Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 6, June-2019

Determination of Heavy Metals in Waste Dumpsites in Lafia Town and Environs

Solomon J. Anzene
Department of Science Laboratory Technology,
Nasarawa State Polytechnic, Lafia,
Nigeria

***Abstract*:- The potential threat of heavy metals from urban waste dumpsites to human health has led to many studies to investigate their levels of concentrations of these elements. In this study, ten (10) samples were obtained from the five different zones within Lafia town and environs. The levels/concentrations of these metals were determined using Atomic Absorption Spectrophotometer (AAS) and is aimed at assessing the levels and risk of heavy metals, contamination in waste dumpsites in Lafia and its environs. The analysis revealed that the mean concentrations of Pb (138.456mg/kg), Cd (7.2813mg/kg), Zn (432.296mg/Kg), Se(0.515mg/kg), at the waste dumpsites observed exceeded their WHO/FAO guidelines and geochemical backgrounds reported in the literature. While Pb and Zn were observed in all the sites, Cd and Se were detected in only 3 to 4 out of the 10 sites analysed. However, the concentrations of As, Cr, Fe, Cu, Mn Ni Ba, Co were within tolerable limits and therefore pose no risk. These metals originate from both natural and anthropogenic sources, gradual build-up of toxic metals in the dumpsites. The study recommends putting adequate measures and creating awareness so as to monitor and mitigate any ill effects arising from uncontrolled disposal of wastes to prevent harm to the environment and jeopardizing our health and upsetting the balance of nature.**

Keywords:* *Heavy metals, contamination, concentration, anthropogenic, environment

1.0 INTRODUCTION

All wastes have the potential to cause environment damage. One of the recent global challenges facing towns and cities is solid waste management. The pressure of population growth produces stresses that cause environmental degradation and in particular solid waste thereby polluting air, water and land on which all life so critically depends (Akaeze,2001). Going by the resource and energy demand on the environment and the internal pollution that man inflicts upon himself by inhalation and ingestion of alien chemical substances, man is best described as a chemical factory in terms of materials use and waste.

The most common pollutants found in refuse dumps are heavy metals. These metals enter into our environment from both natural and anthropogenic sources. They contaminate food source and accumulate in both agricultural products and soils and other environmental components through water, air and soil pollution (Kabata-Pendias, 2011).

Soils are the major sinks of heavy metals released into the environment through waste disposals; municipal, medical/pharmaceutical wastes etc; and unlike other organic contaminants which are oxidized to carbon (IV) oxide by microbial action. Most metals do not undergo microbial or chemical degradation, and their total concentrations in soils persists for a long time after their introduction (Zauro et al, 2013).

Heavy metals, sometimes called “trace elements” are typically classified into two major forms including essential and non-essential metals. Essential heavy metals have beneficial role in living things at certain concentration. Some of these important heavy metals include Iron, Manganese, Copper, Zinc, Chromium among others. High concentration of essential metals in biological system could lead to toxicity on the exposed organisms. While others such as Lead, Cadmium, Mercury and Arsenic have no known role in living organisms and as such, they are highly lethal even at low concentration (Sylvester *et al*, 2017).

Heavy metals are elements with high relative atomic mass. The term is common to transition metals such as Cu, Pb, Hg, As, Zn, Cr, Fe (Ali *et al*, 2005). These metals cause environmental pollution from a number of sources including dumpsites where leaching of metals ions from soil into lakes rivers by rain occur. Heavy metals are non-biodegradable pollutants which eventually bioaccumulate in the environment and may be concentrated in food chain.

Lafia, being a major city in North Central Nigeria is faced with waste disposal problems near residential areas and other public places. Therefore it is a common site to find huge dumpsites within residential areas along major and minor roads.

Poor waste management, improper collection and disposal of refuse are among the key factors responsible for the multiple of problems threatening the Nigeria’s environment (Iwegbue *et al* ,2007). Many heavy metals, Pb, Hg, As, Cd, Ba, Ag which are known poisons are present in wastes.

