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SEASONAL VARIATIONS IN PHYSICO–CHEMICAL CHARACTERISTICS OF SOIL AND GROUNDWATER AROUND SELECTED DUMP SITES IN ABA, SOUTHEASTERN, NIGERIA

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ABSTRACT

This study assessed the physical and chemical status of ground water and soil around selected open dumpsites in Aba, Abia State, Nigeria in rainy and dry seasons. The study sampled waste dump around residential areas of Emelogu, Enyimba and Ndiegoro all in the city of Aba. Soil and groundwater samples were collected in September and March for the rainy and dry seasons respectively. One other location at least 10 km away from a dumpsite within the study area was also sampled and considered as control. Soil samples were collected randomly at three different parts of each of the dumpsites at three depths of 0 – 15 cm, 15 – 30 cm and 30 – 45 cm. Control soil samples were also collected in the same way. The soil samples were collected using the soil auger. Data from the laboratory were analyzed using Analysis of Variance (ANOVA). The result of the physico-chemical analysis in soil showed a pH range of 5.87 to 6.75 in the wet season while in the dry season ranged from 6.00 to 6.95. The highest concentration of sulphate, nitrate, and phosphate in the wet and dry seasons were 298/445 mg/kg, 1551/1577 mg/kg and 320/338 mg/kg respectively. The water samples in the dry season were acidic at record low of 3.66. Sulphate levels in water samples recorded a peak level of 5.96 mg/kg and 5.0 mg/kg for wet and dry seasons in the Emelogu site. Phosphate levels in water samples recorded a peak level of 6.08 mg/kg and 1.65 mg/kg for wet and dry seasons in the Enyimba and Emelogu sites. In the soil samples, the concentration of lead at the three dumpsites (1.004 – 2.11mg/l) differed significantly from the control (0.104 – 0.197mg/l) in both the wet and dry seasons. In the water the concentration of lead around the three dumpsites (0.001 – 0.04 mg/l) differed significantly from the control (0.001 mg/l) in both the wet and dry seasons. The findings of the study revealed that the physico – chemical analyses showed elevated values of most of the parameters analysed in soil and groundwater in the vicinity of the dumpsites compared with the control. Government should involve industries in the management of waste by making them responsible for the wastes generated from their products.

KEYWORDS: *Water, Soil, Physico-chemical, Metals, Waste, Aba, Nigeria*

INTRODUCTION

In most cities of developing nations management of municipal waste has resulted to creation of several open dump sites with little or no control (Singh and Chandel, 2020). Greedy (2016) stated that unavailability of adequate finance and technology are in the forefront of increasing numbers of open waste dumps. This has been effectively linked to increase in population and growing urbanization around the city areas.

Abul (2010) states that solid waste is classified based on where it comes from. For example, municipal waste refers to residential waste, hazardous waste refers to industrial waste, and infectious waste refers to medical waste. However, there are environmental issues with the ways that these wastes are handled, stored, collected, and disposed of (open dumpsites) (Otabor *et al*., 2018). Open dump sites are frequently used by municipalities as a primary location for disposing of waste (Jhamnani and Singh, 2009; Longe and Balogun, 2010). These occur only in the vicinity of municipalities and are located where land is available, with little regard for public safety or the environment (Sabohi and Abdul, 2009; Adefemi and Awokunmi, 2010).

In a recent statement, Alao (2023) stated that a comprehensive approach to environmental security is necessary due to ongoing careless waste disposal, disruptive human behaviour toward environmental management, and environmental policies. In the views of Osujieke *et al*. (2018), the field of sustainable land-use practices is expanding quickly intending to achieve environmental health, food security, nutrition security, and biosafety. The physical and chemical qualities of soil deteriorate as a result of poor land-use practices. A sustainable use of soil resources requires careful consideration of the qualities of the soil.

Ulakpa *et al*. (2021) established that the physicochemical properties of soils from dumpsites varies significantly from those of non-dump site soils in Nigeria. they established that higher values of hydrogen ion (pH), electrical conductivity (EC), organic carbon (OC), organic matter (OM), Available Phosphorus, organic nitrogen (ON), basic cations and cation exchange capacity (CEC) were observed in soil around dumpsites. Recent findings have strongly attributed open dumpsites as major sources of water and environmental pollution (Divya *et al*., 2020; Laskar *et al*., 2022).

