ORGANIC MATTER AND HEAVY METALS LEACHATE EFFECT ON SOILS OF SELECTED DUMPSITES IN SELECTED NORTH CENTRAL STATES OF NIGERIA

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ARTICLE INFORMATION

ABSTRACT

This research was conducted to assess the presence of some heavy metals Chromium (Cr), Iron (Fe), Copper (Cu), Manganese (Mn), Lead (Pb), Zinc (Zn) and Aluminum (Al) in municipal solid waste dumps. Heavy metals in the soils were determined at varying depths of 0-5cm, 5-15cm and 15-30cm to assess the extent of pollution and the effects of pH and organic matter in the soil. Heavy metals concentrations were analysed using Atomic Absorption Spectrophotometer. The results revealed a significant difference ($p < 0.05$) in the concentrations of heavy metals across varying depth at the dumpsites when compared with control points in the same location. Mn had the highest mean 131.22 ± 25.98 mgkg^{-1} followed by Fe, which is 69 ± 11.02 mgkg^{-1} at the dumpsites. Mean concentration of all the Heavy metals investigated at the various dumpsites studied were significantly higher than at the control point and below the maximum standard levels set by FAO and WHO for agricultural soils. Result of particle distribution indicated higher sand content (> 80.0%) and lower clay and silt contents in both dumpsite and control site which implies the ease of movement of dissolved metals in the soil environment. Organic Matter (OM) content at dumpsites was observed to be slightly higher than at the control sites. The data also signifies that as pH decreases and %OM decreases the concentration of these heavy metals decreases down the soil profile. It is, therefore, concluded that accumulation of heavy metals in depth was highly correlated with pH and organic matter content.

1.0 Introduction

Industrialisation and population growth have changed the composition and quantity of waste generated in the society. This has led to the rapid increase in open and hazardous dumpsites in urban and suburban areas in Nigeria. Most human activities create waste, and the process in which this is taken care of can posture danger to nature and general wellbeing (Adedosu et al., 2013). Most products from various section of life ends up at dumpsites and because of the heterogeneity and intricacy of these wastes, these dumpsites contain an assortment of

contaminants which can contaminate the soil of the area (Kumar et al., 2002). Dumping of waste without legitimate sorting may result in builds up of heavymetals, for example, arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg) and zinc (Zn). These overwhelming metals, when found in solid waste, have been known to deliver significant ecological effects (Suman et al., 2011; Ebong et al., 2007). The dissolved metals move towards groundwater which in most cases are supplied for domestic and agricultural use thus finding their way into the food chain and influencing human wellbeing (Dosumu et al., 2003).

Open dumping of municipal solid waste practised by developing countries around the world including Nigeria in most cases is the primary cause of environmental degradation and has raised public health concerns. These dumpsites may contain unclassified waste and poisonous or radioactive materials that can be hazardous to the environment (Uwakwe, 2012). He further stated that malodour radiating from the waste dumpsite has a disturbing effect on the environment and general wellbeing of the populace. Leachate from open dumpsites contaminates the soil with heavy metals (Duruibe et al., 2007; Amadi et al., 2010). Cancer, heart diseases and teratogenic abnormalities are attributed to groundwater pollution via leachate from the waste dumpsites (Lenntech et al., 2004; Duruibe et al., 2007; Kumar et al., 2002).

Mobility, availability, and distribution of heavy metals is controlled by adsorption and desorption qualities of soils (Aboyade, 2004). The adsorption and desorption of substantial metals have been shown to be related to soil properties, including pH, organic matter content, cation exchange capacity (CEC), the substance of earth minerals, calcium carbonate, Fe and Mn oxides (Ikem et al., 2002; Adjia et al., 2008; Altaher and Agatemor, 2010). However, out of these soil properties, soil pH was found to assume the most critical part in deciding metal speciation, dissolvability from mineral surfaces, development, and inevitable bioavailability of metals (Ogundiran and Afolabi, 2008; Sherene, 2010). A positive connection between soil pH, heavy metal mobility and accessibility to plants has been very much reported in various investigations. For instance, with diminished soil pH, the emotional increments in substantial metal desorption from soil constituents and dissolution in soil solution was observed for Cd, Pb and Zn (Yang et al., 2006; Ukpong et al., 2013). The mobility and bioavailability of heavy metals likewise increase with diminished soil pH (Joseph et al., 2006; Esmaeilil et al., 2010; Oyeku and Eludoyin, 2010), subsequently improving the uptake of heavy metals by plants and consequently creating negative impact to human wellbeing (Akaeze, 2001; Cappuyns et al., 2004).

Aside soil pH, organic matter content in soil is additionally a standout amongst the essential soil properties influencing heavy metal availability. Organic matter content of the soil is a noteworthy contributor to the capacity of soils for holding heavy metals in an exchangeable form. Moreover, organic matter additionally supplies organic chemicals to the soil solution that can serve as chelates and increase metal availability to plants (Clemente et al., 2003). The role played by organic matter on metal availability has been broadly studied. It was accounted for that substantial metal adsorption into soil constituents declined with diminished organic matter content in soils (Eddy et al., 2003; Altaher and Agatemor, 2010). Also, the dissolved organic matter in soils could increase the mobility and uptake of heavy metals to plant roots (Aboyade, 2004; Adjia et al., 2008). Cu, Fe, Mn and Zn are necessary minerals for plant development, yet Cr and Pb are non-essential however toxic to plants at a low level and to humans through a food chain. In this way, it is necessary to assess the impact of soil properties on the availability and the uptake of heavy metals by plants to limit the dangerous implications and the translocation to the food chain. This study aimed at assessing the organic matter and heavy metals leachate in selected dumpsites in North Central States, Nigeria.

