FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 4 No. 1, March, 2020, pp 348 – 354

HEAVY METALS SPATIAL VARIABILITY AMONG DUMPSITES IN KANO METROPOLIS, KANO STATE, NIGERIA

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ABSTRACT

The study reported the spatial distribution of some selected heavy metals (Zn, Pb. Cd. Cr and Ni) among dumpsites in Kano Metropolis, Kano State, Nigeria. Forty-two soil samples (from seven municipal solid waste dump sites) were analysed using Flame atomic absorption spectrophotometer. The mean concentration of heavy metals in the surface soils (0-15 cm) indicated that Zn (0.10 mg/ kg), Pb (1.03, mg/kg), Cd (0.007 mg/kg), Cr (0.15 mg/kg) and Ni (0.17 mg/kg) while the mean value of heavy metals in the sub surface soils (15-30) were Zn (0. 11 mg/ kg), Pb (0.26mg/kg), Cd (0.008 mg/kg), Cr (0.15 mg/kg) and Ni (0.17 mg/kg). The mean concentrations of the five studied heavy metals (Zn, Pb, Cd, Cr and Ni) were below WHO (2007) and DPR (2002) standard. Results of heavy metal spatial variability showed that concentration of Zn and Pb in soils were significantly different ($P < 0.05$) between the dumpsites and for Cd, Cr and Ni concentration in soils were not significantly different ($P > 0.05$) among the dumpsites. Pearson's correlation coefficient showed moderate positive and significant associations between Zn and Cd ($r = 0.580$, $P < 0.05$) while negative and significant association existed between Pb and Ni ($r = -0.314$, $P < 0.01$). Based on recommendation, there is need of the ministry of Health and Sanitation Agency like Refuse management and Sanitation Agency (REMASAB) and NESREA to come up with health education programmes for the general population on the dangers of illegal growing of dumpsites around Zone settlement in the cities of Kano Metropolis.

Keywords: FAAS, Concentration, Municipal Solid waste, Person's coefficient, NESREA

INTRODUCTION

Waste disposal whether domestic, commercial or industrial is a growing problem in the world as a result of human civilization and no method of solid waste disposal so far is completely safe (Okeyode and Rufai,2011). Municipal and industrial solid wastes contain a variety of potentially significant chemical constituents and pathogenic organisms that could negatively affect public health, air, soil and groundwater qualities. These constituents include regulated hazardous priority pollutants such as heavy metals, poly-aromatic hydrocarbons , polychlorinated biphenyls and other persistent organic pollutants (Ikem, *et al*., 2002; Osibanjo, 2003; Anetor, *et al*.,2008).Most dumpsites are located within the environment of living communities (Abdus-Salam *et al*., 2011). The dumpsites are often not lined nor basement prepared for selective adsorption of toxic substances. Therefore it is prone to release pollutants to nearby water and to the air through leachates and dumpsite gases respectively. Industrialization, population growth and un-planned urbanisation have partially or totally turned the environment to dumping sites for waste materials which is unhealthy (Alimba *et al*., 2006; Ikem *et al*., 2002). Many water resources have been rendered unsafe and hazardous to man and other living systems as a result of indiscriminate dumping of refuse (Bakare *et al*., 2005).Dangers posed by leachate from municipal dumpsites depends on the waste composition, volume, life time, temperature, moisture, availability of oxygen, soil morphology, and the relative distance of the sites to nearby living community and water body (Longe and Balogun, 2010; Ogundiran and Afolabi, 2008; Slake *et al*., 2005).Many authors have documented issues of heavy metal contamination in many urban areas across Nigeria. For example,Jimoh and Sabo (2013) determined the heavy metals of Pb, Cu, Fe, Cr, Cd, Zn, Mn and Ni in dumpsites of Kano Metropolis, in order to carry out a sequential analysis of metals in municipal dumpsite composts of Kano Metropolis. Similarly, Koki and Jimoh (2013) have both reported the level of heavy metals in soils from dump site of tanneries and farmlands in Challawa Industrial Estate Kano, Nigeria. But there are limited works on spatial variation of heavy metal around the dumpsite of Kano Metropolis. Therefore, the objectives of the present work were to assess the spatial variation of heavy metals among the dumpsites of Kano Metropolis and to establish the association between the studied heavy metals.