According to reports, Nigeria is among the 50 world's biggest active dumpsites from 30 countries given the fact that Nigeria alone keeps 12 % of the 50 world's biggest active dumpsites (UNEP, 2015). With the adverse effects of dumpsites on human health and the environment, urgent attention is required to prevent the prevailing indiscriminate wastes disposal in developing nations because the situation has reached a critical point (Vaccari *et al*., 2019; Parvin and Tareq, 2021). This study is aimed at assessing the physical and chemical status of ground water and soil around selected open dumpsites in Aba, Abia State, Nigeria.

MATERIALS AND METHODS

Study Area

The study was conducted in Aba, Abia State. Aba is made up of Aba North and Aba South Local Government Areas. Aba is located between latitude 05º 07′N and longitude 07º 22′E (map of study area, Figure 1). It covers an area of 901 km^2 (348 sq mi) and stands on an elevation of 205 m (673 ft) (Aba, Nigeria

2024). It is bordered in the North by Osisioma Local Government Area, in the West by Ugwunagbo and finally in the East by Obioma Ngwa Local Government Area of Abia State. According to the National Population Commission Census of 2006, Aba had the population of 833,590.

The Dumpsites considered for this study were Emelogu dumpsite in Aba North, located at 05º 06.200′N and 007º 23.629′E, Ndiegoro dumpsite located in Aba South at 05º 05.784′N and 007º 23.391′E and the Enyimba dumpsite located in Aba South at 05º 06.850′N and 007º 19.692′E. The Emelogu and Ndiegoro areas are residential areas inhabited by low, middle- and high-income earners and the dumpsites sampled receive mostly household wastes from these areas. However, the Emelogu dumpsite (Plates 1, 2 and 3) is also accessed and used by contracted waste management agents. The Ndiegoro dumpsite (Plate 2) is located adjacent to Aba River which flowed through the city.

