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ASSESSMENT OF HEAVY METAL CONTAMINATIONS OF SOILS FROM DUMP SITES IN JOS METROPOLIS, NORTH CENTRAL NIGERIA

[1]Odewumi S. C., [1]Ajegba O. Q., [2]Bulus J. A. and [1]Ogbe Idoko

[1]Department of Science Laboratory Technology, Faculty of Natural Sciences, University of Jos, Jos, Nigeria
[2]Department of Geology, Faculty of Natural Sciences, University of Jos, Jos, Nigeria

Corresponding E-mail: sholaodewumi@yahoo.com

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ABSTRACT

A study was carried out to determine the heavy metal contamination of the soils in three refuse dumpsites in Jos metropolis located in Rayfield Resort, Dariye Park and Farin Gada within the Jos-Bukuru Complex of Younger Granite Province of northcentral Nigeria. Six (6) soil samples were collected at depth of 40 cm from the three dumpsites. The soil samples were subjected to X-Ray fluorescence (XRF) analysis to determine the concentrations of heavy metals. The values of heavy metals in the soils from the three dumpsites were found to be: zirconium (382.537-1045.734 ppm), strontium (54.584-185.030 ppm), uranium (8.496-12.055 ppm), rubidium (60.189-111.280 ppm), thorium (13.305-30.138 ppm), lead (26.790-277.342 ppm), arsenic (7.971-27.819 ppm), zinc (129.790-734.643 ppm), copper (31.899-247.048 ppm), nickel (42.454-72.670 ppm), iron (22162.547-64319.262 ppm) and manganese (214.146-449.344 ppm). These heavy metals concentration observed at the dumpsites exceeded the World Health Organization (WHO) permissible limits for soils. The values of Zr, Sr, U, Rb, Th, Pb, As, Zn, Cu, Ni, Fe and Mn in soils from the dumpsites could be attributed to the availability of metal containing wastes at the dumpsites which have eventually leached into the underlying soils. Heavy metals contaminations of soils from the dumpsites as revealed in this study can be associated with the decomposition of domestic and industrial wastes indicating anthropogenic sources. It is also possible that geologic processes such as weathering, leaching and dissolution as a result of acidic conditions with pH values of 4.50 to 5.27 in the soil samples can result to a geogenic sources of metal accumulation.

Keywords: dissolution, leaching, anthropogenic, waste and decomposition

INTRODUCTION

The studies of the determination of waste generation in Nigeria have been reported by Adedibu (1985) and Mbuligwe (2002). The management of compositions of the municipal solid wastes has been affected by many factors (Ogwueleka, 2009; Imam *et al.,* 2008) and recycling of these wastes will help to mitigate the effect in the environment (Agunwamba, 1998; Ogwueleka, 2009). Heavy metals in the soils seem to be mobile (Kuo *et al.,* 1983; Kaasalainen and Yli Halla, 2003) and soils in an environment can be contaminated from a lot of anthropogenic sources (Khan *et al.,* 2008; Zhang *et al.,* 2010 and Basta *et al.*, 2005; Akinwale, 2019).

Refuse dumpsites are located in different areas in Jos due to increase in population (Odewumi *et al.,* 2020). Dumpsite wastes are commonly burnt to get rid of the organic matter while ashes obtained are rich in metal contents due to the non-segregation of the wastes at the dumpsites. Invariably, the burnt ashes are not just from the organic sources but also from the metal constituents of the dumpsites. The burnt ashes are leached into the soil, thereby contaminating both the environment and soils. The present study focused on the determination of heavy metals contaminations of soils from three dumpsites located at Rayfield Resort, Dariye Park and Farin Gada areas within Jos metropolis (Fig. 1).

