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Full Length Research

Distribution of Heavy Metals on Soils of Solid Waste Dump Sites in Port Harcourt Rivers State, Nigeria

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The study experimentally examined physico-chemical properties of soil in selected dumpsites (Eliozu, Iwofe and Igwuruta) in Port Harcourt Metropolis. Soil samples were collected in labelled polythene bags and taken to laboratory for analyses. Three leachate samples were randomly collected from the dumpsites into a labelled, sterilised plastic container and taken to laboratory for analyses. Descriptive statistics and inferential statistics (ANOVA) were used. Results showed soil pH was more acidic in the dumpsites than control plot. Findings showed sand dominated the particle size and highest sand content at topsoil (0-15cm). Analysis showed soil pH decreased in acidity with increasing soil depth at control plot and dumpsites areas. Total organic carbon was higher at dumpsites than control plot. Mean total organic carbon was highest at topsoil (0-15cm) and lowest at 30-45cm soil depth. Mean Pb, Fe, Cr, Zn, Ni and Cd were significantly higher at dumpsite than control plot at 0.05 significant levels. Heavy metals concentrations were lower than permissible limit of USEPA. Mean pH, total organic carbon, Pb, Fe, Cr, Zn, Ni and Cd decreased with increasing soil depths. Acidic level of leachates from dumpsites ranged from 4.63 to 5.13; and more acidic than USEPA permissible limit. Findings revealed mean NO_3, SO_4, PO_4, Pb, Cr and Zn of leachates were highest at Igwuruta Dumpsite and higher than USEPA permissible limit. Study recommends proper monitoring and management of waste at open dump sites to forestall possible pollution of ground water.

Key Words: Distribution, Heavy-Metals, Soils, Waste-Dump- Site, Port Harcourt.

INTRODUCTION

Proper wastes disposal has been a serious problem in Port Harcourt and most cities in Nigeria. In Nigeria leachates from refuse dumpsites constitute a source of heavy metal pollution to both soil and aquatic environment, (Obaliagbon and Owolojoba, 2006). In some cases, waste are dumped recklessly with no regards to the environmental implications while in some dumpsites, waste is burnt in the open

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and ashes abandoned at the sites. The burning of wastes gets rid of the organic materials and oxidized the metals, leaving the ash richer in metal contents. After the process of oxidation and corrosion, these metals will dissolved in rain water and leached into the soil from where they are picked up by growing plants, there by entering the food chain. Improper waste management methods also cause the contamination of underground water, while most of the metals are being washed away by runoff into streams and rivers thereby contaminating the marine environment. Consequently, these metals accumulate in fish and other aquatic organisms, hence posing a health threat to the consumer, (Njojju and Ayoka, 2006). Recent studies have also shown that waste dumpsite can transfer significant levels of toxic and heavy metals into the soil environment. Eventually the metals are taken up by parts of plant and some are transferred into the food chain. Consequently, soil higher in heavy metal, concentration can result in higher levels of plant uptake. Although, the rate of metals uptakes by crop plants could be influenced by factors such as metal species, plant species, plant eye and plant part. In recent times, most of the dumpsites are used as fertile soils for the cultivation of some fruits and vegetables. Most farmers collect the decomposed parts of the dumpsites and apply to their farms as manure. These cultivated plants take up these heavy metals either as mobile ion in the soil solution through their leaves or root thereby making it unhealthy for human consumption, (Uzolo and Oti, 2006). Heavy metals, is the term commonly adopted as a group name for the metals which are associated with pollution and toxicity. They may also include some elements which are very essential for living organisms at low concentrations. Among these heavy metals, some have been found to be of serious hazard to plants and animals; they have been listed by the European Commission to include; As, Cd, Cr, Cu, Pb, Hg, Ni, Al and Zn. Heavy metals are metals with a density of at least five times that of water. Heavy metals are stable elements that cannot be established by the body; as such they are passed up in the food chain to human beings (Bioaccumulation). The most common and harmful heavy metals are Al, As, Cd, Cu, Pb, Hg, and Ni etc., heavy metals in general have no basic function in the body and can be highly toxic. They are present in drinking water, food and countless human made chemicals and products. Hence, this study has been carried out to assess the heavy metals distribution in soils of solid waste dumpsites in Port Harcourt. Several dumpsites exist in Port Harcourt and its environs. These dumpsites are usually surrounded by luxuriantly growing vegetation and a number of intrinsic factors that include soil type and other environmental factors control the plant species/population.

The objective of the study was to evaluate the level of some heavy metals distribution in soils of solid waste dumpsites in Port Harcourt, Rivers State.

MATERIALS AND METHODS

This study adopted the experimental research methods. Also reconnaissance survey, site description and soil analysis were carried out.

Reconnaissance Survey

Field reconnaissance survey was carried out in Eliozu, Iwofe and Igwuruta dumpsites in Port Harcourt. This visit helped to familiarize the researcher with the environment. The location of the control plot was also determined during the course of the visit; see Figure 1 (sample location map).

Site description

The study was carried out on dumpsites in Iwofe, Eliozu, and Igwuruta, both in Port Harcourt Metropolis and a relatively disturbed secondary rainforest site was used as the control. The control site was about 1000 metres away from the dumpsite. The heavy anthropogenic activities and the corresponding huge amount of wastes that was generated and discarded on daily basis lead to the choice of Iwofe, Eliozu, and Igwuruta dumpsite for this study.

Eliozu, Iwofe and Igwuruta dumpsites are located in Port Harcourt Metropolis comprising of Obio/Akpor LGA, Ikwerre LGA and Port Harcourt City LGA. The dumpsite in Iwofe, Eliozu and

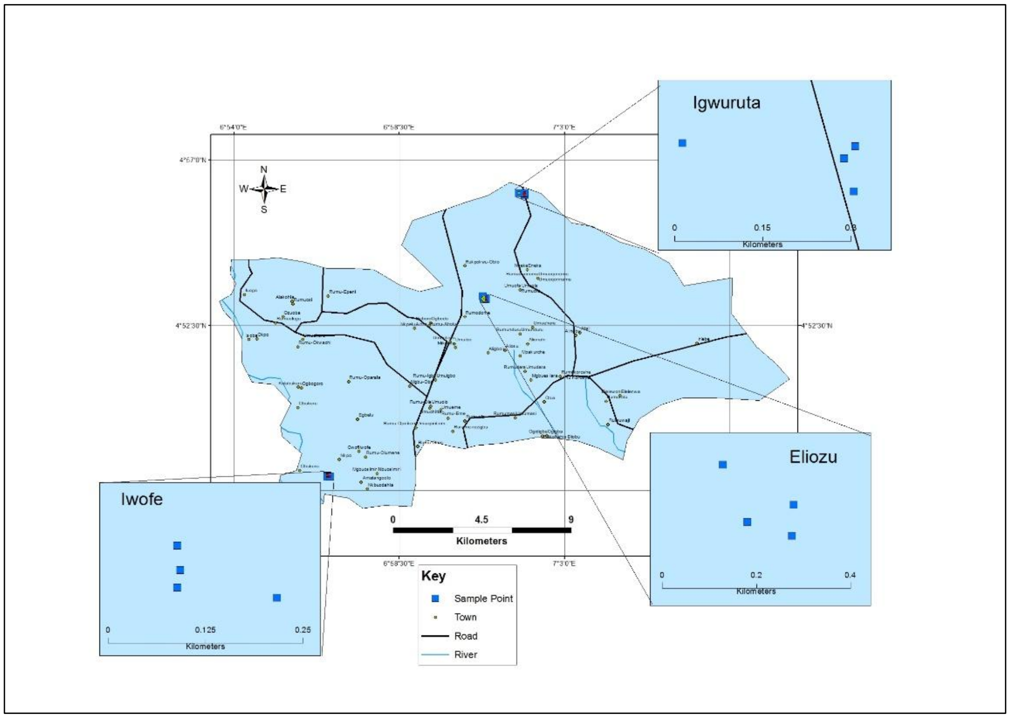

Figure 1. Study Area Port Harcourt Metropolis Showing Sample Locations.

