

Assessing the Edaphic Properties and Leachate Variability at a Municipal Solid Waste Dumpsite in Aba, Abia State

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Abstract

This research was carried out to assess the heavy metal characteristics of soils and the physicochemical parameters of the leachate of a municipal solid waste dumpsite in Ariaria, Aba, Southeastern Nigeria were investigated for possible pollution impacts. Soil samples were collected in three replicates from three sampling points within the dumpsite and a control located about 150m at three horizons at 0–15, 15–30 and 30–45cm depths. Leachate samples were also collected and tested for qualities using standard methods. Descriptive statistics, Pearson correlation and geochemical index were used to analyze data at PCr> Cu>Pb>As>Zn. The subsoil (16–45cm) recorded the highest geoaccumulation index making it the most affected of the depths investigated; which is attributed to high precipitation in the area causing leaching. The high porous sand compositions, high heavy metal levels and microbial abundance, as well as low clay compositions recorded in the study could make groundwater aquifers of the study area susceptible to pollution from the dumpsite origin. Both Federal and state government should be committed to stipulated environmental standard as enshrined in our laws.

Keywords: Heavy metals, Leachate, Geoaccumulation, Edaphic Properties, Physicochemical and microbial parameters

1.0. INTRODUCTION

Solid waste management is in crisis in many of the country's urban areas as population continuous to grow, this has led to the ever-increasing quantities of domestic and commercial waste while space for disposal decreases.

The gradually increasing population and the proliferation of basic industrial processes particularly in major cities of the world has led to emergence of civilization that have greater impact on the environment (Abdus-Salam *et al.*, 2011). The industrial revolution gave birth to environmental pollution and the large volume of industrial chemical discharges has added to the growing load of untreated domestic waste. The disposal of domestic, commercial and industrial waste in the world is a problem that continues to grow with human civilization and no method so far is completely safe. Experience has shown that all forms of waste disposal have negative consequences on the environment, public health, and local economies. High concentrations of heavy metals in municipal solid waste (MSW) now dominate the outflow from most cities (Bergback *et al.*, 2001). This is a result of human activities like manufacturing, agricultural production, and industrial activities. The presence of uncontrolled dumpsites in most localities in Nigeria is as a result of the indiscriminate deposition of the wastes, prevalently food waste and putrescible materials. While MSW can be reused as organic fertilizer or for soil amendment after biological transformation (Manios, 2004), the heavy metals contained in it and its products restrict its beneficial use and disposal of the wastes. This

is an increasing concern for MSW management (Zennaro *et al.*, 2005; Jung, *et al.*, 2006). According to Zhang *et al.* (2010), studies on the occurrence and distribution of heavy metals in MSW could assist policy makers and management authorities in eliminating the major contaminant sources. This will effectively modify MSW collection, handling, treatment, and disposal practices (Zhang *et al.*, 2010).

Metals are known to be present in soil in different chemical forms, which influence their reactivity and hence their mobility and bioavailability (Ostman *et al.*, 2006). Heavy metals concentrations in soil are associated with biological and geochemical cycles and are influenced by anthropogenic activities such as agricultural practices, industrial activities and waste disposal methods (Zaayah *et al.*, 2004).

Study on waste disposal entails constant assessment of many interactions involved and the upgrading of existing waste disposal operations which requires a considerable understanding and knowledge of issues such as; waste generation, its management strategies, socio-cultural practices at household levels and environmental impact analysis. Conversely, based on the increase in population of cities and sustainable growth exceeding the size and regeneration power of the natural environment, we would agree that generation of waste is associated with human settlement, due to more buildings, commercial activities and infrastructures in the urban areas; waste generated is ever increasing in quantity and complexity (Akhionbare, 2015; Wuana & Okeimen, 2011).

However, integrated solid waste management involves the development and operation of disposal system designed to manage urban waste in a healthful, economic, environmentally friendly and conserving manner. Almost all the methods of solid waste management and disposal systems in our cities with particular reference to Aba town create environmental problems which have adverse effect on community health. The effects of dumping waste in an open uncontrolled dumpsite are very significant and can affect ecosystem, aesthetics, and sanitation, socio-economic and general quality of the environment at large.

2.0. METHODOLOGY

2.1. Study Area

Ariaria waste dump is located along the boundary between Osisioma LGA and Aba North LGA, in Abia state. It is between latitude 5°06'17''N and longitude 7°19'50''E having an elevation of 204ft. The waste dump is about 51,900m². It is a commercial town found in the eastern part of Nigeria. It has one of the largest markets in Nigeria (Ariaria international market) which attracts people mainly from different parts of the country. The large market has attracted industrial locations within the state and its environs, assorted commodities and goods are usually found in various locations of the town. These commercial and industrial activities are precursors of different quantities of waste that have constituted environmental nuisance in the city. This results to random dumpsites of varying sizes with the ones under study. The area is prone to flooding and erosion due to poor drainage system which is attributed to various waste dumped along drainages which block the channel flow of run-offs. The nearest building to the major dump is about 20m away while the nearest farm land is 8–15m away. The site has been and is currently used for the disposal of different kinds of wastes and has being existing over 20 years.

