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An Assessment of Leachate Pollution of Olusosun Landfill on Groundwater Resources in Ikeja Local Government Area, Lagos State

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ABSTRACT

Twenty water samples were collected to assess the level of groundwater contamination at Ojota landfill sites. 25 parameters analyzed include temperature, turbidity, total dissolved solids, electrical conductivity, pH, total alkalinity, total acidity, chloride, nitrate, phosphate, sulphate, bicarbonates, dissolved oxygen, magnesium, zinc, calcium, copper, iron, arsenic, lead, chromium, sodium, potassium, manganese and cadmium. The results showed that the mean value for pH was 6.1 and the concentration of total alkalinity ranged from not detected to785mg/L, chloride from not detected to 250mg/L, nitrate from not detected to 15.6mg/L, phosphate from not detected to 1.91mg/L, sulphate from not detected to 15.6mg/L, bicarbonates from 8.9 to 36.6mg/L, dissolved oxygen from 1.42 to 5.71 mg/L, magnesium from 0.01 to 0.47 mg/L, zinc from 0 to 0.01mg/L, calcium from 0.61 to 8.3mg/, copper from 0.01 to 0.8mg/L iron from not detected to 0.49mg/L, arsenic was not detected, lead from not detected to 0.269mg/L, chromium from 0 to 0.1mg/L, sodium from 0 to 0.69mg/L, potassium from 0 to 0. 651mg/L and total hardness from 8 to 87mg/L. The concentration of total alkalinity, nitrate, dissolved oxygen, iron and lead did exceed the limit of WHO drinking water standard of 200mg/L, 10mg/L. 2mg/L, 0.03mg/L and 0.015mgL respectively in some samples. However, the concentration of zinc, copper, phosphate, sodium, calcium, magnesium, potassium, sulphate, bicarbonate and chloride are within the limit of WHO drinking water standards. Arsenic, chromium and cadmium in most of the samples were below the detection limit or not higher than 0.1mg/L. Gibb's diagram showed that the concentration of the dissolved chemical constituents was the result of t dissolution of host rock minerals due to water – rock interaction. Water in the study area is not potable due to contamination by total alkalinity, nitrate, dissolved oxygen, iron and lead, therefore water should be discarded or treated before use.

Keywords: Landfill, Leachates, Physico-chemical, Pollution, dissolution

1.0. Introduction

Water is the most abundant resource on earth which may occur on the earth's surface as surface water and below the phreatic level as groundwater. Water is critical to our daily lives and is an extraordinary compound in nature. It covers 71% of Earth (USGS, 2014). It has this unique position among other natural resources because a country can survive in the absence of any other resource, except water (Garg, 2009). For groundwater to serve its useful purposes it must not have a direct link with a landfill to avoid contamination by leachate

Landfill practice is the disposal of solid wastes by infilling depressions on land. The depressions into which solid wastes are often dumped include valleys (abandoned) sites of quarries, excavations, or sometimes a selected portion within the residential and commercial areas in many urban settlements where the capacity to collect, process, dispose of, or re-use solid waste in a cost-efficient manner is often limited. The study area is the Olusosun landfill site which is the largest of the landfill sites in Lagos state and is situated in the Northern part of Lagos within Ikeja Local Government Area, and it receives approximately 40% of total waste products from Lagos (LAWMA, 2011).

Leachate is typically composed of dissolved organic matter, inorganic macro components (such as chlorides, iron, aluminum, zinc and ammonia), and xenobiotic organic compounds such as halogenated organics. Other chemicals including pesticides, solvents and heavy metals may also be present. Leachates are potentially hazardous waste from landfill sites. If not handled properly, it can cause pollution of groundwater, resulting in health problems and may affect the environment. Once polluted, groundwater may forever remain polluted without remedy or treatment. Diseases may spring up through water pollution, especially groundwater contamination, which may rapidly spread beyond human expectations because of its flow mechanism (Afolayan *et al.,* 2012). One of the major factors that make the earth habitable for humans is the presence of water. Water is the basis of life and therefore the development of water resources is an important component in the integrated development of any area. It is therefore important that leachates are treated and contained to prevent the occurrence of pollution (Kostova, 2006).