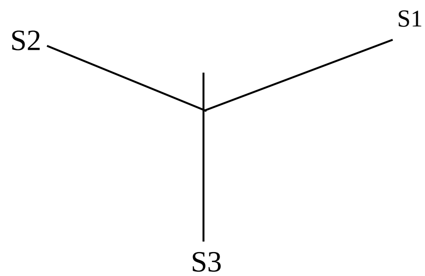
MATERIALS AND METHODS

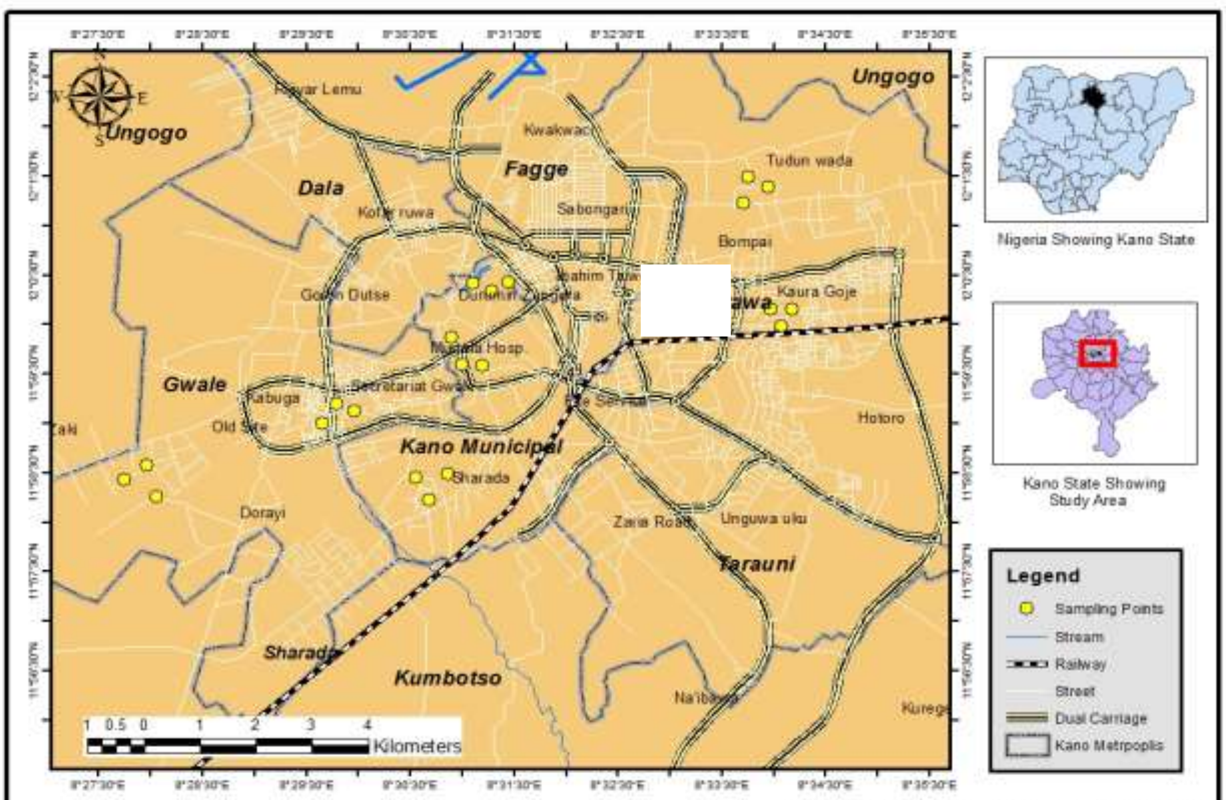
STUDY AREA

Kano Metropolis is the capital city of Kano state, Nigeria. It is located between latitude11^0 59' to 12^0 02' N and longitudes $8^0$33' to 8^0 40'E with a total urban land area of 137 km^2 and 499 km^2 metropolitan area. It is made up of six Local Government Areas (Dala, Fage, Gwale, Municipal, Nasarawa, and Tarauni) and some parts of Kumbotso, Ungogo, and Tofa Local Government Areas. Kano metropolis has an estimated population of over 4 million people with a male – female ratio of about 1 to 1.32 (Maigari, 2014),

