Original Research Article

Impact of leachate on Physicochemical Properties of Soil, within the Vicinity of Oghara Medical Dumpsite, Delta State. Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Authors NPO., AB. And JA. *designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors AO and OIG managed the analyses of the study. Authors NPO and AB managed the literature searches. All authors read and approved the final manuscript.*

ABSTRACT

Assessing the level of toxic metals in pollution prone areas is imperative in order to ascertain their present levels. Top soil TS (0-15 cm) and sub soil SS (15-30 cm) samples and leachate were obtained in Oghara Teaching Hospital dumpsite. Three locations in the dumpsite were sampled. The soil and leachate was characterized using standard methods. The results shows that the pH was acidic with a range value of 4.26-5.48, electrical conductivity EC (29-197) µs/cm, cation exchange capacity CEC (11.58-25.10) meq/100g, nitrogen N (0.21-0.49) %, organic matter O.M (3.77-9.18) %, organic carbon O.C (2.18-5.31) %, SO_4^{2-} (5.66-29.53) meg/100g, PO_4^{3-} (5.07-54.29) meg/100g, Clay (13.60-17.62) %, Silt (2.21-2.99) % and Sand (79.86-84.13) %. The soil samples contain elevated levels of heavy metals with iron having the highest concentration. The metal concentrations are; 3328.50-6569.40, 117.70-267.70, 49.38-205.76, 11.63-87.21, 1.50-5.45 and 10.29-18.57 mg/kg for Fe, Zn, Mn, Cu, Cd and Pb respectively. The fractionation results follows the order B1 > R > B2 > B3. The mobility factor was high which is an indication of mobile nature of these metals, with lead (Pb) being the least mobile metal. The result of the leachate characterization are; pH (5.9), total dissolve solids TDS (32 mg/l), total suspended solids TSS (3700 mg/l), dissolve oxygen DO (1.40 mg/l), biological oxygen demand BOD (84 mg/l), chemical oxygen demand COD (214 mg/l), Ca^{2+} (62.20 mg/l) and Mg^{2+} (28.00 mg/l). This research is an eye opener to the indiscriminate dumping of hospital waste, as these can be a major source of heavy metals pollution if not properly checked.

Keywords: Physico-chemical, Hospital dumpsite, Leachate and Heavy metals.

INTRODUCTION

The unsightly accumulation of wastes generally affects the aesthetic value of the urban environment, destroy the land scape and to an extent pulsate the environment. It also increases the breeding conditions of some disease vectors and pathogens which invariably increases the morbidity (malaria, dysentery and diarrhea) and mortality (Civeria and Lavaado, 2008) as well as the cost of medical expenditure among the local residents (Ejeona and Umah, 2000). Generally, the practices at dumpsites are not effective. Dumping is unrestricted to industrial, agricultural, domestic and medical wastes and up in one site. As a result of poor control, medical and hazardous wastes end up at municipal dumpsites even though they have their own special dumping areas. The uncontrolled manner in which solid waste is disposed off at most hospital dumpsites creates serious environmental degradation. Hospital wastes refers to all waste, biological or non biological from hospitals, that is discarded and not intended for further use and these include: pathological, infectious, hazardous chemicals, radioactive wastes, stock cultures, blood and blood products, animal carcasses, pharmaceutical wastes, pressurized containers, batteries, plastics, low level radioactive wastes, disposable needles, syringes, scal-pels and other sharp items. These are in addition to food wastes, clinical bandages, gauze, cotton and other miscellaneous wastes. Other types of waste include toxic chemicals, cytotoxic drugs, flammable and radio-active wastes that can often be considered infectious (Auta and Morenikeji 2013). Hospital wastes are generated as a result of patients' diagnosis and/or treatment or immunization of human beings or animals. Hospital wastes are a universal set having subsets like infectious and hazardous wastes. Wrongly managed hospitals wastes can result in severe health hazards. It has been reported that hospital waste is one of the most toxic Waste (Inyang, *et al*., 2013). Countries with little or no proper hospital waste management are prune to severe chronic respiratory syndrome (SARS). Several accidents have been reported where mishandling of hospital wastes led to infections (Shang and Jia, 2002). Hospital wastes are so infectious / hazardous that every means of improper disposal pose a threat to the environments. Studies so far in Nigeria have revealed a zero level of proper management of hospital wastes, in spite of the risk associated with this knowledge gap (Abah and Ohimain, 2011). The uncontrolled manner in which hospital waste is disposed off at most hospital dumpsites creates serious environmental degradation. The inadequate waste disposal translates into economic and other welfare issues (Zurbrugg, 2002). Leachate from hospital waste dumpsite can decompose and also increase in volume if exposed to rainfall. Leachates have the potential of polluting ground water.

Consequently due to the above situation in developing countries such as Nigeria, it becomes imperative to evaluate the effect of hospital waste on soil physico-chemical properties and heavy metal content in Delta State Teaching Hospital Dumpsite Oghara.