Igwuruta has been in existence for more than ten years.

Site 1:- The Iwofe burrow pit lays at latitude 04°48'30.392"N and longitude 006° 56'.549"E in Obio/Akpor LGA. The burrow pits about 115m deep and 130m wide is located in a high density area of the city. Iwofe is along the busy University of Education Road. It is currently being used by the Rivers State Environmental Sanitation Authority as a dumpsite. The ditch was excavated to source materials for road construction in the area. At the time of sampling, a portion of the pit was filled with water being drained from the road and fresh wastes dumped were awaiting compaction (Figure 2).

Site 2:- The Eliozu Dumpsite lies between latitude 04°'53.228"N and Longitude 007°00'.816"E. The study area is within the Obio/Akpor LGA of Rivers State. The burrow pits were excavated during the construction of the Air-force-Eliozu roads between 2003 and 2014.Wastes dumped at the site includes domestic wastes, motor tyres, plastic materials, cartons, leather materials, cans, clothing and market waste. The high number of schools, churches, markets and fabricating companies in the area has resulted to high population density and high accumulation of wastes (Figure 3).

Site 3:- Igwuruta is located on latitude 04°56'.097"N and Longitude 007°01'7.930"E. Igwuruta is a moderately populated sub-urban environment. The burrow pits which was excavated during the construction of Igwuruta-Eneka – Rumukurushi road in 2003 and 2014, was converted to solid waste dumpsites and it is an open dumpsite and its proximity to residential areas gives it high patronage. It was observed that solid waste was the major type of waste in the dumpsites. Its composition included plastics, metal scraps, roofing sheets, food waste, saw dust, leather materials, agricultural waste, medical waste, wood, fabrics, and many others. It was also observed that the varieties and volume of wastes received by Iwofe, Eliozu, and Igwuruta dumpsite attracted scavengers who sort these wastes for money to make a living, especially the plastics, tins and metals waste

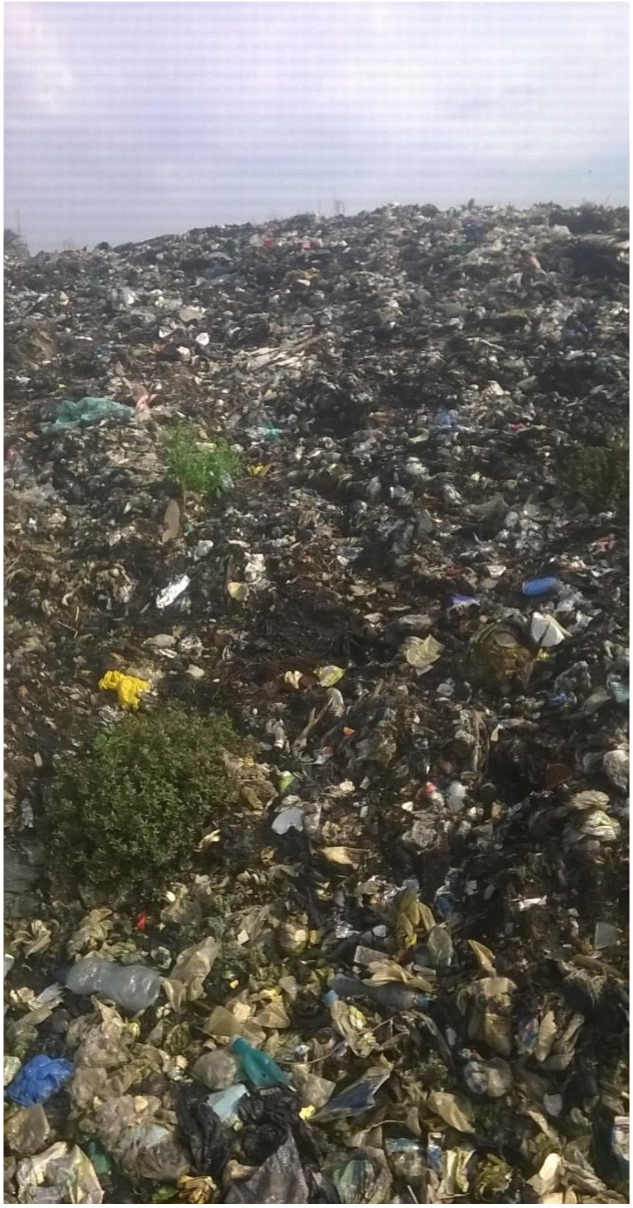

Figure 2. Iwofe Dumpsite, PortHarcourt.

materials. Scavengers, birds, rodents, reptiles and micro-organisms abound on the decaying portions of the dump site (Figure 4).

Sampling Methods

The random sampling technique was used in soil sample collection and controls to ensure valid and reliable results with high level of certainty. The collected soil samples were analysed in the laboratory.

Soil Sampling Technique and Collection

Three soil samples were randomly collected from each dumpsite and control plot at the depths of 0-15cm, 15-30cm and 30-45cmwith the use of soil auger. Thus, a total of nine soil samples were collected in each dumpsite and control. A total of thirty six soil samples were used for this study. The soil samples were collected into a well-labelled polythene bags and taken to the laboratory for analyses. Three leachate samples were also randomly collected from the dumpsites. The leachate samples were collected at the same spot where soil samples were collected in each dumpsite. Leachate samples were collected into a well labelled and sterilised plastic container and taken to laboratory for analyses. **Laboratory analysis:-**The soil samples were air-dried, grinded mechanically using a stainless steel roller and sieved to obtain < 2mm fraction. A 30 g sub-sample was taken from the original bulk soil of <2 mm fraction and re-grounded to obtain <200 µm fraction using a mortar and pestle.

Soil Particle Size Composition:- Soil particle size composition was analysed using the hydrometer method.

Total organic carbon:- Total organic carbon was determined by Walkey and Black's rapid titration method (Walkey and Black, (1934); Van et al.,1999).

Soil and Leachate pH:- Soil pH and Electric conductivity was measured potentiometrically in 0.01M calcium chloride solution using 1:2 soil/water solutions.

Soil and Leachate Heavy metals :- Extracts used for determining heavy metals (trace elements) was obtained by leaching soil samples using 0.1N EDTA. The concentrations of extractable trace metals such as Lead (Pb), Zinc (Zn), Chromium (Cr), Cadmium (Cd) and Nickel (Ni) in the solutions were determined using atomic absorption spectrophotometer (AAS), (Pansu, and Gautheyrou, 2006). Also, the heavy metals in leachate samples were determined using AAS. **Anions: -** (Nitrate, Sulphate and Phosphate).

