World Journal of Innovative Research (WJIR)
ISSN: 2454-8236, Volume-7, Issue-5, November 2019 Pages 11-18

Soil and Leachate Quality Aspects of Ariaria Market Dumpsite Aba Southeast Nigeria

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***Abstract*— The heavy metal characteristics of soils and the physicochemical parameters of the leachate of a municipal solid waste dumpsite in Ariara, 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 P<0.05 and 0.01. As, Pb, Cu, Zn, Cr and Cd ranged as follows: (4.15–5.38mg/kg), (73.4–93.8mg/kg), (122.5–141.0mg/kg), (180.4–232.2mg/kg), (61.1–76.5mg/kg) and (25.8–44.0mg/kg) while pH, EC, COD, BOD and TDS from the leachate averaged 8.1±0.81, 1763.3±154.4mg/l, 1383.1±148.2mg/l, 123.4±20.6mg/l and 2.43x106±3.57x105mg/l respectively. Means for Sulphate (163.5±13.1mg/l), Chloride (1231.8±67.22mg/l), Nitrate (82.1±12.2mg/l), Coliform count (225.0±15.0cfu/ml) and Faecal coliform (160.3±4.5cfu/ml) all recorded elevated values in the leachate. Mean sand and clay compositions were (54.6± 1.57%), (21.5±5.92%) and (23.8± 0.48%) respectively. There were significantly higher concentrations of Pb, Cu, Zn, Cr and Cd at the dumpsite than control location at P<0.05, with their levels exceeding the background levels in mineral soils. At 0.01 confidence limit pH recorded significant negative correlation with all the heavy metals; whereas clay showed significant negative correlation with Zn (r=-0.486*) and Cd (r=-0.476*). Cd, Cr and Pb recorded high geoaccumulation index value and the order of heavy metal enrichment was Cd>Cr> 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.**

***Index Terms*— Solid waste, industrialisation, relative abundance, Heavy metals, Leachate.**

I. Introduction

Solid waste management is in crisis in many of the countries 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 emergency 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 garbage in the world is a problem that continues to grow with human civilisation 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 (Zauyah, *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. The study will clearly reveal likely influences or effects and thus calls for a renew need for a better organized knowledge about waste disposal than has been over the years. Conversely, based on the increase in population of cities and

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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 And 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. These can be achieved by using different waste collection methods such as; communal collection method, Door to Door collection, Block method and Kerbside method (Gallardo, *et al*., 2010). 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.

II. METHODOLOGY

Study Area

Ariara 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 281m in length and 184.7m in width. The area is a commercial town found in the eastern part of Nigeria. It has one of the largest market in Nigeria (Ariara 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 (Fig 1).Abia state lies in the tropical rain forest belt of Nigeria Its heaviest precipitation occurs during September The mean monthly rainfall during the rainy season is 335mm and falls to 65mm during the dry season. The annual rainfall is between 2000m and 2250mm (Adindu *et al*., 2012). Also the temperature is very high throughout the year with an annual range of 23°C while mean relative humidity ranges from 60 – 90%. Highest and lowest monthly mean relative humidity are observed during rainy and dry seasons respectively (Kalu, 2012).Its major economic contributions are textiles, pharmaceuticals, plastics, cement and cosmetics. There is also a brewery and distillery within the city.

Sampling

Samples were collected at three (3) locations within the dumpsite. A fourth sample was collected 200m North of the sampling points. The labelled samples are: A, B, C, D with D as the control (Fig 1). 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.

Sample Analysis

Leachate samples were analysed for physicochemical parameters using standard methods while soil samples were analysed for heavy metalconcentrations using atomic absorption spectrophotometer (AAS)according to standard methods (APHA, 2000). Possible metal-metal, metal-pH relationships were investigated using the Pearson correlation coefficient to determine significant levels (95% confidence). To quantify the degree of pollution in the refuse dump soils the Geoaccumulation index I_{geo} was calculated by using the relationship (Agyarko *et al*., 2010)

$$I_{geo} = \left\{ \frac{Dn}{1.5 \, xCn} \right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Dn = measured concentration of heavy metal in the refuse dump soil (ppm);

Cn = measured concentration of heavy metal in the control soil (ppm), and

1.5 = background matrix correction factor.