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2.   Materials and Methods

2.1   Study area description

Nasarawa, Niger and Kogi States are situated within the north-central part of Nigeria. The population for Nasarawa, Niger and Kogi States are 2,040,097., 3,950,249 and 2,099,046, respectively, with each State having a land mass of 27,117 km2, 76,363 km2and 29,833 km2 respectively. The population in each of the study areas was unevenly distributed such that commercial, industrial and agricultural, recreational and administrative, and residential dumpsites were scattered everywhere throughout the city, thus serving as point sources of heavy metals (Adamu et al., 2003). Three sampling stations were established within each State based on the population of the locality and availability of major dumpsites.

2.2   Soil Sampling

Soil samples were randomly collected in triplicates from the various study locations at a soil depth ranging between 0 – 15 cm, 15 – 30 cm and 30 – 45 cm, respectively with a control point at each of the location. The sampling process was carried out using a depth calibrated soil auger as suggested by Olufunmilayo et al., (2014). The control points were located 100 m away from each cluster which served as the Reference site (RF). Most of the dumpsites were located outside the major cities. The various samples collected were carefully placed in a plastic bag, tightly sealed and marked. This reduced the presence of microbial activities from the study location, and substantial were elements were expelled during the process. This sampling process is similar to that of Asiagwu et al. (2007) and Pam et al. (2013).
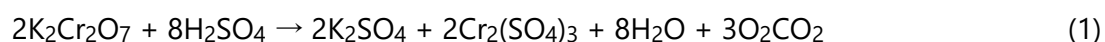
2.3   Heavy metals Analysis

In the laboratory, the soil samples were air dried for 72 hours at room temperature, after which the soil samples were grounded to fine particle sizes using laboratory pestle and mortar. The soils were sieved with a 2 mm sieve as described by Opaluwa et al. (2012). A sample of 5 g of air-dried grounded soil sample was placed inside a 25 ml conical flask and 5 mL of concentrated H_2SO_4, 25 ml of concentrated HNO_3, and 5ml of concentrated HCl were added to the soil sample. The content of the tube was warmed at 200 °C for 1 hour after which it was left to cool to room temperature (Bukar et al., 2012). After the cooling process, 20mL of distilled water was added, and the mixture was filtered to complete the digestion. The filtrate was added to a 50ml volumetric flask and allowed to settle for 15 hours after which the filtrate was investigated for metals using the Atomic Absorption Spectrophotometer (AAS) as described by Pam et al. (2013).

2.4   Determination of soil pH

Twenty grams of air-dried soil sample was weighed placed into a 50 mL measuring glass and 20 mL of distilled water was added to the sample. The solution was allowed to remain in a fixed position for 30 minutes. The solution was filtered and was used to determine the status of pH in each of the soil samples collected. The Hach pH meter was utilised to determine the pH level in each of the samples. pH Meter was calibrated using pH calibration buffer solution for pH 4, 7 and 10. The electrode of the meter was dipped into the filtrate and the pH meter readings taken to the nearest 0.05 unit.

2.5   Determination of Organic Matter

The organic carbon of soil was determined using the wet oxidation method in accordance with the process employed by Kumar et al. (2019). The organic carbon is oxidised by $K_2Cr_2O_7$ in the presence of H_2SO_4 towards the formation CO_2

$$2K_2Cr_2O_7 + 8H_2SO_4 \rightarrow 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 3O_2CO_2 \tag{1}$$

$$3C + 3O_2 \rightarrow 3CO_2 \tag{2}$$

Soil organic matter was determined by the titrimetric technique described by (Bukar et al., 2012). Samples were grounded to pass-through a 0.5 mm sieve after which they were weighed and transferred to 250 cm^3 Erlenmeyer flasks (Shigaki and Dell, 2015). Precisely 10 cm^3 of 1 M potassium dichromate was pipetted into each container and swirled tenderly to disperse the soil followed by addition of 20 cm^3 of concentrated sulphuric acids. The flask was swirled tenderly until soil and reagent are thoroughly mixed. The mixture was then allowed to remain in a fixed position for 30 minutes on a glass plate to allow for the oxidation of potassium dichromate to chromic acid. 100 cm^3 of distilled water was added were followed by addition of 3-4 drops of ferroin pointer, after which the mixture was titrated with 0.5 M ferrous sulphate solution. A clear titration was correspondingly done,and the rate of organic carbon was computed from the condition:

$$\frac{(MeK_2Cr_2O_7 - MeFeSO_4) \times 1.331 \times 100 \times F}{Mass\,(g)\,of\,soil\,(dried)} \tag{3}$$

F = Correction factor (1.33)

Me = Molarity of solution transferred X ml of solution used

% of organic matter in soil = % of organic carbon x 1.729

2.6 Statistical Analysis

Data obtained were analyzed using MINITAB version 14.0 (Ahaneku and Sadiq, 2014). Pearson correlation analysis was used to verify the relationship between examined variables and non-equilibrium one-way analysis of variance (ANOVA). The Duncan multiple range tests were used to separate means that were significantly different. The methodswere significantly different where $P \leq 0.05$ and insignificant when $P > 0.05$ at 95 % confidence interval (Ogundiran and Osibanjo, 2009).