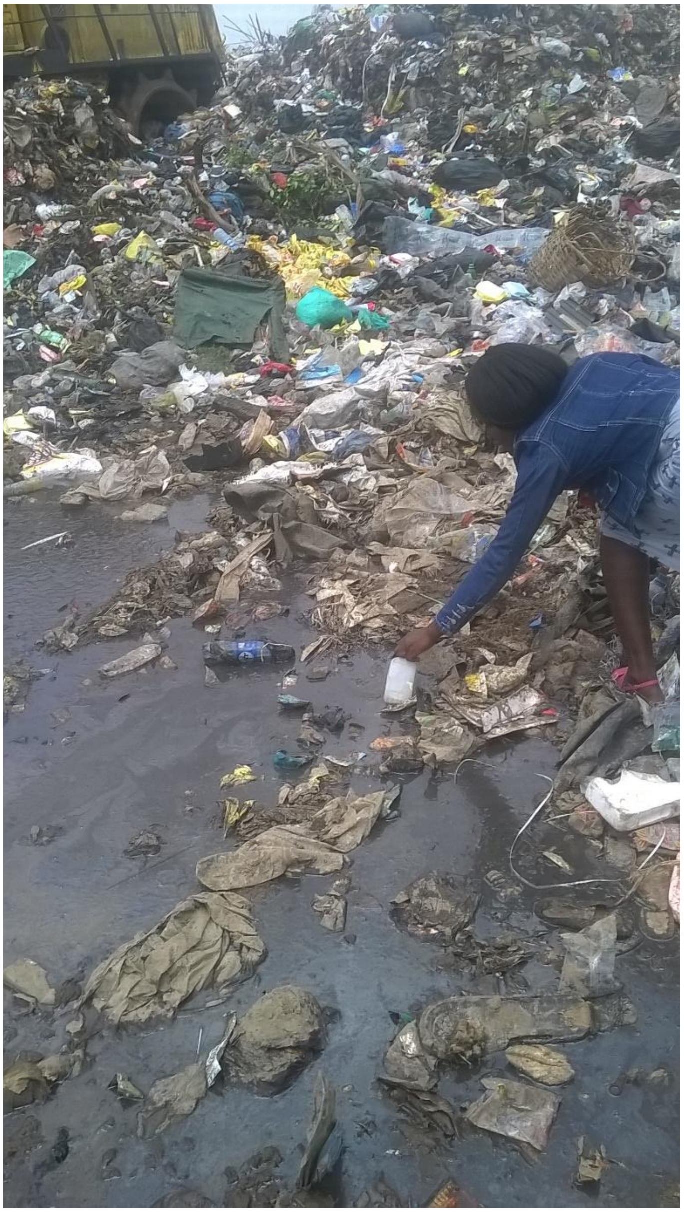

Figure 3. Eliozu Dumpsite, Port Harcourt.

Leachate:- The anions in leachate samples were determined using Ion Chromatography (IC) .

Data Analysis

Descriptive statistics was used to explain the mean values of the soil physical and chemical properties in the dumpsite and control site. Inferential statistics such as pairwise t test, analysis of variance (ANOVA) and one sample t-test were used to test the formulated hypotheses. Hypothesis 1 which states that there is no significant difference in the soil properties between the dumpsites and control plot was tested using t-test. Hypothesis 2 which states that there is no significant variation in the soil properties among the dumpsites was tested using ANOVA. Hypothesis 3 which states that there is no significant variation in soil properties in the dumpsites among the soil depths was also tested using ANOVA. All statistical analyses were performed using SPSS version 20.0. The data generated from the study were further presented in tables and charts.

RESULTS

Physico-Chemical Properties of Soil in the Dumpsites and Control Plot

Soil pH: It is revealed that soil pH was acidic at 0-15 cm depth of soil profile in all the dumpsites having a range from 4.70 to 4.73. At the 15-30cm depth, the mean pH was more acidic in Iwofe Dumpsite than other dumpsites. However, at the depth of 30-45cm, mean soil pH was very acidic in Iwofe Dumpsite (4.80±0.1) but relatively acidic in Eliozu Dumpsite. In Eliozu and Iwofe Dumpsites, the mean soil pH was less acidic at the soil depth of 30-45cm than the soil depths at 0-15cm and 15-30cm. Analysis also revealed that soil pH decreased in acidity with increasing soil depth at the control plot see Table 1.

Sand:- The sand content of the dumpsite and control is presented in Table 2. The analysis shows that sand content in the entire study locations was very high ranging from 85.00% to 89.87% at soil depth of 0-15m, 81.60% to 85.53% at soil depth of 15-30cm and 81.60% to 86.20% at 30-45cm soil depth. At soil depth of 0-15cm, Iwofe and Igwuruta Dumpsites recorded the highest sand content while Igwuruta Dumpsite recorded the lowest mean sand content (81.60±0.5%) at the soil depths of 15-30cm and 30-45cm. Analysis also shows that Eliozu Dumpsite recorded the highest sand content at the soil depth of 30-45cm. In Eliozu Dumpsite, the sand

Figure 4. Igwuruta Dumpsite, Port Harcourt.

content was highest at the soil depth of 30-45cm (86.20±2.2%) while highest mean sand content in Iwofe and Igwuruta Dumpsites was recorded at the topsoil (0-15cm).

Silt (%):- The analysis of the silt content is shown in Table 3, and it revealed that the mean silt at 0-15cm soil depth was highest in Eliozu Dumpsite (6.00±1.5%) and the least can be observed in Iwofe Dumpsite (3.77±0.8%). At 15-30cm soil depth, the mean silt was highest in Igwuruta Dumpsite (8.40±0.5%) and the least was found in Iwofe Dumpsite (6.07±1.2%). At 30-45cm soil depth, the mean silt was 4.93% in Eliozu Dumpsite, 7.13% in Iwofe Dumpsite and 8.42% in Igwuruta Dumpsite. The mean silt at the soil depth of 0-15cm, 15-30cm and 30-45cm was 2.2%, 8.2% and 7.8% respectively. The mean silt was highest at 15-30cm in Eliozu Dumpsite (6.87±1.3%) while the highest mean silt was recorded at 30-45cm soil depth in Iwofe Dumpsite (7.13±0.5%). In Igwuruta the mean silt at subsoil was higher than the topsoil.

Clay:- The analysis on clay contents at the dumpsites and natural forest are presented in Table 4. It is shown that Eliozu Dumpsite recorded the highest mean clay (9.00±0.9%) at soil depth 0-15cm while Igwuruta Dumpsite recorded the highest mean clay (10.00±0.0%) at soil depth 15-30cm. Igwuruta Dumpsite recorded the highest mean clay (11.00±0.0%) at the soil depth of 30-45cm. There was a slight variation in the clay contents between the dumpsite and natural forest at all depths of soil. Comparing the mean clay contents across the soil depth in each dumpsite, the analysis revealed that in Eliozu Dumpsite, highest mean clay (9.00±0.9%) was recorded at 0-15cm soil depth. In Iwofe Dumpsite, highest mean clay (10.00±0.0%) was recorded at 30-45cm soil depth while in Igwuruta Dumpsite, highest mean clay (11.00±0.0%) was recorded at 30-45cm.

Total Organic Carbon: The analysis of total organic carbon at the dumpsites and control are shown in Table 5. It is shown that the mean total organic carbon ranged from 3.01% to 3.35% at the soil depth of 0-15cm with Igwuruta Dumpsite having the highest among other dumpsites. At both 15-30cm and 30-45cm soil depths, the mean total organic carbon was highest in Igwuruta Dumpsite. At all soil depths, the mean total organic carbon was higher at the dumpsites than the control. Furthermore, in all the dumpsites and control plot, the mean total organic carbon was highest at the topsoil (0-15cm) and lowest at the 30-45cm soil depth.

Pb:- Considering the concentration of Pb in the dumpsites and control as displayed in Table 6, the analysis shows that the highest Pb concentration

Table 1. Soil pH Concentration.

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	*USEPA
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	4.70±0.2	4.73±0.1	4.70±0.2	6.00±0.1	7.5
15 – 30	4.77±0.1	4.67±0.0	4.97±0.1	6.30±0.2	
30- 45	5.00±0.2	4.80±0.1	4.98±0.1	6.31±0.2	

Source: *USEPA, (1991).

Table 2. Sand Content (%).

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	USEPA
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	85.00±2.3	89.87±0.6	89.87±0.3	88.4±0.1	**NIL**
15 – 30	84.4±1.9	85.53±1.7	81.60±0.5	82.4±0.3	
30- 45	86.20±2.2	82.87±0.5	81.60±0.5	82.2±0.1	

Table 3. Silt Content (%).

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	USEPA
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	6.00±1.5	3.77±0.8	5.80±0.8	2.2±0.1	**NIL**
15 – 30	6.87±1.3	6.07±1.2	8.40±0.5	8.2±0.2	
30- 45	4.93±1.8	7.13±0.5	8.42±0.5	7.8±0.2	

Table 4. Clay Contents.