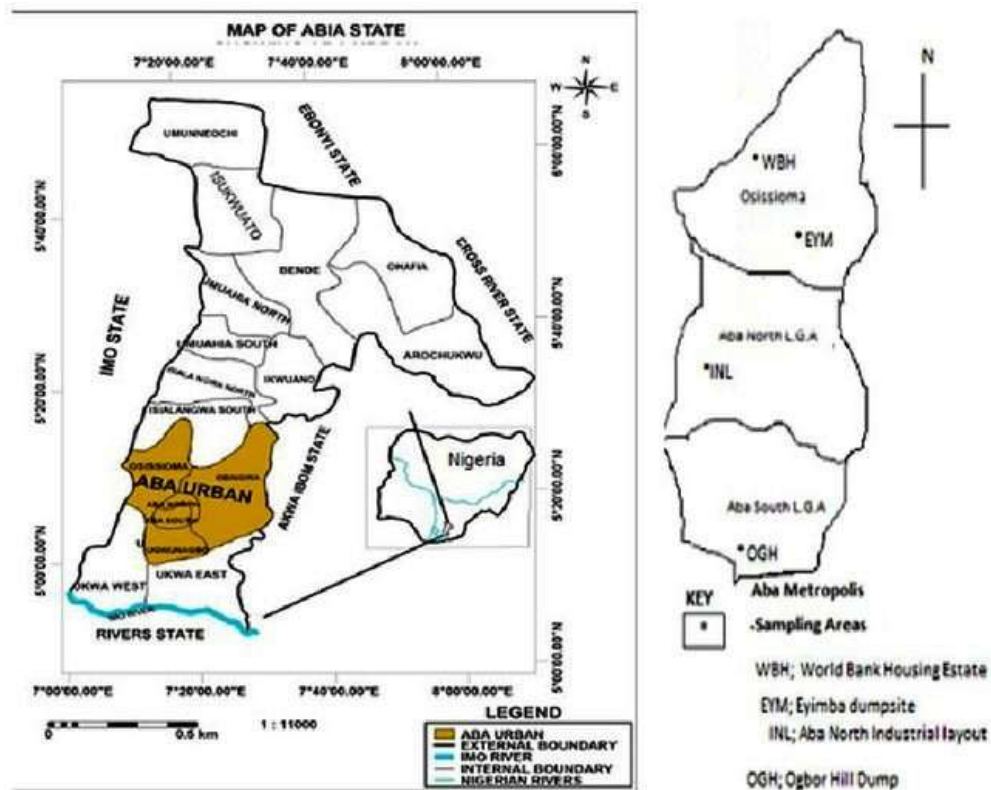


Figure 1: Map of study location showing sampling points.

2.2. Field Procedure

Investigation field trip was undertaken and routine materials and methods to be used in the field study were noted. The study area was toured to observe the activities in and around the dumpsite in Ariaria, Aba. Scavengers, villagers and other persons occupying around the dumpsite were interviewed and relevant information gathered. Such information include; age of the waste dump, age of some heaps, age of each partitions, kinds of materials dumped, how frequent, modes of waste disposal, are there farming activities; kinds of crops normally cultivated around the area etc.

2.3. Method of Data Collection

The method that was employed is the instrumentation method. This involves the use of instrument both in sample collection and its analysis. Samples were collected at three (3) locations within the dumpsite. A fourth sample was collected 200m North of the sampling points. The labeled samples are: A, B, C, D with D as the control. The distances between the points are 50m from A to B, 40m from B to C, 50m from A–C and the control point 200m away from the waste dump. The sampling points were geo-referenced as follows;

With the use of stainless soil auger, soil samples were collected at 3 different horizons (0–15cm, 15–30cm, 30–45cm) from these locations, a total of 12 soil samples were collected and analysed by transferring them into a well labeled polythene bags that was taken to the laboratory not later than 4 hours from the time of collection. Instruments such as; soil auger, meter rule, measuring tape, masking tape, marker pen, overall, nose mask, hand gloves, safety boots, and polythene bags were used.

Table 1: GPS Coordinates of Sampling Points

POINTS	ELEVATION	NORTHING	EASTING
A	202ft	5°06'59"	7°19'67"
B	181ft	5°06'67"	7°19'61"
C	172ft	5°06'76"	7°19'68"
D	176ft	5°06'70"	7°19'25"

Source: *Fieldwork by Researchers*

2.4. Statistical Analysis

Data that were collected were analyzed using descriptive statistics, Pearson correlation analysis was carried out to find out how variables relate to each other and coefficient of variation were used to determine how variables may vary in the study sites. Charts were used to represent some relationships pictorially. All analysis was carried out using EXCEL 2007 and SPSS 17.0.

Table 2: Geoaccumulation Classification

Geoaccumulation Index I_{geo}	I_{geo} Class	Contamination Intensity
>5	6	Very strong
>4–5	5	Strong – Very strong
>3–4	4	Strong
>2–3	3	Moderate – strong
>1 – 2	2	Moderate
>0–1	1	Uncontaminated – Moderate
>0	0	Practically uncontaminated

Sources: Agyarko *et al.*, 2010

3.0. RESULT PRESENTATION

The results from this study are presented in Tables 3 – 6 below

Table 3: Heavy Metal Concentrations and Edaphic Variables across the sampling points at the dumpsite in Aba.

S/No	Parameters	Method Used	0-15cm			16-30cm			31-45cm		
			1	2	3	1	2	3	1	2	3
1.	pH	ASTM 1293B	7.9		7.2	7.8		7.5	7.9		7.7
			7.9			7.7			7.8		
2.	As (mg/kg)	APHA 301A	4.16		4.21	4.95		5.20	5.10		5.38
			4.15			5.22			5.35		
3.	Pb (mg/kg)		93.8		82.5	90.5		88.1	93.2		86.6
			78.0			84.2			73.4		
4.	Cu (mg/kg)		135.5		132.4	140.0		141.0	230.2		195.4
			128.2			136.5			194.2		
5.	Zn (mg/kg)		232.2		221.3	225.5		180.4	70.8		65.2
			198.6			188.8			61.1		
6.	Cr (mg/kg)		70.5		65.0	76.5		73.8	30.5		31.0
			60.5			68.0			31.2		
7.	Cd (mg/kg)		32.0		30.5	44.0		33.8			
			25.8			30.3					