Samples Collection and Sampling Points

Forty-two soil samples were collected from seven municipal solid waste dumpsites of Kano Metropolis using circular plot method. In each dumpsite, three point's soil samples were collected from the depth (S1, S2 and S3). At each point, two soil samples were collected from the depth of 0-15cm and 15-30cm. Each soil sample was composed of 2 sub-samples collected around the corresponding sampling point, and all the sampling coordinates were recorded by portable GPS. The samples were carefully handled right from the field to the end of the laboratory analysis to avoid contamination. The Figure 2 shows soil sampling points in each of the seven dumpsites





Source :Cartography Lab Geography Department BUK(2019)

Figure 2 Kano Metropolis showing the distribution of sampling points

Laboratory Analysis

1.25 g of each sample was digested with 20 mL aqua regia (HCl + HNO_3, 3+1 v/v) in a beaker (open-beaker digestion) on a thermostatically controlled hot plate. The digest were heated to near dryness and cooled to ambient temperature. Then 5.0 mL of hydrogen peroxide was added in parts to complete the digestion and the resulting mixture heated again to near dryness in a fume cupboard. The beaker walls were washed with 10 mL of de-ionised water and 5 mL HCl were added, mixed and heated again. The resulting digest was allowed to cool and transferred into a 50 mL standard flask and made up to the mark with de-ionised water. Pb, Cd, Ni, Zn, and Cr heavy metal elements were then analyzed by direct aspiration of the sample solution into a Perkin- Elmer model 2380 flame atomic absorption spectrophotometer (AAS)..

Data Analysis

The data obtained were analyzed using descriptive statistics and one way (ANOVA) was used to compare means and significantly different means were separated using LSD; Pearson moment correlation analysis was also done to correlate studied heavy metal around the dumpsites using SAS package 9.2 (SAS, 2007).

RESULT AND DISCUSSION

Heavy Metal Concentrations in Municipal dumpsites of Kano metropolis

The table 1 shows the mean summary of heavy metal concentrations in surface soils around dumpsites of Kano Metropolis, the heavy metal analyze include; Zn, Pb, Cd, Cr and Ni ..

Table 1: Concentrations of Heavy Metals in (mg/kg) collected from seven Dumpsites of Kano Metropolis

	Mean Concentration of heavy metal**s** in surface soils (0-15 cm)				
Dumpsites	Zn(mg/Kg)	Pb(mg/Kg)	Cd(mg/Kg)	Cr(mg/kg)	Ni(mg/Kg)
D/Zungura	0.009	0.002	0.007	0.021	0.303
Murtala hosp.	0.252	7.11	0.006	0.234	NA
Sharada	0.30	0.022	0.025	0.274	0.06
K/Goje	0.003	0.035	0.003	0.004	NA
T/wada	0.028	0.046	0.002	0.246	0.149
Dorayi	0.014	0.002	0.003	0.144	0.493
Gwale	0.06	0.002	0.005	0.163	0.190

Sources: Laboratory Analysis, 2019

a) Zinc Concentration(0-15cm)

The Mean concentration of Zinc was highest in Sharadah (0.30mg/kg) and lowest in Durumin Zungura dumpsite (0.009 mg kg-1). The range of values obtained for zinc (Zn) in these dumpsites was different to the values (0.583-1.351 mg kg-1) reported by Agber *et al*., (2013) for soil sample close to municipal refuse dumpsites in Markudi, Nigeria. It is clearly noticed that Zn concentration in all the dumpsites was much lower than maximum allowable limits of soils in Nigeria (140 mg kg-1), (Department of Petroleum Resources, 2002).

b) Lead Concentration (0-15cm)