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	USEPA
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	9.00±0.9	6.37±0.2	4.33±1.1	9.4±0.3	**NIL**
15 – 30	8.73±0.6	8.40±0.6	10.00±0.0	9.4±0.2	
30- 45	8.87±0.9	10.00±0.0	11.00±0.0	10.0±0.1	

was recorded at Igwuruta Dumpsite (57.43±4.2 mg/kg) at the topsoil (0-15cm). At 15-30cm soil depth, Iwofe Dumpsite recorded the highest Pb concentration among the dumpsites (49.27±2.6 mg/kg) while the mean Pb concentration was highest in Igwuruta Dumpsite at 30-45cm soil depth(36.97±9.4 mg/kg). The mean Pb concentration was higher in the dumpsites than the control. The mean Pb was highest in all the dumpsites at the topsoil (0-15cm). The mean Pb

Table 5. Total Organic Carbon (%).

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	USEPA
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	3.01±0.6	2.47±0.6	3.35±1.1	1.92±0.3	-
15 – 30	2.03±0.5	1.85±0.3	2.52±0.8	1.29±0.3	
30- 45	1.33±0.5	1.28±0.2	2.50±0.8	1.03±0.1	

Table 6. Concentration of Pb (mg/kg).

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	*USEPA
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	49.37±3.6	53.13±3.8	57.43±4.2	0.001±0.0	420
15 – 30	47.37±7.0	49.27±2.6	35.97±8.4	0.001±0.0	
30- 45	34.07±2.1	34.63±9.7	36.97±9.4	0.001±0.0	

Source: *[6]

Table 7. Concentration of Fe (mg/kg).

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	USEPA
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	827.13±64.4	799.73±101.0	1167.13±100.1	133.4±6.8	-
15 – 30	822.77±77.8	757.43±32.7	988.37±4.2	138.1±7.9	
30- 45	760.33±42.9	661.77±82.7	950.37±4.1	67.5±3.1	

in all the dumpsites was lower than the maximum permissible level of Pb of USEPA (420 mg/kg).

Fe:-The analysis on the Fe concentration in the dumpsites and control are shown in Table 7 whereby it is revealed that the mean Fe was highest in Igwuruta at all the depths of soil while the least was recorded at Iwofe Dumpsite. The analysis also showed that the Fe concentration reduced with increasing soil depths in the dumpsites. The Fe concentrations were higher in the dumpsite than the control.

Cr: - The concentrations of Cr at the dumpsites and control at different soil depths are presented in Table 8. It is shown that the mean Cr at all soil depths (0-15cm, 15-30cm and 30-45cm) was highest in Igwuruta Dumpsite (56.23±2.1 mg/kg) among the dumpsites. Also, the highest mean Cr concentration was recorded at the topsoil in all the dumpsite. The mean Cr concentration decreased with increasing soil depths in all the dumpsites. The mean Cr was very low in the control at all soil depths. The concentration of Cr in the dumpsite was lower than the USEPA permissible level (3000 mg/kg).

Zn: - The analysis of the concentration of Zn in all the dumpsites and control is presented in Table 9. It is shown that the mean Zn was highest in Iwofe Dumpsite at 0-15cm (55.13±3.9 mg/kg) and 15-30cm (46.93±2.2 mg/kg). The highest mean Zn at 30-45cm soil depth was recorded in Igwuruta Dumpsite. In all the dumpsites, the mean Zn decreased with increasing soil depths. At all soil depths, the concentrations of Zn were higher in the dumpsite than the control. It is also shown that the

Table 8. Concentration of Cr (mg/kg).

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	*USEPA
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	34.43±6.6	42.47±2.8	56.23±2.1	0.001±0.0	3000
15 – 30	32.93±4.0	40.67±1.4	46.63±2.2	0.001±0.0	
30- 45	30.60±4.2	30.10±4.1	44.61±2.1	0.001±0.0	

Source: *[6]

Table 9. Concentration of Zn (mg/kg).

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	USEPA*
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	53.30±7.8	55.13±3.9	47.20±6.9	0.001±0.0	7500
15 – 30	40.97±5.5	46.93±2.2	33.87±6.0	1.96±0.4	
30- 45	19.00±0.8	33.17±7.4	33.77±6.0	0.001±0.0	

Source: *[6]

Table 10. Concentration of Ni (mg/kg).

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	USEPA*
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	7.73±1.2	8.13±3.9	7.75±1.7	0.001±0.0	75
15 – 30	8.06±0.6	3.44±1.7	2.17±2.2	0.001±0.0	
30- 45	3.00±1.6	0.02±0.0	2.15±1.4	0.001±0.0	

Source: *[6]

maximum permissible limit of Zn (7500 mg/kg) of USEPA was higher than the mean Zn in all the selected dumpsites.

Ni: - The analysis of Ni concentrations in the dumpsites and control is presented in Table 10. It is revealed that Iwofe Dumpsite recorded the highest mean Ni at 0-15cm soil depth (8.13±3.9 mg/kg), Eliozu Dumpsite at 15-30cm (8.06±0.6 mg/kg) and 30-45 cm (3.00±1.6 mg/kg). It is also shown that the concentrations of Ni decreased with increasing soil depths in the dumpsites except in Eliozu Dumpsite. The mean Ni concentration was higher in the dumpsites than control. Comparing the mean Ni with the maximum permissible limit of USEPA, it is revealed in Table 10 that the mean Ni was lower than the maximum permissible level of USEPA (75 mg/kg).

Cd: - The mean Cd concentrations in the dumpsites and control are shown in Table 11 and it is revealed that Igwuruta Dumpsite recorded the highest mean Cd concentrations (14.23±2.6 mg/kg) at the topsoil (0-15cm). The highest mean Cd was recorded in Eliozu Dumpsite at both 15-30cm (9.13±0.5 mg/kg) and 30-45cm (9.51±0.9 mg/kg). The mean Cd decreased with increasing soil depth in all dumpsites except in Eliozu Dumpsite. The mean Cd

Table 11. Concentration of Cd (mg/kg).

Depth (cm)	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	Control	USEPA*
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
0 – 15	10.45±0.7	6.43±1.5	14.23±2.6	0.001±0.0	85
15 – 30	9.13±0.5	5.25±1.9	5.81±3.0	0.001±0.0	
30- 45	9.51±0.9	3.04±1.5	5.74±2.1	0.001±0.0	

Source: *[6]

was higher in dumpsites than control at all soil depths. The maximum permissible level (85 mg/kg) was higher than the mean Cd in each of the dumpsites.

Significant Variations in the Soil Properties between Dumpsites

Furthermore, the significant variation in the mean values of soil properties between at most two of the dumpsites using the least square difference (LSD) is shown in Table 12. Between Eliozu and Igwuruta Dumpsites, there was significant variation in pH (Mean Difference (MD)=-0.2111; p=0.037); sand (MD=4.68; p=0.003); clay (MD=-3.06; p=0.000). Total organic carbon (MD=1.23; p=0.019); Pb (MD=18.42; p=0.001); Zn (MD=23.20; p=0.000); Ni (MD=-4.67; p= 0.005) and Cd (MD=4.25; p=0.034). However, between Eliozu and Iwofe Dumpsites, there was significant variation in sand (MD=4.40; p=0.005); clay (MD= -2.48; p=0.003); and Zn (MD=11.29; p=0.028). None of the soil properties investigated showed significant variation between Igwuruta and Iwofe Dumpsites.

The analysis of chemical properties of leachate samples from the dumpsites are shown in Table 13. It is revealed that the pH levels of leachates in all the dumpsites were acidic ranging from 4.63 to 5.13. It was more acidic in Iwofe Dumpsite (4.63±0.1). The mean pH of leachate samples in the dumpsites was lower than the maximum permissible level of USEPA (6-9) suggesting that the leachate in the entire study sites was very acidic. The mean NO_3 was highest in Igwuruta Dumpsite (16.67±0.1 mg/l) and the lowest was recorded in Iwofe Dumpsite (14.80±0.1 mg/l). The maximum permissible level of NO_3 of USEPA (10 mg/l) was lower than the mean NO_3 of the dumpsites. The analysis also revealed that the mean SO_4, PO_4, Pb, Cr and Zn were highest in Igwuruta Dumpsite. However, the lowest concentration of the mean PO_4, Pb, Cr and Zn was recorded in Eliozu Dumpsite while the mean SO_4 was lowest in Iwofe Dumpsite. The mean PO_4, Pb, Cr and Zn of leachate samples from the dumpsites were higher than the maximum permissible levels of USEPA while the mean SO_4 of the leachate sample from the dumpsite was lower than the maximum limit (1000 mg/l).