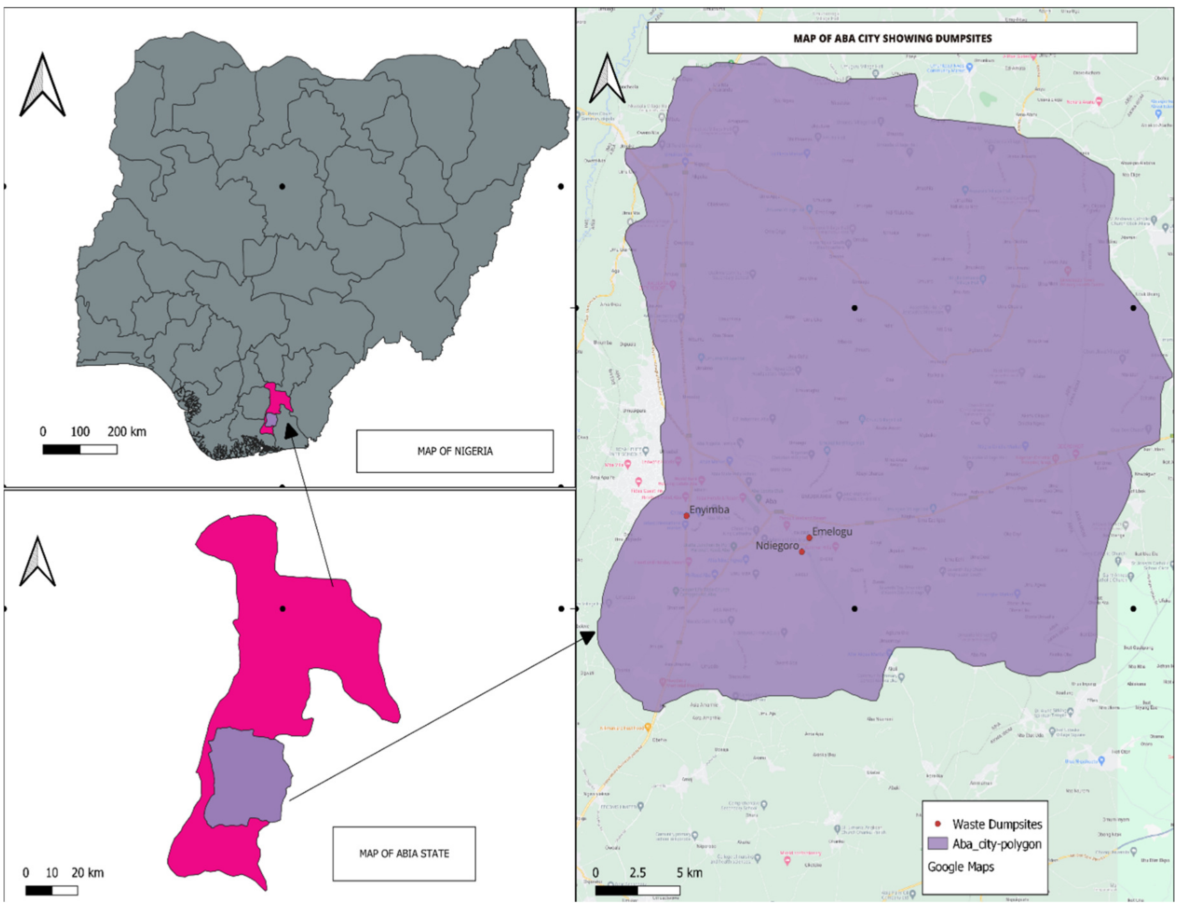

Fig. 1: Map showing the waste dump location site for this study

Sample Collection

Soil and groundwater samples were collected in September and March for the rainy and dry seasons respectively from Emelogu, Ndiegoro and Enyimba dumpsites were areas. One other location at least 10 km away from a dumpsite within the study area was also sampled and considered as control. Soil samples were collected randomly at three (3) different parts of each of the dumpsites at three (3) depths of 0 – 15 cm, 15 – 30 cm and 30 – 45 cm using the soil augre. Control soil samples were also collected in the same way.

Groundwater samples were collected from three different boreholes around each of the dumpsites using pre-cleaned bottles and the control water samples were collected from the areas where the control soil samples were taken. The samples were collected in the early hours of the day and taken to the laboratory within 24 hours. The Locations of the dumpsites and boreholes were determined using the GPS (Global Positioning System).

Sample Analyses

The analyses were done in two parts for the soil and water samples. The first part was analyses of some non-metal physico – chemical parameters and the second part was the heavy metal analyses using Atomic, Absorption Spectrophotometer (AAS).

Table 1: Summary of methods for non-metal physico – chemical analyses

Physico – chemical parameter	Method
pH	Hannah pH meter
Electrical Conductivity	Hannah conductivity meter
Phosphate	Spectrophotometry at 700nm wavelength
Sulphate	Spectrophotometry at 470nm wavelength
Nitrate	Spectrophotometry at 410nm wavelength
Alkalinity	Titration with 0.02N HCl

Data Analyses

Analysis of Variance (ANOVA) was used to analyse data from the laboratory. The design used for the analysis was a three-factor factorial experiment in completely randomized design. The three factors were season, depth and location. The treatment means across the three locations and depths were compared using the Duncan's Multiple Range Test (DMRT) while the means between the two seasons were compared using the Least Significant Difference (LSD).

RESULTS AND DISCUSSION

From table 2, the pH of the three dumpsite soils in the wet and dry seasons showed no significant difference (at 0.05 level of significance) from the pH values of the control at the three depths. The pH values ranged from slightly acidic to near neutral. The near neutral pH could be due to the high organic content (biodegradable wastes) that tend to buffer the soil at the dumpsites.

The Electrical Conductivity values of the three dumpsites were significantly higher than that of the control. There were also significant differences among the three dumpsites with the Enyimba dumpsite (location 3) showing the highest conductivity. This could be due to the activities of shoe/bag manufacturers and welders around the area. Wastes from these activities were also disposed of at the dumpsite. More so burning of wastes at the site may have contributed to the high conductivity observed. Emelogu dumpsite (dumpsite 1) also showed high conductivity. This could be due to its use by contractor waste management agencies who dump wastes packed from different parts of the city at the site. The least conductivity was from the Ndiegoro dumpsite, which was accessed and used by only residents of the area and received mainly household wastes.

During the wet season, there was no significant difference between the sulphate values of dumpsites 1 and 2 and the control at the soil surface. However, at depth 2 and 3, the sulphate values of the dumpsites were significantly higher than that of the control. The observed increase downwards could be because of percolation due to rain. Dumpsite 3 showed significantly higher values than the control at depths 1 and 2. In the dry season, the sulphate values of the dumpsites were significantly higher than that of the control. Nitrate and phosphate analyses showed no significant difference between the dumpsites and the control.

From Table 3, the pH of most of the groundwater samples analysed (6.50 – 6.90) during the wet season, even though lower than the pH of the control (7.03), were within the WHO standard (6.5 – 8.5). However, borehole 6 in location 2 had a lower pH of 6.43 and so is not suitable for drinking.