The Mean concentration of lead in the soil ranged between (0.002 mg/kg) in Gwale Secretariat to (7.71 mg/kg) in dumpsite behind Murtala Mohd specialist Hospital. The highest concentration of Pb in dumpsites behind Murtala Mohammad Hospital could be attributed to the disposal of waste containing chemicals, dry cell batteries,owing to the close proximity of the Hospital. The concentration of lead values in the dumpsites of Kano Metropolis was far lower than 24.70-54.20 mg kg-1 reported by Akinbile(2012) for land fill site at Akure, Nigeria, Parth *et al.*, (2011) also reported 42.90-1833.50 mg kg-1 lead in soil waste disposal sites in Hyderbab city, India.. The concentration of lead was far lower than Department of Petroleum Standard in Nigeria and WHO and DPR (2002) standard with Maximum allowable limit of 100 mg/kg and 85 mg/kg respectively.

c) Chromium Concentration (0-15cm)

As per results from Table 1, the level of Cr content in different sampling area was ranged from 0.004 in Kaura Goje to 0.274 mg/kg (Sharada). Cr concentration was different than the results reported by (Amos, Bamidele, Onigbinde, 2013) for similar study at Yenagoa in Nigeria in which mean Cr ranged from (0.005-0.006 mg/kg). The maximum concentration of Cr was 0.274 mg kg-1 from Sharadah dumpsite and this value is far below the MAL of Cr for Nigeria (100.0 mk kg-1), (DPR, 2002). Sources of Cr in the soils could be due to waste consisting of lead chromium batteries, coloured polythene bags, discarded plastic materials and empty paint containers (Jung *et al*., 2006).

d) Nickel Concentration (0-15cm)

The highest mean concentration of Ni (0.493 mg/kg) was found in Sharadah dumpsite while Ni was not detected in Murtala Mohammad and Kaura Goje dumpsite with concentration value of (-0.102 mg/kg) and (-0.07 mg/kg) respectively . The absence of Ni in these dumpsites could be attributed to the lack of waste containing household appliances tools, combustion of fossil fuels, nickel mining and electroplating. Ni concentrations in soils at both waste dumping sites were also lower compared to similar study at Kenya, Kadhodeki municipal solid waste dumping sites (17.44 mg/kg) (Murugi, 2009). The result of Ni concentration obtained in these dumpsites was far lower than DPR standard limit of (35mg/kg) in Nigeria.

e) Cadmium Concentration (0-15cm)

The mean concentration of (Cd) was ranged from the 0.002 in Tudun Wada to 0.025 in sharada dumpsite. This was different with the earlier reports (Azeez *et al.,* 2013; Olarinoye *et al*., 2009) whose cadmium concentration was found in the range of 0.003 to 0.006. Similar to our findings Omtunde *et al*., (2011) reported that the detection of Cd in some dumpsites in Lagos State, Nigeria. Nigeria is having the lowest Cd MAL of 0.80 mg kg-1 (DPR, 2002). Similarly, these values were far lower compared to a study by Anietie and Labunmi (2015) that reported Cd Concentration ranging from 28.56 ± 17.95mg/kg to 40.17 ± 18.21 mg/kg.

Table 2: Concentrations of Heavy Metals in (mg/kg) collected from seven Dumpsites of Kano Metropolis

	Mean Concentration of heavy metal**s in surface soils (15-30 cm)**				
DUMPSITES	**Zn(mg/Kg)**	**Pb(mg/Kg)**	**Cd(mg/Kg)**	**Cr(mg/kg)**	**Ni(mg/Kg)**
D/Zungura	0.001	0.003	0.005	0.070	0.046
Murtala hosp.	0.097	1.77	0.012	0.114	0.002
Sharada	0.55	0.051	0.020	0.104	0.179
K/Goje	0.026	0.114	0.009	0.281	0.250
T/wada	0.013	0.033	0.004	0.319	0.117
Dorayi	0.017	0.003	0.005	0.177	0.190
Gwale	0.063	0.002	0.006	0.07	0.450

Sources: Laboratory Analysis, 2019

a) Zinc Concentration (15-30cm)

