 and Salati et al, 2010). These heavy metals have the ability to enter the human body through inhalation, ingestion and dermal contact absorption (Adelekan, et al, 2011). The toxicity of these metals is a major environmental concern and potentially dangerous because of bioaccumulation. Through the food chain; they tend to accumulate in the soil, water, sediment and organisms because they are not easily degradable. These toxic metals get to human through food chain.

High concentration of these metals causes wide range of diseases in human such as abdominal pain, hypertension, cardiovascular diseases, immune dysfunction, liver disease, anorexia and kidney related disorders as well as various kinds of cancers due to excessive intake in contaminated food and drinking water. For instance, heavy metals such as lead (Pb), Cadmium (Cd) and Arsenic (As) etc are toxic and most especially lead can adversely influence the intelligence development of children, cause excessive lead in the blood, induce hypertension, nephropathy and cardiovascular disease. Research have shown that soil contamination by heavy metals is a serious

environmental problem with significant implication for human health (Yashim, Agbaji, Gimba and Idris, 2016).

These heavy metals are characterized by their toxicity. The complexity of chemical speciation of these metals gives information about their bioavailability, mobility and toxicity which total metal determination alone could not provide the information leading to their availability and mobility.

Dumpsite is where waste materials are disposed and is the oldest form of waste management (Ibrahim et al, 2013). Historically dumpsites have been the most popular method of un-organized waste disposal and remain so in many places around the world. Most dumpsites are located within the vicinity of living communities and wetlands.

This study seeks to determine the mobility and availability of selected trace metals in soil samples from the selected dumpsites.

Materials and Method

All the chemicals and reagents used were of analytical grade (AR) and double distilled water was used throughout the research work.

Study Area

Three dumpsites in Lafia were selected for the research work, because they are the major dumpsites where all the waste in the city are deposited, this involve disposal of metal containing materials. Lafia is the capital of Nasarawa State in middle belt of Nigeria, with the population of 330,712 in habitats according to the 2006 census. The city lies at the latitude $8^{\circ}29'38.04''$ N and longitude $8^{\circ}55.11''$ E.

Sample Collection and Treatment

Soil samples from the three dumpsite were collected using stainless steel scoop into a polyethylene bags previously soaked with dilute nitric acid for 24hrs, rinsed with distilled water and dried. The samples were collected in three different locations of each of the dumpsite and mixed thoroughly to obtain a representative sample at the depth of 0 – 5cm and 10 – 15cm. These samples were then transported to

postgraduate chemistry laboratory and air dried for two weeks at room temperature and grinded with mortar and pestle. The grinded soil sample was sieved using 0.2mm sieve size and bottled in a polyethylene bottles for further treatment.

For the total metal determination, one gram of each of the dried sieve soil from each dumpsite was digested with a mixture of 15ml hydrochloric acid (concentrated) and 25ml nitric acid for 2hrs at 100°C after cooling the mixture was filtered and made up to 50ml with double distilled water and the concentration of these metals were quantified in triplicate which the mean and the standard deviation was computed. The quantification was done using AAS model 7000 series East and West Analytical instrument, after running series of standards to obtained a calibration curve which was used for the quantification of the metals.

For the speciation analysis Tessier et al 1979 method was used as described below.

1. Exchangeable. Each of the three sieved soil samples 1.00g each was extracted using 20ml of 1m MgCl_2 in an orbit mechanized shaker for one hour at a pH of 7, after which the mixture was filtered and the filtrate was analyzed for the selected metals using AAS model 7000 series East and West Analytical instrument.
2. Carbonate fraction: - The residue from fraction 1 was shaken with 20ml 1m CH_3COONa at room temperature for five hours at the pH of 5. The filtrate was analyzed by AAS model 7000.
3. Fe – Mn/Reducible fraction: The residue from the fraction 2 was extracted with 10ml 0.04m $\text{NH}_2\text{OH.HCl}$ and 10ml of 25% CH_3COOH at 96°C for 6hrs. The filtrate was analyzed with AAS 7000.
4. 3.Organic Fraction: - The residue from fraction 3 was extracted with 9ml of 0.02m HNO_3 and 15ml of H_2O_2 at 85°C on a water bath for 5hrs after 2hrs another 15ml of 30% H_2O_2 was added.
5. Residual Fraction: The residue from fraction 4 was extracted using aqua regia (7.5ml of 37% HCl and 2.5ml of 65% HNO_3 at 85°C (Maina et al, 2012). The concentrations of the heavy metals were determined by Atomic absorption spectrometry (AAS) model 7000 East and West Analytical instrument.