3.0 Results and Discussion

Each of the states was divided into three catchment zones according to the spatial distribution of dumpsites. Niger had Borgu, Bida and Minna, Kogi had Lokoja, Okene and Kabba while Nasarawa had Lafia, Akwanga, and Nasarawa as the dumpsite locations. Heavy metal concentrations in all the catchments were higher than at the reference sites and lower than the threshold values (Tabak et al., 2005; Aislabie et al., 2006; Ahaneku and Sadiq, 2014). The results show that the Mn and Fe contents in the study location of Niger State were observed to be highest while a higher concentration of Cr and Al were observed in Kabba dumpsite area of Kogi State. These results were linked to the life style of the people within the communities. Interestingly, the concentration of Zn and Cu were highest in Lafia dumpsite area of Nasarawa State. The variation in the physicochemical properties in relation to the soil depth is similar to the findings of Mohammed et al., (2015) which is evident in the results presented in Tables 1, 2, and 3. The results showed that as pH decreases and % OM increases, heavy metals concentration increases down the soil profile.

3.1 Iron (Fe)

Figure 1 below, shows results of Fe concentrations across soil profile in all the sampling locations including the Reference (RF) site.

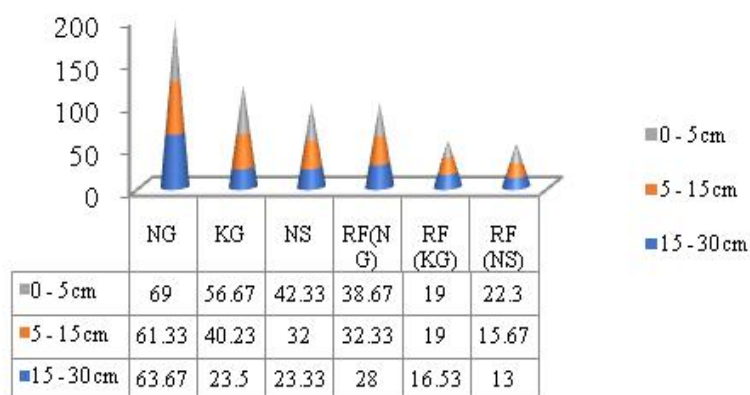|	NG	KG	NS	RF(NG)	RF (KG)	RF (NS)
▪ 0 - 5 cm	69	56.67	42.33	38.67	19	22.3
▪ 5 - 15 cm	61.33	40.23	32	32.33	19	15.67
▪ 15 - 30 cm	63.67	23.5	23.33	28	16.53	13

Figure 1: Fe concentrations (mg/kg) at various dumpsites by the depth

The results obtained showed that Fe showed a gradual decrease in its concentration across all the sampled locations including their respective RF points. The high content of Fe in the soil samples was observed at 5 cm depth in the dumpsites of Niger State (NG) (69.00 ± 11.02 mg/kg) and the lowest concentration at RF site of Nasarawa State (NS) (13.00 ± 2.08 mg/kg). The observed values were below WHO permissible limits of between 3000-250000 mg/kg as reported by Monechot et al. (2014). Akan et al. (2013) stated that heavy metals are uniformly distributed in the upper soil layer to a depth of 5 cm. Also, Iwegbue et al. (2013) observed a significant distribution of Fe across soil layers from 0 -15 cm to 15 – 30 cm depth. Results of Fe concentration obtained in this present study were lower than that obtained in residential and commercial dumpsites soil reported by Onyedika (2015). pH plays a vital role in the availability of heavy metals in soils. Akan et al. (2013) reported that heavy metal distribution in the soil increased with a decrease in soil pH from 6.21 to 7.72 and 0.51 to 3.79% OM which could be linked to the chemical processes within the soil. These observations agrees with the current studies where the distribution of Fe across varying depth increases as pH decreases from 6.81 to 6.59 and % OM from 0.75 to 2.2 %.

The ANOVA results at $p < 0.05$ revealed there is a significant difference in the concentrations of Fe across soil profile. Furthermore, results of Duncan's multiple range tests compared the means and indicated a significant difference between all dumpsites against the Reference (RF) sites.

3.2   Chromium (Cr)

The results of Cr content across the various soil profiles in all the sampled locations are presented in Table 2. It was observed that there were varying concentrations of Cr in all the sampled areas. Cr content was found to be high at dumpsite of NS (29.00 ± 1.15 mg/kg) and low at RF point KG (0.60 ± 0.00 mg/kg). The mean level of Cr in all the dumpsites is highest at 0 – 5 cm depth; these observations are in agreement with previous studies that soil contaminated by anthropogenic activities typically contains highest and varied content of heavy metals at the surface horizons (Chopin et al., 2003; Boularbah et al., 2006; Ahaneku and Sadiq, 2014). In this study, Cr content was much lower when compared to that reported by Adefemi and Awokunmi (2009) in dumpsites soil within Ado-Ekiti town, South West Nigeria. This was higher than the content published by Dauda et al. (2011) in a study conducted in Keteren Gwari dumpsite, Niger State but below the permissible limits of 150 mg/kg for France; 100 mg/kg for Austria and Spain; 60 mg/kg for Germany and Sweden; and 30 mg/kg for Denmark (Adelekan and Abegunde, 2011); 240 mg/kg in Nigeria (DPR-EGASPIN, 2002). The content of Cr slightly decreases with increased depth in both disposal and reference sites in all the locations. ANOVA

result shows there is a significant difference in the concentration of Cr across depth profile, but by sites, only Niger State (NG) and Kogi State (KG) sites showed higher Cr concentrations than the reference locations.