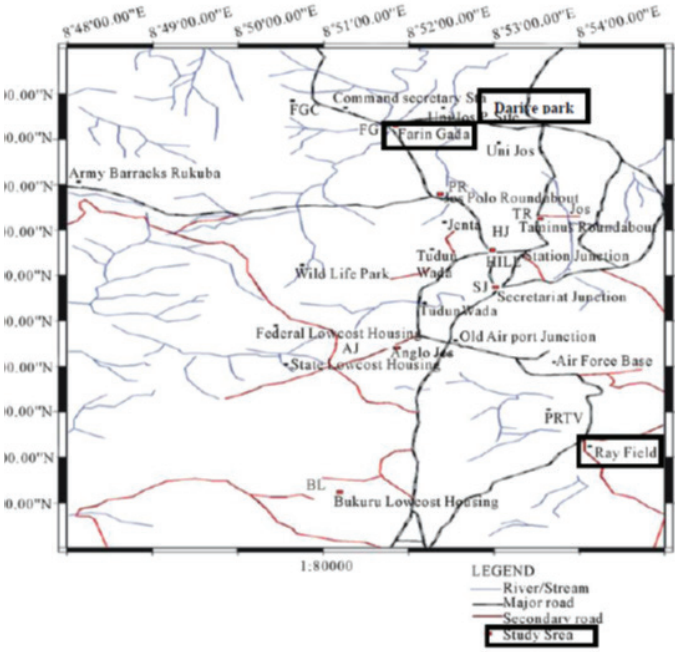

Figure 1: Location map of study area (RayField, Farin Gada and Dariye Park) within Jos Metropolis (Adeniran *et al.,* 2013)

MATERIALS AND METHODS

This present study was carried out in Jos metropolis, Plateau State, northcentral Nigeria. Jos is located between latitudes 9048'00" to 9059'00"N and longitudes 8048'00" to 8055'00"E. The present study was carried out in three solid waste dumpsites located at Rayfield Resort, Dariye Park and Farin Gada within Jos metropolis (Fig. 1)

Soil samples were collected at depth of 40cm from three dumpsites within Jos metropolis namely: (i). Two (2) samples were collected at Rayfield Resort dumpsite on latitudes 09°50'36.2" to 09°50'39.5" N and longitudes 008°54'43.0" to 008°54'55.2"E; (ii). Two samples were collected at Dariye Park dumpsite along Bauchi junction on latitudes 09°57'33.1" to 09°57'33.4"N and longitudes 008°53'20.1" to 008°53'20.5" E and (iii). Two samples were collected at Farin Gada dumpsite on latitudes 09°57'25.5" to 09°57'26.2"N and longitudes 008°51'48.5" to 008°51'48.8" E.

The soil samples were collected by digging for a depth of 40cm in the subsurface at the three dumpsites using a shovel. The samples were placed in different labelled sample bags. The depth of each of the sampling point was measured using a measuring tape. The samples were moved from the dumpsites to the Laboratory for sample preparation and geochemical analysis. The samples were air-dried at room temperature to remove moisture and the dried samples were ground to powdered form using agate mortar and pestle.

Five grams of the ground samples were measured using analytical balance and packaged into different sample bags for geochemical analysis. Six soil samples were subjected to X-Ray fluorescence (XRF) analysis at the Department of Science Laboratory Technology, University of Jos, Nigeria. The pH analysis was also carried out on dried soil samples using a pH meter.

RESULTS AND DISCUSSION

The results of heavy metal concentrations of soils from the three dumpsites are presented in Table 1. Figure 2 shows heavy metals concentrations of soils from Rayfield Resort dumpsite and Figure 3 shows heavy metals concentrations of soils from Dariye Park dumpsite while Figure 4 shows heavy metals concentrations of soils from Farin Gada dumpsite. The Comparison of the values of heavy metals from Rayfield Resort, Dariye Park and Farin Gada dumpsites with FAO/WHO (2001) permissible limits are presented in Table 2.

Molybdenum content in Rayfield Resort ranges from 6.951 to 7.285 ppm, Dariye Park ranges from 7.196 to 14.926 ppm and Farin Gada ranges from 8.18 to 9.365 ppm respectively. Mo values in all three dumpsites are below WHO (2001) permissible unit of 45 ppm (Tables 1 and 2). Zr content in Rayfield resort (471.296 – 482.354 ppm), Dariye park (382.537 - 1045.734 ppm) and Farin Gada (487.296 - 657.573 ppm) dumpsites exceeded WHO permissible unit of 5 ppm in soils (Table 2).