Most of the heavy metals enter the food chain via plant uptake. Vegetables absorb these metals from the ground, as well as from deposits on the parts of vegetables exposed to air from polluted environment.

Many inorganic can accumulate in plants and result in toxic effects to animals and human, such as anaemia and kidney malfunctioning. Hence due to various devastating effects of heavy metals in human, it is significant to ascertain the levels of these heavy metals contamination and advice the Government and populace of the danger and ways of mitigating them.

Heavy metals are natural constituents of the earth’s crust and human activities have drastically altered or changed the balance, biochemical and geochemical cycles of some heavy metals. Environmental pollution, is a result of man’s

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 6, June-2019

increasing activities such as improper waste disposal due mainly to the significant increase in economic activities and industrialization (Sanayei *et al* ,2009). Due to the accumulation of heavy metals in biological systems through contaminated water and soil, therefore a better understanding of heavy metals sources, their accumulation and their effect of their presence in water, soil and plant system is important particularly on risk assessment.

2.0 MATERIALS AND METHODS

2.1 Study area

The study area is Lafia metropolis with about fifty neighbhoods. Lafia is the capital of Nasarawa State which is located in the Middle Belt Region of Nigeria. The state lies between longitude 7° and 9° 37`E of the Greenwich Meridian and has an absolute of 181.5m above sea level (Akwa *et al*,2007).

Lafia is located within the geological Afo Younger Granites complex within the Middle Benue Trough. Afo younger granite complex is the younger granite complex in Nigeria. The Younger Granites are distinctive series of alkali feldspar granite hosting minerals like cassitterite, columbites as major minerals. Lafia which is the last segment of the Middle Benue trough is underlined by basement complex rocks and has appreciable layer of sedimentation notable for water detention (Okegye,2010).

2.2 Sample collection and preparation

Soil samples (wastes) of topsoil (0-12cm) were collected from dumpsites in each of the five zones of Lafia metropolis (North, South, East, West and Central). Composite samples were made out of them in a polyethylene bag and taken to the laboratory for analysis. The samples were air dried, ground to pass through a 2mm sieve using mortar and pestle.

2.3 Determination of pH

The pH of the samples were determined by adding 25ml of distilled water to 10g of air dried and sieved soil sample. The mixture was stirred for 10 minutes and allowed to stand for 1hour. The electrode of the pH meter was immersed into the slurry and readings are taken (Obaliagbon *et al, 2006).*

2.4 Digestion of samples

2.0g of the sieved soil samples was digested for 3hours at 85°C in 12ml of aqua regia (3:1 HCl-HNO_3v/v) using a hot plate in a fume cupboard until white fumes are observed. The sample was allowed to cool to room temperature and then dilute with 20ml of 2% Nitric Acid (v/v). The mixture was then transferred into a 100ml volumetric flask after filtering using Whatman No. 42 filterpaper and made to mark with distilled water. The extracts (digested soil waste samples) were analyzed for the heavy materials; Pb, As, Cd, Cr, Fe, Zn, Se, Cu, Mn, Ni , Be, Co; using Atomic Absorption Spectrophotometer (AAS: iCE 3000 series).

2.5 Statistical tools

The results obtained was analyzed statistically by using the Mean (x) Coefficient of Variation (CV) and Standard Deviation(SD).

3.0 RESULTS AND DISCUSSION

Table 3.1 presents the summary of results, the pH, mean concentrations of Heavy metals studied in waste dumpsites from the study area.

