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Strategic Monitoring of Groundwater Quality Around Olusosun Landfill in Lagos State for Pollution Reduction and Environmental Sustainability

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ABSTRACT

As urbanization and population increase in the megacity, there is a need for engineering intervention and strategic monitoring of groundwater around landfills for environmental sustainability, pollution reduction and public health. This study evaluated water's physical and chemical parameters in wells and boreholes near the Olusosun landfill in Lagos State to determine how they impact groundwater quality. An Atomic Absorption Spectrometer (AAS) was used to evaluate groundwater samples obtained from five locations within the dump site. Some water parameters, such as dissolved oxygen (DO), iron (Fe), lead (Pb), manganese (Mn), and magnesium (Mg), had concentrations that were higher than the WHO, NESREA, and Nigerian Standard for Drinking Water Quality (NSDWQ) standard limits in some sampling sites, with mean concentrations of 0.33 mg.L^{-1}, 0.04 mg.L^{-1}, 0.74 mg.L^{-1}, and 0.74 mg.L^{-1}, respectively. A small amount of lead was identified in the groundwater of the study area. A major source of air and groundwater pollution, the Olusosun landfill has a detrimental impact on the health of those who live there. Solid waste, groundwater interactions, and contaminated migration into the nearby neighbourhood were studied. It was observed that the degradation of waste products in dump sites releases harmful leachate into the groundwater. Even though some heavy metal concentrations in the study area are still within WHO, NESREA, and NSDWQ standard limits, investigations and further monitoring should be conducted regularly to assess the concentrations of heavy metals in groundwater.

INTRODUCTION

The open dump disposal system is the most popular technique of solid waste disposal in Lagos and the rest of the country. This disposal strategy, like the landfilling waste management system, is most common in developing nations worldwide due to the related cheap costs. According to (Longe & Balogun 2010), landfills dispose of practically all solid waste created in low and middle-income nations due to abundant land and low operational costs. On the other hand, landfills and dump sites have health and environmental problems. While "poor operation and management of municipal solid waste (MSW) dump present a substantial threat to the environment, particularly "surface water, and groundwater," this is the case. Uncontrollable waste disposal, a lack of liners and leachate treatment and disposal facilities, insufficient compaction, inappropriate site design, the presence of scavengers, and low operational control are all features of open dumps.

In many places around the world, groundwater provides a significant source of fresh water for drinking. With many benefits over surface water, it is a significant renewable resource. Because of its superior capacity for self-cleansing and simplicity of treatment, groundwater is usually less polluted than surface water. As the population increases, so does the worry about trash disposal. A lack of waste disposal options causes this. Most urban dwellers must use open landfills to dispose of their trash. Degradation of these waste products releases harmful leachate into the groundwater. Due to insufficient water delivery by the Lagos State Water Corporation in these regions, groundwater is an important water source near the many dumpsites in Lagos. Current waste management procedures in Lagos represent a threat to

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O.J. Oyebode: https://orcid.org/0000-0003-2792-146X the quality of surrounding groundwater to landfills, given the rising dependency on water for irrigation purposes and the fact that, in the majority of instances, little or no treatment is conducted on the water before consumption. Lagos has no truly sanitary landfills, and trash disposal facilities can only be regulated dumps. Controlled landfills are inspected and monitored, and they maintain track of incoming wastes, waste compaction, and soil cover application. A sanitary landfill, unlike a controlled dump, is well maintained. As illustrated in Fig. 1, the facility is strategically positioned and fitted with liner and leachate collecting systems, which prevent leachate from penetrating groundwater. Fig. 1 illustrates the state of major landfills.