Results and Discussion

Table 1: Total metal concentration (mgkg⁻¹)

Sample	Pb	Cu	Zn	Fe	Mn	Cd	Cr
Dumpsite A	1.306 ± 0.05	0.071 ± 0.01	0.950 ± 0.05	0.730 ± 0.05	0.100 ± 0.01	0.25 ± 0.10	0.370 ± 0.02
Dumpsite B	1.501 ± 0.20	0.140 ± 0.01	3.20 ± 0.70	0.43 ± 0.02	6.680 ± 0.30	0.430 ± 0.02	0.460 ± 0.04
Dumpsite C	0.650 ± 0.03	0.214 ± 0.02	3.850 ± 0.40	0.320 ± 0.01	0.320 ± 0.02	ND	0.400 ± 0.03
Dumpsite A ₁₂	ND	ND	ND	ND	0.370 ± 0.02	0.100 ± 0.01	0.430 ± 0.02
Dumpsite B ₁₂	ND	ND	ND	ND	ND	0.22 ± 0.01	0.120 ± 0.01

ND = Not Detected

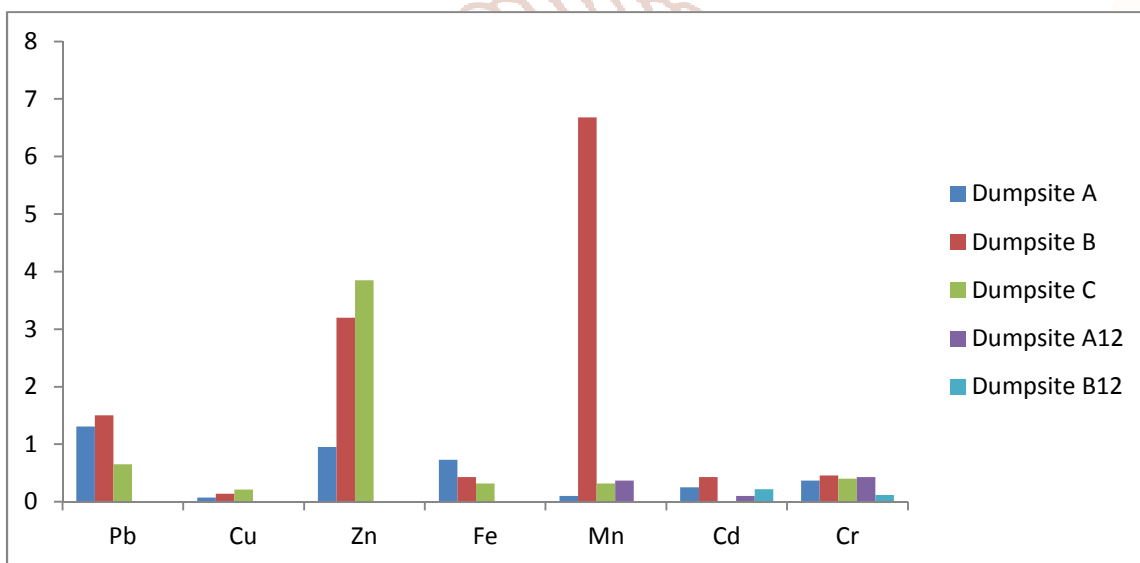


Figure 1 Concentration of total metals in various Dumpsites (mg/kg)