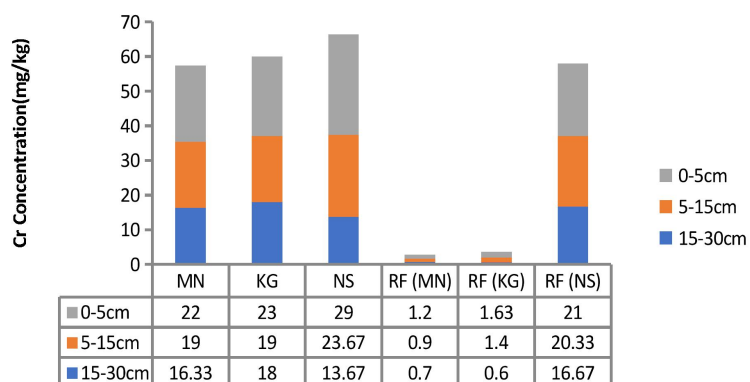|	MN	KG	NS	RF (MN)	RF (KG)	RF (NS)
■ 0-5cm	22	23	29	1.2	1.63	21
■ 5-15cm	19	19	23.67	0.9	1.4	20.33
■ 15-30cm	16.33	18	13.67	0.7	0.6	16.67

Figure 2: Cr concentrations (mg/kg) at various dumpsites by depth.

3.3   Manganese (Mn)

The results of the Mn analysis are presented in Figure 3. The highest Mn concentration was observed at depths of between 0 – 5 cm at a dumpsite in NG (131.00 ± 25.98 mg/kg) while the lowest was at RF site of KG (7.00 ± 5.00 mg/kg). The mean values decrease down the soil profile for both the dumpsites and the reference point. This was observed to be similar to the works of Pam et al. (2013) and Adelekan and Abegunde (2011). They worked in dumpsites soil around the mechanic village in Makurdi and municipal dumpsites in Ibadan respectively. In their study, they observed that pH and OM may be responsible for the variations in concentration at varying depth. The concentration of Mn in the soil in this study was higher compared to that reported by Amadi and Nwankwoala (2013) in their study on Enyimba dumpsites in Aba. The values were considerably lower compared to Mn level found in Esso, Gbangbara, and Eyagi dumpsites respectively in Bida, (Niger State) as reported by Nda-Umar et al. (2012) and lower than that reported by Onyedika (2015) for urban soils of Bauchi State. This is attributed to the soil pH which is slightly acidic and makes the distribution of this metal to be at a slow rate. Although the concentration of Mn obtained in this study is higher compared to other metals but less than the world-soil average (Kabata-Pendias, 2011).
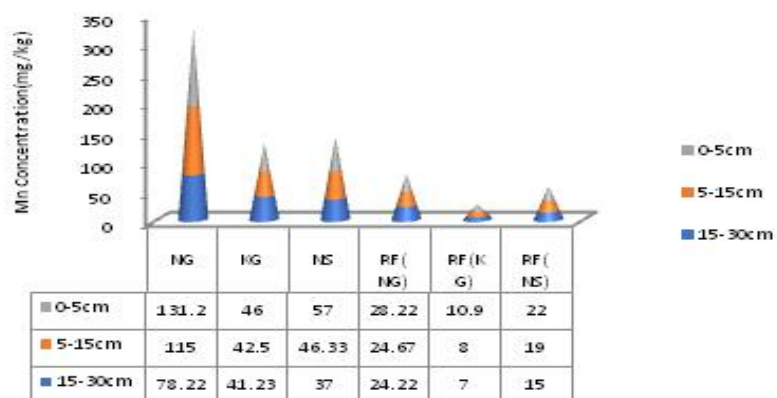
	NG	KG	NS	RF (NG)	RF (KG)	RF (NS)
■ 0-5cm	131.2	46	57	28.22	10.9	22
■ 5-15cm	115	42.5	46.33	24.67	8	19
■ 15-30cm	78.22	41.23	37	24.22	7	15

Figure 3: Mn concentrations (mg/kg) at various dumpsites by the depth.

The result of analysis of variance (ANOVA) at p<0.05 showed that there was a statistically significant difference in Mn content across soil profile. Furthermore, the results of Duncan's multiple range tests compared the various means and indicated a significant difference between all dumpsites and RF sites.

3.4 Zinc (Zn)

The Zn concentrations for the various sites is presented in Figure 4 with the highest mean concentration at NS dumpsite (46.67 ± 8.69 mg/kg) and the lowest at the RF location NG (1.40 ± 0.23 mg/kg). From results obtained, Zn content at the various dumpsites was higher compared to the control which may be due to contamination from the dumpsites as a result of anthropogenic activities. The concentration of Zn in all the sampled points increased with a decrease in both pH and % OM across the various soil depths. Zn accumulation within the soil depth was detected by Ogundiran and Osibanjo (2009), while Olufunmilayo et al. (2014) in their study on dumpsite soil observed a decrease of Zn from the top layer of 0 – 15 cm; 15 – 30 cm and 30 – 45 cm depth. These results obtained is similar to that in this study as a high level of Zn content was observed at 5cm depth and decreases down the soil depth of 30 cm with a decrease in pH and %OM. The result of Zn content in the present this study is similar to the results obtained in Cameroon, Southeast Korea and Yauri of Kebbi State, Nigeria (Yahaya et al., 2010) but higher as compared to studies conducted in Lafia dumpsites by Opaluwa et al. (2012) and lower when compared to other studies (Shinggu et al., 2007; Ogundiran and Osibanjo, 2009; Nwachukwu et al., 2011). Acidic pH levels within the study area makes it easier for the solubilization of Zn compounds (Abechi et al., 2010). In this study, pH ranged from 6.33-6.87 as presented in Table 3 which indicates that the soil is slightly acidic. Hence, Zn accumulation in soil layers is expected to be at a slow rate. The study carried out by Pam et al. (2013) and Akoto et al. (2008) showed that pH of between 6.36 and 6.4 conforms to this study. This might be responsible for the low value of Zn obtained in this current study as compared to other studies. However, the values of Zn obtained in this study is below the permissible limits of 1 – 900 mg/kg in the soil (Kabata-Pendias and Pendias, 2001; Hague et al., 2008). ANOVA results revealed there is statistically (p<0.05) significant difference in the concentrations across soil profile. Furthermore, results of Duncan's multiple range tests to compare means indicated a significant difference between all dumpsites against the RF sites.