Table 1.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

Agyarko*et al*., 2010

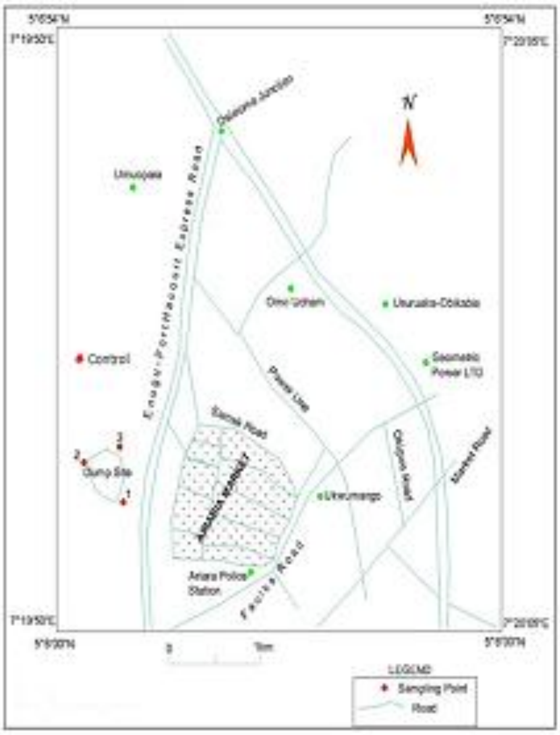


Fig 1. Map of study area showing sampling points

III. RESULTS AND DISCUSSION

Result (Table 1) show 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.

Significantly higher metal levels were recorded in the dumpsite (Table 1) than the control locations (Table 2) 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, 2009 and Ogbuagu *et al.*, 2013.

The pH values at the dump site ranged between 7.2 and 7.9 (Table.1). 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 3) (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). Figure 2 and 3 shows pH variation with heavy metals.

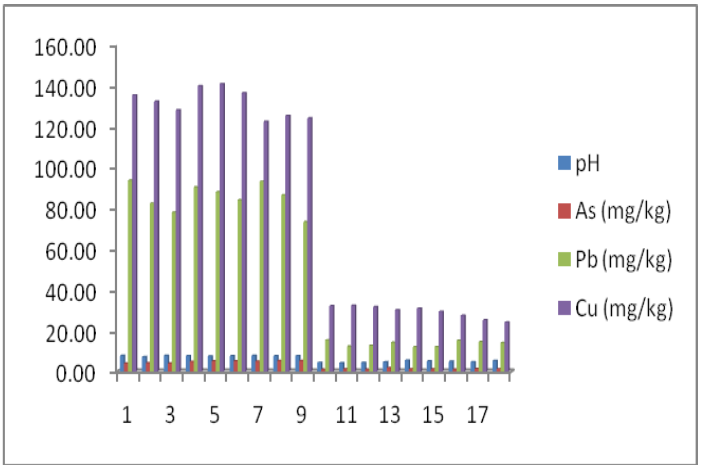


Figure 2: Variations of pH, As, Pb and Cu Across the refuse dumpsite and Control locations

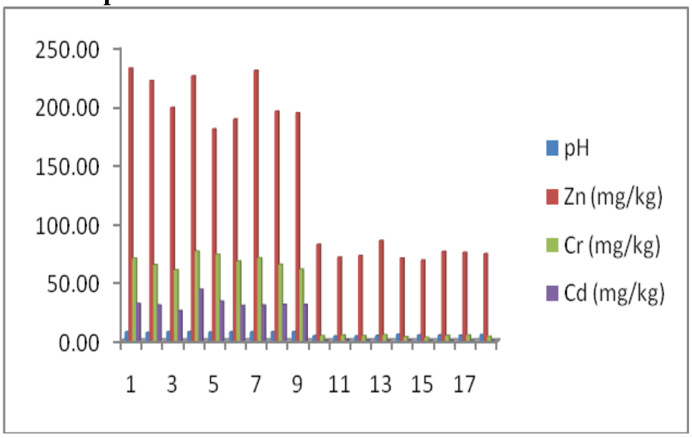


Figure 3: Variations of pH, Zn, Cr and Cd Across the refuse dumpsite and Control locations

In this study, Zinc recorded high concentrations with a mean value of 207.4mg/kg (Table 1 & Fig 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 and 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 Odero *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 (Table 6).