During the dry season, the pH of all the samples analysed were acidic (3.66 – 4.76) with boreholes at location 2 showing greater acidity (3.66 – 3.78) than boreholes in other locations (4.32 – 4.76). All the ground water samples in the dry season are not suitable for domestic use, especially drinking when compared with WHO recommendations. The effect of acidic waters on human health and the environment have been widely reported. For example, acidic waters have been known to be aggressive and enhance the dissolution of iron and manganese causing unpleasant taste in water (Edwards *et al.*, 1983).

It is important to note that the control borehole also showed an acidic pH (4.76) during the dry season. This suggests that the low pH in the study area may not only be due to dumpsites in the area. There could be other factors affecting the quality of the groundwater in the area. However, the higher acidity shown by boreholes in location 2 could be attributed to the age of the dumpsite in the area which might have had a longer impact on the groundwater in the area.

The near neutral pH observed during the wet season could be due to infiltration and dilution effect of rainwater. The electrical conductivities of water samples were higher than that of the control except for borehole 1 in location 1. Boreholes in location 2 showed very high conductivity (249 – 367 µS/cm) when compared with the control (25µS/cm). Boreholes in location 3 (Enyimba) were next in the level of conductivity (42 - 70µS/cm). the least conductivity was shown by boreholes in location 1. The conductivity of all the boreholes analysed are within WHO recommendations for drinking water. Sulphate, phosphate, nitrate concentrations and alkalinity of groundwater. The sulphate and phosphate results for the boreholes were higher than that of the control but still within WHO recommendations. The nitrate values for boreholes in location 1 (3.73 – 10 .81) and location 3 (5.20 – 10.60) were lower than that of the control (11.3) while the nitrate values for location 2 (18.3 – 32.4) were significantly higher than that of the control. The nitrate values for most of the water samples analysed are above WHO standard (10mg/l) and so are not suitable for drinking. Nitrate, the most highly oxidized form of nitrogen compounds is commonly present in surface and groundwaters because it is the end product of aerobic decomposition of organic nitrogen (Akinbile *et al.,* 2011). Unpolluted natural waters usually contain only minute quantities of nitrate. Values of nitrate higher than the WHO standard show the presence of pollutants in the water samples. The alkalinity results were within WHO recommendations. Generally, these findings are consistent with the soil analysis which suggests that the groundwaters in the study sites are being impacted by the dumpsites, with the oldest dumpsite (location 2) having the highest impact, followed by location 3, and then location 1. All the physico – chemical parameters analysed in the water samples were higher in the wet season than the dry season. This could be due to increased volume of water and run off in the wet season. The wetter a landfill or dumpsite is, the greater the seepage runoff and chemical enrichment of the groundwater resource (Oyeku *et al.,* 2010).

From Table 4, the concentrations of metals in sampled soils indicate evidence of relative increase at the dumpsites. The concentration of lead at the three dumpsites (1.004 – 2.11mg/l) differed significantly from the control (0.104 – 0.197mg/l) in both the wet and dry seasons. The dumpsites showed higher concentrations of the metal. However, there was no significant difference at 0.05 level of significance, among the lead values of the three dumpsites. Lead is non-essential for plants and animals and is toxic by ingestion being a cumulative poison (Amadi *et al.,* 2013). Lead toxicity leads to anaemia both by impairment of haemo-biosynthesis and acceleration of red blood cell destruction. In addition, lead reduces sperm count, damages kidney, liver, blood vessels, nervous system and other tissues in human (Amadi *et al*., 2013).

Iron (72 – 154mg/l) and zinc (7.6 – 12.8mg/l) analyses showed significantly higher values at the vicinity of the dumpsites than the control [Iron (38 – 48.67mg/l) and zinc (1.6 – 4.73mg/l)]. There was also significant difference among the dumpsites with the Ndiegoro dumpsite (location 2) showing the highest value of iron metal. However, for zinc metal, the values compared similarly among dumpsites. Zinc is an essential growth element for plants and animals but can be toxic at elevated concentration. Excessive concentration of zinc in soil leads to phyto-toxicity as it is a weed killer (Amadi *et al.,* 2013).

The values of cadmium at the three dumpsites (0.09 – 1.56mg/l) were significantly higher than that of the control (0.004 – 0.022mg/l). Cadmium at location 2 (1.56mg/l) and location 3 (0.81mg/l) were higher than the target values of the standard (0.8). The observed high cadmium value may be due to age of the dumpsites and on site burning of waste at dumpsite 3 in addition to age. Majolabe *et al*., (2011) confirmed that the burning of waste in dumpsites destroys the organic components, oxidizes metals, thereby enriching the ashes left behind in metal.