MATEERIALS AND METHOD

Study Area

The study area is Oghara, a town in Ethiope West Local Government Area of Delta State, Nigeria, and is located between latitude 5035′1’’N and longitude 5051’16’’E. The city has road intersections connecting Sapele to Warri and Benin. It has various educational Institutions such as the Delta State Polytechnic in Otefe-Oghara, Western Delta University and Delta State University Teaching Hospital (DELSUTH). This teaching hospital has a dump site where all their wastes are dumped untreated. This makes it a point source of concern. Table 1 show the coordinate of the dumpsite and the control site which is 100 m away from the dumpsite. Fig. 1 shows the map of Oghara with sampling points.

Table 1: Site code, Coordinates and Site Description

Location	Coordinates	Site Description
Control site	5^0 56’ 18.61’’N, 5^0 41’ 33.22’’E	The site is located at Ogharefe ,Ogini road. It is characterized by residential buildings.
Hospital Waste Dumpsite	5^0 56’ 40.56’’N, 5^0 41’ 13.52’’E	The site is located at Ajmuyawve area closed to Oghara junction. It is characterized by ariable lands.

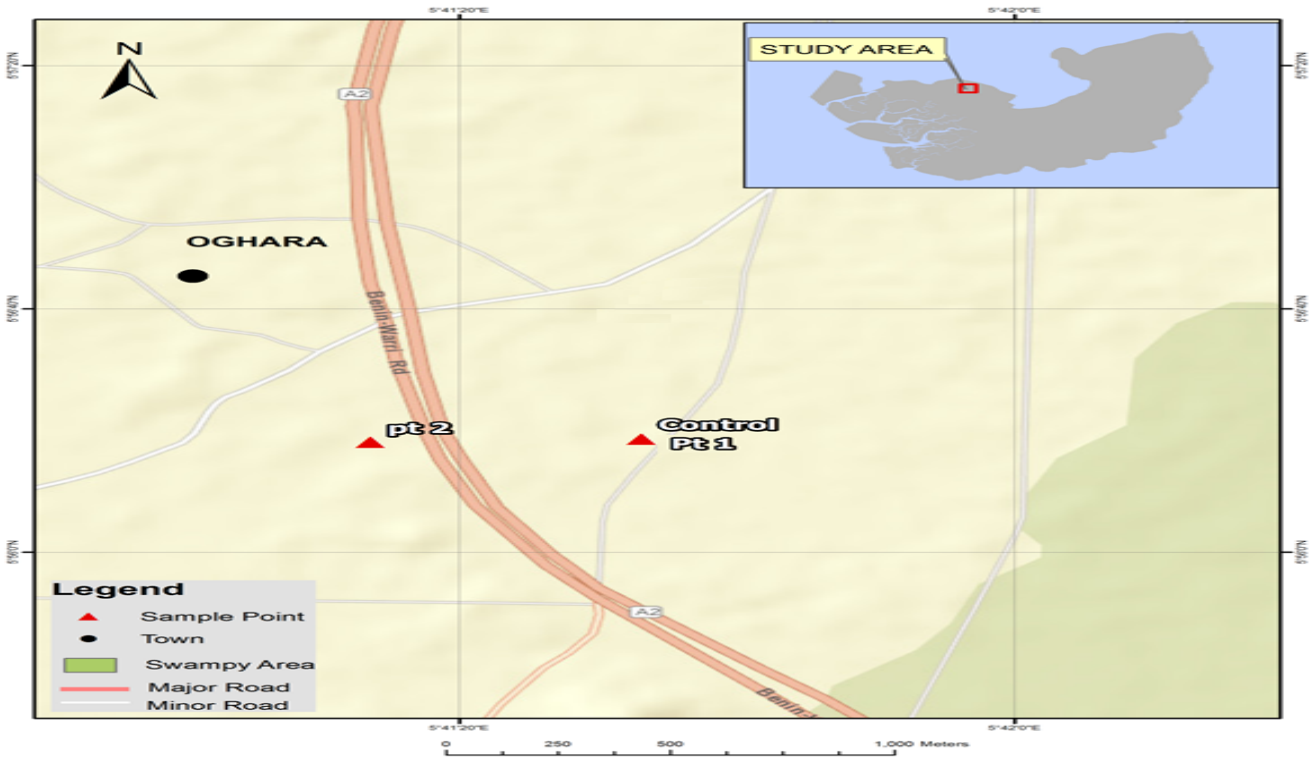

Fig 1: Map of Oghara City showing sampled sites (Nwaka, 2016**)**

Sample Collection and Preparation

Composite soil samples were collected at a depth of 0-15 and 15-30 cm from the hospital dumpsite in Oghara using standard soil (hand) auger. Three different locations, was chosen from the dump site. Soil samples of control site were also collected. The geographical position coordinates of the sampled locations were identified and mapped using global position system (GPS). The collected samples were transferred into a black polythene bag, properly labeled and transported to laboratory. The samples were air-dried for a period of two weeks in a well-ventilated space. The dried representative soil samples were crushed in porcelain mortal and sieved through 2 mm (10 mesh) stainless sieve. The air-dried <2 mm soil samples were stored in airtight polythene bags and labelled prior to analysis. Since the dumpsite was not equipped with a leachate collector, the leachate was collected at the base of the dumpsite and was sampled randomly from three different locations and mixed. The leachate sample was transferred immediately to the lab and stored in the refrigerator.

