ISSN 2250-3153

Determination of Heavy Metal Pollution in Soil Collected from the Bank of River Yobe Nigeria.

[1]Mustapha Usman Nasir and [2]Muhammad Bashir Barkoma

[1]Department of Chemistry, Yobe State University Damaturu, Nigeria
[2]Department of Integrated Science, Atiku Abubakar College of Legal and Islamic Studies

DOI: 10.29322/IJSRP.10.05.2020.p101113
http://dx.doi.org/10.29322/IJSRP.10.05.2020.p101113

Abstract- The study was carried out to determine the level of pollution, by selected metals Cr, Cu, Fe, Pb and Zn in soil samples collected from bank of River Yobe, Nigeria were bank of the river is used as dumping site while the other part is used as farmlands. The samples were collected from four different locations and were analyzed for soil nutrients, heavy metals and pollution indices. The nutrient concentrations in this study showed that the soil samples had low (< 100 kg/ Acre) levels of nitrogen. Also phosphorous levels in sites P1 and P3 were found to be low in concentrations while medium (100-200 kg/ Acre) levels were registered in sites P2 and P4. High (> 200 kg/Acre) level of potassium level was recorded in the sampling sites. The concentrations of Cr, Cu, Fe and Pb in the soil samples were found to be above the WHO permissible limits. The contamination factor and geoaccumulation index in all the sampling sites indicated low to moderately contamination level. The findings of this research work proved that the samples collected were polluted by the metals under study.

Index Terms- Dumpsite, Heavy Metal, Pollution, River water.

I. Introduction

Environmental problems posed by solid waste range from health hazards, soil and water pollution, repulsive sight and offensive odour (Safiuddin *et al.*, 2011). The resultant effect of these is the degradation of environmental quality. Alimba *et al.* (2006) explained that dumpsites are usually located within the vicinity of living communities and wetlands. These dumpsites are often not lined nor basement prepared for selective adsorption of toxic substances.

Udosen *et al.* (2006) deduced that waste dumpsites can transfer significant levels of toxic and persistent metals into the soil environment. Moreover, Helmenstine (2014) realised that the decay of these solid wastes releases substances that can affect the soil nutrients content, increase the concentration of heavy metals in the soil, altering the natural balance of nutrients available for plant growth and development thereby affecting species diversity and agricultural productions.

Biswas *et al.* (2010) explained that heavy metal content of soils is a critical measurement for assessing the risks of refuse dumpsites. Since these contaminants affect the environmental qualities in and around such open dumpsites, monitoring of soil qualities especially heavy metal content in dumpsite becomes necessary which can facilitate to recommend suitable remedial measures.

Soil is a vital resource for sustaining two human needs of quality food supply and quality environment (Idris, 2015). Heavy metal pollution in soils refers to cases where the quantities of the elements in soils are higher than maximum allowable concentrations and this is potentially harmful to biological life at such locations (Adeleken and Abegunde, 2011).

Heavy metal concentrations in soil are associated with biological and geochemical cycles and are influenced by anthropogenic activities such as agricultural practices, industrial activities and waste disposal methods (Jing *et al.*, 2018).

A study by Sardar *et al.* (2013) observed the presence of large amounts of heavy metals in soil could also lead to the prevention of plants growth, uptake of nutrients, physiological and metabolic processes, chlorosis, and harm to root tips, minimized water and uptake of nutrients and impairment to enzymes. Wong *et al.* (2003) revealed that heavy metals are potentially toxic to crops, animals and humans when contaminated soils are used for crop production. Toxicity sets in when the heavy metal content in the soil exceeds natural background level (Dung *et al.*, 2013).

Heavy metal in contaminated soil affects the ecosystem due to leaching into groundwater or when they are taken up by plants and animals, which results in great risks due to bioaccumulation (Bhagure and Mirgane, 2011).

Most of the studies show that the use of waste water contaminated with heavy metals for irrigation over long period of time increases the heavy metal contents of soils above the permissible limit. Ultimately, increasing the heavy metal content in soil also increases the uptake of heavy metals by plants depending upon the soil type, plant growth stages and plant species (Mushtaq & Khan, 2010).