Testing of Hypotheses

Hypothesis 1

Ho: There is no significant difference in the soil properties between the dumpsites and control plot
H_1: There is significant difference in the soil properties between the dumpsites and control plot
The aggregated mean values of soil properties in the dumpsites and control are shown in Table 14. Furthermore, the analysis of Paired Sample T –Test of the soil properties between the dumpsites and control was generated from the data and also presented in Table 14. The mean pH was very acidic in the dumpsites while relatively less acidic in control. The mean pH was significantly varied between the dumpsite and control plot. The particle size composition (sand, silt and clay) was predominantly dominated by sand content in both dumpsite and control. Sand, silt and clay slightly varied between the dumpsite and control plot. The mean total organic carbon was 2.26% in the dumpsite while it was 1.91% in the control plot. No significant variation existed in the total organic carbon between the dumpsite and control plot. The

Table 12. Multiple Comparison of Soil Properties in the Dumpsite using Least Square Difference (LSD).

Dependent Variable	(I) Dumpsite	(J) Dumpsite	Mean Difference (I-J)	Std. Error	p value	95% Confidence Interval	
						Lower Bound	Upper Bound
pH	Eliozu	Iwofe	-.08889	.09547	.361	-.2859	.1082
		Igwuruta	-.21111*	.09547	.037	-.4082	-.0141
	Iwofe	Eliozu	.08889	.09547	.361	-.1082	.2859
		Igwuruta	-.12222	.09547	.213	-.3193	.0748
	Igwuruta	Eliozu	.21111*	.09547	.037	.0141	.4082
		Iwofe	.12222	.09547	.213	-.0748	.3193
Sand	Eliozu	Iwofe	4.40000*	1.40688	.005	1.4963	7.3037
		Igwuruta	4.68889*	1.40688	.003	1.7852	7.5926
	Iwofe	Eliozu	-4.40000*	1.40688	.005	-7.3037	-1.4963
		Igwuruta	.28889	1.40688	.839	-2.6148	3.1926
	Igwuruta	Eliozu	-4.68889*	1.40688	.003	-7.5926	-1.7852
		Iwofe	-.28889	1.40688	.839	-3.1926	2.6148
Silt	Eliozu	Iwofe	-1.92222	.95284	.055	-3.8888	.0443
		Igwuruta	-1.63333	.95284	.099	-3.5999	.3332
	Iwofe	Eliozu	1.92222	.95284	.055	-.0443	3.8888
		Igwuruta	.28889	.95284	.764	-1.6777	2.2555
	Igwuruta	Eliozu	1.63333	.95284	.099	-.3332	3.5999
		Iwofe	-.28889	.95284	.764	-2.2555	1.6777
Clay	Eliozu	Iwofe	-2.47778*	.74795	.003	-4.0215	-.9341
		Igwuruta	-3.05556*	.74795	.000	-4.5992	-1.5119
	Iwofe	Eliozu	2.47778*	.74795	.003	.9341	4.0215
		Igwuruta	-.57778	.74795	.447	-2.1215	.9659
	Igwuruta	Eliozu	3.05556*	.74795	.000	1.5119	4.5992
		Iwofe	.57778	.74795	.447	-.9659	2.1215
Total Organic Carbon	Eliozu	Iwofe	.80889	.49000	.112	-.2024	1.8202
		Igwuruta	1.23111*	.49000	.019	.2198	2.2424
	Iwofe	Eliozu	-.80889	.49000	.112	-1.8202	.2024
		Igwuruta	.42222	.49000	.397	-.5891	1.4335
	Igwuruta	Eliozu	-1.23111*	.49000	.019	-2.2424	-.2198
		Iwofe	-.42222	.49000	.397	-1.4335	.5891
Pb	Eliozu	Iwofe	9.11111	4.77561	.068	-.7453	18.9675
		Igwuruta	18.42222*	4.77561	.001	8.5658	28.2786
	Iwofe	Eliozu	-9.11111	4.77561	.068	-18.9675	.7453
		Igwuruta	9.31111	4.77561	.063	-.5453	19.1675
	Igwuruta	Eliozu	-18.42222*	4.77561	.001	-28.2786	-8.5658
		Iwofe	-9.31111	4.77561	.063	-19.1675	.5453
Fe	Eliozu	Iwofe	75.14444	83.11553	.375	-96.3976	246.6865
		Igwuruta	127.84444	83.11553	.137	-43.6976	299.3865
	Iwofe	Eliozu	-75.14444	83.11553	.375	-246.6865	96.3976
		Igwuruta	52.70000	83.11553	.532	-118.8420	224.2420
	Igwuruta	Eliozu	-127.84444	83.11553	.137	-299.3865	43.6976
		Iwofe	-52.70000	83.11553	.532	-224.2420	118.8420

Table 12. Contd.

Cr	Eliozu	Iwofe	4.30000	4.57599	.357	-5.1444	13.7444
		Igwuruta	8.60000	4.57599	.072	-.8444	18.0444
	Iwofe	Eliozu	-4.30000	4.57599	.357	-13.7444	5.1444
		Igwuruta	4.30000	4.57599	.357	-5.1444	13.7444
	Igwuruta	Eliozu	-8.60000	4.57599	.072	-18.0444	.8444
		Iwofe	-4.30000	4.57599	.357	-13.7444	5.1444
Zn	Eliozu	Iwofe	11.28889*	4.81210	.028	1.3572	21.2206
		Igwuruta	23.20000*	4.81210	.000	13.2683	33.1317
	Iwofe	Eliozu	-11.28889*	4.81210	.028	-21.2206	-1.3572
		Igwuruta	11.91111*	4.81210	.021	1.9794	21.8428
	Igwuruta	Eliozu	-23.20000*	4.81210	.000	-33.1317	-13.2683
		Iwofe	-11.91111*	4.81210	.021	-21.8428	-1.9794
Ni	Eliozu	Iwofe	1.82644	1.50209	.236	-1.2737	4.9266
		Igwuruta	4.66167*	1.50209	.005	1.5615	7.7618
	Iwofe	Eliozu	-1.82644	1.50209	.236	-4.9266	1.2737
		Igwuruta	2.83522	1.50209	.071	-.2649	5.9354
	Igwuruta	Eliozu	-4.66167*	1.50209	.005	-7.7618	-1.5615
		Iwofe	-2.83522	1.50209	.071	-5.9354	.2649
Cd	Eliozu	Iwofe	3.64544	1.89576	.066	-.2672	7.5581
		Igwuruta	4.25422*	1.89576	.034	.3416	8.1669
	Iwofe	Eliozu	-3.64544	1.89576	.066	-7.5581	.2672
		Igwuruta	.60878	1.89576	.751	-3.3039	4.5214
	Igwuruta	Eliozu	-4.25422*	1.89576	.034	-8.1669	-.3416
		Iwofe	-.60878	1.89576	.751	-4.5214	3.3039

*. The mean difference is significant at the 0.05 level.
Chemical Properties of Leachates from the Dumpsites

analysis also showed that the mean Pb, Fe, Cr, Zn, Ni and Cd were significantly higher in the dumpsite than control plot at 0.05 significant levels. Thus, null hypothesis (Ho) is accepted for sand, silt, clay and total organic carbon whereas alternative hypothesis (H_1) is accepted for pH, Pb, Fe, Cr, Zn, Ni and Cd. Therefore, there is significant variation in pH, Pb, Fe, Cr, Zn, Ni and Cd between the dumpsites and control plot.