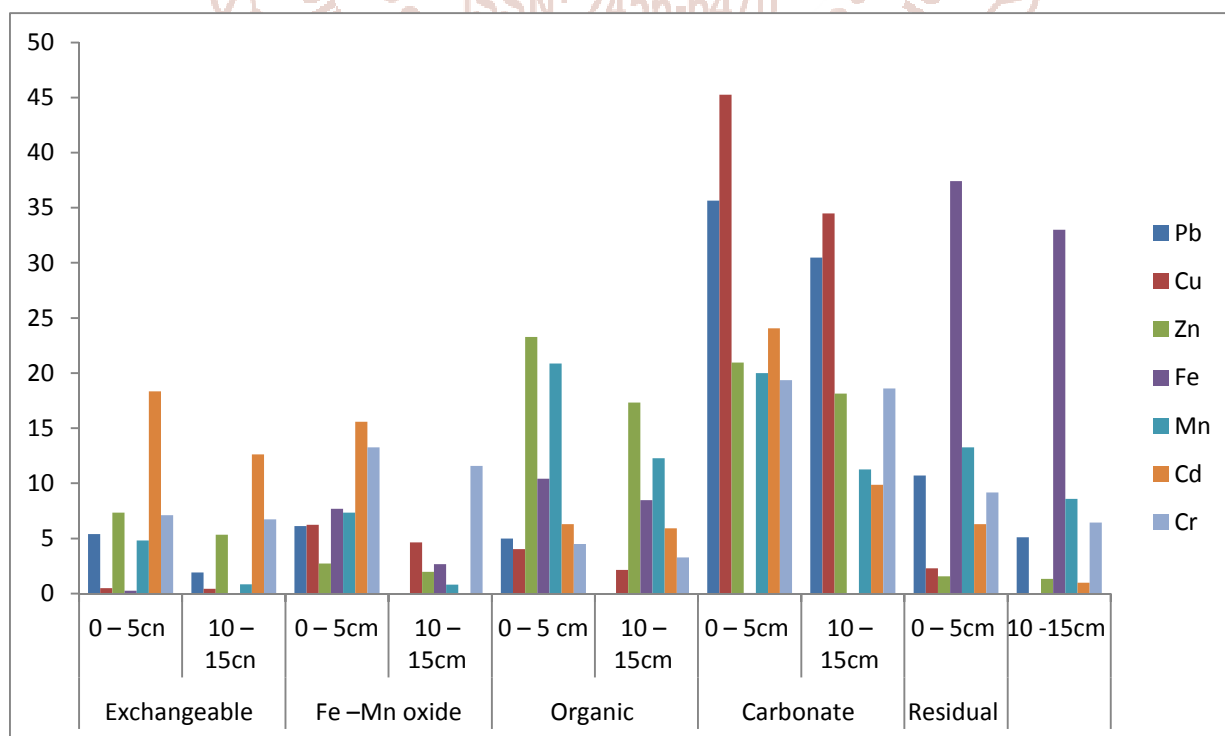


Figure2. Percentage concentration of metals from various fractions in dumpsite A

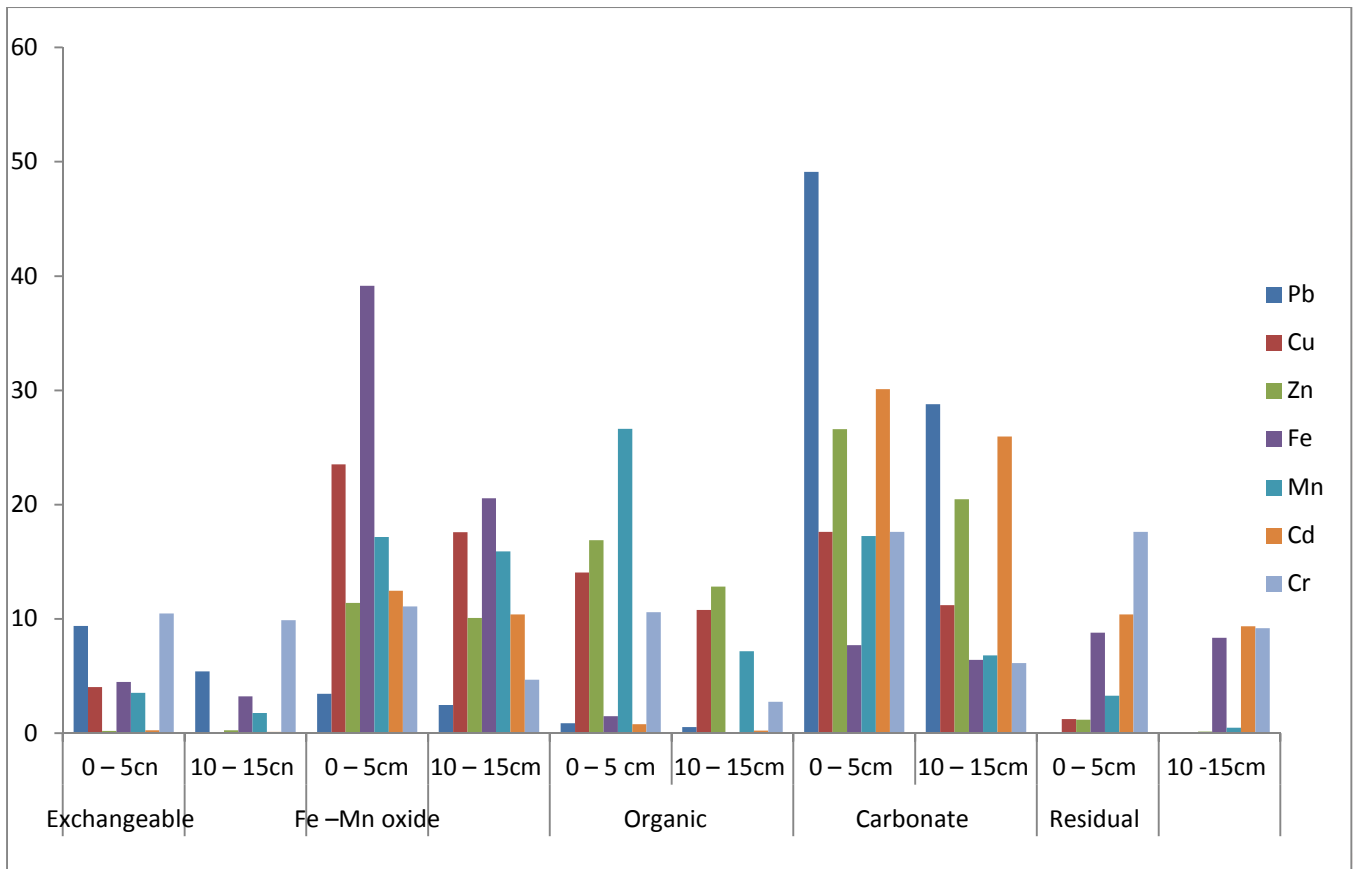


Figure 3 Percentage concentrations of metals in the control dumpsite A

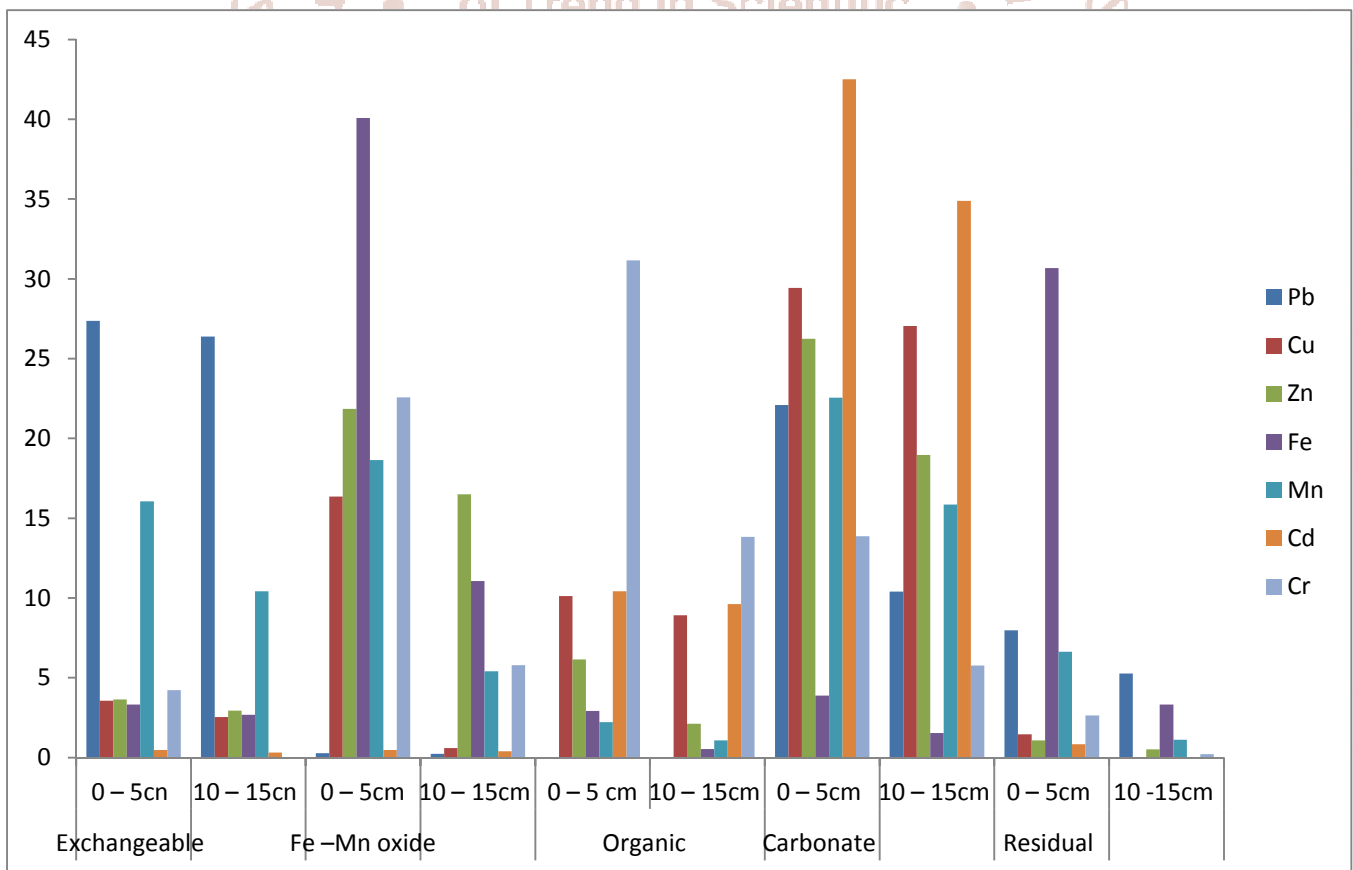


Figure 4 percentage concentrations of various fractions in dumpsite B

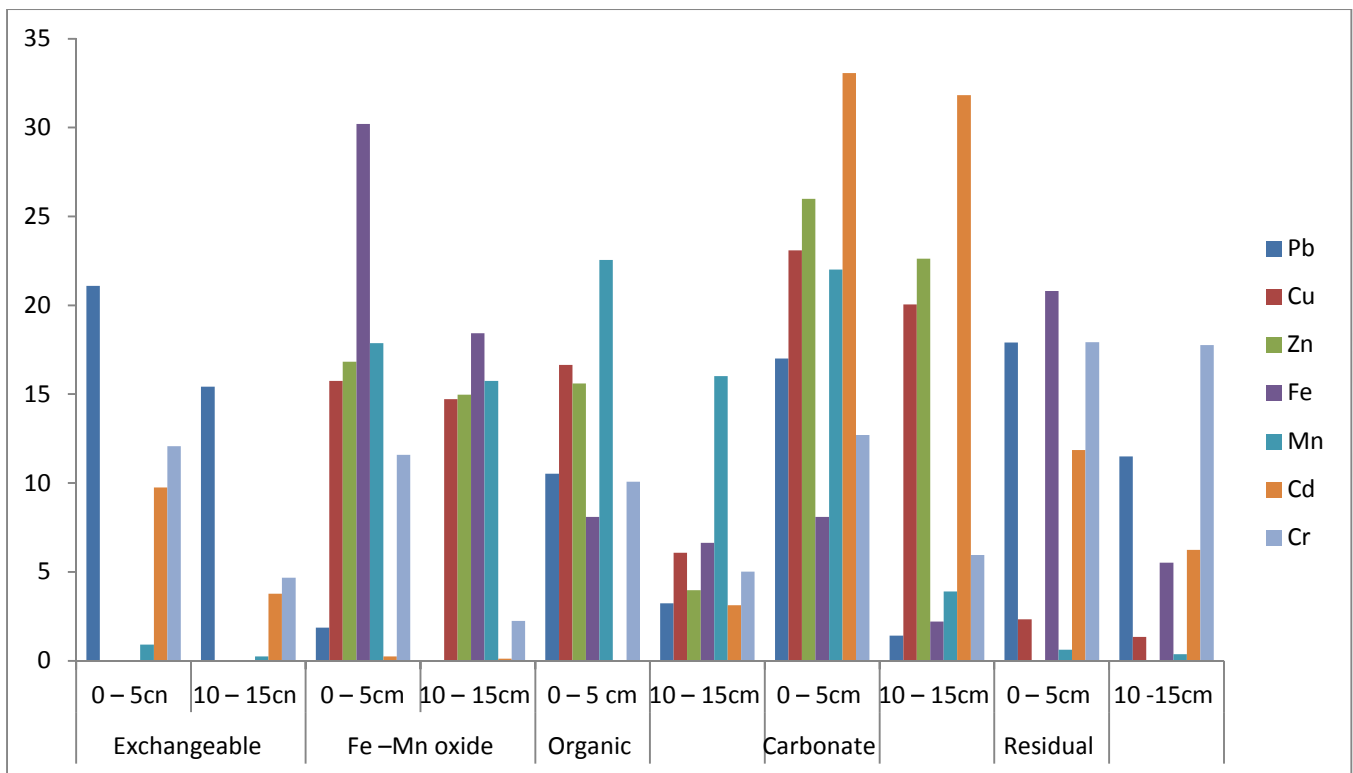


Figure 5 Percentage concentrations of various fractions in control dumpsite B

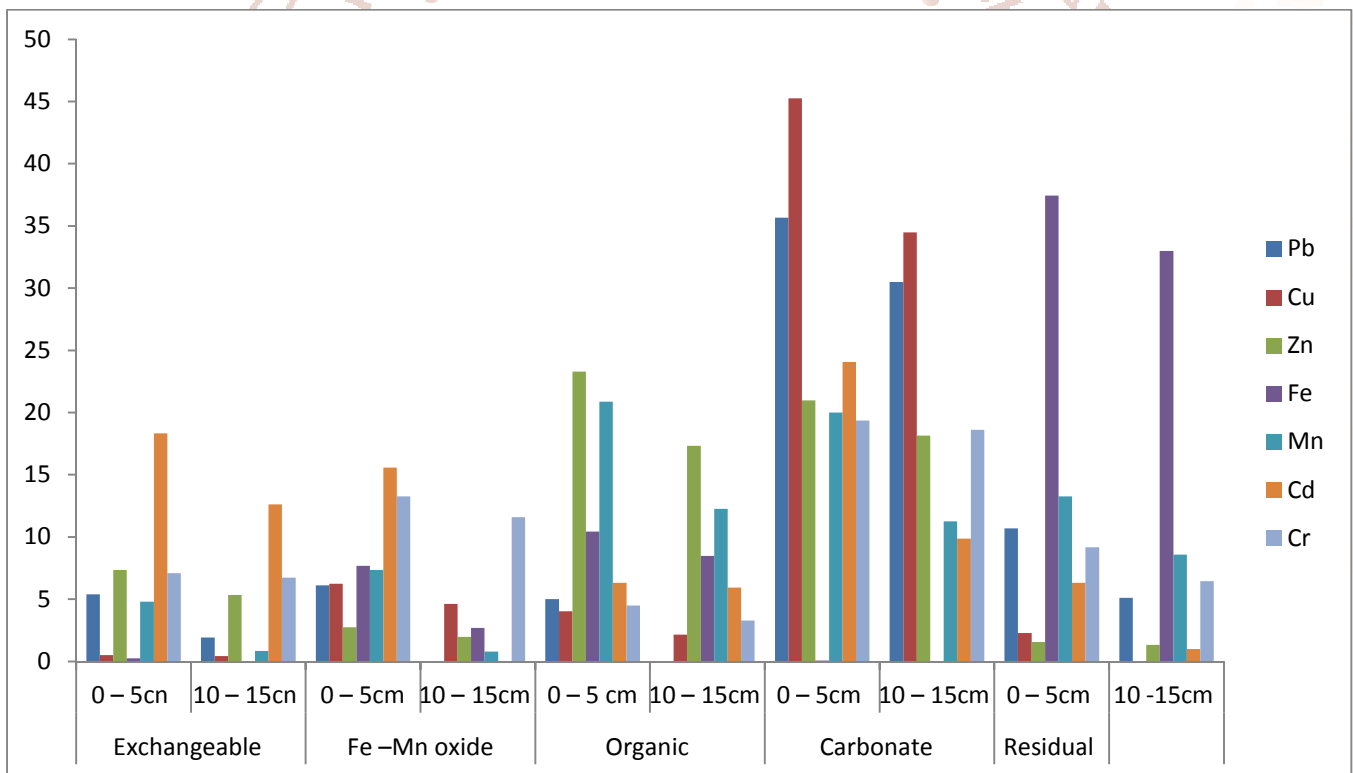