The problem of solid waste management in Nigeria has become a complex issue as a result of high population growth, accelerated urbanization and industrialization (Aguwamba, 2003). It is estimated that each Nigerian generates about 0.85 kg of waste per day totalling about 119 million tons of municipal and industrial waste per annum (Ayatomuno, 2004; Cookey, 2008). The bank of river Yobe has been used as dumping site as well as farmlands for both raining and dry season farming. This study is targeted at determining the level of heavy metals and soil nutrients collected from the river bank in order to ascertain the soil quality for agricultural purposes.

II. Description of the Study Area

The Yobe River, also known as the Komadougou Yobe or the Komadougou Yobe (French: *Komadougou Yobé*), is a river in West Africa that flows into Lake Chad through Nigeria and Niger. Its tributaries include the Hadejia River, the Jama'are River and the Komadugu Gana River. River Yobe is situated in the Sudan Sahel zone of the Northeast of Nigeria. It covers a total area of 148,000km^2 and the river meets around Nguru-Gashua wetland area about 250km north of Damaturu, the Yobe State capital. The river is located in Gashua, Bade local government of Yobe State, the town lies near Nguru-Gashua wetland economic and ecological system (Badejo *et al.*, 2017).

III. Sampling Design

A systematic sampling technique (equal probability method) was used in selecting the sampling sites. Soil samples were obtained from three purposively selected different locations across the river dumpsite where suburban farming are being practised. About 1.0 kg each of the soil samples and fallowed agricultural field soil sample (Control) were collected from the sampling locations, at a depth of 6.0 inches. The samples were gotten from four different locations including the control: near the dumpsite (river bank) P1, away from the dumpsite (50 m) P2, away from the dumpsite (> 100 m) P3 and the control (> 100 m away from P3) P4. The experimental design consist of 4 samples and 3 replicates.

IV. Sample Analysis

The soil nutrients (NPK) were determined using standard operating procedure indicated in a soil testing kit while the Cr, Cu, Fe Pb and Zn were spectrophotometrically determined using a BUCK scientific AAS, Model 210VGP.

V. Discussion

Table 1: Showed the nutrient in the soil samples.

Nutrient	P1	P2	P3	P4
pH	6.00 ± 0.25	7.33 ± 0.47	7.70 ± 1.05	7.20 ± 0.32
Nitrogen	L1 2kg/Acre	L1, 2kg/Acre	L1, 2kg/Acre	L1, 2kg/Acre
Phosphorous	L1, 2kg/Acre	M1, 11kg/Acre	L2, 8kg/Acre	M1, 11kg/Acre
Potassium	H2, 25kg/Acre	H2, 25kg/Acre	H2, 25kg/Acre	M2, 18kg/Acre

VI. Nutrient in Soil Samples

Table 1 displays the results of pH, nitrogen, phosphorous and potassium in a soil sample collected from the four different locations around the dumpsite namely P1, P2, P3 and P4. Soil pH directly affects the life and growth of plants as it affects the availability of all nutrients in the soil. In this study, it was observed that the pH of the soil ranged between slightly acidic 6.00 and slightly above neutral 7.70. Furthermore, pH has being reported as a simple and direct measure of the overall chemical condition of the soil and at pH 6.5, nutrients available to plants from the soil are at their highest (Praveena and Rao, 2016). The solubility of nutrients in the soil has been reported to be correlated to pH. The pH levels in P1 were slightly acidic and this tends to have an increased micronutrient solubility and mobility as well as the increased heavy metal concentration in the soil (Ogbonna *et al.*, 2009). When compared to other research it is in concordance with the findings of Obianefo *et al.* (2017).

Nitrogen is an important building block of proteins, nucleic acids and other cellular constituents which are essential for all forms of life. Nitrogen is such an important key nutrient element for plants that it warrants careful management, and if mismanaged can lead to severe environmental problems (Kahl, 2004). The results obtained show that all the sampling points had low amount of nitrogen 2 kg/Acre. The amount of phosphorous in the soil were recorded to be low in sites P1 and P3 while sites P2 and P4 were recorded to be in medium range. In addition to this, the amount of phosphorous may increase in the soil as a result of the transport of leachate from the dumping site. The findings of the present study agreed with the moderate level of phosphorous obtained in the findings of Deshmukh and Aher (2017). Potassium is considered the second important macro element for soil and crop productivity. Hence, an excess of potassium is not harmful (Goswami and Sarma, 2008). Potassium content in the soil is due to the degradation of solid waste and it is one of the essential elements for healthy growth (Eddy *et al.*, 2006). Except P4 which had medium level of potassium, all the other sampling points had high values of 25 kg/ Acre. The high level of these nutrient may be attributed to the composition of the wastes since the majority of the wastes come from a household with high organic matter content.