	Particle Size Distribution	Sieve						
8.	Sand (%)		65	62	62	59	62	59
9.	Silt (%)		61		59		59	
10	Clay (%)		15	14	16	16	16	19
			14		17		19	
			20	24	22	25	22	22
			25		24		22	
11	Bulk density	Hydrometer	2.05	2.12	2.22	2.42	2.17	2.25
			2.40		2.60		2.42	
12	Moisture content (%)	Oven Dry	8.3	7.3	7.0	6.2	5.1	5.8
			6.2		6.2		5.5	

Source: Fieldwork by Researchers

Result (Table 3) shows considerable levels of heavy metals with Zn recording the maximum value of 232.2mg/kg at the depth of 0–15 at station 1. Cu (140.4mg/kg), Pb (93.8mg/kg), Cr (76.5mg/kg) and Cd (44.0mg/kg) recorded significant high values across the refuse dumpsite site at the topsoil level (0–15cm). As (5.8mg/kg) recorded its highest value at the depth of 31–45cm in station 3. The pH values averaged 7.9 at the topsoil and 7.6 at the subsoil levels.

From Table 3, it was observed that sandy soil is predominant from the sieve analysis, averaging 61% at the topsoil, 59% at the 16–30cm and also 59% at the subsoil (31–45) levels. On the other hand, silt averaged 14% at the topsoil, 16% at 16–30cm level and 16% at the subsoil level. Clay averaged 25% at the 0–15cm, 24% at the 16–30cm and 22% at the subsoil level. The moisture content decreased downward with the topsoil averaging 7.26% across the three points as against 5.46% recorded for the subsoil.

Table 4: Heavy Metal Concentrations and Edaphic variables across the sampling points at the control location in Aba.

S/No	Parameters	Method used	0-15cm			16-30cm			31-45cm		
			1	2	3	1	2	3	1	2	3
1	pH	ASTM 1293B	4.5		4.3	4.7		5.6	5.0		4.8
			4.4			5.2			5.4		
2	As (mg/kg)		1.16		1.21	1.95		1.20	1.10		1.38
			1.05			1.22			1.35		
3	Pb (mg/kg)	APHA 301A	15.5		12.4	14.3		12.2	15.2	14.6	14.2
			12.8			12.0					
4	Cu (mg/kg)		32.2	32.4	31.8	30.2		31.0	27.5		25.3
						29.5			24.2		
5	Zn (mg/kg)		82.2		71.3	85.5		70.4	76.2		75.4
			72.6			68.8			74.2		
6	Cr (mg/kg)		4.5	5.0	4.5	5.5		3.8	4.8	5.2	4.1
						3.2.0					
7	Cd (mg/kg)		0.10		1.54	0.15		0.80	0.15		0.01
			0.8			0.30			0.12		
	Particle Size Distribution	Sieve									

8	Sand (%)		55 53	52	49	46	47	44 43	46
9	Silt (%)		20 26	27	26	30	27	29 29	27
10	Clay (%)		25 21	21	25	24	26	27 28	27
11	Bulk density	Hydrometer	1.40 1.50	1.42	1.63 2.00		2.00	1.70 1.65	1.16
12	Moisture content (%)	Oven Dry	4.4 4.2	4.3	4.3 4.7		4.5	5.1 6.2	5.3

Source: Fieldwork by Researchers

Results from the control site (Table 4) show a considerable low level of contamination from heavy metal species with Zn and Cu and Pb recording the maximum values across the stations and points; Zn averaged 75.36mg/kg at the topsoil, 74.90mg/kg at the 16–30cm and 75.20mg/kg at the subsoil level. Cu averaged 32.136mg/kg at the topsoil level, 30.23mg/kg at the 16–30cm and 25.66mg/kg at the subsoil level. Pb averaged 13.56mg/kg at the topsoil level, 12.83mg/kg at the 16–30cm and 14.66mg/kg at the subsoil level. The pH averaged 4.4 at the topsoil, 5.16 at the 16–30cm level and 5.06 at the subsoil level.

It was observed that sandy soil was predominant from the sieve analysis, averaging 52% at the topsoil, 47% at the 16–30cm and also 44% at the subsoil (31–45) levels. On the other hand, silt averaged 26% at the topsoil, 28% at 16–30cm level and 28% at the subsoil level. Clay averaged 22% at the 0–15cm, 25% at the 16–30cm and 27% at the subsoil level. The moisture content increased downward with the topsoil averaging 4.30% across the three points as against 5.53% recorded for the subsoil.

Table 5: Quality of Leachate across the sampling points at the Ariaria Market waste dumpsite in Aba.

S/ N	Parameters	Standard Disposal of Treated Leachate	Station I	Station II	Station III	Mean
1	Ph	5.5 – 9.0	7.2	8.3	8.8	8.1
2	EC (μS/cm)	1000	1586	1826	1868	1763.3
3	COD (mg/L)	160	1250	1542.8	1356.5	1382.6
4	BOD (mg/L)	30	102	125	143.2	123.4
5	TDS (mg/L)	2100	2.35x10 ⁶	2.12x10 ⁶	2.82x10 ⁶	2.43x10 ⁶
6	Total Alkalinity (mg/L)	600	2,853	2685.5	2902	2813.3
7	Total Hardness (mg/L)	600	850	882	964	898.6
8	Sodium (mg/L)	200	820	940.5	882	880.7
9	Sulphates (mg/L)	250	178	152.5	160	163.5
10	Chloride (mg/L)	250	1168	1225	1302	1232
11	Nitrate (mg/L)	45	68.6	92.5	85.2	82.1
12	Coliform count (CFU/100ml)	150	240	210	225	225

13	Faecal coliform (CFU/100ml)	NS	165	156	160	160.3
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Source: WHO (2008); *Fieldwork by Researchers*

The levels of the various physicochemical parameters of leachate samples determined across the sampling locations at the Ariaria market waste dumpsite are shown in Table 5 pH ranged from 7.2 to 8.80. High values were recorded in the concentrations of: TDS (range: 2.12×10^6 mg/l - 2.82×10^6 mg/l), Electrical Conductivity (1586.0 - 1868.0 μ S/cm), COD (1250.0 - 16.40mg/l), Sulphate (92.97- 104.47mg/l) and Nitrate (1.53 - 3.52mg/l) across the three (3) sampling points, within the dumpsite.