Strontium content in Rayfield Resort (127.452-128.523 ppm), Dariye Park (54.584 - 133.79 ppm) and Farin Gada (121.323 - 185.03 ppm) exceeded WHO permissible unit of 4 ppm (Table 2). Farin Gada sample 2 has a high U concentration of 12.055 ppm while Rayfield Resort 1 has U concentration of 8.496ppm (Table 1) and these values are higher than WHO permissible unit of 3ppm (Table 2). Rubidium concentration in Dariye Park (82.111 - 111.280 ppm), Rayfield Resort (70.162 - 75.654 ppm) and Farin Gada (60.189 - 62.956 ppm) exceeded the WHO permissible unit of 7ppm (FAO/WHO, 2001).

Thorium concentration in Rayfield Resort (26.214-30.138 ppm), Farin Gada (16.045 - 27.129ppm) and Dariye Park (13.305 - 24.278 ppm) exceeded WHO

permissible limit. Mercury was detected in only Dariye Park sample 1 (11.186 ppm) but did not exceed WHO permissible limit (FAO/WHO, 2001). Zinc content in Farin Gada (518.467 - 734.643 ppm), Dariye Park 2(178.924 - 241.411 ppm) and Rayfield Resort (129.790-132.918 ppm) exceeded WHO permissible unit of 50 ppm. Zinc is essential for several functions in the human body (Chasapis *et al.,* 2012; Salako *et al.,* 2016; Marias and Blackhurst, 2009; Garba *et al.,* 2015).

Manganese content of Dariye Park (431.358 - 449.344 ppm), Farin Gada (372.828 - 420.584 ppm).and Rayfield Resort (214.146-215.179 ppm) exceeded WHO permissible unit of 50 ppm (FAO/WHO, 2001). Farin Gada 2 (27.819 ppm) has the highest concentration of arsenic followed by Dariye Park 2 (8.288ppm) and then Rayfield Resort 1 (7.971 ppm). Arsenic concentration in the dumpsites exceeded WHO permissible unit of 0.39 ppm. Nickel concentration in Farin Gada (50.010 - 72.670 ppm), Dariye Park (62.145 - 66.257 ppm) and Rayfield Resort (42.454 – 45.767 ppm) exceeded WHO permissible unit of 35ppm.

Iron concentrations in Rayfield Resort (55365.967-64319.262ppm), Dariye Park (43115.402 - 54106.148 ppm) and Farin Gada (22162.547 - 25082.350 ppm) are higher than WHO tolerance unit of 50 ppm (FAO/WHO, 2001). Iron plays an essential role in the metabolic processes (Sevcikova *et al.,* 2011; Beard, 2001; Izah *et al.,* 2016; Lieu *et al.,* 2001; Iwegbue *et al.,* 2013). Copper content of Farin Gada (171.167 - 247.048 ppm) and Dariye Park 2 (42.540 - 76.135 ppm) are higher than WHO tolerance unit of 36 ppm except in Rayfield Resort with Cu values of 31.899 to 35.354 ppm. Copper is one of the essential heavy metals found in the environment (Prashanth *et al.,* 2015). The concentration of lead in Farin Gada (268.829 - 277.342 ppm), Dariye Park (35.706-56.954 ppm) and Rayfield Resort (26.790 -38.640 ppm) exceeded WHO tolerance units of 5 ppm.

Table 1: Heavy metal concentrations (ppm) of soils from dumpsites within Jos metropolis