Heavy metal concentrations in soil samples

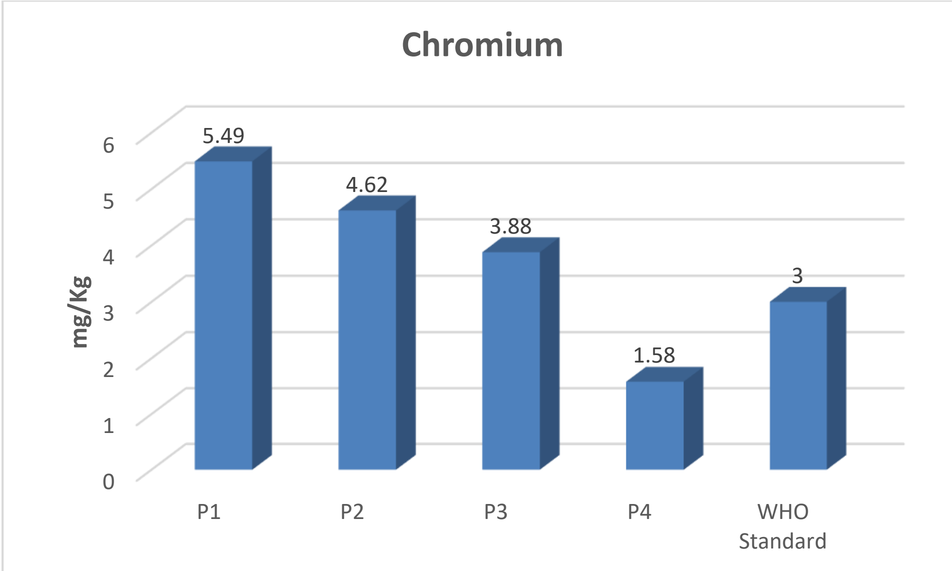

Figure 1: Chromium concentrations obtained from the soil samples

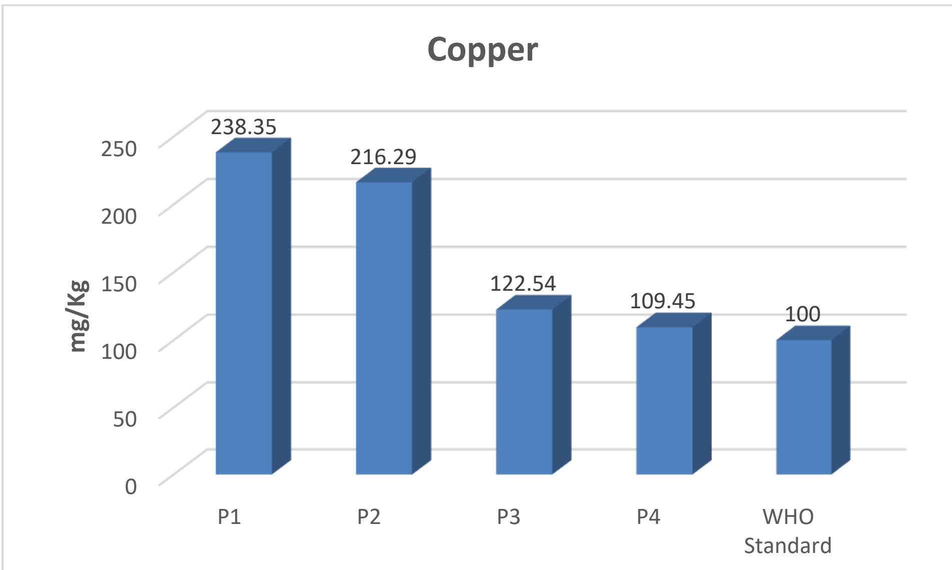

Figure 2: Copper concentrations obtained from the soil samples