3.1. Descriptive Statistics

Table 6: Descriptive statistics of Edaphic Variables across the sampling points in the Ariaria Market waste dumpsite and the control location in Aba.

Parameters	N	Minimum	Maximum	Range	Mean	Std. Deviation	EPA (2008)
pH	18	5.9	7.9	2.0	7.03	0.612	-
As (mg/kg)	18	1.05	5.38	4.33	3.0744	1.87962	7.2
Pb (mg/kg)	18	12.0	93.8	81.8	49.6500	37.28839	11
Cu (mg/kg)	18	24.2	141.0	116.8	80.5389	52.93523	250
Zn (mg/kg)	18	68.8	232.2	163.4	141.2889	69.46927	60
Cr (mg/kg)	18	3.8	76.5	72.7	36.2222	32.85038	10
Cd (mg/kg)	18	0.01	44.0	43.99	16.2817	16.65083	3
Sand (%)	18	43.0	65.0	22.0	54.6111	7.21224	-
Silt (%)	18	14	30	16	21.5000	5.92353	-
Clay (%)	18	21	28	7	23.8889	2.32351	-
Bulk density	18	1.16	2.6	1.44	1.9506	.41917	-
Moisture content (%)	18	4.1	9.2	5.1	6.2389	2.17286	

N = Number of samples, EPA = Environmental Protection Agency

Source: *Fieldwork by Researchers*

The descriptive statistics of the impacted and control samples are presented in Table 6. pH recorded a mean value of 6.29 ± 1.49 and its range fell within the EPA 2008 standards. As, Pb and Cr recorded mean values of 3.07 ± 1.87 , 49.65 ± 37.28 and 80.54 ± 52.93 respectively. The maximum value of as (5.38mg/kg) fell below the stipulated standard for a mineralized soil while the maximum values of Pb (93.8mg/kg) and Cu (141.0mg/kg) fell above the standard.

Zn, Cr and Cd recorded mean values of 141.28 ± 69.46 , 36.22 ± 32.85 and 16.28 ± 16.65 respectively. The maximum values of Zn (232.2mg/kg), Cr (76.5mg/kg) and Cd (16.65mg/kg) were all above the prescribed standard. Sand, Silt and Clay recorded mean values of 54.61%, 21.5% and 23.8% respectively

3.1.1. Spatial variation in Edaphic parameters of waste dumpsite in Aba

Spatial variations were observed in the levels of the edaphic variables measured across the sampling points and at the various depths of soils sampled. Minimum levels of pH (4.3) and As (1.05mg/kg) were recorded in the control location at the soil depth of 0–15cm. However, the mean maximum levels of 7.9, 5.38mg/kg were all recorded at the depth of 31–45cm. The minimum levels of Pb (12.00mg/kg) and Cu (24.20mg/kg) were recorded at control location at

the soil depths of 16–30cm and 31–45cm respectively whereas the maximum values were recorded at the depth of 0–15cm and 16–30cm respectively. Zn (70.40mg/kg) recorded its minimum value in the control location at the soil depth of 16–30cm and recorded the maximum levels of (232.20mg/kg) in the dumpsite at the soil depth of 0–15cm. Minimum levels of Cr (4.1mg/kg) and Cd (0.01mg/kg) were recorded at the control location soil depth of 31–45cm, while maximum values of 76.50mg/kg and 44.00mg/kg respectively were recorded at the dumpsite soil depth of 16–30cm.

Minimum levels of sand (45%), Silt (20%) and Clay (21%) were all recorded in the control location at the depth of 30–45cm for Sand and 0–15cm for Silt & Clay. Their maximum levels were all recorded in the dumpsite at the depth of 0–15 cm for sand (65%) and Clay (25%) while Silt (19%) was recorded at 31–45cm.

3.1.2. Spatial Variation in Leachate Quality of Waste Dumpsite in Aba

Spatial variations were observed in the levels of the physicochemical parameters of the leachate samples measured across the sampling points. Minimum levels of pH (7.2), EC (1586 μ S/cm) and Total Hardness (850mg/l) were recorded at the sampling station 1, while Total Alkalinity (2685.5mg/l) recorded its minimum at station 2. However, their maximum levels of 8.8, 1868mg/l, 964mg/l and 2902mg/l were all recorded at station 3.

COD and BOD recorded minimum values (1250mg/l) and (125mg/l) both at station 1, whereas their maximum values (1542mg/l) and (143.2mg/l) were recorded at station 2 and 3 respectively.

Minimum levels of Na (820mg/l), Chloride (1168mg/l), NO₃ (68.6mg/l) were recorded at station 1 while that of SO₄ was recorded at station 2. However, the maximum value for Na (940.2mg/l) and NO₃ (92.5mg/l) were recorded at station 2 whereas the maximum for SO₄ (178mg/l) and Chloride (1302.5mg/l) were recorded at station 1 and 2 respectively.

Variations across the points for Total coliform count and Faecal coliform count. The minimum values 210cfu/ml and 156cfu/ml were recorded at station 2, while the maximum values 240cfu/ml and 165cfu/ml were recorded at station 1. TDS recorded its minimum value (2.12x10⁶mg/l) at station 2 and its maximum (2.82x10⁶mg/l) at station 3.