Determination of Physico-Chemical Properties of Soil

pH: Twenty grams of the soil sample was weighed into a 50mL beaker and 20 mL of distilled water was added. The soil/water mixture (ratio 1:1) was allowed to stand for 30 mins and stirred occasionally with a glass rod. The pH meter was calibrated using buffer 4 and 7. The electrodes were rinsed and subsequently immersed into the soil/water mixture. The pH was recorded. (Anegbe *et al*., 2014)**.**

Cation Exchange Capacity: Five grams of soil sample was weighed into a 250 mL polypropylene bottle and 100 mL of 1M NH_4OAc solution was added and stoppered. The mixture was shaken for 30mins in a mechanical shaker (Heldoph) at 200 rpm for 30mins. The supernatant was filtered through Whatman No.1 filter paper. The concentration of K^+, Na^+, Mg^{2+} and Ca^{2+} in the extract were determined as described by Ugbone and Okuo (2011).

Particle Size Analysis - Hydrometer Method

Fifty grams of soil sample were weighed into a 250 mL beaker, 100 mL of distilled water and 10 mL of concentrated H_2O_2 were added to the soil. The content of the beaker was heated until frothing stopped. The mixture was cooled and transferred into shaking bottles. 20 mL of sodium hexametaphosphate solution was added and the mixture was shaken for 1 hr. The suspension was transferred to 1 L sedimentation cylinder and brought to mark with distilled water. A plunger was used to agitate the suspension. The hydrometer was then lowered into the suspension and its reading was taken after 40 seconds. The temperature was noted. The first reading, R_1, gave the percent clay and silt. The suspension was allowed to stand for 2 hrs before the hydrometer reading was taken again. The second reading, R_2, gave the percent clay (Anegbe and Okuo 2013).

The method describe by Anegbe *et al*., (2014b) was used to determine the organic carbon content. The concentration of phosphorus was obtained as described by Oviasogie *et al*., (2006). The nitrogen content was determined by colorimetric method (Vogel, 2008). Sulphate-Sulphur

(SO_4^{2-}) was determined as described by Yahaya, (2009). The total metal content was determined as described by Anegbe, 2016. The leachate was characterized using standard methods for the examination of water and waste water describe by Osayande *et al.,* (2015).

RESULT AND DISCUSSION

The results of the physico-chemical properties of the soil from hospital dumpsite in Oghara, along with the control are presented in Table 2. Soil pH is the most widely accepted parameter which exerts a controlling influence on the availability of micro-nutrients and heavy metals in the soil to plants (Igwe *et al.*, 2005). The pH of the soils from the hospital dump site ranged 4.26-5.48, this was higher than the value reported by Ukpong *et al.,* (2015), who reported a pH of 8.9. The pH of the Hospital dumpsite was acidic (Table 2) which may be as a result of the nature of waste such as infectious waste (suspected to harbour pathogens), pathogical waste (human tissues or fluid), sharps (neddles and scalpels), pharmaceutical waste (drugs which are no longer needed or expired), genotoxic waste (substances with genotoxic properties e.g cancer drugs), chemical waste (laboratory reagents), waste with high content of heavy metals (broken thermometers and blood pressure gauges), pressurized containers (gas cylinders/aerosol canisters) and radioactive waste such as unused liquids from radiotherapy (Park, 2002). The pH of the dump site was found to be more acidic than that obtained from the control soils which has 6.55 and 6.65 for top soil (0-15 cm) and sub soil (sub soil). The acidity of the soil in the studied site decreased with depth. This acidic top soil may be as a result of the presence of this hospital waste in the top soil which gradually leaches down the soil due to the sandy nature of the soil. Soil electrical conductivity (EC) is a measure of the amount of salts in soil (salinity of soil) Anegbe *et al*., 2017. Electrical conductivity values ranged from 29-197 μscm^{-1} for hospital dump sites. The EC values for the hospital dump sites were found to decrease from top soil to sub soil. However the sub soil value was higher in the control site and the value was very low when compared to the hospital dump sites (Table 2). This could be as a result of the waste (needles, scalpels, broken thermometers and blood pressure gauges) present on the top soils which contributed to high EC values. Similar range of values has been reported by (Badejo *et al*., 2013; Oguntimehin and Ipinmoroti, 2007). However these values are higher than the values reported by (Achi *et al*., 2011; Akpoveta *et al*., 2010; Akan *et al*., 2013). The high conductivity may also be attributed to the availability of a high amount of metal substances, in the dump sites whose content