Figure 6 Percentage concentrations of metals in various fractions in dumpsite C

Among the selected trace metals studied (Pb, Cu, Zn, Fe, Mn, Cd, and Cr), in the total metal concentration shown in Table 1, Mn has the highest concentration of 6.680 mg/kg in dumpsite B, and this could be attributed to the nature of the waste deposited in this dumpsite since the control of the same dumpsite B₁₂

shown Mn could not be detected properly because the concentration at which they are found is below the instrument detection limit. Some of the metals such as Pb, Cu, Zn and Fe were both detected in the three dumpsite (A, B, C) but were not detected in the control which suggests the waste dumped in this site

might actually be the source of pollution. Apart from Mn, Zn shows a concentration of 3.850 mg/kg in dumpsite C followed by dumpsite B with 3.20 mg/kg and least with dumpsite A with the concentration of 0.950 mg/kg. Lead (Pb) was also next to zinc with the concentration of 1.501 mg/kg in dumpsite B, followed by Dumpsite A (1.306 mg/kg) and least in dumpsite C with the concentration of 0.650 mg/kg, this could be attributed to combustion of fuel from vehicles since these dumpsites located by the road side. For the control, there is presence of Cd and Cr from both dumpsite A and B control, this could be attributed to deposition by air/wind. Mn was not detected in control B but present in dumpsite B, this suggests that the waste from this dumpsite releases Mn to the soil.