Nickel concentrations at the three dumpsites (1.79 – 2.69mg/l) were significantly higher than that of the control (1.21mg/l), but lower than the target values of the DPR standard (35mg/l).

Chromium values of the dumpsites showed no significant difference from that of the control. Chromium is carcinogenic by inhalation and corrosive to tissue (Lin *et al*., 2002). All the heavy metals analysed for in the soil samples were within the target values of DPR except for cadmium which was higher than the target values at the Ndiegoro and Enyimba dumpsites. This is in line with the findings of Amadi *et al.,* (2013) who discovered that the soils around the Enyimba dumpsite were moderately contaminated by cadmium amongst other metals analysed for. Cadmium metal is used as an anticorrosive, electroplated on steel.

Cadmium sulphide and selenide are commonly used as pigments in plastics, batteries and in various electronic components. It is also used with inorganic fertilizers produced from phosphate ores and when these products are no more serviceable, they are thrown into the dump as waste. During decomposition, the cadmium component is leached into the surrounding soil and over time gets accumulated in the soil. Cadmium is extremely toxic and the primary use of soil high in cadmium in form of manure for the cultivation of vegetables and other food crops could cause adverse health effect to consumers such as renal disease and cancer. Moreover, when ingested by humans, cadmium accumulates in the intestine, liver and kidney and chronic exposure to cadmium causes proximal tubular disease and osteocalcin (Amadi *et al.,* 2013). Therefore, the soils from this dumpsite are not suitable for agricultural purposes.

Generally, the concentration of metals in the dumpsites as compared with the control confirms that the dumpsite is a possible source of heavy metal to the soil. The findings further indicate that most of the metals studied are not only localized at the topsoil, but have travelled 30 – 45cm down the soil. This suggests that aquifer contamination is inevitable on the long run if dumping at the sites persists. Furthermore, most of the metals analysed for showed slightly higher values in the dry season than the wet season. Yahaya (2009) confirmed that the concentration of heavy metals in soil is higher in the dry season than in rainy season. More so, it was observed that the levels of contamination at the sites were in line with their ages in the following other, Ndiegoro (location 2), Enyimba (location 3) and Emelogu (location 1). Odukoya *et al.,* (2000) observed that age is one of the factors that affect the level of contamination at a dumpsite.

Table 2: Physico – chemical parameters of dumpsite soil

Parameter	Season	Depth 1 (0 – 15 cm)			Depth 2 (15 – 30 cm)			Depth 3 (30 – 45 cm)			Control			Standards	
		L1	**L2**	**L3**	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**	**0 – 15 cm**	**15 – 30 cm**	**30 – 45 cm**	**Target values**	**Inter-vention values**
pH	WET	5.90	6.0	6.27*	6.10	5.87	6.10	6.53*	5.90	6.20*	6.75	6.78	5.86	NA	NA
	DRY	6.66*	6.77*	6.55*	6.39*	6.64*	6.95*	6.86*	6.93*	6.05					
Conductivity(µS/cm)	WET	891*	502*	2402*	1701*	453	2325*	1103*	487*	2795*	136	184.33	151.67	NA	NA
	DRY	852*	491*	2348*	1575*	428	2178*	1033*	433*	2594*					
Sulphate(mg/kg)	WET	159*	99	342*	391*	132*	298*	602*	102*	104*	156.67	101	129.10	NA	NA
	DRY	168*	119*	366*	445*	156*	306*	615*	116*	106					
Nitrate(mg/kg)	WET	692*	684*	689*	699*	617*	1506*	1551*	678*	523	728.33	718.33	96.42	NA	NA
	DRY	700*	707*	700*	714*	647*	1577*	1587*	707*	560					
Phosphate(mg/kg)	WET	273*	299*	237	280*	264*	242*	282*	299*	320*	300	302.33	22.11	NA	NA
	DRY	281*	319*	249	288*	275*	263*	294*	319*	338*					

L1 – Emelogu dumpsite, L2 – Ndiegoro, dumpsite and L3 – Enyimba dumpsite.
All values are mean values of three replicates.
The means identified with * differed significantly from others according to the results of the Duncan's Multiple Range Test.
$LSD_{0.05}$ values: pH = 0.49, Sulphate = 4.35, Nitrate = 5.77, Phosphate = 4.69. The wet and dry season mean values differ significantly if the difference between the means of the two seasons at a particular depth and location is greater than the LSD value.
LSD →Least Significant Difference.
NA – Not available.