4.0. DISCUSSION

Significantly higher metal levels were recorded in the dumpsite (Table 3) than the control locations in this study, and the order of abundance of the metals in the refuse dump site was Zn>Cu>Pb>Cr>Cd>As. Pb, Cu and Zn recorded decreasing concentrations with depth. This can be attributed to direct contacts with waste sources at the dumpsite which caused these pollutants to be concentrated in the topsoil (Akhionbare, 2009). On the other hand, As, Cr and Cd recorded increasing concentration with depth which can be attributed to the season (rainy season, with possibility of increased leaching owing to high sand content of soil), this agrees with the findings of Akhionbare (2013); Akhionbare (2009) and Ogbuagu *et al.* (2013).

The pH values at the dump site ranged between 7.2 and 7.9 (Table 3). This could be the result of high exchangeable bases content of the leachate (Sodium 880.7Mg/L and Chloride 1232Mg/L) around the dump (Table 5) (Akinbile (2012); Ogbuagu *et al.*, (2013)). The major effects of soil acidification on plants includes the reduction in nutrients supply, increased concentrations of metal ions in solution, especially of aluminium, and manganese, copper, zinc

which may be toxic. The moderate to neutral soil pH observed implied that the soils' exchangeable acidity may be low. Consequently, adsorption of heavy metals to the soil is not expected to be high to any appreciable extent (Okoronkwo *et al.*, 2006). Numerous studies have shown that lowering the soil pH decreases the adsorption of heavy metals and thus increases their concentration in the soil solution (Harter, 1983; Salt *et al.*, 1995); thus, it is advisable to keep the pH of soil at a moderate value. The values from this study ranged from 5.9–7.2 with an average of 6.55 at the dump site and 6.9–7.9 with an average of 7.48 at the control location. According to Isirimah *et al.* (2003), most plants and soil microorganisms thrive in soils with pH range of 6–7.5. The pH is a very important property, having great effect on solute concentration and sorption/adsorption by soil contaminants (Oguntimehin *et al.*, 2005). The pH values in all the soil depths at the dump site were slightly above neutral (above 7) tending towards alkaline; hence most of the other micronutrient like Zn tends to be less available when soil pH is above 7.5 (Jensen *et al.*, 2010).

In this study, Zinc recorded high concentrations with a mean value of 207.4mg/kg (Table 3) which is very similar to the high level reported by Ogbuagu *et al.* (2013) and Akhionbare (2013). Zn occurs naturally in soil (about 70mg kg⁻¹ in crustal rocks) (Davies & Jones, 1988), but concentrations are rising unnaturally, due to anthropogenic additions. Disposal of waste material containing Zn, like discarded Zn roofing materials and the combustion of waste materials are the major sources of Zn at the dumpsite of study. According to Odera *et al.* (2000), high Zn concentration could also come from the decomposition of electrical materials, roofing sheets, cooking utensils, alloys, electroplating and chemical effluents. Zinc is a trace element that is essential for human health and its shortages can cause birth defects. Water-soluble zinc that is located in soils can contaminate groundwater. Plants often have a Zn uptake that their systems cannot handle, due to the accumulation of Zn in soils. Zn can also interrupt the activity in soils, as it negatively influences the activity of microorganisms and earthworms, thus retarding the breakdown of organic matter (Greany, 2005). Despite this high concentration, the geochemical index (I_{geo}) computations suggest that the soils at these dumpsites are not polluted. This observation was further confirmed by the geoaccumulation classification by Agyarko *et al.*, 2010, which showed uncontaminated - moderate pollution intensity.

Cu recorded the next highest concentrations amongst the heavy metal species analysed, it averaged 131.73mg/kg. Copper is an essential micronutrient required by plants for their healthy growth. The soil normal range of copper according to USEPA is 250mg/kg (USEPA, 2008). The concentrations of copper for the dumpsites soil ranges from 122.5–141.0mg/kg. These concentrations were higher than those reported by Agyarko and Berlinger (2010) and David *et al.* (2009). The likely sources of Cu to this dumpsite could be attributed to the disposal of electrical components like copper wires and Cu alloy components used by battery chargers and electrical component fabrication works going on in Ariaria; other sources include the disposal of roofing and plumbing materials (Lenntech, 2015). This observation was further confirmed by the geoaccumulation index calculation, which showed moderate pollution intensity.

Pb concentrations in this study recorded a mean value of 85.59mg/kg at the refuse dump site and range 73.40–93.80mg/kg (Table 3), this was above that recorded for a similar studies by Ayolagha (2000), Akhionbare (2013) and Ogbuagu *et al.* (2013). This elevated value may have been contributed by the disposal of Pb containing waste materials like batteries, plumbing materials and solders which are commonly discarded from the Ariaria market. This could lead

to uptake by plant and food crops and subsequent bioaccumulation and biomagnification in the food chain which can lead to poisoning (plumbism) or even death (Baldwin & Marshall, 1999). The gastrointestinal tract, kidneys, and central nervous system are also affected, even as children exposed to it are at risk of impaired development, lower IQ, shortened attention span, hyperactivity, and mental deterioration (Sherry *et al.*, 2008). Adults usually experience decreased reaction time, loss of memory, nausea, insomnia, anorexia, and weakness of the joints when exposed to Pb (Sherry *et al.*, 2008). This high level of Pb in the dumpsite was further confirmed by the geoaccumulation index, which showed moderate pollution intensity.