For the distribution of the metals in the various fractions the results show the concentration decreases as the depth increases. For the exchangeable in dumpsite A as shown in figure 2 all the metals studied are available with Cr having the highest percentages 21.66% in 0 – 5cm depth but not detected as the depth increase (10 – 15cm). Lead (Pb) is next with the percentage of 15.84% within the depth of 0 – 5cm and decreases to 13.36% with the depth of 10 – 15cm. From figure 3 for the control, the metals studied were also detected but at low concentration compared to the main dumpsite where this research was carried out, this mean the dumpsites could possible serves as a reaction site for the magnification of these metals which lead to increase in their concentrations. This trend was also reported by Adekola et al, 2012, Fagbote and Olanipekun, 2010). Similarly, other work by Godwin Oladele et al, 2012 reported high concentration of metals such as Pb, Cu, Zn and Fe where this increase was attributed to exhaust from motor vehicles. For dumpsite B as shown in figure 4 similar pattern as in A was observed. The availability and concentration of the various metals, the order of the concentration is as follows: Pb > Mn > Zn > Cr > Cu > Cd with lead (Pb) having the highest concentration and least in cadmium (Cd) but for the control of dumpsite B Cu, Zn and Fe were not detected.

For dumpsite C in figure 6, Zn has the highest concentration followed by lead. From this results it shows that shallow rooted crops can easily pick up some of these metals and bioaccumulate in the crops since their root is mostly at the surface of soil.

For Fe – Mn oxide fraction, dumpsite A show the highest values of Mn and Fe, this agreed with the work of Uba et al., 2008 who attributed higher values to the precipitating amorphous, hydrous oxides of manganese during the ageing of the dumpsites (Staelens et al., 2006). For the control Zn has the highest value followed by manganese, this result disagreed with the result of Olutona et al., 2012 who reported higher values of Mn associated with carbonate fraction. For dumpsite C the order of concentration is Zn > Pb > Fe > Mn > Cu > Cr > Cd which agreed with the work of Fagbote and Olanipekun (2010) who discovered Zn to be the highest in the Fe – Mn oxide fraction.

For organic fraction dumpsite A showed the highest value of Iron (Fe) (29.18%) followed by Pb, Cd and Zn 17.32% and 19.91% but the control has Zn to be highest with the value of 16.89% followed by manganese. For dumpsite B lead was not detected in this fraction but chromium has the highest concentration of 31.15%. For the control Mn (22.55%) has the highest within 0 – 5cm depth followed by Cu (16.65%), then Zn (15.60%) but least in iron with the concentration of 8.10% for the depth of 0-5cm but for the depth of 10 – 15cm Mn (16.02%) is the highest and least with Zn (3.98%).

For dumpsite C the order is Zn > Mn > Fe > Pb > Cu > Cr > Cd other researchers reported same pattern (Fagbote and Olanipekun, 2010).

This work also shows that in the carbonate fraction the dumpsite A is in the order of Pb > Cd > Zn > Cu > Cr > Mn > Fe, for the dumpsite A control is in the order of Zn > Pb > Mn > Fe > Cr > Cu > Cd > Fe. For dumpsite B the order is Mn > Zn > Cd > Cu > Pb > Cr > Fe. In the case of dumpsite C the order is Zn > Pb > Cu > Cr > Cd > Fe. Chromium and Iron have a very low value in this fraction. The concentration of iron in this fraction agreed with the work reported by Abdul-salam et al., (2011) which showed relatively low amount of iron in the carbonate fraction. Fagbote and Olanipekun 2010 also reported similar lower amount of iron associated with this fraction.

The last of the fraction which is Residual fraction, most of the metal studied were found and for dumpsite A the order are Mn > Pb > Cd > Cr > Zn > Cu > Fe. For the control Pb was not detected and the order of the distribution is Cr > Mn > Cd > Zn > Fe > Cu. For dumpsite B all the metals studied are available

with cadmium having the least concentration of 0.99% but Zn was not detected for dumpsite C iron has the highest concentration while the order of availability is Fe > Pb > Mn > Zn > Cr > Cu > Cd. Researchers like Effiong and Gilbert 2012 reported similar trend in their work and Wufem et al., 2009 reported same trend in their work with iron having the highest concentration.