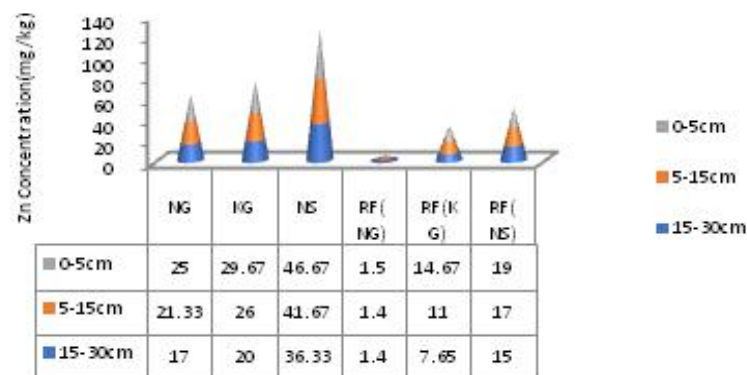| Zn Concentration (mg/kg)	NG	KG	NS	RF (NG)	RF (KG)	RF (NS)
0-5cm	25	29.67	46.67	1.5	14.67	19
5-15cm	21.33	26	41.67	1.4	11	17
15-30cm	17	20	36.33	1.4	7.65	15

Figure 4: Zn concentrations (mg/kg) at various dumpsites by the depth

3.5 Copper (Cu)

The results as presented in Figure 5 revealed that the values of Cu at the dumpsites are higher than the values obtained at the reference points. The highest Cu concentration was detected at dumpsites of NG (40.67 ± 11.22 mg/kg) and the lowest at the RF site of NG (0.90 ± 0.40 mg/kg)

also. The concentration of Cu was also observed to be high at the top layer of the soil (0 – 5 cm) and decreases across soil profile as pH decreases from 6.33 to 6.87 and % OM decreases from 0.89 to 0.73. The values of Cu content found in this study are higher as compared to results for dumpsites soils reported by Olufunmilayo et al. (2014) but below the permissible limits for countries like Australia (100 mg/kg), Canada (100 mg/kg), Poland (100 mg/kg), Japan (125 mg/kg), Great Britain (100 mg/kg) and Germany (50 mg/kg) as reported by Pam et al. (2003). The content of Cu in all the sampled locations decreases with depth of the soil profile. Cu distribution down to 30 cm depth has been reported by Akan et al. (2013), while Ololade (2014) in their study on dumpsite soil observed increased Cu to a depth of 100 cm. This is similar to the works of (Bansal and Sing 2014; Amos et al., 2014) and at variance with the works of Bukar et al. (2012) and Adedosu et al. (2013) which could be linked with the various types of waste generated in the area. In this study, the high level of Cu was noted at 0-5 cm down to 15-30 cm depth, this agrees with the findings of Iwegbue et al. (2013). The mean content of Cu ranged between 14 and 40.67 mg/kg which is similar to what was obtained by Ahaneku and Sadiq (2014) in their study on Minna municipal dumpsites, Niger State.
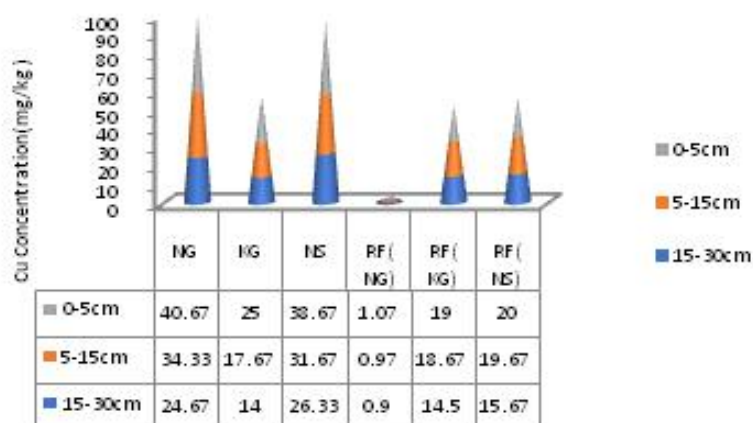

Cu Concentration (mg/kg)	NG	KG	NS	RF (NG)	RF (KG)	RF (NS)
0-5cm	40.67	25	38.67	1.07	19	20
5-15cm	34.33	17.67	31.67	0.97	18.67	19.67
15-30cm	24.67	14	26.33	0.9	14.5	15.67

Figure 5: Cu concentrations (mg/kg) at various dumpsites by the depth

The results of the Analysis of variance (ANOVA) revealed a statistically (p<0.05) significant difference across soil profile. Furthermore, results of Duncan's multiple range tests which compared the means indicated a significant difference between all dumpsites against the RF sites.