Cu recorded the next highest concentrations amongst the heavy metal species analysed, it averaged 131.73mg/kg (Fig 2). 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 Ariara; other sources include the disposal of roofing and plumbing materials. This observation was further confirmed by the geoaccumulation index calculation (Table 6), 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 1 & fig 2) 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 and 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 geoaccumulationindex (Fig 10), 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 1 &Fig 2) The result also is above that recorded by Ogbuagu *et al*., (2013). The geoaccumulation index (Fig 10), 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 4.1) and mean of 0.44mg/kg with range 0.10 – 1.54mg/kg (Table 2) 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 (Fig 10), showed strong pollution intensity which is the highest among the species and indicate Cd pollution in the topsoil and subsoil.

From Table 1, 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

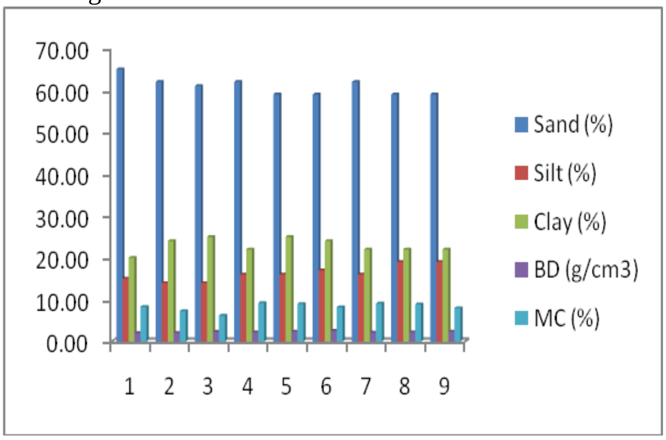


Figure 4: Variations of Sand, Silt, Clay, Bulk density and Moisture content Across the refuse dumpsite and Control locations

The poorly sorted nature of the various particle sizes (Sand 61%, Silt 16% and Clay 23%) (Table 4.1) 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).

The levels of the various physico-chemical parameters of leachate samples determined across the sampling locations at the Ariara market waste dumpsite are shown in Table 4.3,.pH ranged from 7.2 to 8.80. High values were recorded in the concentrations of: TDS (range: 2.12x10^{6}mg/l - 2.82x10^{6}mg/l), Electrical Conductivity (1586.0 - 1868.0µS/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 (Fig 5).

LEGEND
SERIES 1 = Variations of EC across the 3 points

SERIES 2 = Variation of Total Alkalinityacross the 3 points

SERIES 3 = Variation of Total Hardnessacross the 3 points

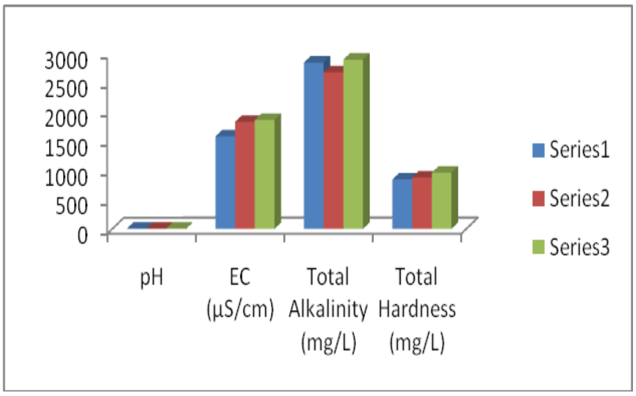
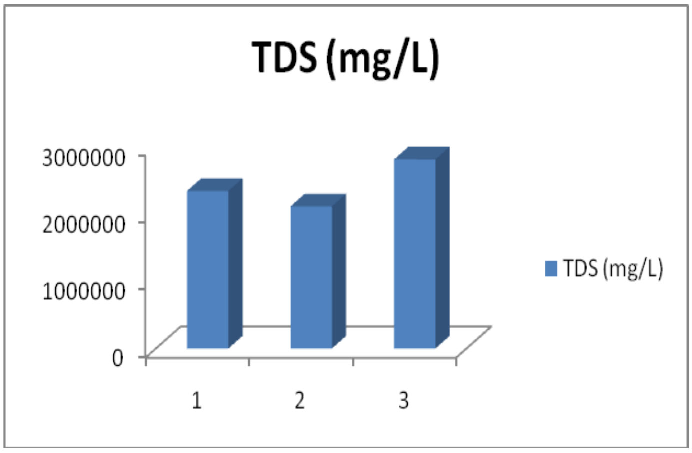


Figure 5: Variations of pH, Electrical Conductivity, Total Alkalinity and Total Hardness of the leachate from the dumpsite

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 3). 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 2.12x10^6–2.82x10^6 mg/l) (Fig 6). 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).