The mean concentration of zinc (Zn) was in the range of 0.001–0.55 mg/kg. The lowest zinc content was obtained in soil collected from Durumin Zungura dumpsite area and the highest in soil collected from Sharada. In comparison with WHO Standards (300 mg/kg) limits it could be observed that the Zn values of the top subsurface soils were far lower than this standard. The chief pollution sources of Zn in soils are metalliferous mining activities, agricultural use of sewage sludge and the use of agro-chemicals such as fertilizers and pesticides. Large concentrations of Zn in the soil have adverse effects on crops, livestock and human (Parth *et al.,* 2011). The results of this study were slightly lower as compared to a study by Lawan *et al*., 2012 on vertical migration of heavy metals in dumpsite soil at Maiduguri Metropolis dumpsite, Nigeria that reported mean zinc concentration at 1.80 ± 0.01mg/kg.

a) Lead Concentration (15-30)

The highest mean concentration of (1.77mg/kg) mg/Kg was detected at Murtala Mohammad Dumpsite and the lowest concentration of (0.002) mg/kg was found at Gwale Secretariat dumpsite .These values were far lower than (100 mg/kg) WHO (2007) maximum tolerable levels. The present study was far lower than the result obtained from similar study by Umoh and Etim (2013) of 0.0034 to 1.54 mg/kg for soils from dumpsites within Ikot-Ekpene in Akwa-Ibom State, Nigeria. The highest concentration of Pb in dumpsites behind Murtala Mohammad Hospital could be attributed to the disposal of waste containing chemicals, dry cell batteries,owing to the close proximity of the Hospital.

b) Cadmium Concentration

The mean concentration of cd in soils range from 0.004 mg/kg in Tudun Wada soil to 0.012mg/ kg in Murtala Mohammad dumpsite. The concentrations of cadmium obtained in this study were lower than WHO (2007) recommended maximum limit for soil that is 3 mg/kg.The Cd content reported in this study was different with 0.50 – 4.20mg/kg reported under varied land uses in Lagos State by Anyakora *et al*., (2013) and it is lower than the WHO (2007) maximum concentration limit of 3mg/kg. A study by Amadi and Nwankwoalae, (2013) reported concentration of Cd between 0.18- 2.60 mg/kg with a mean concentration of 1.40mg/kg these results were different to the findings in this study.

c) Chromium Concentration (15-30)

The mean concentrations of Cr in the dumpsite soil range between (0.07-0.31 mg/kg), the lowest Cr concentration (0.007 mg/kg) was found in two dumpsites Durumin Zungura and Gwale dumpsite while highest Cr concentration (0.31 mg/kg) was obtained in Tudun Wada. The result of the present study was far lower than the critical permissible level which is 70 mg/kg for soil recommended for (WHO) 2007 standard limit. The lowest concentration of Cr in the soils could be due to the absence of waste consisting of lead chromium batteries, coloured polythene bags, discarded plastic materials and empty paint containers (Jung *et al*., 2006**).**

The result was lowest to than Cr concentration (131-249 mg kg-1) reported by (Adie and Osibanjo, 2009) from soil pollution by slag from an automobile battery manufacturing plant in Nigeria and this was very high due to the nature of the activities of the facility. Anthropogenic input of Cr comes from solid wastes, where approximately 30% of Cr originates from plastics packaging materials and lead-chromium batteries (Jung *et al*., 2006).

d) Nickel Concentration

In the studied soil samples, the mean concentration of Nickel (Ni) concentrations ranged from 0.02 mg/kg in Murtala Mohammad dumpsite to 0.451 mg/kg. The values of Ni obtained in this study were lower than WHO, (2007) recommended maximum limit that is 50 mg/kg. The value of Ni was remarkably lower than 0.455.24 mg kg-1 and 21.00-52.00 mg kg-1 of Ni reported by Adie and Osinbanjo, (2009) and Olarinoye *et al*., (2009) .The major sources of nickel contamination in the soil are metal plating industries, combustion of fossil fuels, and nickel mining and electroplating.