Heavy metals	**Rayfield Resort 1**	**Rayfield** Resort 2	**Dariye** Park 1	**Dariye Park 2**	**Farin Gada 1**	**Farin Gada 2**
Molybdenum (Mo)	**6.951**	**7.285**	**14.926**	**7.196**	**9.365**	**8.18**
Zirconium (Zr)	**471.296**	**482.354**	**1045.734**	**382.537**	**657.573**	**487.296**
Strontium (Sr)	**127.452**	**128.523**	**54.584**	**133.79**	**121.323**	**185.03**
Uranium (U)	**8.496**	**ND**	**ND**	**ND**	**ND**	**12.055**
Rubidium (Rb)	**70.162**	**75.654**	**82.111**	**111.28**	**62.956**	**60.189**
Thorium (Th)	**30.138**	**26.214**	**24.278**	**13.305**	**16.045**	**27.129**
Lead (Pb)	**26.790**	**38.640**	**56.954**	**35.706**	**268.829**	**277.342**
Arsenic (As)	**7.971**	**ND**	**ND**	**8.288**	**ND -**	**27.819**
Zinc (Zn)	**129.79**	**132.918**	**178.924**	**241.411**	**518.467**	**734.643**
Nickel (Ni)	**42.454**	**45.767**	**66.257**	**62.145**	**72.67**	**50.010**
Copper (Cu)	**31.8999**	**35.354**	**42.540**	**76.135**	**171.167**	**247.048**
Iron (Fe)	**64319.26**	**55365.967**	**54106.15**	**43115.4**	**25082.35**	**22162.55**
Manganese (Mn)	**214.146**	**215.179**	**449.344**	**431.358**	**372.828**	**420.584**
Mercury (Hg)	**ND**	**ND**	**11.186**	**ND**	**ND**	**ND**
pH value	**5.27**	**5.11**	**4.69**	**4.65**	**4.78**	**4.50**

ND: Not detected

Table 2: Comparison of the values of heavy metals from three dumpsites with FAO/WHO (2001) permissible limits

Heavy metals	WHO Standards	Rayfield Resort	Dariye Park	Farin Gada
Mo	**45**	**6.951 - 7.285**	**7.196-14.926**	**8.180-9.365**
Zr	**5**	**471.296 – 482.354**	**382.537-1045.734**	**487.149-657.573**
Sr	**4**	**127.452 - 128.523**	**54.584-133.790**	**121.323**
U	**3**	**8.496**	**ND**	**12.055**
Rb	**7**	**70.162 - 75.654**	**82.111**	**60.189-62.956**
Th	**15**	**26.214 - 30.138**	**13.305-24.278**	**16.045-27.129**
Pb	**85**	**26.790 - 38.640**	**35.706-56.954**	**268.829-277.342**
As	**0.39**	**7.971**	**8.288**	**27.819**
Hg	**72**	**ND**	**11.186**	**ND**
Zn	**50**	**129.790 - 132.918**	**178.924-241.411**	**518.467-734.643**
Cu	**36**	**31.899 - 35.354**	**42.540-76.135**	**171.167-247.048**
Ni	**35**	**42.454 – 45.767**	**62.145-66.257**	**50.010-72.670**
Fe	**50**	**55365.97 - 64319.26**	**43115.40-54106.15**	**22162.55-25082.35**
Mn	**50**	**214.146-215.179**	**431.358-449.344**	**372.828-420.584**