Landfills have served for many years as the ultimate disposal sites for all types of waste; municipal solid waste, industrial sewage and hazardous waste. Physical, chemical and biological processes interact simultaneously to bring about the overall decomposition of the wastes. One of the by-products of this mechanism is chemical laden leachate. The impact of landfill leachate on the surface and groundwater has given rise to a number of studies in recent years (Mor *et al.,* 2006). It is therefore important to study the water quality in areas especially those around these landfill sites to examine its impact on groundwater quality. Factors affecting groundwater are nature the of bedrock geology, depth from surface soil, vegetation, climatic variation, the permeability of sediments, and topography, while anthropogenic is the nature of human activities, urbanization, industrialization and waste management disposal, amongst others. Significantly, a number of detailed studies of leachate plumes indicate that they rarely extend more than a few hundred metres from the landfill, and all but a handful of the most persistent contaminants are completely attenuated (Christensen *et al.,* 1994; Robinson *et al* 1999). Concentrations of both reactive and conservative contaminants decrease with the distance along the groundwater flow path therefore, leachate migration is in line with the distance decay principle (Taylor, 1983). The concentration of a pollutant at any point removed from its source may vary throughout the year due to seasonal influences on recharge and release of the contamination, or reaction times governed by variations in factors such as temperature (Taylor & Allen, 2006). Any site where waste is concentrated, processed, and stored, even for a short period of time, may be a potential point source of groundwater contamination. Lee and

Jones (1991) assert that approximately 75 percent of the estimated 75,000 sanitary landfills pollute adjacent groundwater with leachate. Leachate derived from waste deposits (landfills, refuse dumps) includes a wide range of contaminations, depending on the types of waste deposited. The purpose of this study is to determine the level of groundwater contamination through leachate percolation in the study area.

2.0. Materials and methods.

2.1. Study Area

The Olusosun landfill, which began operation in 1992, is located at Ojota in Lagos State, Nigeria. The landfill size is 42.7 hectares (Plate 1) by Lagos Waste Management Authority (LAWMA), 2011), and it is situated about 10km Southeast of Ikeja Local Government Area, and between latitudes 6° 23'N and 6° 41'North of the Equator and longitudes 2°42'E and 3° 42'East of Greenwich meridian (Oyeku and Eludoyin, 2010). The waste is made up of domestic, market, institutional and industrial wastes. The landfill sites have also witnessed rehabilitation.

Plate 1: A view of the landfill in Ojota, Lagos, Nigeria

2.2 Geology and physiography of the Study Area

Ojota belongs to the coastal plain sand formation which is made up of loose sediment ranging from silt, clay and fine to coarse-grained sand. The exposed rock unit in the area consists of poorly sorted sands with lenses of clays (Figure 1). The sands are in part cross-bedded and show a transition to continental characteristics (Jones, 1964, Omatsola and Adegoke, 1981). The age Oligocene to Recent was assigned to this formation based on fauna contents. The next depositional cycle is a sequence that extends from Precambrian to Recent. The formations recognized in the Nigerian part of the Dahomey basin are the Abeokuta group: Afowo Formation, Ewekoro Formation, Ilaro Formation and the coastal plain sands.