In conclusion the primary objective of this study was to determine the mobility and availability of selected trace metals in soil from dumpsite, all the metals studied are available and their concentration decreases as the depth increases and the concentration of these metals are higher in the dumpsite than the control which shows that dumpsite contribute greatly in releasing of metals to the soil.

References

1. Abdul-salam, N, Ibrahim, M.S and Fatoyinbo F.T (2011) Dumpsite in Lokoja, Nigeria. A silent pollution Zone for underground water. *Journal of Waste Management and Bioresources Tech.* pp 21 – 30.
2. Adelekan B.A., Abegude, K.D (2011) Heavy metals contamination of soil and good water at automobile mechanic villages in Ibadan, Nigeria, *International Journal of Physical Sciences* 6 (5) 1045 – 1058.
3. Alloway, B.J (1995) *Heavy metals in soil* John Willey & Sons new York.
4. Effiong, U, Etirn and Gubert, U. Adie (2012) Assessment of toxic heavy metal leaching in top soil samples within the vicinity of a limestone's quarry in South Western Nigeria. *African Journal of Environmental Science and Techn.* Vol. 6(8) pp 322 – 330
5. Fagbote, E.O and Olanipekun, O.E (2010) Evaluation of the status of heavy metals pollution of soil and plant (chromokenaodwata) of Agbabubitmendposit Area, Nigeria publisher by America Eurasian *Journal of Scientific Research* 5(4) 241 – 248.
6. Godwin O.O, Olapeju, G.A and Emmanuel A.A (2012) A study of chemical speciation of metals in aquatic bottom sediments of Aiba reservoir, Iwo, Nigeria, *African Journal of Environmental Science and Tech.* Vol. 16(8) 312 – 321.
7. Ibrahim E.G, Egila, J.N and Gube – Ibrahim, M.A (2013) speciation of some selected trace metals in soil samples from dumpsite in Lafia, Nasarawa State. *Nigeria Journal of Multidisciplinary Research Volume* 5(2) 63 – 73.
8. Maina, H.M, Egila, J.N and Shagai, M.H (2012), Chemical Speciation of Some Heavy Metals in Sediment in the Vicinity of Ashaka Cement Factory Gombe State, Nigeria. *Journal of Research in Environ. Science and Tech.* Vol. 1(7) pp186
9. Mansouri, B, Baramaki, R, and Ebrahim Pour, M (2012) acute toxicity bioassay of mercury and silver on capeotajusca (black fish) *journal of toxicology and industrial health* 28 (5) 393 – 398.
10. Olutona, G.O, Olapeju, G.A and Emmanuel, A.A (2012). A study of chemical speciation of metals in aquatic bottom sediment of Aiba reservoir Iwo Nigeria. *African Journal of Environmental Science and Techn.* Vol. 1. 6(8) 312 – 321.
11. Salati, S and Moore, F (2010) Assessment of heavy metal concentration in the Khoshik River water and sediment shiraz south west Iran. *Environmental monitoring and assessment* 164 (1) 677 – 689.
12. Sanchez IJ. Manino, N, Vanquero, M.C, Ansorena, J and LEgoiuru (2007) Metal pollution by old lead – zinc mines in Urumea River Valley (Basque count Spain) soil, birta and sediment water, air and soil pollution 107 (1) 303 – 319.
13. Tessier, A. Campbell, P.G.C and Blsson, M (1979) sequential extraction procedure for the speciation of particulate trace metals. *Analytical Chemistry* 52 (1) 45 – 53.
14. Uba, S. Uzariu, A, Hanson, G. F. S and Balarabe, M.L (2008) Assessment of heavy metals bioavailability in Dumpsite of Zaria metropolis Nigeria. *African Journal of Biotechnology* Vol 7 (2) 120 – 130.
15. Wufem, B.M, Ibrahim, A.Q. Gim, NS, Mohammed M.AEkanem E.O and Shibdawa, M.A (2007) speciation of heavy metals in the sediments of Gubi dam Bauchi state, Nigeria *Global Journal of Environmental Science* 8(2) 55 – 63
16. Yashim, Z.I, Agbaji, E.B, Gimba, C.E and Idris, S. O (2016) mobility and bioavailability of some heavy metals in soil from selected metals dumpsites in Zaria, Nigeria. *Book of proceeding of the 12th chem Class Conferenc CSN ABU Chapter.*