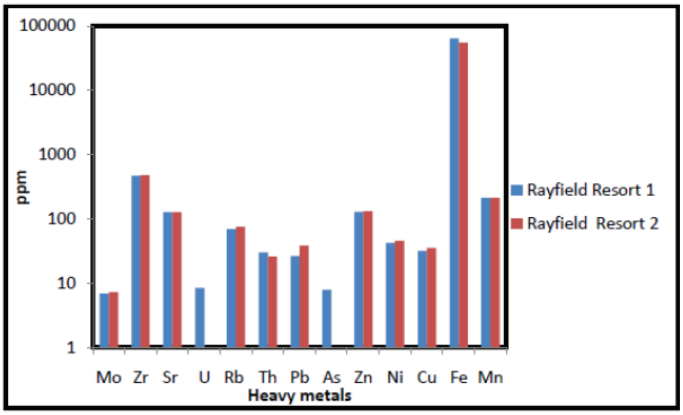

Figure 2: Heavy metals concentrations of soils from Rayfield Resort Dumpsite

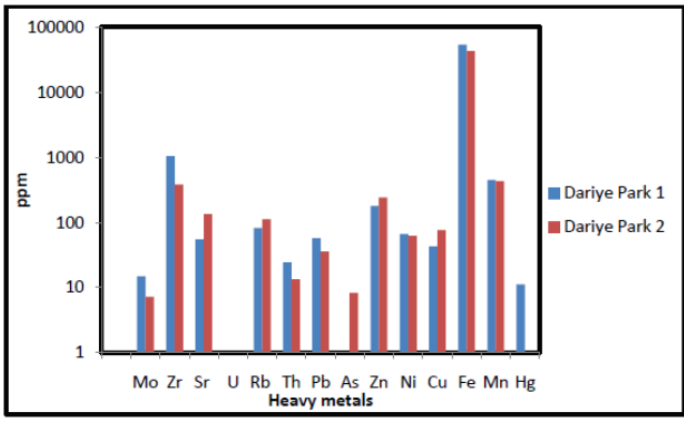

Figure 3: Heavy metals concentrations of soils from Dariye Park Dumpsite

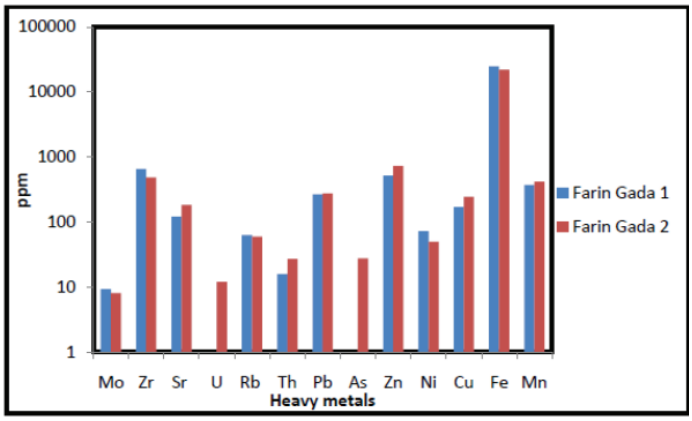

Figure 4: Heavy metals concentrations of Soils from Farin Gada Dumpsite

Heavy metals obtained from the XRF analysis of soils underlying the dumpsites in Jos include: Zr (382.537-1045.734 ppm), Sr (54.584-185.030 ppm), U (8.496-12.055 ppm), Rb (60.189-111.280 ppm), Th (13.305-30.138 ppm), Pb (26.790-277.342 ppm), As (7.971-27.819 ppm), Zn (129.790-734.643 ppm), Cu (31.899-247.048 ppm), Ni (42.454-72.670 ppm), Fe (22162.547-64319.262 ppm) and Mn (214.146-449.344 ppm) respectively. These heavy metals were observed to have contaminated the soils surrounding the dumpsites from anthropogenic and/or geogenic sources. This is similar with the report of Bello *et al.,* (2015) on dumpsite from Katsina where soils were contaminated from anthropogenic sources.

Orudu and Leizou (2017), reported heavy metals values in soils from dumpsite in Yenagoa and stated that the values were within permissible levels. The Pb and Ni values were significantly lower than the values of Pb (26.790-277.342 ppm) and Ni (42.454-72.670 ppm) obtained from three dumpsites within Jos metropolis which were higher than WHO permissible limits and pose a threat to people in the area. Azeez *et al.,* (2011) reported on dumpsite from Abeokuta and showed that Cu, Cr, Mn, and Zn accumulated at soil depths between 0–40 cm while Pb, Fe and Ni were at depths above 40 cm. The Mn values (214.146 - 449.344ppm) obtained from the dumpsites in Jos are lower than Mn value reported by Azeez *et al.,* (2011) while Ni values (42.54-72.670 ppm) from the dumpsites in Jos are higher than Ni reported by Azeez *et al.,* (2011) from Abeokuta. This attests that the soils underlying the dumpsites in Jos were contaminated by heavy metals from the wastes.