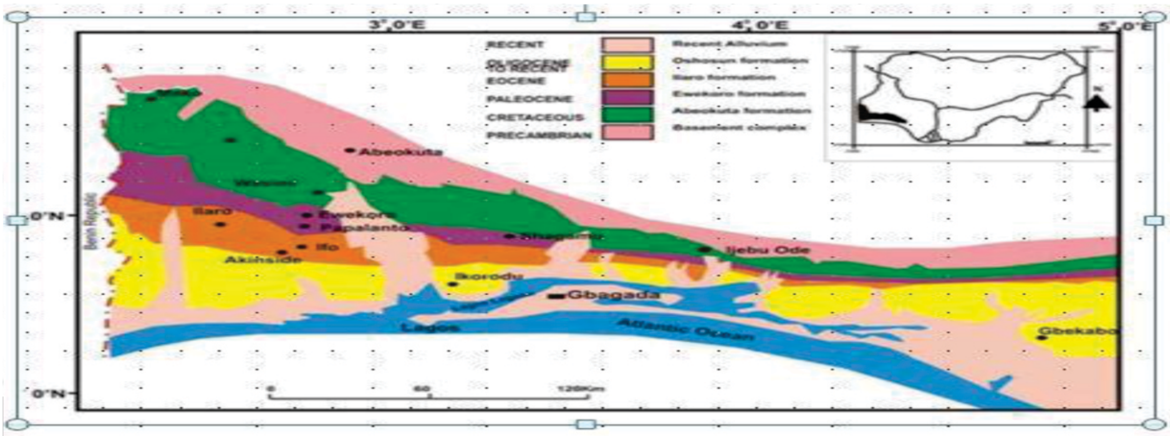

Figure.1: Regional Geology of Dahomey Basin (Lagos State and Environs) (Durotoye, 1975).

Lagos has a tropical climate. There is significant rainfall in most months of the year. The short dry season has little effect on the overall climate. Generally, the state has two climatic seasons; Dry (November- March) and Wet (April-October). The dominant vegetation of the area is the swamp forest of the fresh water and mangrove swamp forests, both of which is influenced by double rainfall the pattern of the state, which makes the environment a wetland region.

2.3 Field sampling and analytical methods

Field sampling was done in the month of July 2021 during the peak of the rainy season. 20 water samples were collected from the study area using 2 litres of plastic bottles which were washed with diluted nitric acid and rinsed with de – ionized water prior to water collection. Plastic containers of the water samples were capped immediately to minimize oxygen contamination and escape of dissolved gases. Water samples were labeled right there on the field to avoid problems arising from sample identification. Chemi cal parameters measured include pH, total acidity, total alkalinity, total hardness, chloride, nitrate, phosphate, sulphate, bicarbonate, dissolved oxygen, magnesium, zinc, calcium, copper, iron, arsenic, lead, chromium, sodium, potassium and total alkalinity. Heavy metals were determined in the laboratory by Atomic Absorption Spectrometer, sodium and potassium by flame emission spectrometer and other parameters by titration. Physical parameters measured include temperature, turbidity, electrical conductivity and total dissolved solids. These analyses were done according to the prescribed standard method of APHA, 2002.

3.0. Results and Discussion

The results of the analyses are presented in Tables 1, 2 and 3

Table 1: Physical parameters

Physical	Temperature	Turbidity	Total Dissolved Solid (TDS)	Electrical Conductivity	pH
WHO 2017	35 – 40 ^{0}C	5 NTU	300 mg/L	100 µS/cm	6.5 - 8.5
BH01	26.2	0.19	60	0.23	6.2
BH02	26.1	0.47	56	0.42	6.1
BH03	26.3	1.51	61	0.28	5.7
BH04	26.1	0.32	7	0.59	6.3
BH05	26.1	1.18	10	0.29	6.0
BH06	26.0	1.70	5	ND	5.9
BH07	26.1	0.32	35	0.12	7.9
BH08	25.8	0.52	67	0.54	5.8
BH09	26.3	0.44	19	0.39	6.9
BH10	25.7	0.57	17	0.21	6.0
BH11	26.2	1.92	22	0.34	5.8
BH12	26.5	0.65	5	0.16	6.1
BH13	25.9	0.83	11	0.45	6.3
BH14	26.2	1.42	38	ND	6.0
WL01	25.8	0.79	24	0.31	6.7
WL02	26.1	0.19	46	0.26	8.1
WL03	26.4	1.85	8	0.47	6.2
WL04	26.0	0.90	41	ND	7.1
WL05	26.3	0.15	13	0.14	6.5
WL06	26.1	0.34	21	0.27	6.9
Mean	26.1	0.81	29	0.27	6.01