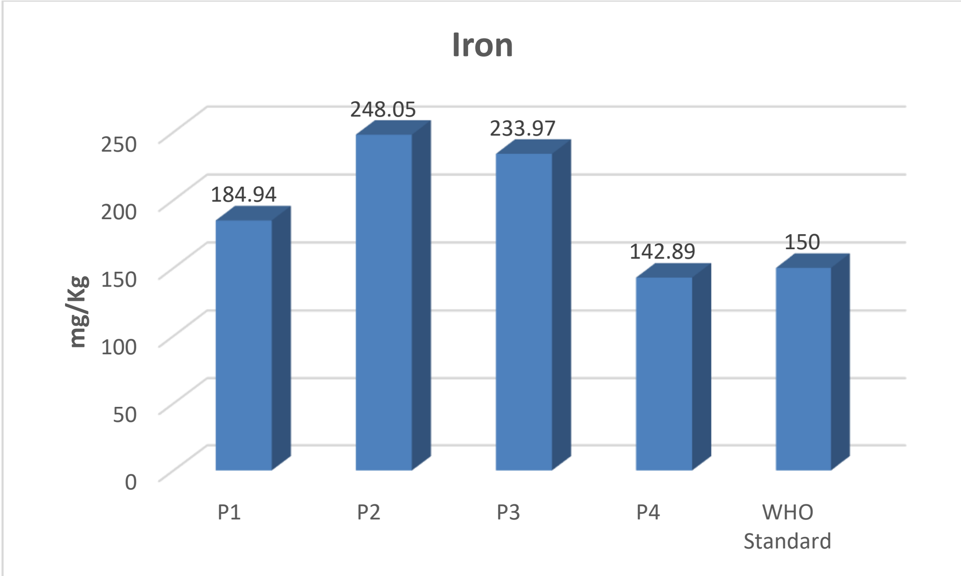

Figure 3: Iron concentrations obtained from the soil samples.

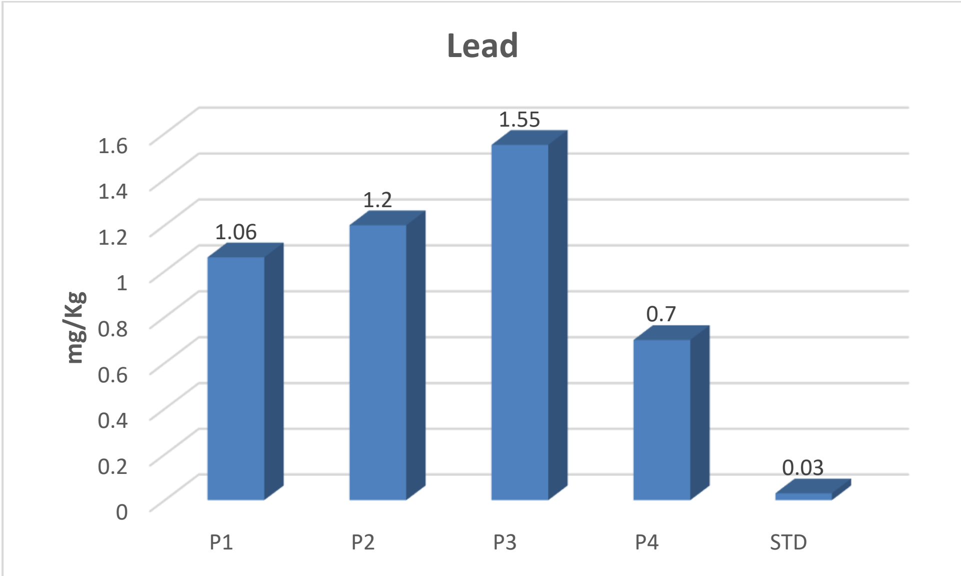

Figure 4: Lead concentrations obtained from the soil samples.