148 are eventually leached into the underlying soils and hence led to an increase in the concentration of
149 some ions such as sodium, calcium, aluminum and hydrogen in the soils. Electrical conductivity is
150 an important indicator of soil health. It affects crop yields, crop suitability, plant nutrient availability,
151 and activity of soil microorganisms which influence key soil processes including the emission of
152 greenhouse gases such as nitrogen oxides, methane, and carbon dioxide. Excess salts hinder plant
153 growth by affecting the soil-water balance (Anegbe *et al*., 2017). For certain non-saline soils,
154 determining EC can be a convenient and economical way to estimate the amount of nitrogen (N)
155 available for plant growth (Hazelton and Murphy, 2007). According to Hazelton and Murphy (2007),
156 the soil CEC is a measure of the negative site of the soil colloid in which the positive charge cation
157 act on. The cation exchange capacity (CEC) is a direct contribution from the clay and organic matter
158 contents of soil. Soil CEC is also known as a good indicator for evaluating soil fertility. The cation
159 exchange capacity (CEC) is the number of moles of positive charge adsorbed per unit mass. In this
160 study, the CEC values were low with a range of 11.58-25.10 meq/100g (Table 2). The low values
161 were attributed to high sandy nature of the soil, a soil low in CEC content but high in sand is
162 susceptible to high leaching because the retention power of heavy metals in its soil is low (Anegbe
163 and Okuo, 2013; Anegbe *et al*., 2014). The CEC was very high in the hospital dump site soils
164 compared with the control (4.61-5.46 meq/100g). This is logical following the high organic matter
165 content determined in the impacted area which resulted in increased exchange sites for the base
166 metals (K, Na, Ca, Mg). This is as a result of high organic matter content such as pathological waste
167 (human tissues or fluids) present in the hospital dumpsite, the interaction between the organic and
168 these base metals prevent them from leaching, hence higher value when compared to control which
169 has low organic matter content. The

170 **Table2: Physico-chemical Properties of the Examined Soils in the Hospital Dumpsite along with the Control**

SITES	Location	Depth (cm)	pH	EC (µs/cm)	Ca (meq/100g)	Mg (meq/100g)	Na (meq/100g)	K (meq/100g)	CEC (meq/100g)	N (%)	O.M (%)	O.C (%)	SO_4^{2-}(meq/100g)	PO_4^{3-}(meq/100g)	Clay(%)	Silt(%)	Sand (%)
Hospital	Location	0-15	4.55	60	13.23	3.80	1.43	2.51	20.97	0.23	4.15	2.40	27.51	41.60	15.21	2.99	81.80
Dumpsite	one	15-30	4.65	29	14.92	4.19	2.28	3.16	24.55	0.49	9.18	5.31	29.53	23.75	16.26	2.67	81.07
	Location	0-15	4.26	101	8.66	0.81	0.91	1.20	11.58	0.21	3.77	2.18	24.28	54.29	13.60	2.26	84.13
	two	15-30	5.40	45	10.58	0.81	0.99	1.32	13.70	0.30	5.36	3.10	17.77	50.88	14.50	2.15	83.35
	Location	0-15	5.48	197	13.62	3.89	2.33	2.86	22.70	0.42	7.52	4.35	5.66	5.10	16.72	2.21	81.07
	three	15-30	5.45	166	15.10	4.86	2.21	2.93	25.10	0.48	8.96	5.18	16.79	5.07	17.62	2.52	79.86
Control	Control	0-15	6.55	7.00	1.76	1.62	0.89	0.34	4.61	0.09	0.78	0.45	16.99	8.82	8.18	2.35	89.47
site	Location	15-30	6.65	17.00	3.17	0.64	1.10	0.54	5.46	0.05	0.50	0.29	17.19	8.74	13.15	4.41	82.44

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Nitrogen content, organic matter, organic carbon content, sulphate and phosphates content ranged from 0.21-0.49 %, 3.77-9.18 %, 2.18-5.31 %, 5.66-29.53 mg/kg and 5.07-54.29 mg/kg respectively for hospital dump sites. These values were low when compared to control site and also lower than the values reported by Eneje *et al*., (2012). The presence of organic carbons indicates some microbial activities in the dumpsite soil. In addition the organic carbon, nitrogen, phosphorus, EC, sulphate level were found to have direct relationship with pH, and these parameters decrease as the pH decreases, and this is in agreement with Anegbe and Okuo (2013); Anegbe *et al*., (2016). From the textural analysis, the Hospital site and control soils have low clay and silt content and a high sand fraction (79.86-89.47 %). The silt and clay fractions ranged from 2.15-4.41 and 8.18-17.62 % respectively. In general, all soil examined contained less than 23 % clay. The soil texture plays an important role in mobility of metals in soil Anegbe *et al*., (2017). Texture reflects the particle size distribution of the soil and thus the content of fine particles like oxides and clay. These compounds are important adsorption media for heavy metals in soils. The clay soil retains high amount of metals when compared to sandy soil. Thus it is predictable that the dump site soil and the control site under investigation are susceptible to leaching. These results indicate that hospital waste had a significant effect on all the soil properties. Generally, the hospital waste increased the values for soil pH, CEC, EC, organic matter and total nitrogen when compared to control (uncontaminated soil). This is attributable to the decomposition and mineralization of the biodegradable solid wastes in the site leading to the release of minerals as well as basic cations into the soil which caused increases in soil physicochemical properties (Eneje *et al*., (2012).

Table 3: Heavy Metals of the Examined Soils in the Hospital Dump Site along with the Control.