**ND – Not Detected*

Table 2: Chemical parameters

	pH	Total Acidity	Total Alkalinity	Total Hardness	Cl	NO_3	PO_4	SO_4	HCO_3	DO
W.H.O 2017	6.5 - 8.5	NS	200	100	250	10	5	250	500	2.0
NSDWQ	6.5 - 8.5	NS	NS	NS	250	50	NS	100	NS	NS
BH01	6.2	34	25	38	12	3.6	0	2.3	18.3	5.53
BH02	6.1	38	35	32	11	1.4	0.85	3.0	24.4	5.26
BH03	5.7	45	20	28	27	5.0	1.28	1.6	36.2	5.54
BH04	6.3	56	45	34	13	4.3	0.74	3.7	30.5	5.71
BH05	6.0	49	10	24	127	3.5	0	15.6	21.7	5.68
BH06	5.9	76	35	12	14	6.9	0	1.0	14.9	4.36
BH07	7.9	115	370	87	ND	12.7	1.91	4.2	28.5	**5**
BH08	5.8	67	15	36	11	5.3	0.80	2.0	12.1	5.71
BH09	6.9	270	40	16	24	4.4	0.49	2.6	16.8	3.15
BH10	6.0	39	196	53	44	ND	1.16	9.4	29.4	5.28
BH11	5.8	41	43	28	17	**11.2**	0	3.8	36.6	4.78
BH12	6.1	57	19	67	28	4.8	0.76	ND	34.7	4.72
BH13	6.3	30	ND	49	54	1.9	ND	0.3	12.0	1.88
BH14	6.0	24	36	14	ND	3.7	0.41	7.1	11.5	5.47
WL01	6.7	37	10	28	102	15.6	0.56	0.9	19.2	4.85
WL02	8.1	ND	785	62	ND	5.1	0.85	3.0	10.9	5.34

WL03	6.2	42	20	8	27	3.7	0	1.1	15.6	4.54
WL04	7.1	126	274	54	13	5.4	1.23	10.4	8.9	**5.2**
WL05	6.5	56	55	18	4	10.2	0.91	2.8	18.6	1.42
WL06	6.9	58	15	72	28	6.3	0.78	3.7	12.9	2.43
Mean	6.4	63	112.4	38	27.8	5.75	0.64	3.93	20.7	4.59

**ND – Not Detected *NS – Not Supplied*

Table 3: Cations and heavy metals

Parameters (mg/L)	Magnesium	Zinc	Calcium	Copper	Iron	Arsenic	Lead	Chromium	Sodium	Potassium
WHO	150	1.5	200	0.5	0.03	0.20	0.015	0.1	200	<20
NSDWQ	0.2	3	NS	1	0.3	NS	0.01	0.05	NS	NS
BH01	0.08	0.01	6.40	0.02	0.05	ND	0.011	0	0.32	0.059
BH02	0.12	0	8.10	0.05	0.03	ND	0.016	0	0.39	0
BH03	0.05	0	4.99	0.01	0.04	ND	0.004	0	0.48	0.022
BH04	0.16	0	4.32	0.04	0.47	ND	0.018	0	0.27	0.404
BH05	0.03	0.01	8.30	0.03	0.02	ND	0.006	0	0	0.250
BH06	0.06	0	3.90	0.03	0.49	ND	0.012	0	0.24	0.651
BH07	0.29	0.01	0.61	0.08	0.01	ND	0.015	0	0.49	0
BH08	0.10	0	2.85	0.05	0.03	ND	0.004	0	0.08	0.048
BH09	0.47	0	0.92	0.06	0.01	ND	0.001	0	0.69	0.052
BH10	0.24	0	1.28	0.11	ND	ND	0.003	0	0.29	0.310
BH11	0.11	0.00	0.67	0.09	0.00	ND	0.017	0	0.51	0.506
BH12	0.20	0.01	2.06	0.14	0.01	ND	0.006	0	0.32	1.349
BH13	0.04	0	0.92	0.06	0.04	ND	0.001	0.00	0.79	0
BH14	0.01	0	2.12	0.02	0.02	ND	ND	0	0	0.035
WL01	0.04	0.01	7.25	0.04	0.06	ND	0.010	0	0.35	0.196
WL02	0.06	0	1.18	0.10	0.01	ND	0.269	0	0.50	0.071
WL03	0.11	0	5.40	0.08	0.03	ND	0.04	0.00	0.24	0
WL04	0.09	0	1.51	0.03	0.02	ND	0.002	0	0.29	0.596
WL05	0.05	0	0.86	0.01	0.04	ND	0.027	0	0.31	0.079
WL06	0.03	0	3.12	0.03	0.01	ND	0.005	0	0.17	0.042
Mean	0.13	0.15	3.34	0.10	0.08		0.025	0.01	0.34	