Table 3.1 Summary of the pH and mean concentration of heavy metals in waste dumpsites from the study area.

				mg/kg			
Sample/Site	pH	Cd	Pb	As	Cr	Fe	Zn
1	6.32	16.325	239.103	4.551	11.478	2027.155	203.130
2	6.57	ND	ND	6,352	11.489	2166.120	23.895
3	6.12	ND	24.185	2.445	24.243	2728.003	517.925
4	5.94	1.493	401.918	1.002	26.228	2738.008	965.375
5	5.92	4,026	25.490	0.664	14.700	2195.450	197.113
6	5.89	ND	68.660	ND	14.455	2494.340	681.995
7	5.67	ND	16.555	ND	8.823	2691.188	32.555
8	5.87	ND	98.020	0.642	15.168	2821..578	427.548
9	5.90	ND	233.718	0.338	23.668	2966.230	1149.78
10	5.97	ND	ND	4.165	13.558	2673.110	123.640
$\bar{X}$	6.02	7.2813	138.456	2.520	16.381	2550.118	432.296
SD	$\pm$0.25	$\pm$7.934	$\pm$139.28	$\pm$2.254	$\pm$6.082	$\pm$315.992	$\pm$394.171
CV(%)	4.15	108.96	100.60	89.44	37.13	12.39	91.18

			mg/kg			
Sample/Site	Se	Cu	Mn	Ni	Ba	Co
1	ND	48.425	69,890	5.475	2.315	1.590
2	ND	4.390	95.950	0.580	6.331	0.393
3	ND	7.048	191.918	2.188	1.002	4.123
4	0.623	24.430	238.595	1.068	5.612	2.423
5	0.335	10.365	130.590	0.173	7.468	1.405
6	ND	93.153	193.183	3.855	9.331	0.498
7	ND	12.638	160.703	ND	10.201	0.495
8	ND	16.663	237.703	0.800	15.612	1.720
9	0.887	19.428	309.563	1.645	0.365	1.888
10	0.214	16.623	123.513	ND	4.991	1.815
$\bar{X}$	0.515	25.32	175.161	1.973	6..323	1.635
SD	$\pm$0.302	$\pm$26.83	$\pm$73.654	$\pm$1.826	$\pm$4.641	$\pm$1.111
CV%	58.64	105.96	42.05	92.55	73.40	67.95

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 6, June-2019

Key:
$\overline{X}$=mean
SD: Standard Deviation
CV: Co-efficient of Variation
ND:Not Deducted

The pH of the study area ranged from 5.67 to 6.32 with a mean value of 6.02. The slight acidic values might be due to the dumping of acid containing waste materials like batteries on the dumpsites. The overall mean pH indicated acidic soil and this is attributed to industrial pollution of acidic gases, effect of bush burning and the harmattan dust (Esu, 1987). pH is very critical for most metals, since metal availability is relatively low when the pH is around 6.5-7; with the exception of Mo, Se and As; the mobility of metals decreases with increasing pH because of the formation of insoluble hydroxide, carbonate and organic complexes (Iwegbue, 2010).

The concentration of Cadmium range from 1.493mg/kg to 16.325mg/kg with a mean value of 7.2813mg/kg above 3mg/kg the permissible limit or tolerable levels (Kloke, 1979; Kabata,2011). Apart from S1, S4 and S5, Cadmium was not detected in seven dumpsites. Cadmium is very much connected with non-residual fractions of heavy metals and thus makes them mobile and potentially bio-available for uptake by plants (Benedicta,2017). The high concentration of Cd at S1 might be as a result of burning of electronic waste containing Cadmium-Nickel batteries, pigments and paints. Significant concentration of cadmium may have gastrointestinal effect and productive effects on livestock. Jabeen, Shah, Khan and Hayat (2010) also reported that Cadmium causes both acute and chronic poisoning, adverse effect on kidney, liver, vascular and the immune system.

The levels of Cadmium observed in sites 1,4 and 5 were similar to values reported for soils of municipal waste dump in South Western Nigeria (Bamgbose *et al*, 2000).

The concentration of Lead range from 16.555mg/kg to 401.918mg/kg with a mean value of 138.456mg/kg which has exceeded the threshold limit of 100mg/kg (Klobe, 1979). Lead was recorded in all the sites except S2 and S10. The high concentration could be attributed to burning of electronic waste materials such a refrigerators, used computers, cables, printers, photocopy machines, automobile tyres, batteries, air condition among others (Benedicta, 2017).