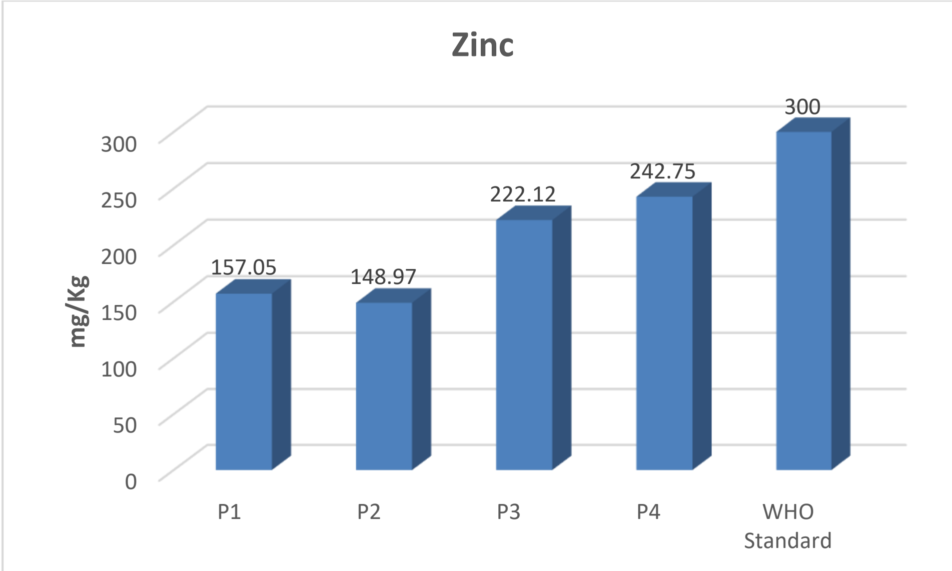

Figure 5: Zinc concentrations obtained from the soil at bank samples.

Figure 1-5 describes the concentration of heavy metals in soil samples. Except P4 which had chromium concentration of 1.58 ± 0.02 mg/kg but all the other soil samples collected had the concentrations of chromium above the permitted limit of 3 mg/kg set by WHO. P1 had the highest value of 5.49 ± 0.13 mg/kg while P2 and P3 had 4.62 ± 0.05 and 3.88 ± 0.30 mg/kg respectively. The results followed the order of P1 > P2 > P3 > P4. The high levels of Cr in the soil samples may be attributed to domestic waste disposed around the farmlands. Normally, chromium toxicity is due to physical contact with contaminated dust or soil (Onakpa *et al.*, 2018).

All the obtained results from the soil showed that the values of copper were above the WHO standard of 100 mg/kg, with P1 having the highest concentration of 238.35 0.34 mg/kg and P4 with the lowest concentration of 109.45 ± 1.39 mg/kg. P2 and P3 had the values of 216.29 ± 3.82 and 122.54 ± 0.49 mg/kg respectively and the results followed the order of P1 > P2 > P3 > P4. The results obtained from this study were higher than 0.536 – 1.504 mg/kg reported by Nazir *et al.* (2015), 7.692 – 15.309 mg/kg obtained by Nnaji and Igwe (2014) and 21.5 mg/kg reported by Tasrina *et al.* (2015). According to WHO standards the recommended limit of iron in soil is 150 mg/kg. Site P4 fell within the recommended limit but all the other soil samples collected were fells above the acceptable limit. The concentrations of iron in soil varied between 142.89 ± 0.02 to 248.05 ± 0.02 mg/kg with P2 having the highest value followed by P3 with 233.89 ± 0.01 mg/kg while P1 had 184.95 ± 0.01 mg/kg and the lowest value was obtained from P4. The findings were in the order of P2 > P3 > P1 > P4.The results were in agreement with 143.1 – 313.5 mg/kg obtained by Nazir *et al.* (2015).

The lead concentrations in soil samples were recorded to be between 0.70 ± 0.01 to 1.55 ± 0.02 mg/kg with P4 having the lowest value of 0.70 ± 0.01 mg/kg, P1 with 1.06 ± 0.00 mg/kg, P2 with 1.20 ± 0.00 while P3 recorded the highest value of 1.55 ± 0.02 mg/kg. From the results obtained the concentration of lead were found to be above the approved limit set by WHO. The findings of the present study agreed with 2.58 mg/kg obtained by Ripin *et al.* (2014), 2.312 – 7.047 mg/kg obtained by Nnaji and Igwe (2014) and 68.83 mg/kg reported by Tasrina *et al.* (2015). Lead as a soil contaminant is a widespread issue; it accumulates with age in bones aorta, and kidney, liver and spleen. The high level of lead in soil may not be unconnected with the dumpsite as materials that contained lead like batteries may leach into the soil and increases its level.

Zinc concentrations ranged from 242.75 ± 1.87 to 148.97 ± 3.82 mg/kg. P1 had the value of 157.05 ± 0.33 and P3 had the value of 222.12 ± 1.66 mg/ kg. P2 and P4 had the lowest and the highest values respectively. The findings followed the order of P4 > P3 > P1 > P2. Zinc concentrations in this study fell within the permissible limits recommended by WHO and the findings of this study were in concordance with 57.126 – 106.159 mg/kg obtained by Nnaji and Igwe (2014) and 123.5 mg/kg reported by Tasrina *et al.* (2015).