**ND – Not Detected *NS – Not Supplied*

The temperature ranged between 25.8^0C - 26.3^0C below the standard limit of 35◦C - 40◦C, indicating the presence of foreign bodies such as active micro-organisms (Akinbile and Yusoff, 2011). The pH scales runs from 0-14, water having a pH between 1 and 6 is considered to be acidic. Water having a pH of 7 is the midpoint of the scale and it's considered to be neutral and from 8 to 14 is alkaline. pH values in the study area ranged between 5.7 and 8. 1, which is slightly acidic to slightly alkaline. WHO drinking standard for pH is 6.5- 8.5. The samples' conductivity values ranged from 0.59 µS/cm to not detected. WHO (2017) standard is 1000µS/cm for drinking water. This is the measure of the amount of all dissolved both organic and inorganic substances in the water. TDS values ranged between 97.90 – 110.77mg/L with the mean value of 1159mg/L. The palatability of drinking- water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/L; good, between 300 and 600 mg/L; fair, between 600 and 900 mg/L; poor, between 900 and 1200 mg/L; and unacceptable, greater than 1200 mg/L. Turbidity ranged from 0.15 to 1.92 NTU, WHO maximum permissibility standard for turbidity is 5 NTU, which indicates that water samples here are free from suspended and colloidal particles and therefore is within WHO (2017) drinking limits. This is the water contain high mineral contents which usually contain magnesium (Mg^{2+}) and calcium (Ca^{2+}).Total hardness ranged from 8mg/L to 87mg/L. There is no evidence of permanent adverse health effects from the consumption of hard water. Out the 20 groundwater samples, all were within stated WHO limits. Concentrations ranged between 0.01 and 0.11mg/L. High intakes of Copper can cause liver and kidney damage which may eventually lead to death. It also causes stomach ache, dizziness, vomiting and diarrhea. Concentrations in BH01, BH03, BH06, WL01, WL06, and WL04 were found to exceed both WHO, (2017) and NSDWQ, (2015) standards. Iron concentration in the water samples ranged between 0.01 and 0.47mg/l. The presence of Iron in water can lead to a change in colour of groundwater (Rowe *et al.,* 1995). Lead was observed to be above drinking standard limits in BH02, BH04, BH07 and WL02. Concentrations ranged between 0.001 and 0.269mg/L. Lead has many toxic effects on human health with children being the most vulnerable population (Payne, 2008). Higher levels of lead in water may produce permanent brain damage and kidney dysfunction (ATSDR, 2007**).** The Zinc concentrations from the study area were very low compared to the recommended WHO and NSDWQ limits. Although WHO (2017) does not state a permissible limit for zinc, a concentration between 3 and 5 mg/L is good for healthy living (ATSDR, 2007). Arsenic concentrations in all the water samples were below detection (BD). Long-term exposure to arsenic from drinking water can cause cancer and skin diseases (Ravenscroft et al, 2009). The analysis shows that the concentration of chromium in the various water samples was below detection (BD). Chromium is highly carcinogenic, therefore, minimal intake has been advocated (WHO, 2011). Calcium in the water ranged between 0.61 to 8.3 mg/L. The presence of calcium ion in the water is most likely to be from the dissolution of the limestone. Out of the 20 groundwater samples, all were within stated WHO limits. Magnesium concentrations ranged between 0.01 and 0.47mg/L. This range is below the 150mg/L WHO limits for drinking. High concentrations of magnesium