Site	Location	Depth(cm)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
Hospitals	Location 1	(0-15)	4379.6	267.7	107	52.33	2.4	18.57
		(15-30)	6569.4	117.7	139.92	58.14	1.5	15
	Location 2	(0-15)	3457.88	153.1	61.73	29.07	2.25	11.43
		(15-30)	3328.5	153.1	49.38	11.63	1.5	11.43
	Location 3	(0-15)	5824.9	160.0	205.76	87.21	5.45	12.56
		(15-30)	5386.91	135.0	189.45	56.28	2.5	10.29
Control	Location	(0-15)	771	10.2	8.23	11.63	0	1
		(15-30)	759	9.5	7.58	11.63	0	1.04

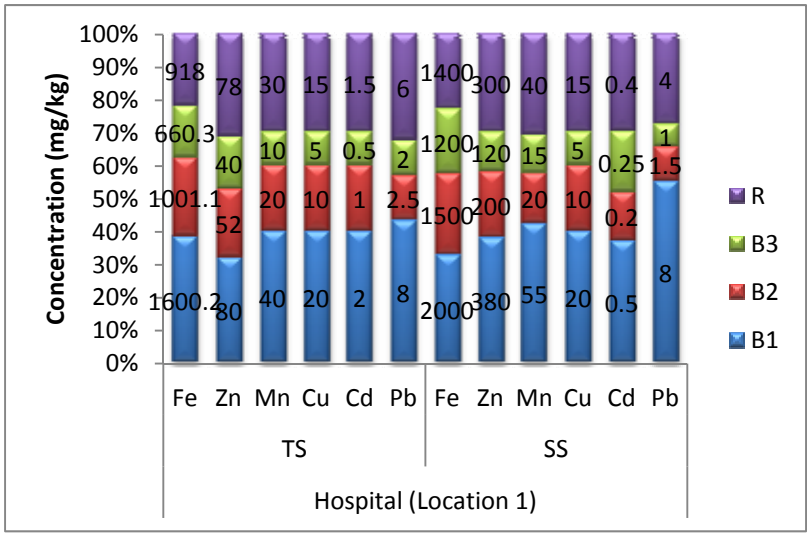
The results of heavy metals in the hospital dumpsite are presented in Table 3. The results showed that the heavy metals were generally higher in the top soils (0-15) cm than the sub soils (15-30) cm. This is probably because the top soil is the point of contact. Previous studies have shown that surface soils are better indicators of metallic burdens (Amusan *et al*., 2005; Stephen, 2013). The heavy metals from the hospital dumpsite were significantly higher than the levels observed in the control sites. Umoh and Etim (2013) reported that the concentration of metals in soils at the decomposed biodegradable waste dumpsite and 100 m away (control site) from dumpsite indicated that there is a relative increase in the concentration of heavy metal at dumpsites compared to those in soils at 100 m away (control site) from the dumpsite. This is in agreement with the present study. This could be attributed to the availability of metals containing wastes at dumpsite (especially hospital dump site) which eventually leached into the underlying soils. The metals considered in this study include the metals which are micro-nutrient such as iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) and the non-essential/toxic heavy metal such as cadmium (Cd) and lead (Pb) which are toxic to plant when present in the soil at concentrations above tolerance level. From the results obtained, the concentration of lead at dumpsite ranged from 10.29-18.57 mg/kg for hospital dump site (Table 3) and the control site has 1.00 mg/kg for