Table 3: Physico – chemical parameters of sampled borehole water

Parameter	Season	Location 1 (Emelogu)			Location 2 (Ndiegoro)			Location 3 (Enyimba)			Control	WHO standard
		B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**		
Distance of B from Dumpsite(m)		206.27	292.14	237.56	37.15	84.77	314.49	259.39	170.99	197.20	9741.70	
pH	WET	6.57	6.57	6.9	6.53	6.53	6.43	6.57	6.63	6.50	7.03	6.5 - 8.5
	DRY	4.9	4.37	4.55	3.71	3.78	3.66	4.32	4.39	4.76	4.55	
Conductivity(µS/cm)	WET	32.33	65.67	38	379	273	398	83	61	54		1500
	DRY	22.33	58	28	367	262	249	70	51	42	25	
Sulphate(mg/l)	WET	5.96	0.03	0.14	0.09	0.06	0.06	0.06	0.03	0.07		100
	DRY	5.0	0.02	0.01	0.06	0.04	0.05	0.04	0.01	0.04	0.02	
Nitrate(mg/l)	WET	3.73	10.81	4.70	32.4	18.3	22.70	7.30	10.60	5.20		10
	DRY	3.30	9.7	3.50	27.7	16.4	19.40	6.20	8.70	4.0	11.3	
Phosphate(mg/l)	WET	6.08	5.40	3.90	3.54	3.99	5.26	5.71	6.53	6.54		250
	DRY	1.65	1.66	0.58	2.5	2.5	1.18	0.62	0.24	0.49	1.2	

All figures are mean values of three replicates.
B= Borehole. B1, B2 and B3 (location one), B4, B5 and B6 (location two), B7, B8 and B9 (location three).

Table 4: Heavy metal profiles in dumpsite soils

Parameter	Season	Depth 1 (0 – 15 cm)			Depth 2 (15 – 30 cm)			Depth 3 (30 – 45cm)			Control			Standard	
		L1	L2	L3	L1	L2	L3	L1	L2	L3	0 – 15 cm	15 – 30 cm	30 – 45 cm	Target values	Inter-vention values
Lead(mg/kg)	WET	1.63*	2.00*	1.78*	1.14	1.65*	1.74*	1.05	1.004	1.62*				85	530
	DRY	1.05*	2.11*	0.61*	0.05	0.13	1.34*	0.10	0.07	0.84*	0.197	0.004	0.104		
Iron(mg/kg)	WET	95*	140*	90*	96*	115*	72	84*	77*	73					NA
	DRY	106*	154*	95*	110*	126*	76	86*	78	81*	38	43.33	48.67		
Cadmium(mg/kg)	WET	0.62*	1.56*	0.81*	0.49*	0.44*	0.61*	0.42*	0.45*	0.30				0.8	12
	DRY	0.09	0.52*	0.36*	0.22*	0.33*	0.30*	0.14	0.28*	0.46*	0.004	0.022	0.01		
Nickel(mg/kg)	WET	1.99*	2.43*	2.27*	1.56*	1.62*	1.36*	0.23	0.81*	0.62*				35	210
	DRY	2.69*	1.79*	2.45*	1.41*	1.86*	2.60*	0.01	2.50*	1.42*	0.92	1.08	1.21		
Chromium(mg/kg)	WET	0.07*	0.07*	0.06*	0.032*	0.03*	0.06*	0.005	0.02*	0.02*				100	380
	DRY	0.006	0.05*	0.03*	0.003	0.01	0.01	0.001	0.01	0.05*	0.002	0.001	0.003		
Zinc(mg/kg)	WET	10.66*	10.76*	9.46*	9.76*	10.09*	9.58*	6.69	10.75*	10.81*				140	720
	DRY	11.20*	12.8*	7.6	10.80*	9.7*	12.20*	10.90*	10.80*	12.70*	4.73	4.43	1.6		

L1 – Emelogu dumpsite, L2 – Ndiegoro, dumpsite and L3– Enyimba dumpsite.
All values are mean values of three replicates.
The means identified with * differed significantly from others according to the results of the Duncan’s Multiple Range Test.
$LSD_{0.05}$ values: Lead = 0.56, Iron = 4.239, Cadmium = 0.59, Chromium = 0.025, Zinc = 1.54. The wet and dry season mean values differ significantly if the difference between the means of the two seasons at a particular depth and location is greater than the LSD value.
LSD →Least Significant Difference.