Heavy metals contaminations of soils from the dumpsites in Jos resulted from the decomposition of waste from anthropogenic sources resulting in leachate plume that migrated from dumpsites to the soils. This is similar with the report of Dirisu *et al.*, (2019) on heavy metals contaminations on soils of Ewhare Dumpsite (Agbaro-Warri) that was linked to the decomposition of waste that migrated from the dumpsite to the soil. The values of Fe (22162.547-64319.262 ppm) and Pb (26.790-277.342ppm) in the subsurface soils were higher than the values of heavy metals reported by Ukpong *et al.,* (2013) on soils around Uyo Waste Dumpsites

The values of Zr , Sr, U, Rb, Th, Pb, As, Hg, Zn, Cu, Ni, Fe and Mn obtained from the soils underlying the dumpsites within Jos metropolis are attributed to the availability of metal containing wastes at dumpsites in Dariye Park, Farin Gada and Rayfield Resort which have eventually been leached into the underlying soils. This is similar with the report of Ilori *et al.,* (2012) and Awokunmi *et al.* (2015) on dumpsites from Ilesha. The concentrations of the selected heavy metals (Mn, Cd, Cr, Pb and Fe) reported by Ilori *et al.,* (2012) were lower than the WHO maximum permissible limit. This in contrast with Jos dumpsites where the values of Zr, Sr, U, Rb, Th, Pb, As, Zn, Cu, Ni, Fe and Mn exceeded WHO permissible limits

The soils underlying the dumpsites in Dariye Park, Farin Gada and Rayfield Resort have been contaminated with heavy metals and this is indicated by higher concentration of heavy metals obtained in the soils (Table 1). The soil depths where samples were collected occur in the zone of accumulation (Levinson, 1980).

Nickel values (42.454-72.670 ppm) from

three dumpsites in Jos (Table 1) were higher than the soil grand mean worldwide Ni value of 22 ppm reported by Kabata-Pendias and Pendias (2001). Nickel is concentrated in soil horizons rich in organic matter and clays (Lin et al., 2008; Van Hullebusch *et al.,* 2006). Nickel and some other heavy metals are mobile in acid conditions, where dissolution and leaching are more likely to occur (Alloway, 1995). The pH values of the soil samples from the present study shows acidic conditions with pH values of 4.50 to 5.27 (Table 1). This indicates that Ni which is in mobile form could be leading to leaching and dissolution in the area suggesting the contribution of a geogenic source of metal accumulation.

The high concentrations of Pb (26.790-277.342 ppm) and Zn (382.537-1045.734 ppm) obtained at the depth of 30 to 50 cm in the soils underlying the dumpsites in Jos were higher than the soil grand mean worldwide values of Pb (25 ppm) and Zn (64 ppm) reported by Kabata-Pendias and Pendias (2001). Zn is very mobile and bioavailable metal, and the high contents in soil from dumpsites suggests anthropogenic and/or geogenic origin. Pb values (26.790-277.342 ppm) obtained from the dumpsites in Jos were relatively high compared to the soil grand mean worldwide Pb value of 25 ppm. This indicates that the source of Pb contamination could be anthropogenic and/or geogenic sources.

Thus, Heavy metals contaminations of soils from dumpsites can be associated with the decomposition of domestic and industrial wastes indicating anthropogenic sources while geologic processes such as weathering, leaching and dissolution as a result of acidic conditions suggest geogenic sources.

CONCLUSION

The values of Cu, Zn, Fe, Ni, As and Mn from Farin Gada, Dariye Park and Rayfield Resort dumpsites were found to exceed the WHO permissible limits of soils. Higher values of these metals can be toxic to humans and as well damage major organs like liver, kidneys and lung.

The values of Zr , Sr, U, Rb, Th, Pb, As, Hg, Zn, Cu, Ni, Fe and Mn in soils underlying the dumpsites are attributed to the availability of metal containing industrial and domestic wastes at dumpsites which have eventually been leached into the surrounding soils.