Major sources of Cr contamination include releases from electroplating processes and the disposal of Cr containing wastes (Smith *et al.*, 1995), the two activities which are rife in Aba. Chromium has been associated with allergic dermatitis in humans (Scragg, 2006). This study recorded a mean value of 67.93mg/kg and range between 61.10–76.5mg/kg (Table 3). The result also is above that recorded by Ogbuagu *et al.* (2013). The geoaccumulation index showed moderate-strong pollution intensity.

Cd equally showed high concentrations in the dump site having a mean value of 32.12mg/kg and ranged 31–44mg/kg (Table 3) and mean of 0.44mg/kg with range 0.10 – 1.54mg/kg (Table 4) at the control. The application of agricultural inputs such as fertilizers, pesticides, and biosolids (sewage sludge), the disposal of industrial wastes or the deposition of atmospheric contaminants increases the total concentration of Cd in soils, and the bioavailability of this Cd determines whether plant–Cd uptake occurs to a significant degree (Weggler *et al.*, 2004). This high concentration of cadmium at the dump site may be due to the decay of abandoned electric batteries and other electronic components (Mull, 2005), which are commonly observed in the dumpsite. The geoaccumulation index showed strong pollution intensity which is the highest among the species and indicate Cd pollution in the topsoil and subsoil.

4.1. Moisture Content and Soil classification in the Dumpsite

The poorly sorted nature of the various particle sizes (Sand 61%, Silt 16% and Clay 23%) (Table 3) indicates that these soils probably have not been formed from the natural process of weathering of the underlying parent material but rather from deposited materials (Okoronkwo *et al.*, 2006). The sandy texture of the soils, however, predisposes them to leaching of pollutants (Akhionbare, 2013). With low water retention capacity (Moisture 6.4%), particularly in study area that recorded high rainfall amounts (Nyle and Ray, 1999).

4.2. Variation of Leachate Quality in the Dumpsite

Leachates from this study were amber coloured and alkaline with pH range of 7.20 to 8.80. This is typical of samples from aged wastes and such wastewater requires high coagulant dosage to ensure coagulation of pollutants if chemical treatment is desired (Harrison, 1996). The age of the dump plays a role in determining the heavy metals concentrations of Leachate (Akhionbare, 2013). Depending on the stage of organic degradation of the waste, metals not bound to any remaining organic matter could become subject to oxidation and dissolution into the leachate (Akhionbare, 2013).

Leachates analysed during this period (rainy season) showed higher concentrations of pollutants particularly for conductivity, dissolved solids, BOD, COD, Sodium, Sulphate, Chloride and coliform counts (Table 5). This could be attributed to surface water ingress into the dumpsite that promotes solubilisation of pollutants from actively decomposing waste mass into leachates emanating from the landfill site (Campbell, 1993).

Total dissolved solid contents indicate the ability of water to dissolve the organic and inorganic constituents. A high concentration of dissolved solids increases the density of dissolving water and reduces the solubility of oxygen gas, (Bangash *et al.*, 2006). From the results, the total dissolved solid concentration in the analysed leachate is high (range 2.12×10^6 – 2.82×10^6 mg/l). These values indicated the presence of organic and inorganic solids that can provide adsorptive sites for certain chemicals and biological agents (Aluko *et al.*, 2001).

Results of BOD (range= 102–143.2mg/l) (Mean= 123.4mg/l) and COD (range= 1250–1542.8mg/l) (Mean= 1382.6mg/l) (Table 5), both fall above acceptable standards of 30mg/l and 250mg/l in standard (WHO, 2008) of disposal of treated leachate. This could cause pollution of the underground water through seepage due to the porous nature of the soil (Akhionbare, 2009c, Ogbuagu, *et al.*, 2013).

Electrical Conductivity and Total Alkalinity values ranged between 1586–1868 μ S/cm and 2685.5–2902mg/l respectively (Table 5) with mean values of 1763.3 μ S/cm and 2813.3mg/l. These values are above the acceptable standards (1000 μ S/cm and 600mg/l) (WHO, 2008) for leachate disposal. Factors promoting Electrical Conductivity includes: nutrient regeneration from bottom sediments, decomposition of organics mainly from the continuous disposal of household waste and mineralization of microbes (Dibia, 2006). The high Alkalinity values could be attributed to the high salts (Na, SO₄, Cl and NO₃) (Akhionbare, 2009).

This study recorded elevated values for some salts; Sulphate (Mean= 163.5mg/l), Chloride (Mean= 1232mg/l) and Nitrate (82.1mg/l) (Table 5). Sulphate values from this study are within the acceptable standards (250mg/l) whereas Chloride and Nitrate values fall above the standard (250mg/l and 20mg/l). There are several sources of sulphate at the dumpsite; decaying plant and animal matter may release sulphate after coming in contact with rain water (Akhionbare, 2013). Sulphate is generally considered to be non-toxic. The consumption of drinking water containing high amount of magnesium or sodium sulphate may result in intestinal discomfort, diarrhoea and consequently dehydration (Akhionbare, 2009).

Nitrate values were considerably higher than the standard limit (45mg/l) WHO, 2008. With time, nitrogen concentration will decrease due to microbial utilization of nitrate compounds and denitrifying as ammonia gas (Bhalla *et al.*, 2013; Wu *et al.*, 2006). Nitrates are the primary contaminant that leaches into groundwater (Akhionbare, 2013). The United States Environmental Protection Agency (USEPA) has set a maximum contaminant level of 10 mg/l for nitrate in public water supplies (USEPA, 2005)

Result showed that the total coliform and faecal coliform counts for the leachate samples were high with mean values of 225cfu/100ml and 160.3cfu/100ml respectively (Table 5). The high number is also not surprising as the waste dump receive waste from diverse sources including household wastes, some of which contain faecal matter; this is typical of Aba metropolis which is battling with inadequate sanitary facilities (Ogbuagu *et al.*, 2013).