Table 2: Results of Contamination factors and Geoaccumulation index.

Metal	Site	**CF**	Indication	**GEOI**	Indication
Cr	P1	3.49	CC	0.84	UC to MC
	P2	2.93	MC	0.67	UC to MC
	P3	2.46	MC	0.50	UC to MC
Cu	P1	2.18	MC	0.37	UC to MC
	P2	1.98	MC	0.28	UC to MC

	P3	1.12	MC	-0.29	PUC
Fe	P1	1.29	MC	-0.15	PUC
	P2	1.74	MC	0.15	UC to MC
	P3	1.64	MC	0.09	UC to MC
Pb	P1	1.52	MC	0.01	UC to MC
	P2	1.71	MC	0.13	UC to MC
	P3	2.21	MC	0.39	UC to MC
Zn	P1	0.65	LC	-0.84	PUC
	P2	0.61	LC	-0.89	PUC
	P3	0.92	LC	-0.49	PUC

LC: Low contamination, CC: Considerable contamination, MC: Moderately contamination, PUC: Practically contamination, UC to MC: Uncontaminated to moderately contaminated.

VII. **Contamination factor (CF)**

Table 2 is the table illustrating the results of contamination factors and geoaccumulation index of the sampling sites. This was done by using the contamination factor categories previously described Tijani *et al.* (2004). Site P1 was considerably contaminated by Cr (3.49), moderately contaminated by Cu (2.18), Fe (1.29) and Pb (1.52) and mildly contaminated by Zn (0.65). The results were in the order of Cr > Cu > Pb > Fe > Zn.

In site P2 the level of contamination by the metals Cr (2.93), Cu (1.98), Fe (1.74) and Pb (1.71) were found to be in moderate contamination while Zn (0.61) was in low contamination level. The results followed the order of Cr > Cu > Fe> Pb > Zn. Site P3 was observed to be polluted by Zn (0.92) at low contamination level while Cr (2.46), Cu (1.12), Fe (1.64) and Pb (2.21) were found to have moderately contaminated the site. The contamination levels followed the order of Cr > Pb > Fe> Cu > Zn. The results obtained showed that Cr and Cu mostly polluted the sampling sites, while Fe, Pb and Zn contributed moderately to the soil pollution. The results also showed that the soil was at risk of being highly polluted if remediation was not taken.

VIII. Geo-accumulation indices

The calculated geoaccumulation index (GEOI) were also presented in Table 2. It is evident from Table 2 that site P1 can be described on ranging from being uncontaminated to being moderately contaminated by Cr (0.84), Cu (0.37) and Pb (0.01) the site was also practically uncontaminated by Fe (-0.15) and Zn (-0.84). This levels of contamination followed the order of Cr > Cu > Pb > Fe > Zn.

Site P2 was observed to be practically uncontaminated by Zn (-0.89) and the level of contamination by Cr (0.67), Cu (0.28), Fe (0.15) and Pb (0.13) ranged from being uncontaminated to moderately contaminated. The results were in order of Cr > Cu > Pb > Fe > Zn. The pollution in site P3 was described as ranging from being uncontaminated to moderately contaminated by Cr (0.50), Fe (0.09) and Pb (0.39) while the site were practically uncontaminated by Cu (-0.29) and Zn (-0.49). The results were in the order of Cr > Pb > Fe > Cu > Zn.

IX. Conclusions

The study was designed to ascertain and compare the levels of physicochemical parameters and heavy metals in soil collected at the bank of River Yobe which is used as dumping site and the results were compared with WHO standards. Four sites (P1, P2, P3 and P4) were selected for sampling. The results of nitrogen, phosphorus and potassium of the soil sample showed that the soil contained low amount of nitrogen from all the four sites tested. Phosphorous in the soil samples were observed to be low in sites P1 and P3 while medium in sites P2 and P4, the amounts of potassium tended to be very high in sites P1, P2 and P3 while in sites P4 the amount was registered as medium. The high level of these nutrient such as potassium may be credited to the composition of the wastes since the majority of the wastes come from households with high organic matter content.

The concentrations of Cr, Cu, Fe and Pb in the soil samples tended to be above the permissible limit except Cr and Pb in site P4 which had the concentrations within the permissible limit and Zn concentrations also fell within the recommended value set by WHO. This could be attributed to the availability of metal-containing wastes at the dumpsite which may leached into the underlying soil and the river water.