Hypothesis 2

Ho: There is no significant variation in the soil properties among the dumpsites.
H_1: There is significant variation in the soil properties among the dumpsites.

The analysis of variance in the soil properties among the dumpsites is presented in Table 15. There was no significant variation in pH, silt, total organic carbon, Fe, Cr and Cd because the p value was higher than 0.05 significant levels. However, there was significant variation in sand (F=6.977; p=0.004), clay (F=9.420; p=0.001), Pb (F=7.441; p=0.003), Zn (F=11.625; p=0.000) and Ni (F=4.891; p=0.017). Therefore, alternative hypothesis is accepted for sand, clay, Pb, Zn and Ni and thus, there is significant variation in sand, clay, Pb, Zn and Ni among the dumpsites.

Hypothesis 3

Ho: There is no significant variation in soil properties

Table 13. Chemical Properties of Leachates in the Dumpsites.

Chemical Properties	Eliozu Dumpsite	Iwofe Dumpsite	Igwuruta Dumpsite	USEPA*
	Mean±SE	Mean±SE	Mea7500n±SE	
pH	5.13±0.1	4.63±0.1	4.83±0.1	6-9
NO_3 (mg/l)	16.00±1.2	14.80±0.1	16.67±0.1	10
SO_4 (mg/l)	14.00±0.6	13.30±0.1	15.93±0.1	1000
PO_4 (mg/l)	14.43±0.1	16.80±0.1	18.73±0.1	2
Pb (mg/l)	75.93±0.1	77.27±0.1	81.80±0.2	5
Cr (mg/l)	69.70±0.1	74.90±0.1	76.70±0.2	0.1
Zn (mg/l)	76.87±0.4	79.50±0.1	84.10±0.1	5

Table 14. Physico-chemical Properties of Soil in the Dumpsite and Control and Paired Sample T-Test Analysis.

Soil Properties	Dumpsites	Control	T-Value	P value
	Mean±SE	Mean±SE		
pH	4.81±0.0	6.03±0.0	-23.015	0.001*
Sand (%)	85.21±0.7	85.8±0.7	-0.727	0.474
Silt (%)	6.37±0.4	7.02±0.5	-1.307	0.203
Clay (%)	8.42±0.4	7.18±0.6	1.723	0.097
Total Organic Carbon (%)	2.26±0.2	1.91±0.1	1.644	0.112
Pb (mg/kg)	44.13±2.4	0.57±0.2	18.737	0.000*
Fe (mg/kg)	863.67±34.2	134.35±8.4	19.042	0.000*
Cr (mg/kg)	40.08±1.9	0.001±0.0	20.847	0.000*
Zn (mg/kg)	40.38±2.6	1.97±0.4	15.656	0.000*
Ni (mg/kg)	4.22±0.7	0.001±0.0	6.037	0.002*
Cd (mg/kg)	7.74±0.8	0.001±0.0	9.326	0.001*

in the dumpsites among the soil depths.

H_1: There is significant variation in soil properties in the dumpsites among the soil depths.

The analysis of variance (ANOVA) in the soil properties among the soil depths in the dumpsites is shown in Table 16. It is revealed that among the soil depths (0-15cm, 15-30cm, 30-45cm) in the dumpsites, significant variation existed in Fe (F=16.650, p=0.000); Cr (F=14.096, p=0.000) and Cd (F=3.684, p=0.040) only. Thus, alternative hypothesis (H_1) is accepted for Fe, Cr and Cd and therefore it can be stated that there is significant variation in Fe, Cr and Cd among the soil depths in the dumpsites.

For multiple comparison of soil variation between at least two soil depths in the dumpsites, it is shown in Table 17 that between 0-15cm soil depth and 15-30 cm, there was significant variation in Fe (MD=-244.54; p=0.000), Ni (MD=3.89; p=0.022) and Cd (4.79; p=0.016). Between 15-30cm and 30-45cm soil depths, there was significant variation in Fe (MD=-308.31; p=0.000) only.

DISCUSSION

The pH level of soil in the dumpsite was more acidic than the control plot. This is relatively similar to the findings of Obire and Oti (2002); Ideriah et al., (2006) and William et al., (2016) whereby the acidity

Table 15. Analysis of variance in the soil properties among the dumpsites.

Soil Properties		Sum of Squares	df	Mean Square	F	P value
pH	Between Groups	.202	2	.101	2.465	0.106
	Within Groups	.984	24	.041		
	Total	1.187	26			
Sand	Between Groups	124.287	2	62.144	6.977	0.004*
	Within Groups	213.767	24	8.907		
	Total	338.054	26			
Silt	Between Groups	19.339	2	9.669	2.367	0.115
	Within Groups	98.053	24	4.086		
	Total	117.392	26			
Clay	Between Groups	47.429	2	23.714	9.420	0.001*
	Within Groups	60.418	24	2.517		
	Total	107.847	26			
Total Organic Carbon	Between Groups	7.045	2	3.522	3.260	0.056
	Within Groups	25.931	24	1.080		
	Total	32.976	26			
Pb	Between Groups	1527.262	2	763.631	7.441	0.003*
	Within Groups	2463.098	24	102.629		
	Total	3990.360	26			
Fe	Between Groups	74304.539	2	37152.269	1.195	0.320
	Within Groups	746084.738	24	31086.864		
	Total	820389.276	26			
Cr	Between Groups	332.820	2	166.410	1.766	0.193
	Within Groups	2261.487	24	94.229		
	Total	2594.307	26			
Zn	Between Groups	2422.661	2	1211.330	11.625	0.000*
	Within Groups	2500.880	24	104.203		
	Total	4923.541	26			
Ni	Between Groups	99.317	2	49.658	4.891	0.017*
	Within Groups	243.678	24	10.153		
	Total	342.995	26			
Cd	Between Groups	95.275	2	47.637	2.946	0.072
	Within Groups	388.143	24	16.173		
	Total	483.418	26			

level at the dumpsites were higher than the control plot. However, the finding is in contrary to the findings of Ali et al., 2014; whereby the mean value of pH at both control site and dumping site in Islamabad City was alkaline. In the same vein, Obasi et al., 2013; also reported alkaline levels of pH that dumpsites were mostly alkaline in nature. The lower pH levels in the dumpsites may results to a major contribution in metal bioavailability, toxicity and leaching capability into the surrounding areas, (Chomuka et al., 2005). The study area was predominantly dominated by sand contents and this agrees with the findings of Ideriah et al., 2006; which reported that the soils of a dumpsite in the

Table.16. Analysis of variance in soil properties among the soil depths.

		Sum of Squares	df	Mean Square	F	p value
pH	Between Groups	.096	2	.048	1.051	0.365
	Within Groups	1.091	24	.045		
	Total	1.187	26			
Sand	Between Groups	13.523	2	6.761	.500	0.613
	Within Groups	324.531	24	13.522		
	Total	338.054	26			
Silt	Between Groups	18.490	2	9.245	2.243	0.128
	Within Groups	98.902	24	4.121		
	Total	117.392	26			
Clay	Between Groups	2.896	2	1.448	.331	0.721
	Within Groups	104.951	24	4.373		
	Total	107.847	26			
TOC	Between Groups	4.139	2	2.070	1.722	0.200
	Within Groups	28.837	24	1.202		
	Total	32.976	26			
Pb	Between Groups	33.229	2	16.614	.101	0.905
	Within Groups	3957.131	24	164.880		
	Total	3990.360	26			
Fe	Between Groups	476771.743	2	238385.871	16.650	0.000
	Within Groups	343617.533	24	14317.397		
	Total	820389.276	26			
Cr	Between Groups	1401.342	2	700.671	14.096	0.000
	Within Groups	1192.964	24	49.707		
	Total	2594.307	26			
Zn	Between Groups	299.134	2	149.567	.776	0.471
	Within Groups	4624.407	24	192.684		
	Total	4923.541	26			
Ni	Between Groups	68.618	2	34.309	3.001	0.069
	Within Groups	274.377	24	11.432		
	Total	342.995	26			
Cd	Between Groups	113.547	2	56.774	3.684	0.040
	Within Groups	369.870	24	15.411		
	Total	483.418	26			

Eastern By-Pass, Port Harcourt had a sandy texture with mean composition of 91.10% of sand. Similarly, the findings were similar to that of, (Amadi et al., 2012). The higher presence of sand in the entire study area could be attributed to the parental material which was basement complex rock. The predominant sand content could increase the porosity and permeability of heavy metals. Amadi et al., 2012; reported that the porosity and permeability of sandy soil can allow the plume from the dumpsite to migrate into the unconfined shallow aquifer to pollute the groundwater. The total organic carbon in the dumpsite was higher than that of the control plot. The result is similar to the findings of Chomuka et al., 2005; Ali et al., 2014. The high levels of total organic carbon in the soils of the dumpsites

Table 17. Multiple Comparison of Soil Properties in Soil Depths.