For the Principal component analysis conducted, the rotated component matrix for the soil sample shows that the first component (PC1) was highly correlated with Sand (0.846), Moisture content (0.782) and Zinc (0.650). Sand is mostly seen at the topsoil with 61% content more than the other soil types. Sand and moisture content contribute high due to the ability to absorb heavy metals. Zinc is used in making alloys of brass and bronze, galvanizing steel and iron products. Its presence is as result of human activities throwing affected materials to the

dumpsite. Excessive concentration in soil leads to phyto-toxicity as it is a weed killer (Aboud & Nandini 2009)

PC2 had high correlation with Cr (0.959), Cd (0.870), Cu (0.754) and Pb (0.703). Human activities in the area involving electroplating pigments, paints manufacturing, fungicides, photography, electric wiring, alloys, cooking utensils, batteries and dye production are possible sources of Cr, Cd, Cu and Pb. When these products are thrown into the dumpsite, these elements are leached away and accumulate at the topsoil where they are absorbed because of affinity for metals by organic matter (Amadi, 2011).

PC3 had high affinity for pH (0.632).the pH of the soil could have contributed to the heavy metal retention in the soil, resulting in low mobility of the metals. (Amadi *et al.*, 2012)

5.0. CONCLUSION

The soil quality of the waste dumpsite was negatively impacted by the introduction of high levels of toxic metals from waste streams, which caused the pollution of the site with Cr and Cd. The predominance of sand in the waste dumpsite predisposes groundwater aquifer to localized contaminations with the persistent pollutants in the dump.

The waste dump in Aba City is a non-engineered low-lying open dump. It has neither any bottom liner nor any leachate collection and treatment system. Therefore, all the leachate generated finds its way into the surrounding environment.

The leachate contains high concentration of organic and inorganic constituents beyond the permissible limits.

REFERENCES

- Abdus-Salam, N., Ibrahim, M. SandFatoyinbo, F. T (2011). Dumpsites in Lokoja, Nigeria: A silent pollution Zone for Underground water. *Waste Management and Bioresource Technology*, (5): 21-30.
- Aboud, S.J., and Nandini, N. (2009). Heavy metal analysis and sediment quality values in urban lakes. *Am. J. Environ. Sci.* 5(6), 678-687
- Agyarko, K., Darte, EandBerlinger, K (2010). Metal Levels in Some Refuse Dumpsite Soils and Plants in Ghana-*Journal of Plant Soil Environ*, 56 (5): 244-251.
- Akhionbare, S. M. O. (2007). Heavy Metal Distribution in Natural Water Sources in the Owan Area of Edo State Nigeria. *inter Res J. in Engr. Sc and Tech.*(IRSSEST) 4(2): 88-95
- Akhionbare, S. M. O. (2009). The Environmental Concepts, Issues and Control of Pollution.*MC Computer Press*. Nnewi, Nigeria p434
- Akhionbare, S. M. O. (2013). The Environmental Concepts, Issues and Control of Pollution.*Springfield publishers Ltd*. Owerri, Nigeria p278.
- Akhionbare, S. M. O. (2015). The Environmental Concepts, Issues and Control of Pollution.*Springfield publishers Ltd*. Owerri, Nigeria p 91 - 105.
- Akinbile, C.O (2012). Environmental impact of landfill on groundwater quality and Agricultural soils in Nigeria.*Journal on Soil & Water Res* 7, 2012 (1): 18–26
- Aluko O.O (2001) Characterization and Treatment of Leachates from a Municipal Solid waste Landfill site in Ibadan. MPH Dissertation.*University of Ibadan, Ibadan, Nigeria*.83-84.
- Amadi, A. N., Olaseinde, P. I., Okosun, E. A., Okoye, N. O and Okunola, I.A (2012).A Comparative Study on the Impact of Avu and Ihie Dumpsites on Soil Quality in Southeastern Nigeria.*American Journal of Chemistry*2 (1): 17-23.
- Amadi, A.N. (2011). Assessing the effects of Aladinma Dumpsite on soil and groundwater using water Quality Index and Factor analysis. *Australia journal of basic and Applied Science*, 5(11), 763-770
- APHA (2012). Standard methods for examination of water and waste water.(22nd, Edn.) APHA, AWWA, WPCF, Washington DC, USA.
- ATSDR (2004) Toxicological profile for copper.US Department ofHealth and Human Services.*Agency for Toxic Substances and Disease Registry* p314
- Baldwin, D. R and Marshall,W. J (1999). Heavy metal poisoning and its laboratory investigation, *Annals of Clinical Biochemistry*, 36(3): 267–300.
- Bangash, F.K., Fida, M. and Fazeel, A.T. (2006).Appraisal of Effluents of Some Selected Industries of Hayatabad Industrial Estate, Peshawar.*J.Chem.Soc.Pak*; 28(1):16-19
- Bergbäck, B., Johansson, K and Mohlander, U (2001). Urban metal flows – A case study of Stockholm. *Water, Air and Soil Pollution* 1: 3–24.
- Bhalla, B., Saini, M. S and Jha, M. K (2013).Effect of Age and Seasonal Variation on Leachate Characteristics of Municipal Solid Waste Landfill *International Journal of Research in Engineering and Technology* 2(8):2321–7308
- Campbell, D.J.V (1993). Environmental Management of Landfill Sites.J.I.W.E.M. Vol.7 No2.pp. 170-173. Charlotte, Y. (1998). Applying COSHH Principles to Waste Management.*Environmental Health Journal*.Vol. 106, No 10.Pp289 - 291.
- David, N. O., Benjamin, L.K and Patrick, O. Y (2009). Some Physicochemical and Heavy Metal Leves in Soils of Waste Dumpsites in Port Harcourt Municipality and Environs *J. Appl. Sci. Environ. Manage* 13(4) 65-70 (2009).
- Davies, B. E. and Jones, L. H. P (1988). Micronutrients and Toxic Elements, in Greany, K. M(2005).An Assessment of Heavy Metal Contamination in the Marine Sediments of Las Perlas Archipelago, Gulf of Panama, M.sc. thesis, School of Life Sciences Heriot-WattUniversity, Edinburgh, Scotland, 114pp