PAST STUDIES

Rivers and lakes account for 0.32 percent of total moisture, with atmospheric moisture accounting for 0.03 percent and soil moisture accounting for 0.05 percent (Gleick 1996). The subsequent groundwater contamination by discharged leachate is the most serious environmental issue surrounding landfill (Afolayan et al. 2012). Landfills have long been the final destination for all types of waste, including municipal solid, industrial, and hazardous waste. Liners at the bottom of modern landfills act as hindrances to leachate migration. However, it is widely recognized that such liners degrade over time and eventually fail to prevent leachate from contaminating groundwater (Jagloo 2002). Natural processes (like precipitation rate, weathering processes, and soil erosion) and anthropogenic effects (like urban, industrial, and agricultural activities, as well as human exploitation of water resources) influence the quality of surface water in a region. Heavy metals are good indicators of contamination in urban soils and street dust, according to (Kholoud et al. 2009). In the context of the periodic table, heavy metals have atomic weights ranging from 63.546 to 200.590 with specific gravities greater than 4 (Kennish 1992). Polluted water with high amounts of nitrates can induce methemoglobinemia (cyanosis) in infants and gastrointestinal problems in adults (Kumar et al. 2006). Environmental engineers and other stakeholders must act quickly to protect the environment and improve public health against environmental dangers, climate change difficulties, ecological challenges, and unsanitary behaviours (Oyebode 2022). The Nigerian government should establish and enforce regulations banning municipal and medical garbage disposal in dumpsites, making some dumpsites available, and offering barriers to keep scavengers away (Oyebode & Otoko 2022). An essential prerequisite for human existence is public health. Waste has a direct relationship with human development, both technologically and socially. Once properly recovered, some waste components have economic value and can be repurposed (Oyebode 2013).

According to Taylor & Allen (2006), landfills are most associated with groundwater contamination by waste-derived liquids in terms of situation assessment. Any location where waste is concentrated, processed, and stored, even for a short time, could be a point source of groundwater contamination. According to Lee & Jones (1991), about 75% of the projected 75,000 waste disposal pollutes nearby groundwater with leachate. Depending on the types of waste deposited,

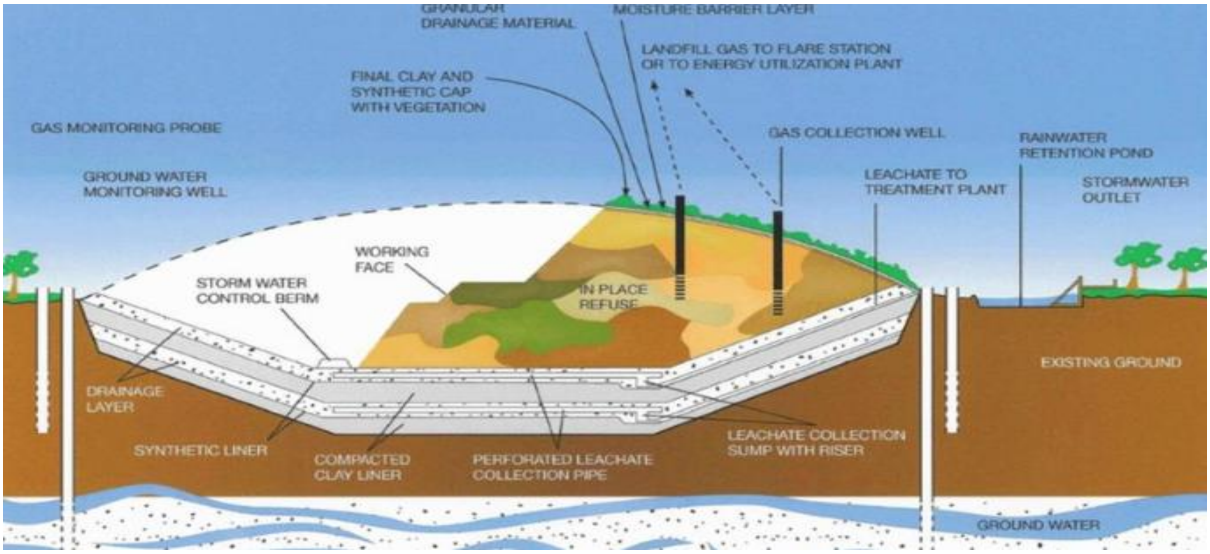


Fig. 1: Diagram of a modern engineered landfill.

leachate produced from waste deposits can contain a wide range of contaminants. Groundwater contamination poses a significant risk to local resource users and the natural environment (Taylor & Allen 2006).