The high concentration of Pb could be attributed to burning of lead-containing products like scrap metals and batteries. Livestock that graze in these sites are likely to be exposed to health risks with regards to lead toxicity through the consumption of forage grasses growing in this area-Lead is reported to cause liver disorders in livestock especially in cattle. It is also reported that lead causes both acute and chronic poisoning and thus, posses adverse effects on kidney, liver, vascular and immune system.

Lead is a toxic heavy metal, which can be taken up by plant from the soil thereby interfering with the food chain. Lead is reported to exert its most significant effect on the nervous system (Zauro *et al*, 2013).

Lead ingestion has been associated with deleterious effects including disorder of central nervous system and lead is widely known to be toxic even at low concentration especially in young children.

The higher levels of Pb in S1, S4 and S5 might be due to high traffic volume, automobile mechanical workshop area. It could also be due to the use of lead compound (Tetraethyl Lead), an additive in premium motor spirit (petrol) in automobiles and also because of its use in soldering metals and paints. The higher Pb concentrations in the study area maybe as a result of atmospheric deposition from anthropogenic sources including motor vehicle emissions, sewage sludge additions or through other industrial emissions.

The concentrations of Arsenic range from 0.338mg/kg to 6.352mg/kg with exception of S6, S7. The mean concentration is 2.520mg/kg which is far below the permissible limit of 20mg/kg (Kloke, 1979). Arsenic has been implicated in lung cancer, especially when arsenic compound inhaled is of low solubility. It has also been reported to have an effect on the liver by causing a disease termed cirrhosis (Aremu *et al*, 2010).

Chromium concentration range from 8.823mg/kg at S7 to 26.228mg/kg at S4 . The mean concentration of Cr is 16.381mg/kg far below the tolerable levels of 59.9mg/kg (Kabata, 2011), 92mg/kg (Rudnik & Gao, 2003). The high concentration of Cr at S4 could be as a result of the recycling of electronic wastes such as refrigerator, used computers, cables, printers, photocopy machines, automobiles tyres and batteries at the site (Benedicta,2017). The main sources of chromium in these dumpsites include textile materials, photographic materials, chromium steels, ceramics and paper (Iwegbue, 2010). Even in small amount, Cr. Stimulates the growth of agricultural crops, an excess of it however promotes various diseases (Vodyanitskii,2016)

The concentrations of Iron in the waste dumpsites studies ranged between 2027.155mg/kg and 2966.230mg/kg, with a mean value of 2550.118mg/kg, which is below a normal range in soil while S9 having the highest concentrations. Iron is essential to all organisms, cofactor in many enzymes and hence proteins, essential trace metals in human metabolism necessary for oxygen-carrying ability of blood (McBride ,1994).

The major sources of iron in these sites include metallic scraps being co-deposited with domestic wastes. The high concentration of Fe could be partly due to Fe content of Lafia soil and partly due to high content of Fe-based waste materials generated through domestic and industrial wastes. Most of the Fe is bound to organic matter and residuals (Abdus-Salam, 2009).

The concentration of Zinc found in the study area ranged between 23.859mg/kg to 1149.78mg/kg with a mean concentration of 432.296mg/kg far above tolerable level of

300mg/kg(Kabata-Pendias, 2011; WHO/FAO, 2001) for soils. The presence of Zinc in the soil at various sites could be attributed to the occurrence of dry cells in the municipal waste and burning of electronic gadgets (Benedicta, 2017). Zinc is essential to all organisms; cofactor in numerous enzymes; necessary for growth healing and overall health (McBride, 1994).

The concentration of Selenium (0.214-0.887mg/kg) with a mean concentration of 0.515mg/kg was not detected in six out of ten waste dumpsites, however the mean concentration fall above the WHO/USEPA guidelines of 0.01mg/kg with attendant high toxicity at high concentration. Selenium is essential to mammals and plants and aids vitamin E action and fat metabolisms (Mcmurry *et al*, 2010).