in water can lead to cerebrovascular diseases which can cause damage to human health. Sodium concentration ranged between 0 and 0.79mg/L in the water samples. The chloride concentration of water samples from the study area is low compared to theWHO limit of 200mg/L. Saline water intrusion, mineral deposits and sewage effluents may contribute significant quantities of sodium to water (ATSDR, 2007). Potassium concentration in the water samples ranged between 0 and 1.349mg/L and is low compared to the WHO limit of 20mg/l., adverse health effects due to potassium consumption from drinking water are unlikely to occur in healthy individuals (Gosselin et al., 1984). Bicarbonate concentrations ranged 8.9-36.6mg/L in the water samples. The bicarbonate concentration of the water samples did not exceed the WHO standard limit of 500mg/L. Consumption of drinking water with bicarbonate on a daily basis may cause metabolic alkalosis causing lungs and kidney to overexert themselves to cleanse the blood. Concentration of Chloride ranged between 4 and 127 mg/L, and were within the stated WHO and NSDWQ limit. The chloride concentration of water samples from the study area is low compared to WHO limit of 250mg/L. Sulphate concentration ranged between 1.0 and 15.6 mg/L. The sulphate concentration from the study area is low compared to the recommended 250mg/L and 100mg/L (WHO, 2017, NSDWQ, 2011) limits respectively. The occurrence of common minerals like gypsum and the discharge of domestic sewage tend to increase sulphate concentration (ATSDR, 2007). Concentrations sulphate in all samples except BH07 and WH01 were found to exceed WHO, (2017) standard limit, however, both samples remained within the NSDWQ, (2011) limit of 50mg/L. Ingestion of nitrates in drinking water has been known to cause methemoglobinamia in infants less than six months (Johnson *et al*, 1987). All samples exceeded the standard limit except in BH13 and WL05. Dissolved oxygen concentration in the water samples ranged between 1.42 and 5.71mg/L. Dissolved Oxygen is essential to the survival of aquatic life (Lenntech, 2012). Out the 20 groundwater samples, concentrations from the study area were below the recommended WHO and NSDWQ limits. Phosphate concentrations in the water samples range between 0 and 1.91mg/L. High phosphate levels in drinking water may cause digestive problems in humans and animals (U.S. EPA, 2001, 2012). Total alkalinity concentrations range from 8-87mg/L. Concentrations in BH07, WL02, and WL04 exceeded WHO standards of water quality.

4.0. Conclusion

This research examined the quality of groundwater around the Olusosun landfill in order to compare the concentrations of the examined variables with the WHO (2017) and NSDWQ (2011) standard limits. Twenty three parameters were tested for in each of the 20 water samples collected. The results indicate low pH, low total dissolved solids, low turbidity and low electrical conductivity. Concentration of nitrate, total alkalinity, iron, lead, copper and dissolved oxygen were above the WHO standard limit in some samples. However, the concentration of total zinc, copper, phosphate, sodium, calcium, magnesium, potassium, sulphate, bicarbonate and chloride are within the limit of WHO drinking water standard. These indicate the water supply may be susceptible to contamination by some micro-organisms. The water therefore is not safe for human consumption and there is a serious need to monitor the groundwater quality in the area.

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