Characteristics of Leachate on groundwater quality

According to Longe & Balogun (2010), the greatest threat to groundwater contamination comes from the leachate produced by the waste material, which mostly contains toxic substances, especially when industrial wastes are landfilled. However, it's widely reported that leachates from non-hazardous waste landfills may contain complex organic compounds, chlorinated hydrocarbons, and metals at levels that endanger surface and groundwater.

Any polluted liquid that results from water percolating through a solid waste disposal site, picking up impurities, and flowing into subterranean regions is referred to as leachate. High moisture levels in some discharged wastes are a second source of leachate. Inadequate solid waste disposal facilities are one of Nigeria's biggest environmental and public health problems today (Oyebode 2019). Organic and inorganic compositions are common in the leachate produced. Furthermore, as time passes, the leachate produced makes its way into ground systems, changing groundwater's physical and chemical properties (Vasanthi et al. 2008). When it comes to time and age, the condition of a landfill can change from aerobic to anaerobic, allowing for different chemical reactions to occur (Taylor & Allen 2006). General geology, the degree of chemical weathering of distinct rock formations, the condition of recharge water, and materials from sources other than rock contact all impact groundwater chemistry. As a result of these elements and their interplay, water quality is complicated (Aghazadeh & Mogaddam 2010). Several extensive investigations of leachate plumes have discovered that they seldom extend more than a few hundred kilometers from the landfill. Still, a few of the most persistent toxins are entirely suppressed (Christensen et al. 1994, Robinson et al. 1999). The most prevalent natural solvent in the world is water. As a result, it dissolves minerals as it flows through the earth. These minerals make up the Total Dissolved Solids (TDS) in water. Because the water in a shallow aquifer moves a smaller distance through the ground, it has less mineralization. In contrast, deeper aquifers are more susceptible to pollution by local land use activities, such as nitrate and microbiological degradation (McLeod et al. 2005).

Analysis of water quality

Water quality may be assessed in a variety of ways. Instead of creating a cost-effective scheme for assessing groundwater quality by collecting samples from boreholes and acquiring usable data, Yeh et al. (2008) attempted to use approaches that cannot properly distinguish the various water contaminants. Using the Water Quality Index approach, a mathematical expression obtained cumulatively and specifying a certain level of water quality may be presented to the public. Because the Water Quality Index incorporates data from numerous water quality measures, it offers a numerical number to the water's overall health (Yogedra & Puttaiah 2008). Combustion produces methane, which may ignite flames, explode, and generate leachate that pollutes groundwater and surface water (Oyelola et al. 2009).

For many years, landfills have served as the dumping area for all types of waste, including municipal solid waste, industrial sewage, and hazardous waste. Physical, chemical, and biological processes all interact simultaneously to decompose waste. Leachate is one of the byproducts of this mechanism. It is produced from rainwater, assisting bacteria in the decomposition process. Leachate typically comprises dissolved organic matter, inorganic macro components (like chlorides, iron, aluminium, zinc, and ammonia), and heavy metals. Other chemicals, such as pesticides and solvents, may also be present. Leachates are a type of hazardous waste that can be found in landfills.

Landfills and dump sites continue to be a source of public health and environmental concern worldwide. This is because of the negative consequences for public health, groundwater and surface water quality, air quality, the greenhouse effect, and global warming. Several uncertainties surround the short and long-term impact of LAWMA-operated dumpsites on the environment and its resources near these dumpsites. On the other hand, residents rely on untreated groundwater, frequently from shallow wells and boreholes, putting them at risk of ingesting any toxic material or compounds in groundwater due to leachate contamination. Landfills have been connected to illnesses, including nervous system damage, ocular and upper respiratory irritation, arrhythmias, and dizziness in humans. Long-term ingestion of hydrogen sulfide (H_2S) and volatile organic compounds like benzene has been linked to cancer development. In a neighbourhood in the United States, liver disease has been related to groundwater pollution leachate produces (Bundschuh et al. 2021).