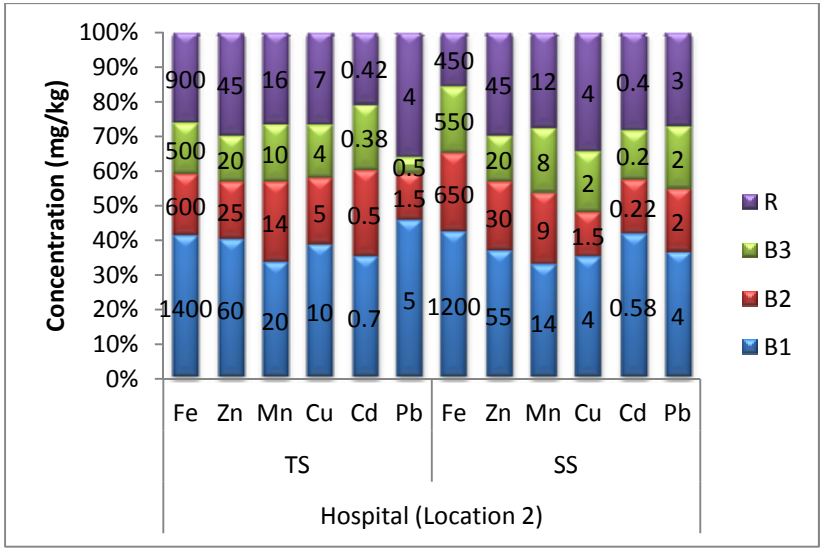
TS and 1.04 mg/kg for SS. The values recorded in this study was far below the 143.80 mg/kg reported by Adama, *et al.*, (2016), in soils around a hospital waste incinerator bottom ash dumps site**.** Since lead is a cumulative pollutant, the pollution of soil by lead remains a very serious problem that should be given much attention by environmental chemists in collaboration with government agencies. Also, effort should be made to educate the public on the health effects of this metal when ingested in excess. Such effects which include damage of the brain, kidney, miscarriage in pregnant women and damage of sperm production organ in male (Sabine and Wendy, 2009). From this study, iron concentration in the hospital dumpsite varied between 3328.5-6569.4 mg/kg (Table 3). Those were far above the value reported by Ebong *et al*., (2008). The control soil has a concentration of 771 mg/kg for TS and 759 mg/kg for SS (Table 3). Studies carried out by Udeme, (2001) revealed results that are comparable to the one obtained in this study. Eddy *et al.,* (2006), suggested that any pollution of the environment by iron cannot be conclusively linked to waste materials alone but other natural sources of iron must be taken into consideration. Despite the fact that iron is a micro nutrient, it should be properly monitored to maintain its concentration in the accepted range to avoid health defect caused by the deficiency or excess amount of it. The cadmium level at the hospital dumpsite (Table 3) varied between 1.50-5.45 mg/kg. The level of Cd was below detection limit in the control site. The levels of Cd recorded in the hospital dumpsite are particularly worrisome since Cd has no any nutritional value. Cadmium was listed by EPA (1991) as one of the 129 priority pollutants and among the 25 hazardous substances. Ingestion of high level of cadmium severely irritates the stomach leading to vomiting and diarrhoea. The level of cadmium in this study when compared to the mean value of 7.54 mg/kg reported by Adama, *et al*., (2016) was low. The concentration of zinc in soils was obtained to range from 117.70-267.70 mg/kg for hospital dumpsite. These values were found to be higher than 69.11 mg/kg reported by Auta and Morenikeji, (2013). Odukoya, *et al.,* (2000), obtained a range of 100.80 to 226.00 mg/kg, which is in agreement with the values obtained in the hospital dumpsite in Oghara town. The intervention value for copper in soil is 190 mg/kg (DPR 1991), whereas the concentration range between 11.63-87.21 mg/kg for hospital dumpsite. Both the dumpsite and control site concentration of copper within the study area falls below the DPR intervention value. World Health Organization (1984) stated that, the injection of copper can lead to severe muscular irritation, nausea, vomiting, diarrhea, intestinal cramps, severe gastrointestinal irritation, and other dangerous health defects. Mn in this study

has a range of 49.38-205.76 mg/kg for hospital dump site. The control has a value of 7.58 and 8.23 mg/kg for top soil and sub soil (Table 3). In general the TS has higher concentration of these metals than the SS, however the concentration of Fe and Cu in location 1 of hospital dumpsite was found to be higher in sub soil than top soil. This could be attributed to the evidence from molecular spectroscopy that heavy metals form strong bonds with specific functional groups of humic substances (HSs) from the organic matter contaminants (OCs), carboxylate ($-COO^-$), phenolic and sulphur-hydryl (-SH) functional groups (Zhao *et al*., 2013; Erdogan, *et al.*, 2007). These may also be as a result of heavy metal-ligand complex formation and competition to destabilize it and forming of new complexes with the heavy metal cation (Sposito, 1994). In general it was observed from this study that all the heavy metals have higher concentrations in the dump site compare to control (Table 3).

Fractionation of Heavy Metals in the Hospital Dumpsite

The sequential extraction scheme is a very useful tool in assessing the mobility and bioavailability of the heavy metals in soils. The distribution of heavy metals in the samples allows us to predict their mobility, bioavailability and toxicity (Anegbe *et al*., 2017). Fractionation of total metal contents may give indications of the origin of the metals. High levels in the exchangeable, acid soluble and reducible may indicate pollution from anthropogenic origin and even high contents in the resistant fractions except the residual fraction may be significant in the long term (Anegbe *et al*., 2017).





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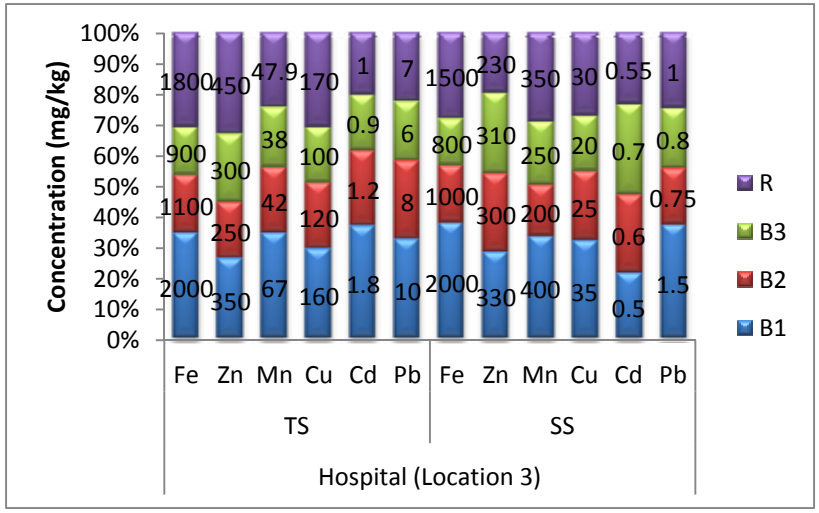