Dependent Variable	(I) Soil Depth	(J) Soil Depth	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
pH	0-15	15-30	.08889	.10051	.385	-.1186	.2963
		30-45	-.05556	.10051	.586	-.2630	.1519
	15-30	0-15	-.08889	.10051	.385	-.2963	.1186
		30-45	-.14444	.10051	.164	-.3519	.0630
	30-45	0-15	.05556	.10051	.586	-.1519	.2630
		15-30	.14444	.10051	.164	-.0630	.3519
Sand	0-15	15-30	-.88889	1.73347	.613	-4.4666	2.6888
		30-45	.84444	1.73347	.631	-2.7333	4.4222
	15-30	0-15	.88889	1.73347	.613	-2.6888	4.4666
		30-45	1.73333	1.73347	.327	-1.8444	5.3110
	30-45	0-15	-.84444	1.73347	.631	-4.4222	2.7333
		15-30	-1.73333	1.73347	.327	-5.3110	1.8444
Silt	0-15	15-30	.27778	.95695	.774	-1.6973	2.2528
		30-45	-1.60000	.95695	.108	-3.5751	.3751
	15-30	0-15	-.27778	.95695	.774	-2.2528	1.6973
		30-45	-1.87778	.95695	.061	-3.8528	.0973
	30-45	0-15	1.60000	.95695	.108	-.3751	3.5751
		15-30	1.87778	.95695	.061	-.0973	3.8528
Clay	0-15	15-30	.61111	.98578	.541	-1.4234	2.6457
		30-45	.75556	.98578	.451	-1.2790	2.7901
	15-30	0-15	-.61111	.98578	.541	-2.6457	1.4234
		30-45	.14444	.98578	.885	-1.8901	2.1790
	30-45	0-15	-.75556	.98578	.451	-2.7901	1.2790
		15-30	-.14444	.98578	.885	-2.1790	1.8901
Total Organic Carbon	0-15	15-30	.25778	.51673	.622	-.8087	1.3243
		30-45	-.67111	.51673	.206	-1.7376	.3954
	15-30	0-15	-.25778	.51673	.622	-1.3243	.8087
		30-45	-.92889	.51673	.085	-1.9954	.1376
	30-45	0-15	.67111	.51673	.206	-.3954	1.7376
		15-30	.92889	.51673	.085	-.1376	1.9954
Pb	0-15	15-30	-2.07778	6.05311	.734	-14.5708	10.4152
		30-45	.47778	6.05311	.938	-12.0152	12.9708
	15-30	0-15	2.07778	6.05311	.734	-10.4152	14.5708
		30-45	2.55556	6.05311	.677	-9.9374	15.0486
	30-45	0-15	-.47778	6.05311	.938	-12.9708	12.0152
		15-30	-2.55556	6.05311	.677	-15.0486	9.9374
Fe	0-15	15-30	63.76667	56.40606	.269	-52.6497	180.1831
		30-45	-244.54444*	56.40606	.000	-360.9608	-128.1281
	15-30	0-15	-63.76667	56.40606	.269	-180.1831	52.6497
		30-45	-308.31111*	56.40606	.000	-424.7275	-191.8947
	30-45	0-15	244.54444*	56.40606	.000	128.1281	360.9608
		15-30	308.31111*	56.40606	.000	191.8947	424.7275

Table 17. Contd.

Cr	0-15	15-30	-5.08889	3.32355	.139	-11.9484	1.7706
		30-45	-17.17778*	3.32355	.000	-24.0372	-10.3183
	15-30	0-15	5.08889	3.32355	.139	-1.7706	11.9484
		30-45	-12.08889*	3.32355	.001	-18.9484	-5.2294
	30-45	0-15	17.17778*	3.32355	.000	10.3183	24.0372
		15-30	12.08889*	3.32355	.001	5.2294	18.9484
Zn	0-15	15-30	-7.32222	6.54359	.274	-20.8275	6.1831
		30-45	-.55556	6.54359	.933	-14.0609	12.9498
	15-30	0-15	7.32222	6.54359	.274	-6.1831	20.8275
		30-45	6.76667	6.54359	.311	-6.7386	20.2720
	30-45	0-15	.55556	6.54359	.933	-12.9498	14.0609
		15-30	-6.76667	6.54359	.311	-20.2720	6.7386
Ni	0-15	15-30	3.89067*	1.59390	.022	.6010	7.1803
		30-45	2.23411	1.59390	.174	-1.0555	5.5238
	15-30	0-15	-3.89067*	1.59390	.022	-7.1803	-.6010
		30-45	-1.65656	1.59390	.309	-4.9462	1.6331
	30-45	0-15	-2.23411	1.59390	.174	-5.5238	1.0555
		15-30	1.65656	1.59390	.309	-1.6331	4.9462
Cd	0-15	15-30	4.78878*	1.85060	.016	.9693	8.6082
		30-45	1.08089	1.85060	.565	-2.7386	4.9003
	15-30	0-15	-4.78878*	1.85060	.016	-8.6082	-.9693
		30-45	-3.70789	1.85060	.057	-7.5273	.1116
	30-45	0-15	-1.08089	1.85060	.565	-4.9003	2.7386
		15-30	3.70789	1.85060	.057	-.1116	7.5273

*The mean difference is significant at the 0.05 level.

indicated the possible presence of organic matter content which can increase following the injection of carbonaceous substances such as oil and other carbonated fluid. On the other hand, relatively higher total organic carbon at the dumpsites than the control could be attributed to release of exchangeable cations during mineralization of organic matter. The higher presence of total organic carbon could also be due to the release of exchangeable cations during mineralization of organic matter (Ali et al., 2014). The higher total organic carbon could increase the presence of soil micro-organisms which are found to be breaking down organic compounds in so, (Osuji and Onojake, 2004). Furthermore, a high content of organic matter within the dumpsites would favour the moisture content, water holding capacity and permeability, (Ibitoye, 2001; Badmus et al., 2014). The concentrations of Pb, Fe, Ni, Cr, Cd and Zn were significantly higher than the control plot. The higher concentrations of heavy metals especially Pb and Cd which are dangerous for human living and sustainability could be attributed to the decay of abandoned electric batteries and electronic components, (Ebong et al., 2008) reported that the presence of Cd could be due to the dumping of PVC plastics, nickel-cadmium batteries, motor oil and automobile waste dump. The presence of Cr in the soils from the dumpsites was very evident and significantly higher than control plot and that of maximum permissible limits of USEPA (0.1 mg/kg). Gosh and Singh, (2005) reported that the non-biodegradability of Cr is responsible for its persistence in the environment; once mixed in soil.