Furthermore, groundwater surrounding dumpsites is a danger of pollution, especially in light of the observed leachate ponds Fig. 1, which form around dumpsites during the wet season. Leachate ponds are formed when water flowing through an unlined landfill or dumpsite above an aquifer is top-dressed; the increased hydraulic head causes leachate to flow downhill and out of the dumpsite. Leachate springs, which are the consequence of outward flow, show that leachate has not only been formed but is also running within the subsurface, providing a public health danger. The lack of environmental protection measures such as artificial sealing liners, upstream diversion, and leachate collecting wells or control facilities near dumpsites exacerbates the threat to groundwater quality. Furthermore, these dumpsites were not discovered using hydrogeological criteria. No hydro-geological investigations were undertaken before sanitary landfill operations to determine the probable link between groundwater flow and dumping sites and the potential consequences of this relationship on groundwater quality inside and around the dumpsites. These dumpsites were once laterite burrow pits where garbage was dumped to help the soil restore itself. Finally, the landfill gases (LFG) created by these dumps harm the environment and public health. Due to the unmistakable stench of hydrogen sulfide and other gases, landfill gases are the leading source of air quality degradation. Greenhouse gases, especially methane and carbon dioxide affect global warming. Fig. 2 presents Water Table Mounding and Leachate Spring at the Periphery of Waste Deposited at a Dumpsite.

Landfill System in the Developing Countries

It has been said that landfills provide the "ultimate means of survival" for the poor in developing nations worldwide, especially in Africa. It also acts as an additional source of raw material for recycling, putting into effect the proverb "one man's food is another man's poison." They view garbage as both a source of wealth and a method of sustenance. Scavengers compete to make "payments" to the dumpsite manager to gain access to the dumpsite for scavenging, especially in Lagos dumpsites. There are various landfill systems throughout the world. In most African nations, open dumps are still the predominant method of trash disposal. Fig. 2 presents a cross-section of an Engineered Sanitary Landfill.

Typically, the first step in a nation's effort to rehabilitate its landfills is establishing a managed or semi-controlled landfill. Controlled dumpsites do some incoming waste inspection and documentation, employ considerable waste compaction, and regulate the tipping front and application of soil to cover the waste.

The surrounding hydrological system instantly absorbs landfill waste. Rainfall, snowmelt, and groundwater, as well as liquids generated by the waste through condensation reactions and solubilization procedures prompted by a series of complex biochemical reactions during the degradation of organic wastes, percolate through the deposit and mobilize other waste components, with the resulting leachate migrating offsite either through direct infiltration on-site or through leachate-laden runoff infiltration. Various factors determine the content of leachate and the degree of contamination it causes, including the age of the landfill, the type of trash it includes and the hydrological characteristics of the landfill (Bidhendi et al. 2010).