LEGEND
1 = Sampling point 1
2 = Sampling point 2
3 = Sampling point 3

Figure 6: Variations of TDS of the leachate from the dumpsite

Results of BOD (range= 102–143.2mg/l) (Mean= 123.4mg/l) and COD (range= 1250–1542.8mg/l) (Mean= 1382.6mg/l) (Table 3) (Fig 7), 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, 2009, Ogbuagu, *et al*., 2013).

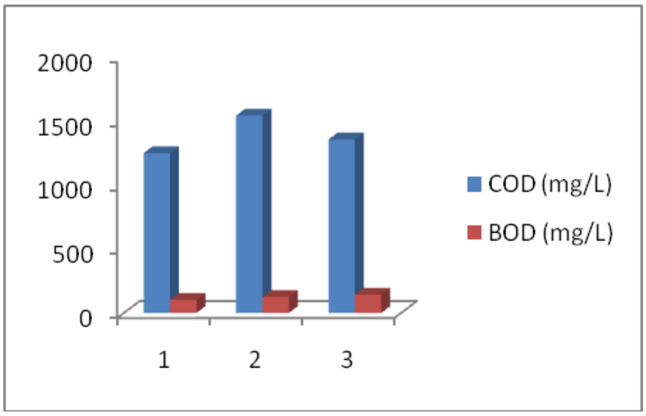


Figure 7: Variations of COD and BOD of the leachate from the dumpsite

Electrical Conductivity and Total Alkalinity values ranged between 1586–1868 µS/cm and 2685.5–2902mg/l respectively (Table 3) with mean values of 1763.3µS/cm and 2813.3mg/l. These values are above the acceptable standards (1000µS/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, SO_4, Cl and NO_3) (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 3). 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 (Fig 8) 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)

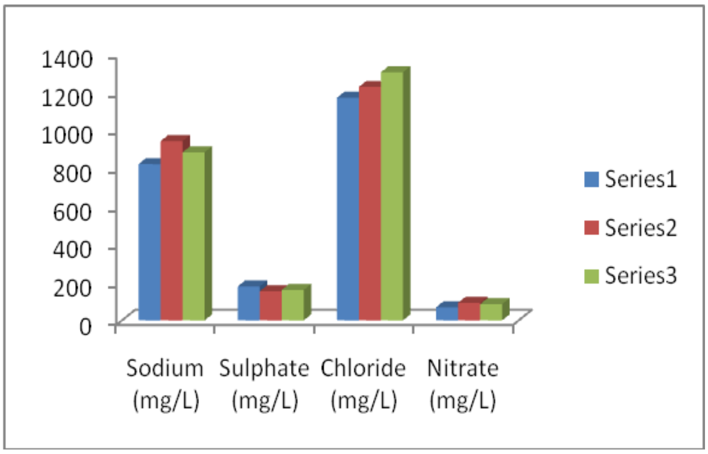


Figure 8: Variations of Na,SO_4, Chloride and NO_3 of the leachate from the dumpsite

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 3 & Fig 9). 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).

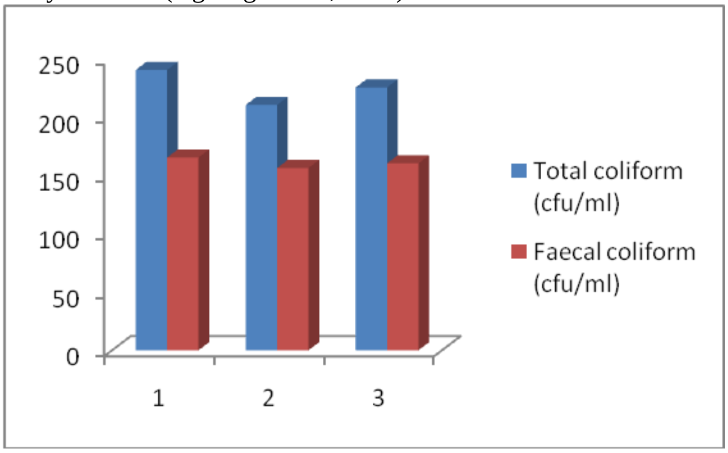


Figure 9: Variations of Total coliform and Faecal coliform of the leachate from the dumpsite

At 0.01 confidence level, pH recorded significant negative correlation with all the heavy metals analysed; As (-0.698**), Pb (-0.801**), Cu (-0.802**), Zn (-0.802**), Cr (-0.788**) and Cd (-0.745**) (Table 4.5).