3.6   Aluminium (Al)

The results of Al are presented in Figure 6. The highest mean concentration of Al was observed at dumpsites NS (16.73±1.56 mg/kg) while the lowest at RF location of KG (6.60±0.00 mg/kg). The concentration of Al was also observed to be high at the top layer of the soil (0 – 5 cm) and decreases downwards to a depth of 15 – 30 cm depth. Mohammed and Bashir (2015) found a significant distribution of Al to a depth of 130 cm. Also, Akan et al. (2013) reported that heavy metals have an even distribution across soil profile to a depth of 5 cm. These results agree with the current study where the distribution of Al across soil profile (leaching) to a depth of 30cm was found throughout the sampling locations with varying concentration levels. Al contents found in this current study are much lower than the mean values of between 26580 – 95270 mg/kg (Beyene and Banerjee, 2011; Mohammed and Bashir, 2015). The obtained mean values of 16.73 mg/kg for Al in this study is lower than the world average crustal abundance of 82300 mg/kg in an uncontaminated soil as reported by Mohammed and Bashir (2015). Analysis of Variance (ANOVA) of the results indicated that there is a significant difference (p<0.05) in the

concentrations across the sampled depths. However, results of Duncan's multiple range tests to compare means indicated a significant difference between all dumpsites against the RF sites.
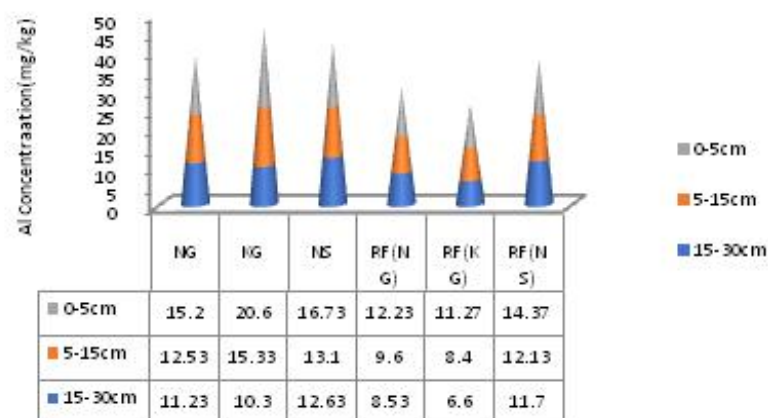

Figure 6: Al concentrations (mg/kg) at various dumpsites by the depth

3.7   Soil Properties

Table 1 presents the average results of soil physicochemical properties in NG dump and RF sites across the different soil depth levels (0 – 15 cm, 15 – 30 cm and 30 – 45 cm) of sampling. Soil pH plays a fundamental role in heavy metal chemistry (Pam et al., 2013). The result obtained in this study, revealed that pH level was significantly higher at the RF dumpsite (6.81 ± 0.05) and lowest at dumpsites (6.59 ± 0.19) similar to other studies on heavy metals in Gboko and Makurdi dumpsite soils by Pam et al. (2013). There was generally a decreasing trend of pH across depth levels. However, the pH suggests that the soil is slightly acidic which means cations movement across soil profile will be slow. The pH values obtained in this current study agrees with results that Nigerian soil is within limit and favour plant growth as reported by Banjoko and Sobulo (2000). The results of ANOVA revealed no significant difference ($p < 0.05$) in the variations. % OM plays a fundamental function in metal binding (Akans et al., 2010). Total % OM of the soil ranged from 0.75 to 2.2% and is similar to the result of OM reported by Iwegbue et al. (2013) which is in the range of 0.8 to 2.8 %. In their study, the highest percentage of OM was observed at a depth of 0-15cm and decrease with increased depth which is similar to OM result obtained in this study. The highest rate of OM was found at the surface layer at a depth of 0-15 cm, and there was a slight difference in the values throughout the depth. The works of Adelekan and Abegunde (2011) also revealed depth-related differences.

Table 1: Summary of physicochemical properties of soils surrounding sampling sites in Niger State (NG) dumpsites.

	Depth (cm)	pH	% OM	% silt	% clay	% sand	Textural class
DS	0-5	6.78 ± 0.09	2.20	7.00	10.70	82.30	Loamy sand
	5-15	6.64 ± 0.18	1.50	6.70	11.00	82.30	Loamy sand
	15-30	6.59 ± 0.19	1.20	6.00	11.30	82.70	Loamy sand
RF	0-5	6.81 ± 0.05	0.82	6.70	12.00	81.30	Loamy sand
	5-15	6.72 ± 0.09	0.80	6.70	10.70	83.30	Loamy sand
	15-30	6.63 ± 0.14	0.75	7.00	10.00	83.00	Loamy sand

The ANOVA result shows no significant variations across soil profile. The values of particle size distribution for NG for sand ranged between 81.3– 83%, silt ranged between 10-12 %, while clay ranged between 6.7-7%. These results agree with that works of Ahaneku and Sadiq (2014) and Amos et al., (2014) in their study of open dumpsites for Maitumbi which had 84.85% of sand, 10.16% of silt, and 4.99% of clay, and Maikunkele had 84.60% of sand,11.79% of silt, and 3.61% of clay. However, the textural classification of the particle size distribution in this study is loamy sand which is typical of soils in Nigeria (Sha'Ato et al., 2000). In Table 2, the results show that pH level decreases downwards the soil depth in the dump and RF sites. Highest values were observed at RF locations (7.09 ± 0.01) while the lowest at dumpsite DS (6.78 ± 0.00). However, there was a slight difference throughout the depth in the dumpsites. This is as a result of a decrease in pH and %OM. Adelekan and Abegunde (2011) in their study on the contribution of municipal refuse dump on heavy metal concentration in Ibadan also revealed depth-related differences in metal concentration.