Heavy metals contaminations of soils from dumpsites can be associated with the decomposition of domestic and industrial wastes indicating anthropogenic sources while geologic processes such as weathering, leaching and dissolution as a result of acidic conditions suggest geogenic sources

REFERENCES

Adedibu, A.A. (1985). A comparative analysis of solid waste composition and generation in two cities of a developing nation. *Environmentalist. 5 (2): 123-127*

Adeniran, M.A., Ekpo, A.O. and Ibekwe, V.J. (2013). Application of Geographic Information System (GIS) in Internal Security Operations, A case study of Jos Metropolis, Plateau State, Nigeria. FIG Working Week 2013, *Environment for Sustainability. Abuja, 2013.*

Agunwamba, J.C. (1998). Analysis of scavengers' activities and recycling in some cities of Nigeria. Environmental Management. 32 (1): 116-127.

Akinwale, O. C. (2019). Environmental pollution; Types, causes, impacts and management for the health and socio-economic well-being of Nigeria, pp.22

Alloway, B. J. (1995). Heavy metals in soils, 2nd Edition, Springer. pp 384.

Awokunmi, E.E., Asaolu, S.S., Adefemi, S.O. and Gbolagade, A.Y. (2015). Contributions of Municipal Solid Waste to Heavy Metal Concentration in Soil Near Oke Ese Dumpsite, Ilesha, Osun State, Nigeria, *International Jour. of Environmental Protection, l 3: 180-186*

Azeez, J. O., Hassan, O. A. and Egunjobi, P. O. (2011). Soil Contamination at Dumpsites: Implication of Soil Heavy Metals Distribution in Municipal Solid Waste Disposal System: A Case Study of Abeokuta, Southwestern Nigeria', Soil and Sediment Contamination. *An International Journal, 20 (4): 370 - 386*

Basta, N.T., Ryan, J.A. and Chaney, R.L. (2005). Trace element chemistry in residual-treated soil: key concepts and metal bioavailability, *Journal of Environmental Quality, 34 (1): 49 - 63*

Beard, J.L. (2001). Iron Biology in Immune Function, Muscle Metabolism and Neuronal Functioning. *Journal of Nutr.131: 568 - 580.*

Bello, S., Zakari, Y.I., Ibeanu, I.G.E. and Muhammad, B.G. (2015). Evaluation of heavy Metal pollution in soils of Dana Steel limited dumpsite, Katsina State, Nigeria using pollution load and degree of contamination indices. *American Journal of Engineering Research. 4 (12): 161-169*

Chasapis, C.T., Loutsidou, A.C., Spiliopoulou, C.A. and Stefanidou, M.E. (2012). Zinc and human health: An update. *Arch. Toxicol. 86: 521 - 534.*

Dirisu, C.E., Biose, E. and Aighewi, I.T. (2019). Heavy Metal Contamination of Ewhare Dumpsite Environment in Nigeria's Niger Delta. SCIREA Jour. of Env. 3(2): 30 - 45

Food and Agricultural Organization/World Health Organization (2001). Food additives and contaminants. Joint FAO/WHO Food Standards ProgrammeAlinorm, (01/12A), pp 1-289

Levinson, A.A. (1980). Introduction to Exploration Geochemistry. Applied Publishing Ltd.,Wilmette, pp 89-91

Garba, Z.N., Ubam, S., Babando, A.A. and Galadima, A. (2015). Quantitative Assessment of Heavy Metals from Selected Tea Brands Marketed in Zaria, Nigeria. *Journal Phys. Science, 26: 43-51*

Ilori, A. O., Thompson, S. O. and Ajayi, O. O. (2012). Investigation of Heavy Metal Content on Dumpsites Soil and Vegetables Grown: A case study of Ilesha metropolis, Nigeria. *International Journal of Advances in Scientific Research and Engineering, 4(12): 178-184*

Imam, A., Mohammed, B., Wilson, D. and Cheeseman, C. (2008). Solid waste management in Abuja, Nigeria. *Waste management, 28 (2): 468 – 472.*

Iwegbue, C.M.A., Nwozo, S.O., Overah, C.L., Bassey, F.I. and Nwajei, G.E. (2013). Concentrations of Selected Metals inSome Ready-to-Eat-Foods Consumed in Southern Nigeria: Estimation of Dietary Intakes and Target Hazard Quotients. *Turkish Journal of Agric. Food Science Technology, 1: 1–7.*

Izah, S.C., Chakrabarty, N. and Srivastav, A.L. (2016). A Review on Heavy Metal Concentration in Potable Water Sources in Nigeria: Human Health Effects and Mitigating Measures. *Exp. Health, 8: 285–304.*

Kaasalainen, M. and Yli-Halla, M. (2003). "Use of sequential extraction to assess metal partitioning in soils," *Environmental Pollution, 126 (2): 225–233.*

Kabata-Pendias, A, and Pendias, H. (2001).Trace elements in soils and plants, 3rd Edition, CRC Press LLC, pp 413.