- Harrison, R.M (1996). Pollution: Causes, Effects and Control. Third edition. *The Royal Society of Chemistry*. 340-365.
- Isirimah, N. O., Igwe, C., and Iwegbue, C. M. A (2003). Important ions in soil Environment. In *Introductory Soil Chemistry and Biology for Agric. and Biotech*. Osia International Publishers Ltd., Port Harcourt, pp. 34–97.
- Jung C. H., Matsuto T and Tanaka N (2006). Flow Analysis of Metals in a Municipal Solid Waste Management System. *Waste Management*. 26:1337–48.
- Manios, T (2004). The Composting Potential of Different Organic Solid Wastes: Experience From the Island of Crete. *Environment International*, 29(8): 1079-1089
- Mull, E. J (2005). Approaches toward sustainable urban solid waste management: Sahakaranagar Layout, Unpublished M.Sc. thesis, International Environment & Science, Lund University, Lund, Sweden, 2005, 37p.
- Nyle, C. B., and Ray, R. N. 1999. *The Nature and Properties of Soils*, 12th ed., Prentice-Hall, Inc, NJ, pp. 743–785.
- Odero, D. R., Semu, E. and Kamau, G (2000). Assessment of Cottage Industries-Derived Heavy Metal Pollution of Soil within Ngara and Gikomba area of Nairobi city, Kenya. *African Journal of Science and Technology*, 1:52 – 62
- Ogbuagu, D. H., Chima, J. I and Balogun, B. A (2013). Aspects of Soil Quality Studies Impacted by a Waste Dumpsite in a Commercial city of Nigeria. *International Journal of Innovative Environmental Studies Research* 1(3): 55–56.
- Oguntimehin, I. I., Ipinmoroti, K. O and Aiyesanmi, A. I (2005). Evaluation of Heavy Metals in Soils at Automobile Workshop in Akure. *Nigerian Journal of Soil Science* 15(2), 151–153.
- Okoronkwo, N. E., Odemelam, S. A., and Ano, O. A (2006). Level of Toxic Elements in Soils of Abandoned Waste Dump Site. *African Journal of Biotechnology* 5(13), 1241–1244.
- Ostman, M., Wahilberg, O., Agren, S., Martensson, A. (2006): Metal and Organic Matter Contents in a Combined Household and Industrial Landfill. *Waste Management*, 26, 29-40.
- Russell's Soil Conditions and Plant Growth*, A. Wild, (Ed), John Wiley & Sons; Interscience, New York, NY, USA, 11th edition pp. 781–814.
- Scragg, A (2006). *Environmental Biotechnology*, Oxford University Press, Oxford, UK, 2nd edition, 249p.
- Sherry, L. D., Joanna, M. G., David, E. J., Warren, S., Jyothi, N., Tim, P., Jonathan, W. W and Peter, J. A. (2008); U.S. Children's Exposure to Residential Dust Lead, 1999-2004: II. The Contribution of Lead-contaminated Dust to Children's Blood Lead Levels; *Environmental Health Perspectives* 10 pp1289
- Smith, L. A., Means, J. L. and Chen, A (1995). *Remedial Options for Metals-Contaminated Sites*. Lewis Publishers, Boca Raton, Fla, USA, 240pp.
- USEPA U.S. Environmental Protection Agency (2005). Non-point Source Control Branch (4503T) 1200 Pennsylvania Avenue, NW Washington, DC 20460.
- Wegglar, K., McLaughlin, M. J. and Graham, R. D (2004). Effect of Chloride in Soil Solution on the Plant Availability of Biosolid-Borne Cadmium. *Journal of Environmental Quality*, 33(2): 496–504.
- World Health Organization (WHO) (2008): *International standards for drinking water* World Health Organization. Geneva, Switzerland. 2nd Ed
- Wu, D., Quan, X., Zhang, Y and Zhao, Y (2006). Long-term Operation of a Compost-based Biofilter for Biological Removal of n-butyl acetate, p-xylene and Ammonia Gas from an Air Stream. *Bioche. Engi. J.* 32(2), 84-92.

- Wuana, R. A and Okieimen, F. E (2011). Heavy metals in contaminated soil: A review of sources, Chemistry, Risk and best available strategies for remediation. *International Scholarly research network*.pp20.
- Zauyah, S., Juliana, B. Noorhafizah, R., Fauziah, C.I and Rosenami, A.B(2004). Concentration and Speciation of Heavy Metals in Some Cultivated and Uncultivated Ultisols and Inceptisols in Peninsular Malaysia. *Super-Soil 3rd Australian New Zealand Soils Conference*, University of Sydney, Australia
- Zennaro M, Cristofori F, Formigoni D, Frignani F, Pavoni B (2005). Heavy Metal Contamination in Compost. *A possible solution. Ann Chim-Rome*95:247–56.
- Zhang, D., Keat, T.S and Gersberg, R.M (2010). A Comparison of Municipal Solid Waste Management in Berlin and Singapore. *Waste Manage.*, 30: 921-933.
- Zhuang, P., McBride, M. B., Xia, H., Li, N., and Li, Z. (2009) Health risk from heavy metals via consumption of food crops in the vicinity of Dabaoshan mine, South China, *Sci. Total Environ.*, 407, 1551– 1561.