Furthermore, Oviasogie and Ndiokwere (2008) in their study reported that lower pH favour availability, mobility and redistribution of the metals like Pb and Cd in the various fractions. Soil pH, for instance, plays a significant role for most heavy metals as reported by Adelekan and Abegunde (2011) that heavy metal availability is relatively low when pH is around 6.5 to 7. This tends to agree with the pH range of 6.78 to 6.89 obtained in this present study, which indicated that the soils are slightly acidic. ANOVA result for these showed no significant ($p < 0.05$) difference in the variations. % OM obtained in the present study is in the range 1.2 to 2.2% which conforms to OM values reported by Akoto et al. (2008) to have the potential to bind toxic ions. ANOVA results for the variations across depth levels show no significant difference.

Table 2: Summary of physicochemical properties of soils surrounding sampling sites in Kogi State (KG) dumpsite.

	Depth (cm)	pH	% OM	% silt	% clay	% sand	Textural class
DS	0-5	6.89 ± 0.05	3.10	10.00	12.00	78.00	Loamy sand
	5-15	6.78 ± 0.11	1.50	9.70	10.70	79.70	Loamy sand
	15-30	6.78 ± 0.00	1.10	11.00	11.30	76.50	Loamy sand
RF	0-5	7.09 ± 0.01	1.02	9.70	10.70	79.70	Loamy sand
	5-15	6.89 ± 0.06	0.95	6.50	12.00	80.50	Loamy sand
	15-30	6.85 ± 0.09	0.91	6.00	13.00	81.00	Loamy sand

According to Amos et al. (2014), the loamy soil has high pollutant leaching potentials. However, the soil of all the study locations predominantly contains high sand fractions (80.0%) that allow high infiltration of water and leachates. Textural classifications of existing soils in the study area are loamy sand soil which plays a significant role in the diffusion of metals ion into and out of soil aggregates (Sherene, 2010). In that study, it was found that the downward distribution of metals correlated with high soil macroporosity. In this study, metal concentration increases depth wise in all the sampling points.

Table 3: Summary of physicochemical properties of soils surrounding sampling sites in Nasarawa State (Ns)

	Depth (cm)	pH	% OM	% silt	% clay	% sand	Textural class
DS	0-5	6.62 ± 0.31	2.30	5.00	14.00	81.00	Loamy sand
	5-15	6.58 ± 0.23	2.20	6.30	11.00	82.60	Loamy sand
	15-30	6.33 ± 0.17	1.30	5.00	11.30	82.60	Loamy sand
RF	0-5	6.87 ±0.30	0.89	6.70	12.30	81.00	Loamy sand
	5-15	6.56 ± 0.16	0.83	7.00	12.30	84.00	Loamy sand
	15-30	6.40 ± 0.05	0.73	7.60	10.60	81.60	Loamy sand

The mean results of soil pH and OM at NG dumpsites and RF sites are presented in Table 3. The highest values were observed at the reference dumpsite RF (6.87 ± 0.01) while the lowest at dumpsite DS (6.33 ± 0.17) indicating that the soils are slightly acidic. This may tend to have increased heavy metal availability and concentration in the soil. This is similar to findings of Amos et al., (2014) who worked on dumpsites soils in Yenegoa where it was discovered that pH and %OM increase heavy metal distribution down the soil profile. The results of ANOVA revealed no significance ($p < 0.05$) in the variations. It was also observed that OM content at all the sites decreased with increasing depth and that accumulation of OM occurs mainly in the top layer(0-5cm) in all the sampling points. OM accumulation at the top layer decreases down to 30-45 cm depth as detected by Olalade (2014). Ayolagha and Onwugbuta (2001) have shown that high OM (> 2.0%) in soils is conducive for heavy metal chelation formation. This is in agreement with OM which ranged from 1.3 to 2.3% as obtained in this study (Table 6). However, dumpsites have higher OM and low pH as compared to that of the control soil. This observation is in line with findings of Oyedele et al. (2008). They reported that dumpsites soil had low pH and high OM in comparison to those at control locations. ANOVA results for the variations across depth levels show no significance. The textural classification of the soil for sand ranged from 81 to 84% which is similar to the report presented by Chindo et al. (2016) with moderate clay and low silt content.

3.8   Correlation Analysis

In NS dumpsites, both Fe and Cu were negatively correlated with OM while Cr positively correlated with pH. However, there was a significant negative correlation between Fe and Cu with OM in NG dumpsites. Fe is significantly correlated with pH as well as Mn and Cu with OM in KG dumpsites. Cu and pH were positively correlated in the KG dumpsites which is similarto the result reported by Iyaka and Kakulu (2009) and Ahaneku and Sadiq (2014) in their study. pH is positively correlated with Cr, Fe, Zn ($p < 0.05$) in all the sites while OM is significantly correlated with Mn and Cu at only KG dumpsites. The relationship between pH, OM content and concentration of heavy metals are presented in Table 4.