The contamination factors in this study showed that the contamination of soil by the metals ranged from low to moderately contaminated. This illustrates that the soil were contaminated by the metals and this has been attributed to anthropogenic activities that are going on and around the sampling sites. The geoaccumulation indices ranged from practically contaminated to moderately contaminated. The results of the pollution indices indicated that the soil samples were contaminated by the dumpsites, even though not at very high levels. The results obtained also showed that almost all the samples collected and tested were polluted either from the same sources or from different sources. Furthermore, the results revealed that sampling points that are close to the dumpsite are almost always having the highest concentrations level of contaminants. Therefore, this study concludes that ongoing human activities such as waste dumping along the river banks have significant negative implications on the environment and may contaminates food crops grown around the vicinity.

REFERENCES

[1] Adelekan, B. A., and Abegunde, K. D. (2011). Heavy metal contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria. International Journal of physical sciences, 6(5), 1045-1058.

[2] Agunwamba, J. C. (2003). Optimization of solid waste collection system in Onitsha, Nigeria. International Journal of Environmental Issues, 1(1), 124-135.

[3] Alimba, C. G., Bakare, A. A. and Latunji, C. A. (2006). Municipal landfill leachates induced chromosome aberrations in rat bone marrow cells. African Journal of Biotechnology, 5(22).

[4] Ayotamuno, J. M. and Gobo, A. E. (2004). Municipal solid waste management in Port Harcourt, Nigeria: Obstacles and prospects. Management of environmental quality: an international journal, 15(4), 389-398.

[5] Badejo, B. I., Abdulrahman, A. K., Dali, Z. J. and Badgal, E. B. (2017). Assessment of physicochemical parameters of River Yobe, Gashua, Yobe State, Nigeria.

[6] Bhagure, G. R., and Mirgane, S. R. (2011). Heavy metal concentrations in ground waters and soils of Thane Region of Maharashtra, India. Environmental monitoring and assessment, 173(1-4), 643-652.

[7] Biswas, A. K., Kumar, S., Babu, S. S., Bhattacharyya, J. K. and Chakrabarti, T. (2010). Studies on environmental quality in and around municipal solid waste dumpsite. Resources, Conservation and Recycling, 55(2), 129-134.

[8] Cookey, P., Nigeria, K. B. A., Richard, A. M., Weridongha, W. and Chukwuemeka, J. P. (2008). Assessment of water supply and sanitation of some coastal communities of the Niger Delta. In 33rd WEDC International Conference, Accra, Ghana, 383-385.

[9] Deshmukh, K. K. and Aher, S. P. (2017). Assessment of Soil Fertility around Municipal Solid Waste Disposal Site near Sangamner City, Maharashtra, India.

[10] Dung, T. T. T., Cappuyns, V. Swennen, R., and Phung, N. K. (2013). From geochemical background determination to pollution assessment of heavy metals in sediments and soils. Reviews in Environmental Science and Bio/Technology, 12(4), 335-353.

[11] Eddy, N. O., Odoemelem, S. A. and Mbaba, A. (2006). Elemental composition of soil in some dumpsites. Journal of Environmental Agricultural and Food Chemistry, 5(3), 1349- 1365.

[12] FAO/WHO. (2002). Schedule 1 maximum and guideline for contaminants and toxins in food. Codex alimentarius-General Standards for Contaminants and toxins in food. Joint FAO/WHO Food Standards Programme, Codex committee, Rotterdam. Reference CX/FAC 02/16.

[13] Goswami, U. and Sarma, H. P. (2008). Study of the impact of municipal solid waste dumping on soil quality in Guwahati city. Pollution research, 27(2), 327-330.

[14] Helmenstine, A. M. (2014). Heavy metals definition. About.com.

[15] http://chemistry.about.com/od/chemistryglossary/g/Heavy-Metal-Definition.htm

[16] Idris, M. B., Khalid, K. D. U. and Abdullahi, Z. (2015). Comparative assessment of heavy metals concentration in the soil in the vicinity of tannery industries, Kumbotso old dump site and river Challawa confluence, at Challawa industrial estate, Kano state, Nigeria. International Journal of Innovative Research and Development, 4(6).

[17] Jing, F., Chen, X., Yang, Z., & Guo, B. (2018). Heavy metals status, transport mechanisms, sources, and factors affecting their mobility in Chinese agricultural soils. Environmental earth sciences, 77(3), 104.