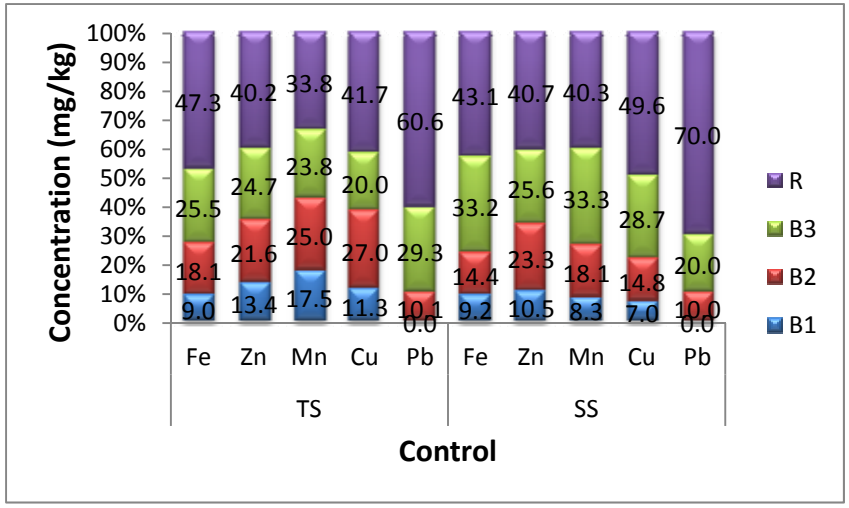

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275 **Figure 3: Fractionation and Distribution of Metals**

The fractionation results reveal that metals in the control site were mainly in the residual fraction, with a range of 33.75-70.00 mg/kg (Fig. 3). Association of these metals in the residual fraction does not generally constitute an environmental risk. This is due to the stable nature of the compound and the fact that the metals are bonded firmly within a mineral lattice that restricts the availability of this metal (Abu-Kukati, 2001; Anegbe *et al*., 2017). Pb, was not fond in fraction B1 (labile fraction), which means it will not be available for plant uptake at the control site. The B1 fraction of all the metals had high concentrations (Fig. 3) with a range of 31-58 %, 33-45 % and 28-40 % for location 1, 2 and 3 respectively. The high concentration of theses metals in these fraction when compare to the control site (0.00-9.04 mg/kg) pose serious environmental problem to the underground water (Anegbe *et al*., 2014a). Also the high concentrations indicate that the metal is of anthropogenic origin and readily available for plant uptake. The concentration in the residual fractions in the three locations ranged 20.40-36.36 %. The residual fraction is considered the most stable, less reactive and less bioavailable since it is occluded within the crystal lattice layer of silicates and well crystallized oxide minerals (Abeh *et al*., 2007; Anegbe, 2016). The fraction can be taken as a guide to the degree of pollution of the soil. The smaller the percentages of the metal present in this fraction, the greater the pollution of the area (Horsfall and Spiff, 2005). Fraction B2 and B3 could be considered relatively stable, slowly mobile and poorly available but could change with variations in redox conditions. It may become more soluble under reducing conditions and less so under oxidizing ones (Horsfall and Spiff, 2005).

Recovering Factor

The efficiency of the BCR sequential extraction scheme was measured by comparing the total metal concentration obtained with their pseudo total concentrations. This approach furnished percent recoveries, (R_f). Recoveries sequential extractions were within the range of 85-100 % of pseudo total metal concentrations of Mn, Cu, Fe, Cd, Pb and Zn respectively, suggesting that both methods extracted similar concentrations of heavy metals from the soil. These result are similar to other studies were the sum of fractions were within ±15 and ±13 (Wuana and Okieimen, 2011) and (Anegbe *et al.*, 2017) of the total metal concentrations by hot acid digestions. These results indicate good agreement with the BCR chemical fractionation and HNO_3-HCl extraction method. The cumulative error in the sequential extraction procedure was reasonably low. Loss of solid material in the decanted supernatant, efficiency of individual

extractants, sampling and analytical variability may have contributed to the differences between metal concentrations by sum of fractions and pseudo total metal concentration.

Table 4 Recovering Factor for Metals (%)

	Location	Depth(cm)	Fe	Zn	Mn	Cu	Cd	Pb
	Location 1	0-15	95.43	93.39	93.46	95.55	92.59	99.62
Hospital		15-30	92.85	98.26	92.91	86.00	90.00	96.67
Dumpsie	Location 2	0-15	98.27	97.98	93.46	89.44	88.89	96.24
		15-30	85.62	97.98	97.20	98.88	93.33	96.24
	Location 3	0-15	99.57	98.40	94.72	93.66	89.91	94.34
		15-30	98.39	98.78	97.53	94.60	94.00	94.41
Control		0-15	96.08	95.10	97.21	98.88	00.00	99.00
Site		15-30	91.30	90.53	94.99	98.90	00.00	96.15

Mobility Factor

Since fraction B_1 represents the first three fractions in the modified Tessier *et al.,* (1979). sequential extraction viz: water-acid soluble, exchangeable, and carbonate bound (Anegbe *et al*., 2017), the relative index of metal mobility called mobility factor, M_f a measure of the potential mobility (Kabala and Singh, 2001); was calculated from the BCR sequential extraction data using the expression:

$$M_f = \left(\frac{B1}{B1+B2+B3+R}\right) \times 100 \qquad (1)$$

The M_f for the metals in different locations did not follow a particular pattern with respect to increasing depth (Table 5). The mobility factors in all the sites were high. High M_f indicates that they originate from anthropogenic sources and interpret the relative high lability and biological availability of the heavy metal in soil (Kabala and Singh 2001; Okuo *et al*., 2016).