Table 4: Correlation coefficients (r) between the pH and OM on heavy metals in dumpsite soils tested

Location	Items	pH	OM	Cr^{2+}	Fe^{2+}	Mn^{2+}	Zn^{2+}	Cu^{2+}	Al^{3+}
NIGER	pH	1							
	OM	0.099	1						
	Cr^{2+}	-0.124	-0.169	1					
	Fe^{2+}	-0.356	-0.821**	0.312	1				
	Mn^{2+}	0.477	-0.643	-0.239	0.3031	1			
	Zn^{2+}	0.501	-0.221	0.527	-0.0091	0.172	1		
	Cu^{2+}	-0.403	-0.738**	0.414	0.849**	0.049	0.274	1	
	Al^{3+}	-0.09	0.126	0.843*	-0.164	-0.374	0.528	0.055	1
KOGI	pH	1							
	OM	-0.742*	1						
	Cr^{2+}	0.333	-0.185	1					
	Fe^{2+}	0.832**	-0.643	0.108	1				
	Mn^{2+}	-0.301	0.159	0.759	-0.413	1			
	Zn^{2+}	0.334	0.008	0.201	0.685	-0.125	1		
	Cu^{2+}	0.827	-0.59	0.770*	0.631	0.203	0.392	1	
NASS	pH	1							
	OM	-0.184	1						
	Cr^{2+}	0.757	-0.548	1					
	Fe^{2+}	-0.143	-0.792*	0.423	1				
	Mn^{2+}	-0.581	-0.077	-0.22	0.482	1			
	Zn^{2+}	-0.563	0.258	-0.305	0.166	0.903	1		
	Cu^{2+}	0.296	-0.967*	0.59	0.641	-0.084	-0.360	1	
	Al3+	-0.139	0.641	-0.365	-0.371	0.374	0.564	-0.709	1

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

3.9 Heavy Metals about pH and Organic Matter (OM) in the Soil

This study revealed that availability of metal cation across soil environment is a function of pH and OM. Figures 7 to 9 illustrates these relationships; as pH and % OM increases with the deepening of soil depth, concentration of metals increases across soil depth.
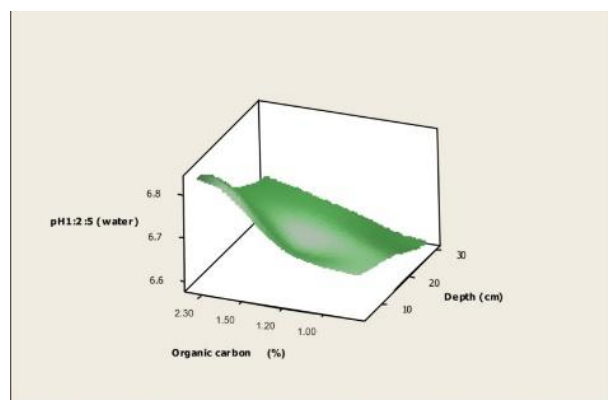
Figure 7: Relationship between pH and OM on Metal availability across soil profile at Niger State (NG) dumpsite
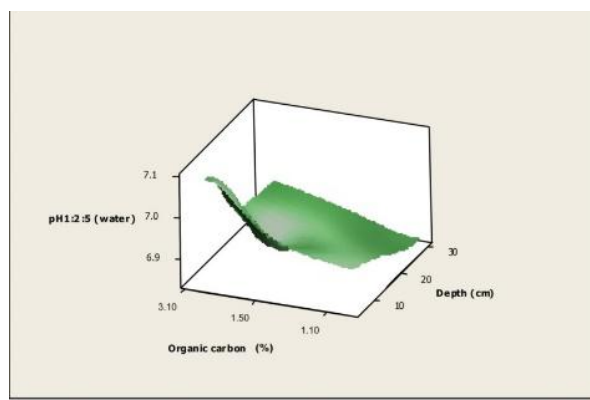

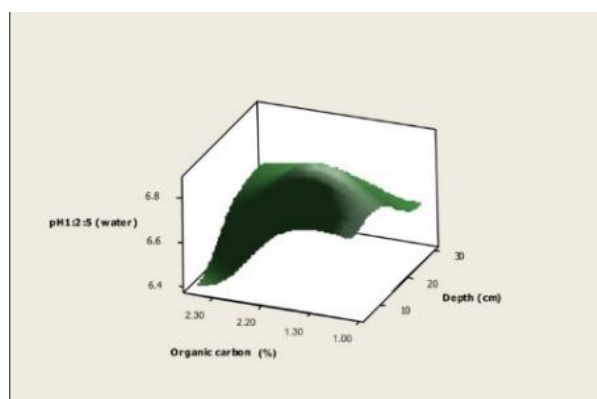Figure 8: Relationship between pH and OM on metal availability across soil depth on Kogi State (KG) dumpsite

Figure 9: Relationship between pH and OM on Metal availability across soil profile at Nasarawa State (NS) dumpsites.

4. Conclusion

Results obtained from this study showed no significant differences (P<0.05) in the concentrations of the investigated heavy metals across the different soil depths of the dumpsites when compared with those of the control points within the same locality. It was revealed that Mn generally had the highest concentrations in all soil profiles studied while Al was least detected at that location. The mean concentration of all the metals in the dumpsites was observed to be significantly higher than those at the control locations though these values were below the permissible limits set by FAO and WHO for agricultural soils. Results of physicochemical properties of the soil revealed that decrease in pH and percentage organic matter increases the concentration of the metals within the study locations with the top soil having the highest concentration. It is therefore recommended that environmental laws should be enforced to prevent any form of anthropogenic activities aim at modifying pH and OM in the soil and to arrest the ongoing buildup of heavy metals in those locations.

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