The concentrations of Copper ranged between 4.390mg/kg and 93.153mg/kg with a mean value of 25.32mg/kg. However the concentrations of copper fall within the tolerable level of 100mg/kg (Kloke, 1979), with site 6 having the highest concentration. The mean concentration recorded could be attributed to burning of electronics gadgets and other copper-based wastes such as automobile spare parts. Copper is essential to organism, cofactor in redox enzymes and necessary to maintain blood chemistry. However, copper can be toxic at high concentration (McBride, 1994).

The concentrations of Manganese range from 69.890mg/kg to 309.563mg/kg with an average value of 175.161mg/kg below threshold limits of 488mg/kg (Kabata-Pendias, 2011). These concentrations of Mn observed in all the sites are similar to studies reported by Iwegbue *et al*, (2010) on some municipal waste dumps in Nigeria. However Mn is essential to all organisms, cofactor in numerous enzymes and necessary for carbohydrate metabolism and bone formation (McMurry,2010).

The concentrations of Ni were recorded in all the waste dumpsites except S7, S10. The concentrations of Ni ranged from 0.173mg/kg to 5.474mg/kg with a mean value of 1.973mg/kg below the permissible limit of 100mg/kg (Klobe, 1979; WHO/FAO, 1984). Nickel aids in the use of Fe and Cu.

Barium concentration range from 0.365mg/kg to 15.612mg/kg with a mean value of 6.325mg/kg below the tolerable level of 100mg/kg reported (Vodyanitskii, 2016). Barium is highly toxic and no biological function.

Cobalt concentration range from 0.393mg/kg to 4.123mg/kg and a mean concentration of 1.635mg/kg below permissible level of 20mg/kg reported (Iwegbue, *et al 2010*). Cobalt is a cofactor in numerous enzymes and an essential trace element in human metabolism; and a component of vitamin B12.

4.0 CONCLUSION AND RECOMMENDATION

The concentrations of heavy metals in waste dumpsites within the study area were determined using Atomic Absorption Spectrophotometer (AAS). The study revealed that the concentrations of metals in these sites investigated; Pb, Cd, Zn, Se were above the established threshold limits set by WHO/FAO and geochemical backgrounds reported in the literature. Their high concentrations could be attributed to increasing anthropogenic activities arising from waste disposal, burning of electronics wastes and high volume of traffic.

Their concentration posse serious risk to the environment. However, the concentrations of other heavy metals, As, Cr, Fe, Cu, Mn, Ni, Ba Co fall below tolerable limits and of no serious harm to the environment. The study has shown that constant monitoring of heavy metals has become imperative in order to prevent excessive build –up of these metals in humans through the food chain. The study, a baseline information for future work has further shown how by our uncontrolled disposal of wastes, we are in danger of ruining our environment, jeopardizing our health; upsetting the balance of nature and poisoning the air, water, soil on which life so critically depend.

5.0 ACKNOWLEDGMENTS

I wish to express my heartfelt gratitude to TETFund through the Institutional Research Committee (IRC) of the Nasarawa State Polytechnic, Lafia for approval of funds for the research. I am also indebted to the following individuals for the roles they played in ensuring the success of the research. They are: Mr. P.P.Ikokoh of Sheda Science and Technology Complex (SHESTCO), Abuja for technical assistance, Mrs. Charity Nwobodo for typing the manuscript, colleagues of the Department of Science Laboratory Technology and other TETfund Research beneficiaries of Nasarawa State Polytechnic, Lafia for the shared knowledge.