The results of a one-way ANOVA (Table 3) of the spatial variation of heavy metal concentration are shown in tables 3. The result test the following hypothesis: first hypothesis (H01): No differences in the dumping sites while second hypothesis (H02): No differences in the concentration of parameters (Zn, Pb, Cd, Cr and Ni) among the dumpsites.

Table 3 Spatial Variation of Heavy metals Among Dumpsites in Kano Metropolis

Element	sources of variation	DF	Sum of Squares	Mean square;	F- ratio	P- value
	Dumpsite	6	0.808	0.135	9.501	.000
Zinc	Depth	1	0.012	0.012	0.824	0.372
	Dumpsite	6	100.859	16.810	2.516	0.045
Lead	Depth	1	6.104	6. 104	0.9134	0.347
	Dumpsite	6	0.660	0.110	1.734	0.150
Cadmium	Depth	1	0.016	0.016	0.251	0.150
	Dumpsite	6	0.297	0.049	0.627	0.707
Chromium	Depth	1	0.04	0.04	0.055	0.815
	Dumpsite	6	0.002	0.000	1.814	0.133
Nickel	Depth	1	2.44	2.44	0.017	0.988

Sources; SPSS Output

The result of table 3 shows the summary of df , Sum of Squares; Mean square; degree of freedom; F- ratio of variation between groups/within groups and p value were computed. The level of significant (p-values) was compare with alpha value of 0.05. The result of (ANOVA, $p < 0.05$) showed that there were significant differences in dumpsites between the heavy metals for Zn and Pb whereas for Ni, Cr and Cd shows no significant difference was found between the studied dumpsites in Kano Metropolis. The result presented in the table 3 (ANOVA, $p > 0.05$) showed that there was no significant differences between the concentration of parameters and soil depth.

Relationship between heavy metal in Municipal solid waste Dumpsites

The result examines relationship between studied heavy metals is presented in Table 4. Correlation analysis based on the Pearson product correlation was conducted to determine the extent of the relationships among metals in soils of different dumpsites in Kano metropolis.

Table 4: Relationship between studied heavy metals concentration (Zn, Pb, Cd, Cr and Ni)

	Zn	Pb	Cd	Cr	Ni
Zn	1	-0.57	.508**		0.39
		.731	.001	.804	.813
Pb	-.057	1			-0.314*
	.731		.565	.159	.043
Cd	.508**		1		0.45
	0.001	0.565		.772	.775
Cr	-0.431			1	0.52
	.804	.159	.772		.745
Ni	0.039				1
	.813	0.043	.775	.745	

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed)

The result presented in Table 4 shows that elemental pairs Zn and Cd were moderately correlated at (r =0.508** at 0.01 level of significant) while Pb and Ni were negatively correlated (r =-0.314* at 0.005 level of significant) **.** The statistically significant positive correlation between Zn – Cd is indicative of the common origin of these elements; while negative correlation between Ni and Pb indicated that they were from difference pollution sources.

CONCLUSION

The result showed that the mean concentration of five studied heavy metals (Zn, Pb, Cd, Cr and Ni) in the surface soils (0-15cm) were in the following decreasing order Pb (1.03 mg/kg) > Ni (0.17) > Cr (0.15 mg/kg) > Zn (0.15 mg/kg) > Cd (0.007 mg/Kg) and mean values for the sub surface soils (15-30cm) were Pb (0.26 mg/kg) > Ni (0.17) > Cr (0.15 mg/kg) > Zn (0.11 mg/kg) > Cd (0.008 mg/kg). The result revealed that mean concentrations of the five studied heavy metals (Zn, Pb, Cd, Cr and Ni) were below WHO (2007) and DPR (2002) standard. The study of heavy metal spatial variability indicated that Zn and Pb in soils were significantly different (P < 0.05) between the dumpsites and for Cd, Cr and Ni concentration in soils showed no significantly different (P> 0.05) among the dumpsites. Pearson's correlation coefficient showed moderate positive relationship between Zn and Cd (r = 0.580, P <0.05) and negative significant association between Pb and Ni (r = -0.314, P <0.01).

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