At 0.05 confidence level, clay recorded a significant negative correlation with Zn (–0.486*), Cd (–0.478*). Also, clay recorded significant negative correlation with MC (–0.495*) (Table 4.5).

Sand recorded a significant positive correlation at 0.01 significant with all the heavy metals analysed, whereas Silt recorded a significant negative correlation at 0.01 confidence level with all heavy metals analysed.

Table 6 show the result of the geochemical accumulation computation, with Cd recording the highest value of 3.19 and 4.49 across the topsoil and subsoil respectively. Cr recorded high value (2.23 and 2.34) at the topsoil and subsoil horizons respectively. As and Cu recorded the least value; both heavy metals recorded 1.01 at the topsoil and 0.94 & 1.14 at the subsoil respectively. The geoaccumulation index (I_{geo}) indicates the deterioration of site quality especially from Cr and Cd.

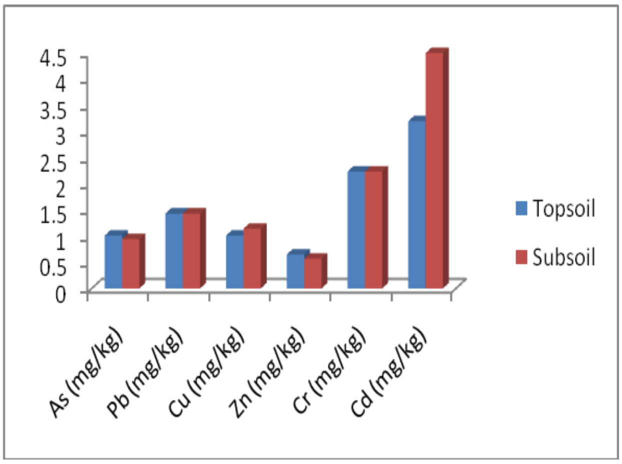


Figure 10: Geoaccumulation pollution index of heavy metals at the Topsoil and subsoil Horizons

IV. 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

[1] Abdus-Salam, N., Ibrahim, M. S and Fatoyinbo, F. T (2011). Dumpsites in Lokoja, Nigeria: A silent pollution Zone for Underground water. *Waste Management and Bioresource Technology*, (5): 21-30.

[2] Adindu, R U, Igbokwe, M U and Lebe, N (2012).Groundwater Mineralization Analysis of Osisioma Local Government Area of Aba, Abia State, Nigeria.*Afr. J. Biotechnol.*, 11(48):10868- 10873.

[3] Agyarko, K., Darte, E and Berlinger, K (2010). Metal Levels in Some Refuse Dumpsite Soils and Plants in Ghana-*Journal of Plant Soil Environ*, 56 (5): 244-251.

[4] Akhionbare, S. M. O. (2015). The Environmental Concepts, Issues and Control of Pollution.*Springfield publishers Ltd*. Owerri, Nigeria p 91 - 105.

[5] Akhionbare, S. M. O. (2013). The Environmental Concepts, Issues and Control of Pollution.*Springfield publishers Ltd*. Owerri, Nigeria p278.

[6] 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

[7] Akhionbare, S. M. O. (2009). The Environmental Concepts, Issues and Control of Pollution.*MC Computer Press.* Nnewi, Nigeria p434

[8] Akinbile, C.O (2012). Environmental impact of landfill on groundwater quality and Agricultural soils in Nigeria.*Journal onSoil & Water Res 7, 2012 (1): 18–26*

[9] 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.

[10] APHA (2000). Standard methods for examination of water and waste water.(22nd, Edn.) APHA, AWWA, WPCF, Washington DC, USA.

[11] Baldwin, D. R and Marshall,W. J (1999). Heavy metal poisoning and its laboratory investigation, *Annals of Clinical Biochemistry*, 36(3): 267–300.

[12] 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

[13] Bergbäck, B., Johansson, K and Mohlander, U (2001). Urban metal flows – A case study of Stockholm. *Water, Air and Soil Pollution* 1: 3–24.

[14] Bhalla, B., Saini, M. S and Jha, M. K (2013).Efffect 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

[15] 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.

[16] CCME, (2015). Landfill Leachate Factsheet: *Canadian Council of Ministers of the Environment, Winnipeg*, Retrieved online on the 4th of November 2015 from: [http://www.thorhildproject.ca/documents/landfill-leachate.pdf].

[17] 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).