As a result of its presence in the environment, Reyes-Guteeitez and Wendy, (2007) reported that the toxicity of Cr in the environment can be risky to human health since chromium can be accumulated on skin, lungs, muscles fat, and it accumulates in liver, dorsal spine, hair, nails and placenta where it is traceable to various heath conditions. Also, Pb increase may also be attributed to the various human activities going on in the area. The concentration of Fe was the highest in the entire study area among the heavy metals investigated in this study. The higher level of Fe in the soil samples can be attributed to the iron and steel scrap that are dumped in the dumpsites at a larger quantity, (Bendz et al., 2005; Raj-Kummar et al., 2012). The pH level of leachate in the entire study area was very acidic. This is relatively similar to the findings of Raj- Kummar et al., (2012), whereby the pH level of leachate from some dumpsites in India ranged from 6.7 to 6.9 confirming that pH level of leachate from dumpsite was acidic. The presence of Zn in the leachate from the dumpsite may be linked to the dumping of batteries and fluorescent lamps, (Raj-Kummar, et al., 2012). High concentration of Pb in the leachate suggests that the wastes are mainly of municipal origin which contains batteries, paint products, metallic items and so on in its composition, (Maiti et al., 2006). The pollution of the surrounding groundwater with heavy metals is evident because of their presence in the soil and leachate samples from the dumpsites. According to, Fatta et al., (1999) and Van et al., (1999), dumpsites have been identified as one of the major threats to groundwater resources globally. It is advisable to avoid using groundwater drawn from the wells located near to the location of dumpsites because of the possibility of being infected with certain diseases that can be linked to the consumption of heavy metals Raj-Kummar et al., (2012). Findings also revealed that among the three dumpsites considered for this study, Igwuruta Dumpsite released heavy metals in soil and leachate at higher levels. This may be attributed to the topography, age of the dumpsite and composition of waste being dumped in that dumpsite. Findings on the lower concentration of SO_4 in the leachate from the dumpsite than the USEPA maximum limit is similar to the findings of Maiti et al., (2006).

CONCLUSION

The dumpsites have increased the concentrations of heavy metals (Pb, Ni, Cd, Cr, Zn and Fe) in soils and most of the heavy metals in the dumpsites decreased with increasing soil depths. Moreso, the concentrations of NO_3, PO_4, Pb, Cr and Zn were higher than the USEPA maximum permissible limit and the highest concentrations of the parameters in the leachate were recorded in Igwuruta Dumpsite.

RECOMMENDATIONS

The study suggested the following recommendations based on the findings from this study: There should be periodic monitoring and assessment of waste dumpsites and soil within the area so as to empirically understand the status of the environmental variables in relation to wastes being disposed into the dumpsites. The government should implement the no littering policy to reduce indiscriminate disposal of wastes in the study area. The three (R) principles of waste management should be encouraged , that is reduce reuse and recycling of wastes, and finally Rivers State Waste Management Agency 's waste collection services should be extended to all nooks and cranny of the state to encourage good sanitation habits amongst the citizens of the state.

REFERENCES

Ali BK, Barrington S and Martinez J (2014). Predicted growth of world urban food waste and methane production. Waste Managt. Res., 24(5):21–33.

Amadi IM, Ndahi NP and Owolabi DA (2012). Levels of Some Hazardous lead levels from Highway Soil, International Journal of Environmental Issues Development, University Consortia; Ikot-Ekpene, Nigeria1(1):102 – 110.

Badmus YA, Klinkenberg E, Drechsel P, Owusu K, Garms R and Kruppa T (2014). Does irrigated urban agriculture influence the transmission of malaria in the city of Kumasi Ghana? ActaTropica, 89(2):125–134.

Bendz AA, Ige PV and Olawale R (2005). Characteristics of Soils and Crops Uptake of Metal in Municipal Waste Dumpsite in Nigeria. J. Human Ecol., 17(3):167 - 71

Chomuka GA, Akpan MM and Mkepenie VN (2005). Heavy Metal Contents of Municipal and Rural Dumpsites Soil and Rate of Accumulation by Carica Papaya and TalinumTriangulare in Uyo, Nigeria. 5 (2):281 - 90.

Ebong GA, Akpan MM and Mkepenie VN (2008).Heavy Metal Contents of Municipal and Rural Dumpsites Soil and Rate of Accumulation by Carica Papaya and TalinumTriangulare in Uyo, Nigeria. 5(2):281 - 90.

Fatta E, Badr O and Probert SD (1999). Economic and environmental evaluations of waste treatment and disposal technologies for municipal solid waste. Applied Energy58(4):209–255

Ghosh FC and Singh M (2005). Contribution of a municipal solid waste incinerator to the trace metals in the surrounding soil. Envtl. Monit. Assess., 182:523–533.

Ibitoye OC (2001). Solid Waste Control and Management. A Seminar Paper Submitted to the department of chemistry, Abia State University, Uturu, Nigeria, 14pp.

Ideriah TJK, Omuaru VOT and Adiukwu PA (2006). Heavy metal contamination of soils around municipal solid wastes dump in Port Harcourt, Nigeria. Global J. Envtl. Sci. 4(1):1 - 4.

Maiti A, Fernández OI and Irabien A (2006). Evaluation of the contribution of local sources to trace metals levels in urban PM2.5 and PM10 in the Cantabria region (Northern Spain). J. Envtl. Monit., 12(7):1451–1458.

Njojju PC and Ayoka AO (2006). Evaluation of heavy metal pollutants from soils at municipal solid waste (MSW) Deposit in Owerri, Imo State, Nig. J. Chem. Soc. Nig., 32(1):57 – 58.

Obaliagbon KO and Olowojoba GB (2006). Distribution of someheavymetalsinleachates from municipal waste dumpsite”. Paper presented at the International Conference on Engineering Research and Development, University of Benin, Benin City–Nigeria, 12Pp.

Obasi DH, Chima JI and Balogun BA (2013). Aspects of soil quality studies impacted by a waste dumpsite in a commercial city of Nigeria. Int. J. Innovat. Envtl. Stud. Res., 1(3):55-68.

Obire BU and Oti NN (2002). Effects of municipal solid waste compost (MSWC) on the productivity and heavy metal concentration of cowpea (Vignaunguiculata) in Owerri, southeastern Nigeria. Int. J. Agric. Rural Develop.,7(2):20- 25.

Osuji LC and Onojake CM (2004). Ebocha and Oil Spillage.Fate of associated heavy metals six months after. Afr. J. Envtl. Assess. Monit., 9:78 – 87.

Pansu M and Gautheyrou J (2006). Handbook of Soil Analysis: Mineralogical, Organic and Inorganic Methods. Springer-Verlag, Berlin Heidelberg, 995pp.

Raj-Kummar G, Krajewski JA and Stros ZG (2012). Solid waste management in Turkey. Waste Managt. Res., 9(1):465-469.

Reyes-Guteeitez M and Wendy G (2007). Human Health Effects of heavy Metals, Center for Hazardous Substance Research. 2Pp

USEPA (1991). United Nation Environmental Protection Agency: Environmental Risk. Your Guide to Analysis and Reducing Risk Rush, No.905/91-017.

Uzolo SD and Oti EE (2006). Determination of Heavy Metal Contents from Dumpsites within IkotEkpene, AkwaIbom State, Nigeria. The Int. J. Engin. Sci., 2(2):123 – 129.

Van RE, Verloo M, Demeyer A and Pauwels JM (1999). Manual for the soil chemistry and fertility laboratory: Analytical methods for soils and plants equipment, and management of consumables. University of Ghent, Belgium 96-105pp.

Van RE, Verloo M, Demeyer A and Pauwels JM (1999). Manual for the soil chemistry and fertility laboratory: Analytical methods for soils and plants equipment, and management of consumables. University of Ghent, Belgium 96-105pp.

Walkey A and Black IA (1934).An Examination of the Detjare Method for Determining Soil Organic Matter and a proposed modification of the Chronic Acid Titratio. Soil Sci., 37:29-36.

William S, Siddique N, Hamid Q and Hakeem MM (2016).Assessing soil pollution from a municipal waste dump in Islamabad, Pakistan: A study by INAA and AAS. Journal of Radio Analytical and Nuclear Chemistry, 285:723–732.