REFERENCES

[1] Abdus-Salam, N; (2009) Assessment of Heavy metals pollution in dumpsites in Ilorin metropolis. *Ethopian journal of Environment studies and management vol. 2(2)*

[2] Adekunle, I.M; and Owolabi, D.A (2003*): International journal of environmental issues.*

[3] Akaeze, C.S (2001), *Solid waste analysis, a research project of Chemistry/Biochemistry University of Uyo, Nigeria.*

[4] Akwa, V.L; Binbol, N.C.,Samaila , K.I; and Markus, N.D. (2007), Geographical perspective on Nasarawa State. *A publication of Geography Department, Nasarawa State University, Keffi, Nigeria.*

[5] Ali, N; Oniye, S.J; Balarabe, M.L and Auta, J; (2005). Concentration of Fe, Cu, Cr, Zn, and Pb in Makera – Drain, Kaduna, Nigeria. *ChemClass Journal Vol. 2,69-73*

[6] Anake, W.U; Adie, G.U; and Osibanjo, O (2009) Heavy metals pollution at municipal solid waste dumpsites in Kano and Kaduna States in Nigeria. *Bull. Chem. Soc. Ethiop. Vol 23(1).*

[7] Anzene, J.S and Malu, P.S (2014) Determination of levels of eight trace metals in ground water sources within and around Lafia metropolis. *International Journal of Innovative science, Engineering and Technology vol. 1;5*

[8] Analytical Assessment of some trace metals in soils around the major industrial areas of North West Nigeria. *Vol.2(6) Trends in Applied Sciences Research*

[9] Aremu, M.O; Atolaiye, B.O; and Labaran, L (2010) Environmental implication of metal

[10] concentrations in soil, plant foods and pond in area around the derelict Udege Mines of Nasarawa State, Nigeria. *Bull.chem.soc.Ethiop 24(3)*

[11] Benedicta, Y. F. M; Emmanuel A; Dzidzo, Y.T; and Frank, N. (2017) Heavy metals concentration and distribution in soils and vegetation at Korle Lagoon area in Accra,

[12] Ghana . *Environmental chemistry, pollution and waste management research Article, cogent environmental science.* Environmental GeoChemistry and Health (2018). Pollution indices as useful tools for the comprehensive evaluation of the degree of soil contamination. *A review Vol. 40 (6).*

[13] Edovi, O.S; and Kpee, F (2010); Index modes assessments of heavy metal pollution in soils within selected abattoirs in Port Harcourt, Rivers State, Nigeria; *Singapore Journal of Scientific Research ISSN 2010-006X.*

[14] Getachew,D; and Hebtamu, D. (2015) Heavy metal pollution of soil around solid waste dumping sites and its impact of Shashemane open landfill, Ethiopia. *Journal of Environment and earth science vol 5 (15).*

[15] Ikpesu, J.E. and Dickson, Y. (2016); Determination of Heavy metals in soils in Nigerian Agip oil company Obiafor/Obrikom Environs. *Journal of Multidisciplinary Engineering Science and Technology (JMEST Vol.3 (2).*

[16] Iwegbue C;M.A; Nwajei; G.E; Overah, C.L; and Ogala, J.E (2010);1) Determination of trace metal concentrations in soil properties of municipal waste dumpsites in Nigeria.

[17] Iwegbue, C.M.A, Enuh, F.N, Isirimah, O.N., and Egun, A.C (2007) Fractionation, characterization and speciation of heavy metals in composts and compost amended *soils, Afr. J. Biotechnol 6(2) 067-078*

[18] Kabata-Pendias , A. (2011). *Trace elements of soils and plants* (4th Ed.)…ppp 28-534CRC Press, Taylor and Francis groupKloke, A, (1979). Content of arsenic, cadmium, chromium, fluorine, lead, mercury and nickel in plants grown on contaminated soils, United Nations -ECE symposium, Geneva. Pp51-53.

[19] McBride, M.B (1994); Environmental Chemistry of soils; Oxford University Press.

[20] McMurry, J; Castellion, N; Ballantime, D.S; Hoeger, C.A; and Peterson, V.E (2010).

[21] *Fundamental of General, organic and biological chemistry, 6th Ed. Practice Hall.*

[22] McLennan, S.M (2001). Relationships between the trace element composition of sedimentary rocks and upper continental crust. Geochemistry, Geophysics, Geosystems Article No. 2000GC000109.