[18] Davies, B. E. and Jones, L. H. P (1988). Micronutrients and Toxic Elements, in

[19] *Russell's Soil Conditions and Plant Growth*, A. Wild, (Ed), JohnWiley& Sons; Interscience, New York, NY, USA, 11th edition pp. 781–814.

[20] De Groot C C,, Marcelis L. F.M, Van der Boogard R and Lambers H (2001a). Growth and dry mass positioning in tomato as affected by phosphorus nutrition and light *Plant cell Environ*. 24:1309–1317

[21] Dibia, A. E. N. (2006). Effect of Biotope Difference on Aquatic Macrophytes along Mini-Chindah Stream in Port Harcourt, Rivers State *M.Sc. Thesis, Rivers State University of Science and Technology, Port Harcourt*, Nigeria, pp: 120.

[22] Gallardo, A.Bovea, M. D. Ibáñez-Forés, V and Colomer-Mendoza, F. J (2010 Environmental assessment of alternative municipal solid waste management strategies. A Spanish case study *Waste Management* 30 (2010) 2383–2395

[23] 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

[24] Harrison, N (2001). "Inorganic Contaminants in Food", In: Food Chemical Safety Contaminants Watson, D. H (Ed) First Edition *Wood Head Publishing Cambridge International* 148-168.

[25] Harrison, R.M (1996). Pollution: Causes, Effects and Control. Third edition.*The Royal Society of Chemistry*.340-365.

[26] Harter, R. D. 1983.Effect of Soil pH on Adsorption of Lead, Copper, Zinc and Nickel.*Soil Science Society of America Journal* 47, 47–51.

[27] 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.

[28] Kalu, K.M., Obasi, N. A., Nduka, F. O., Nwaugo, V. O and Onuabuchi, I.A (2012). Abundance of nocturnal, endophagous and anthropophilic *Anopheles species* in relation to human malaria transmission in an urban and a rural community of Abia State, Nigeria. *J. Entomol*.

[29] Manios, T (2004). The Composting Potential of Different Organic Soild Wastes: Experience From the Island of Crete. *Environment International*, 29(8): 1079-1089

[30] Mapanda, F., Mangwayana, E. N., Nyamangara, J. and Giller, K. E. (2005). The effect of long-term irrigation using wastewater on heavy metal contents of soils under vegetables in Harare, Zimbabwe. *Agric. Ecosys. Environ*., 107, 151–65.

[31] 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.

[32] Narayana, T. (2009). Municipal solid waste management in India: From waste disposal to recovery of resources *Waste Manage.*;29:1163–1166.

[33] NBS, (2018). Nigerian Bureau of Statistic 2012-2017 projections *Demographic statistics bulletin* p26.

[34] Nyle, C. B., and Ray, R. N. 1999.*The Nature and Properties of Soils*, 12th ed., Prentice-Hall, Inc, NJ, pp. 743–785.
[35] Obasi, H. A., Akubugwo, E. I., Ugbogu, O. C and Oluchristian G (2012).Assessment of physicochemical properties and heavy metals bioavailability in dumpsites along Enugu – Port Harcourt expressways, south east Nigeria.*Asian journal of applied sciences*, 5:342–356.
[36] 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
[37] 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.
[38] 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.
[39] 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.
[40] Salt, D. E., Blaylock, V., Kumar, P. B. A. N., Dushenkov, U., Ensley, B. D., Chet, L., and Raskin, I (1995). Phytoremediation: A novel strategy. *Biotechnology* 13, 468–474.
[41] Scragg, A (2006). *Environmental Biotechnology*, Oxford University Press, Oxford, UK, 2nd edition, 249p.
[42] 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
[43] Smith, L. A., Means, J. L. and Chen, A (1995). *Remedial Options for Metals-*
[44] *Contaminated Sites*.*Lewis Publishers, Boca Raton,Fla*, USA, 240pp.
[45] USEPA U.S. Environmental Protection Agency (2005). Non-point Source Control Branch (4503T) 1200 Pennsylvania Avenue, NW Washington, DC 20460.
[46] Weggler, 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.
[47] World Health Organization (WHO) (2008): *International standards for drinking water World Health* Organization. Geneva, Switzerland. 2nd Ed
[48] 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.
[49] 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
[50] Zengin, F and Munzuroglu, O. (2005) Effect of some heavy metals on content of chlorophyll, proline and some antioxidant chemicals in bean (*Phaseolus vulgaris L.*) seedlings. *ActaBiolCrac* 47(2):157–164
[51] 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.
[52] 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.