Table 5: Heavy metal concentrations in groundwater

Parameter	Season	Location 1(Emelogu)			Location 2(Ndiegoro)			Location 3(Enyimba)			Control	WHO standard
		B1	B2	B3	B4	B5	B6	B7	B8	B9		
Distance of B from dumpsite		206.27	292.14	237.56	37.15	84.77	314.49	259.39	170.99	197.20	9741.70	-
Lead(mg/l)	WET	0.03	0.03	0.03	0.04	0.034	0.03	0.04	0.03	0.03	0.001	0.01
	DRY	0.001	0.08	0.3	0.001	0.002	0.05	0.002	0.001	0.004		
Iron(mg/l)	WET	0.005	0.002	0.11	0.002	0.09	0.002	0.003	0.20	0.23	0.002	0.3
	DRY	0.008	0.002	0.15	0.004	0.12	0.003	0.006	0.18	0.31		
Cadmium(mg/l)	WET	0.002	0.002	0.01	0.01	0.005	0.01	0.003	0.003	0.003	0.003	0.003
	DRY	0.00	0.00	0.001	0.00	0.004	0.00	0.002	0.001	0.005		
Nickel(mg/l)	WET	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	DRY	0.00	0.00	0.002	0.00	0.001	0.00	0.00	0.00	0.001		
Chromium(mg/l)	WET	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.006	0.5
	DRY	0.002	0.00	0.00	0.00	0.002	0.00	0.002	0.00	0.00		
Zinc(mg/l)	WET	0.004	0.001	0.002	0.001	0.09	0.002	0.001	0.004	1.00	0.004	5.0
	DRY	0.007	0.002	0.002	0.001	0.11	0.003	0.002	0.006	1.35		

B = Borehole. B1 to B9 represents the nine boreholes sampled around the dumpsite areas, three around each dumpsite area.

Table 5 above shows the concentrations of the investigated heavy metals in the borehole water samples analysed in two seasons. All the water samples analysed were higher in lead concentrations than the control and WHO standard in the wet season (Table 4.14). Some of the water samples showed much higher concentrations of lead in the dry season while others showed lower concentrations.

Iron concentrations of most of the water samples in the wet season were higher than the control but within WHO standard. However, in the dry season, one of the boreholes gave a value of iron (0.31) slightly higher than that of the WHO standard (0.3). Boreholes 3 – 6 showed cadmium value (0.005 – 0.01) higher than the control and WHO standard (0.003) respectively, in the wet season. In the dry season, only boreholes 5 and 9 were higher than the control and standard. The rest of the boreholes were lower in cadmium values in the dry season.

All the water samples showed no nickel and chromium contaminations. The zinc values were also within limits set by WHO but some of the samples were higher in zinc concentration than the control. Concentrations of ions above permissible limits are generally not suitable for consumption. Consuming unsafe drinking water may lead to several water borne diseases and other chronic health related problems. Therefore, provision of safe and quality water to individuals and communities is paramount.

CONCLUSION

The findings of the study revealed that the physico – chemical analyses showed elevated values of most of the parameters analysed in soil and groundwater in the vicinity of the dumpsites compared with the control. Concentrations of nitrate, lead and cadmium were higher than the WHO standard in some of the boreholes tested, and the pH of all the boreholes tested in the dry season were acidic. These findings show that the residents of the area stand a high risk of water related health problems. The dumpsites studied also, generally showed levels of contamination in relation to season, activities going on around them and their ages which suggest that there could be more pollution of groundwater if dumping persists at the locations.

The government should involve industries in the management of waste by making them responsible for the wastes generated from their products. This is known as extended producer responsibility. Industries, through the deposit refund system can retrieve wastes from their products from consumers. In this system, consumers of products with recyclable wastes (like bottles, plastics, and so on) are made to deposit some money which they will be refunded if they return the waste product.

REFERENCES

Aba, Nigeria. (2024, February 29). In *Wikipedia*. https://en.wikipedia.org/wiki/Aba,_Nigeria

Abul, S. (2010). Environmental and health impact of solid waste disposal at Mangwaneni dumpsite in Manzini: Swaziland. *Journal of Sustainable development in Africa*, 12(7): 64-78.

Adefemi, S. O. and Awokunmi, E. E. (2010). Determination of physico-chemical parameters and heavy metals in water samples from

Itaogbolu area of Ondo-State, Nigeria. *African Journal of Environmental Science and Technology*, 4(3): 343.

Akinbile, C. O. and Yusoff, M. S. (2011). Pollution on groundwater supplies in Akure, Nigeria. *International Journal of Environmental Science and Development*. 2(1): 1– 6.