[23] Mirelys, R.A; Alfredo, N; Olegario, N.U, Christenes, W.A; Adriana, M.A; Caroline, N.B, Ygor,

[24] J.A.B (2015); Background concentrations and reference values for heavy metals in soils of Cuba. *Environment Monit Access 187;419 8*

[25] Mustapha, B.J Khalid D.K Zakari, A; (2015) comparative assessment of heavy metals concentration in the vicinity of tannary industries, Kumbotso old dumpsite and river challawa confluence, at Challawa industrial estate, Kano State, Nigeria. *Int. Journal of Innovative research and development;. www.ijird.com vol 4(6)*

[26] Obaliagbon, O.K and Olowoyoba, G.B (2006): "Distribution of some heavy metals in Leachates forms a municipal waste dumpsite". *Paper presented at the international conference on engineering Research and Development, University of Benin, Benin city.*

[27] Okegye, J.I. (2000). Heavy metals pollution from mining practices; a case study of UDEGE MBEKI, A paper presentation at Nasarawa State Polytechnic 3rd ASUP Conference (Unpublished).

[28] Pueyo, M., Mateu, J., Rigol, A vidal, M., Lopez Sanchez, J Rauret, G. (2008) Use of the modified BCR three-step sequential extraction procedure for the study of trace element dynamics in contaminated soils. *Environmental pollution 152 330.341*

[29] Rudnick, R.L & Gao, S. (2003). Composition of the continential crust, treatise on geochemistry. *Treatise on Geochemistry, 3 1-64.*

[30] Sanayei, Y., Ismail N and Talebi, S.M (2009): Determination of heavy metals in Zayandeh Road River, *World Applied Sciences Journal 6(9) 1209-1214;*

[31] Song, Q.J and Greenway, G.M (2006): Kinetic speciation of BCR reference materials. *Intern J. Environ. Anal. Chem 8615). 359-366*

[32] Sylvester, C. I; Sunday, E.B. and Elijah , I. O (2017); Assessment of pollution load indices of Heavy Metals in cassava mill Effluents of contaminated Soil: A case study of small-scale processors in a rural community in the Niger Delta; Nigeria. *Bioscience Methods Vol.8 (1), 1-17.*

[33] Uba, S., Uzairu, A., Harrison, G.F.S, Balarbe, M.L., and Okunola, O.J (2003) Assessment of heavy metals bioavailability in dumpsites of Zaria metropolis, *Nigeria African Journal of Biotechnology 7(2): 122-130*

[34] USEPA (1986): Test Methods of Evaluation for solid waste (USEPA S/W 846 UEPA Washington DC)

[35] Vodyanitskii, Y.N; (2016). Standard for the contents of heavy metals in soils of some states. *Annals of Agrarian Science (14).*

[36] Wang, J., Chen, S, Tion, M., Zheng, X., Gonzales., L., Ohura, T., Massey Simonich, S.L (2012). Inhalation cancer risk associated with exposure to complex polycyclic aromatic hydrocarbon mixtures in an electronic waste and urban area in south china. *Environmental Science and Technology 46 (17),9745-9752.*

[37] Wang., X., Y., Li, Q, B., Luo, Y.M., Ding. Q., Xi, L.M., Ma, J.,M., Cheng, C. L. (2010).

[38] Characteristics of sources of atmospheric polycyclic aromatic hydrocarbons (PAHs) in Shangai, China. *Environmental Monitoring and Assessment.165(1-4); 295-305.*

[39] WHO/FAO. (2007). Joint FAO/WHO Food Standard Programme Codex Alimentarius Commission 13th session , report of the thirty eight session of the codex committee on food hygiene, Houston

[40] Zauro, S.A; Dabai, M.U; Tsafe A.I; Umar, K.J and Lawal, A.M (2013); Extent of some heavy metals contaminator in soil of farmlands around Sokoto Metropolis. *European Scientific journal vol 9(3)*