Table 5. Mobility Factor (M_f) of Metals in the Hospital Dumpsite and Control site

Hospital Dumpsite		Depth(cm)	Fe(%)	Zn(%)	Mn(%)	Cu(%)	Cd(%)	Pb(%)
	Location 1	0-15	38.29	32.00	40.00	40.00	40.00	43.24
		15-30	32.79	38.00	42.31	40.00	37.04	55.17
	Location 2	0-15	41.18	40.00	33.33	38.46	35.00	45.45
		15-30	42.11	36.67	32.56	34.78	41.43	36.36
	Location 3	0-15	34.48	25.93	34.38	29.09	36.73	32.26
		15-30	37.74	28.21	33.33	31.82	21.28	37.04
	Control	0-15	9.04	13.40	17.50	11.30	00.00	0.00
		15-30	9.23	10.47	8.33	6.96	00.00	0.00

Physico-chemical Analysis of Leachate Samples

The leachate generated at bottom of the dumpsite carries numerous contaminants to the soil surface and to adjacent areas. During percolation of leachate through the soil, leachate undergoes various processes such as physicochemical decomposition process, ion exchange reactions, chemical alterations, oxidation, hydrolysis etc. These reactions alter the soil original properties.

Table 6. Physico-chemical Properties of Leachate obtained from the Hospital Dumpsite along with EPA and FEPA Standard

S/N	Parameters(mg/l)	Leachate from Hospital waste	EPA Standard(2009)	FEPA Standard(1991)
1	P^H	5.2	6.00-8.50	6.00-9.00
2	TDS	32	500	2000
3	TSS	3700	NS	NS
4	DO	1.40	6.00-8.00	5.00
5	BOD	84	4.00	50
6	COD	214	250	80
7	Ca^+	62.20	75	200
8	Mg^+	28.00	30	20

The pH value for the leachate from the hospital dumpsite was 5.2. The FEPA (1991) and EPA (2009) recommended values for pH in water are 6-9 and 6-8.5, respectively. The acidity of the entire sample in hospital dumpsite was below EPA standard and this observed result could be as a result of moderate amount of acidic carbonate ($H_2CO_3^-$and HCO_3^-) containing minerals being washed into the soil. The total dissolved solids (TDS) and total suspended solids (TSS) was in the range of 32 and 3700 mg/l respectively. The low level of TDS could be attributed to the fact that low amount of soluble anions and cations were present in the samples (APHA, 1992). The BOD and COD of hospital waste dumpsite were in the range of 84 mg/l and 214 mg/l respectively. High values of chemical oxygen demand (COD) and biochemical oxygen demand (BOD) was an indication of polluted water and signifies the presence of organic, inorganic and oxygen demanding pollutants in the samples. The COD values of the hospital waste dumpsite sample was within the standards and this could be due to the presence of low quantity of oxygen demanding pollutants (Amadi *et a*l., 2006, Akan *et al*., 2008) or because the usage of oxygen by the organisms during decomposition in the sample is balanced. The dissolved oxygen (DO) level of all the samples were not within the FEPA and EPA standards and this shows that the samples have low DO that could not support the activities of the aquatic organisms in the environment (APHA, 1992). The BOD levels in the sample were higher than EPA and FEPA standard. The high level of BOD could be attributed to high level of organic pollutant in the sample and it implies that the sample is polluted. This could be possibly because of low concentration of causing matter such as decaying plants or animal (Axel, 2010). Possible sources of magnesium in the sample sources are due to deposits of magnesite, dolomite among other salts in the area. These salts can be washed or leached from the soil and subsequently ends up in water (Housecroft and Sharpe, 2008). The Mg level in the hospital waste dumpsite is 28 mg/l. Calcium is 62.20 mg/l. Low concentration of calcium in the samples could be attributed to low present of calcium chloride and magnesium chloride in the soil. It could also be attributed to low accumulation of bones of dead animals in the source samples. Up to 75 mg/L of calcium was recommended by EPA probably because calcium is a major mineral used in mineralization of bones and shells (Tordoff, 2011).

CONCLUSION

The results showed elevated levels of the metals under investigation. The soil from the three locations has significant percentage of extractable metals associated with the non-residual

fractions. This indicates that these metals could potentially be remobilized into the soil solutions and then be leached down the soil profiles for further transportation to other environmental compartments, particular ground and surface water environments. The relatively high mobility factor of most of the metals confirms the high liability and biological availability of these metals in some of the studied sites.

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