[18] Joint, F. A. O. (2011). WHO food standards programme codex committee on contaminants in foods. In Fifth Session [displayed 10 February 2014]. Available at ftp: //ftp. Fao. Org/codex/meetings/CCCF/cccf5/cf05_INF. pdf.

[19] Kahl, H. (2004). Role and importance of nitrogen in your soil. Soil and Health Association of New Zealand.

[20] Mushtaq, N., & Khan, K. S. (2010). Heavy metals contamination of soils in response to wastewater irrigation in Rawalpindi region. Pak. J. Agri. Sci, 47(3), 215-224.

[21]

[22] Nazir, R., Khan, M., Masab, M., Rehman, H. U., Rauf, N. U., Shahab, S. and Shaheen, Z. (2015). Accumulation of heavy metals (Ni, Cu, Cd, Cr, Pb, Zn, Fe) in the soil, water and plants and analysis of physico-chemical parameters of soil and water collected from Tanda Dam Kohat. Journal of Pharmaceutical Sciences and Research, 7(3), 89.

[23] Nnaji, J. C. and Igwe, O. U. (2014). Fractionation of heavy metals in soil samples from rice fields in New Bussa, Nigeria. Int. J. Chem. Tech. Res, 6, 14.

[24] Obianefo, F. U., Agbagwa, I. O. and Tanee, F. B. G. (2017). Physicochemical Characteristics of Soil from Selected Solid Waste Dump Sites in Port Harcourt, Rivers State, Nigeria. Journal of Applied Sciences and Environmental Management, 21(6), 1153- 1156.

[25] Ogbonna, D. N., Kii, B. L. and Youdeowei, P. O. (2009). Some physico-chemical and Heavy metal levels in soils of waste dumpsites in Port Harcourt Municipality and Environs. Journal of Applied Sciences and Environmental Management, 13(4).

[26] Praveena, S. G. and Prasada Rao, P. V. V. (2016). Impact of Leachate on Soil Properties in the Dumpsite (A Case study of Greater Visakhapatnam). International Journal of Engineering Research and General Science, 4(1), 235-241.

[27] Ripin, S. N. M., Hasan, S., Kamal, M. L. and Hashim, N. M. (2014). Analysis and pollution assessment of heavy metal in soil, Perlis. Malaysian Journal of Analytical Sciences, 18(1), 155-161.

[28] Sardar, K., Ali, S., Hameed, S., Afzal, S., Fatima, S., Shakoor, M. B., Bharwana, S. A., Tauqeer, H. M., Blaylock, M. J. and Huang, J. W. (2013). "Phytoextraction of metals," in Phytoremediation of Toxic Metals: Using Plants to Clean up the Environment.

[29] Safiuddin, M., Abdus Salam, M. and Jumaat, M. Z. (2011). Utilization of palm oil fuel ash in concrete: a review. Journal of Civil Engineering and Management, 17(2), 234-247.

[30] Tasrina, R. C., Rowshon, A., Mustafizur, A. M. R., Rafiqul, I. and Ali, M. P. (2015). Heavy metals contamination in vegetables and its growing soil. J Environ Anal Chem, 2(142), 2.

[31] Tijani, M. N., Jinno, K. and Hiroshiro, Y. (2004). Environmental impact of heavy metals distribution in water and sediments of Ogunpa River, Ibadan area, south-western Nigeria. Journal of Mining and Geology, 40(1), 73-83.

[32] Udosen, E. D., Benson, N. U., Essien, J. P. and Ebong, G. A. (2006). Relation between aqua- regia extractable heavy metals in soil and manihot utilissima within a municipal dumpsite. International Journal of Soil Science, 1(1), 27-32.

[33] WHO (2000) Safety evaluation of certain food additives and contaminants. International Programme on Chemical Safety. WHO Food Additive Series 52.

[34] Wong, C.S.C., Li, X.D., Zhang, G., Qi, S.H. and Peng, X. Z. (2003). Atmospheric depositions of heavy metals in the Pearl River Delta, China. Atmosphere and Environment, 37: 767- 776.

AUTHORS

First Author – Mustapha Usman Nasir, Department of Chemistry, Yobe State University Damaturu, Nigeria
Second Author – Muhammad Bashir Barkoma, Department of Integrated Science, Atiku Abubakar College of Legal and Islamic Studies

Corresponding Author: mustaphausmannasir@gmail.com