Khan, S., Cao, Q., Zheng, Y.M., Huang, Y.Z. and Zhu, Y.G. (2008). Health risks of heavy Metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. *Environmental Pollution, 152: 686-692.*

Kuo, S., Heilman, P.E. and Baker, A.S. (1983). Distribution and forms of copper, zinc, cadmium, iron, and manganese in soils near a copper smelter," *Soil Science, 135 (2): 101–109*

Lieu, P.T., Heiskala, M., Peterson, P.A. and Yang, Y. (2002). The roles of iron in health and disease. *Mol. Asp. Med. 22: 1–87.*

Lin, C., Negev, I., Eshel, G. and Banin, A. (2008). In situ accumulation of copper, chromium, nickel, and zinc in soils used for long-term waste water reclamation. *Journal of Environmental Quality, 37: 1477 - 1487.*

Marias, A.D. and Blackhurst, D.M. (2009). Do heavy metal counter the potential health benefits of wine? *J. Endocrinol. Metab. Diabetes South African, 14: 77–79.*

Mbuligwe, S. (2002). Institutional solid waste management practices in developing countries; A case study of three academic institutions in Tanzania. Resources, Conservation and Recycling, 35(3): 131-146.

Odewumi, S.C., Aniebue, C. G., Bulus, J.A and Ayuba, M. S. (2020). Heavy Metal Concentrations of mine tailings and plants from selected active mining sites in Du area, Jos Plateau, Northcentral Nigeria. *Journal of Environmental Sciences, 20: 88-97*

Ogwueleka, T. (2009). Municipal solid waste characteristics and management in Nigeria. *Iranian Journal of environmental health science and engineering, 6 (3): 173-180*

Orudu, V.E. and Leizou, K.E. (2017). Determination of heavy metals (Pb, Cd and Ni) in soils of municipal solid wastes dumpsite, Yenagoa Metropolis, Bayelsa State. *Scholars Academic Journal of Biosciences, 5(4): 320-324*

Prashanth, L., Kattapagari, K.K., Chitturi, R.T., Baddam, V.R.R. and Prasad, L.K. (2015). A review on role of essential trace elements in health and disease. *J. NTR Univ. Health Sci. 4: 75 - 78.*

Salako, S.G., Adekoyeni, O.O., Adegbite, A.A. and Hammed, T.B. (2016). Determination of Metals Content of Alcohol and Non-alcoholic Canned Drinks Consumed at Idiroko Border Town Ogun State Nigeria. *Br. J. Appl. Sci. Technol.12: 1–8.*

Sevcikova, M., Modra, H., Slaninova, A. and Svobodova, Z. (2011). Metals as a cause of Oxidative stress in fish: A review.Vet. Med. 56: 537 - 546.

Ukpong, E. C. , Antigha, R. E. and Moses, E. O. (2013). Assessment of Heavy Metals Content In Soils And Plants Around Waste Dumpsites In Uyo Metropolis, Akwa Ibom State. *The International Journal of Engineering And Science. 2 (7): 75 - 86*

Van Hullebusch, E.D., Gieteling, J., Zhang, M., Zandvoort, M.H., Van Daele, W., Defrancq, J. and Lens, P.N.L. (2006). Cobalt sorption onto anaerobic granular sludge: Isotherm and spatial localization analysis. *Journal of Biotechnology, 121: 227 - 240.*

Zhang, X., Xia, H., Li, Z., Zhuang, P. and Gao, B. (2010). Potential of four forage grasses in remediation of Cd and Zn contaminated soils, *Bioresource Technology, 101(6): 2063 - 2066*