Alao, J. O. (2023). Impacts of open dumpsite leachates on soil and groundwater quality. *Groundwater for Sustainable Development*, 20: 100877.

Amadi, A.N. and Nwankwoala, H. O. (2013). Evaluation of Heavy Metal in Soils from Abeokuta dumpsites. *Global Journal of Pure and Applied Sci.,* 4(7): 467 – 472.

Bhattacharya, P. and Bundschuh, J. (2015). Groundwater for sustainable development: crosscutting the UN sustainable development goals. *Groundwater for Sustainable Development*, 1(1): 155-157.

Divya, A., Shrihari, S. and Ramesh, H. (2020). Predictive simulation of leachate transport in a coastal lateritic aquifer when remediated with reactive barrier of nano iron. *Groundwater for Sustainable Development*, 11: 100382.

Greedy D (2016) Landfilling and landfill mining. *Waste Management and Research*, 34: 1–2.

Jhamnani, B. and Singh, S. K. (2009). Groundwater contamination due to Bhalaswa landfill site in New Delhi. *International Journal of Civil and Environmental Engineering*, 3(3): 181-185.

Laskar, N., Singh, U., Kumar, R. and Meena, S. K. (2022). Spring water quality and assessment of associated health risks around the urban Tuirial landfill site in Aizawl, Mizoram, India. *Groundwater for Sustainable Development*, 17: 100726.

Lin, Y. P., Teng, T. P. and Chang, T. K. (2002). Multivariate Analysis of Soil Heavy Metal

Longe, E. O. and Balogun, M. R. (2010). Groundwater quality assessment near a municipal landfill, Lagos, Nigeria. *Research Journal of Applied Sciences, Engineering and Technology*, 2(1), 39-44.

Majolagbe, A. O., Kasali, A. A. and Ghaniyu L. O. (2011). Quality assessment of groundwater Pollution and Landscape in Changhua Country in Taiwan. *Landscape Urban Plan.,* 6(2): 19-35.

Odukoya, O. O., Bamgbose, O. and Arowolo, T. A. (2000). Heavy metals in topsoil of in the vicinity of dumpsites in Ifo and Lagos, Southwestern Nigeria. *Advances in Applied Science Research*, 2(1): 289 – 298.

Osujieke, D. N., Igbojionu, J. N., Imadojemu, P. E. and Iroha, J. N. (2018). Assessment of soil properties as affected by four land use types in Egbeada, south-east Nigeria. *Assessment*, 18(3): 541.

Otabor, K. E., Oviawe, A. P. and Ilori, E. G. (2018). Study on the Impact of Municipal Solid Wastes on Physico-Chemical Properties of Dumpsite Soils in Benin City, Nigeria. Nigerian *Research Journal of Engineering and Environmental Sciences*, 3(2): 529-541.

Oyeku, O. T. and Eludoyin, A. O. (2010). Heavy Metal Contamination of Groundwater Resources in a Nigerian Urban Settlement. *African*

Journal of Environmental Science and Technology, 4(4): 201 – 214.

Parvin, F. and Tareq, S. M. (2021). Impact of landfill leachate contamination on surface and groundwater of Bangladesh: a systematic review and possible public health risks assessment. *Appl. Water Sci.,* 11: 100). https://doi.org/10.1007/s13201-021-01431-3

Sabohi, E. A. and Abdul, R. S. (2009). Leachate composition and groundwater pollution at municipal solid waste landfill of Ibb city, Yemen. *Sains Malaysiana*, 38: 295–304.

Singh, A. and Chandel, M. K. (2020). Physicochemical and FTIR spectroscopic analysis of fine fraction from a municipal solid waste dumpsite for potential reclamation of materials. *Waste Management & Research: The Journal for a Sustainable Circular Economy,* 0734242X2096284.

Ulakpa, R. O. E., Ulakpa, W. C. and Eyankware, M. O. (2021). Quantitative analysis of physical and chemical attribute of soil around power-line dumpsite at Boji-Boji Owa, Delta State, Nigeria. *World News of Natural Sciences*, 35: 118-134.

UNEP, "Global Waste Management Outlook (GWMO) (2015). International Solid Waste Association General Secretariat; p. 16. [Google Scholar]

Vaccari, M., Tudor, T. and Vinti, G. (2019). Characteristics of leachate from landfills and dumpsites in Asia, Africa and Latin America: An overview. *Waste Management*, 95: 416-431. https://doi.org/10.1016/j.wasman.2019.06.032