Difference between Landfills and Dumpsites

A sanitary landfill is a designed system, while a dumpsite

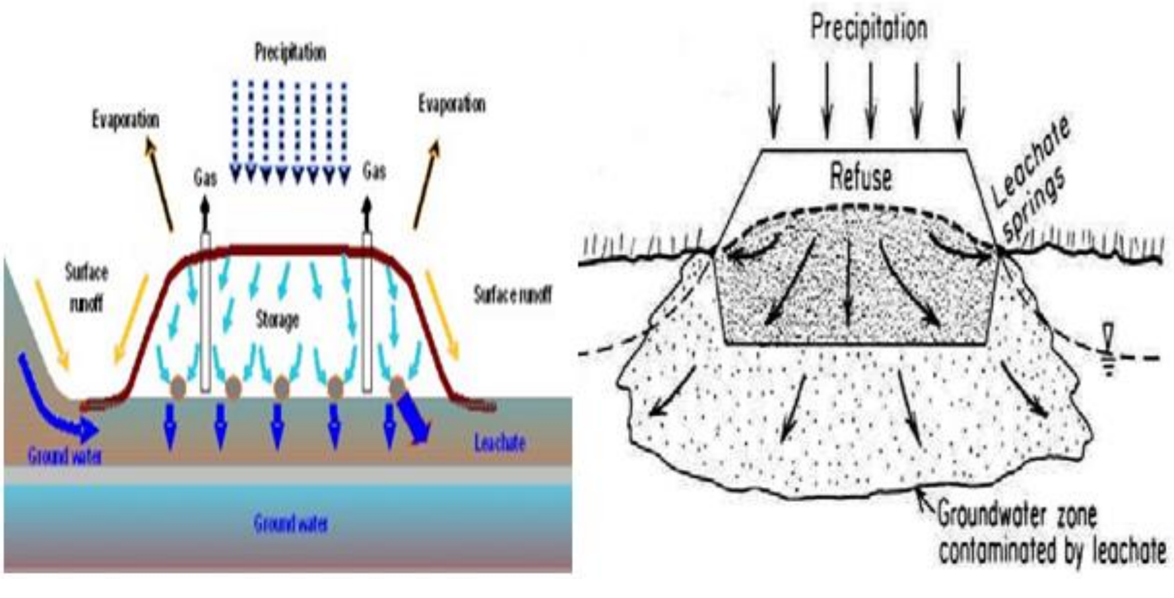
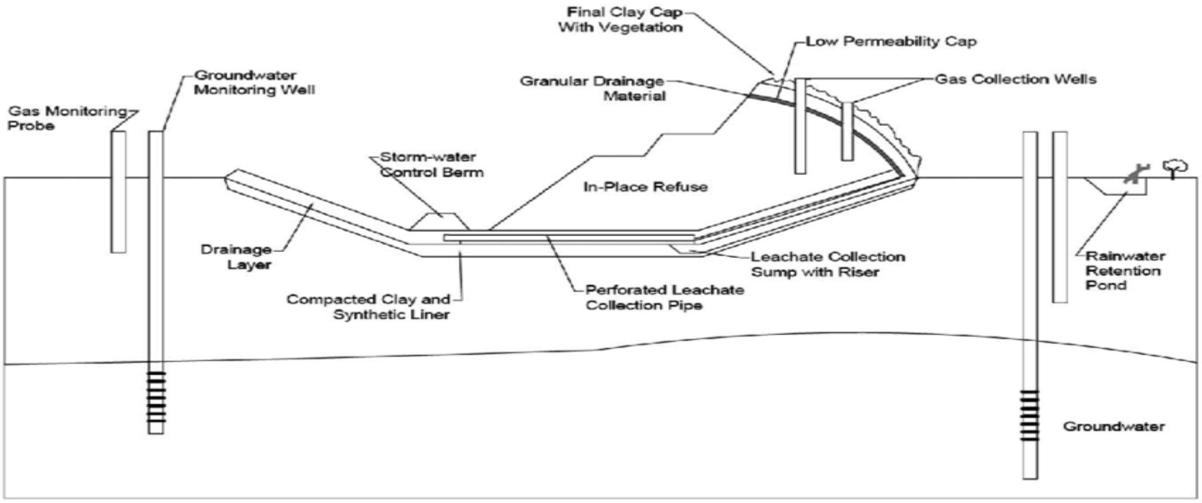


Fig. 2: Water table mounding and leachate spring at the periphery of waste deposited at a dumpsite.



(Source: Zume et al. 2006)

Fig. 3: Cross section of an engineered sanitary landfill.

is an arbitrary location for solid waste disposal. Generally, sanitary landfills are constructed where groundwater and runoff are not an issue. Local governments and residents must be taken into account. Dumpsites are excavated areas of ground where residents dispose of their solid waste. Most families, especially in rural areas, have waste landfills, whereas urban populations share a single dump. The authorities do not regulate solid waste, and there is no oversight over their processing. They can be found practically anywhere and may or may not be covered by soil. They are also unmonitored, which increases the likelihood that solid waste leachate will enter the water supply. Open dumpsites attract flies and rats and generate unpleasant odours that harm humans. The ideal is a landfill confined to a limited area and covered with earthen layers.

Sustainability of Water Development

The water cycle connects the world's fresh water and oceans. Water is roughly 70% of the human body and 60-70% of plant cells. The ocean contains 97 percent of the world's water, providing almost all that falls as rain and snow. About 2/3 of the remaining freshwater is groundwater, with only 0.3 percent in accessible surface waters. Water contamination, whether endogenous or exogenous, is a major issue, particularly in developing countries. Water, particularly groundwater, can become contaminated and remain so without treatment. In its liquid state, water is the substance that allows life to exist on Earth. Every living organism comprises cells constituting at least 60% of water because water is the foundation of life. Access to water resources is a critical component of any area's overall development.

MATERIALS AND METHODS

This section examines the study region from a geological, climatic, vegetation, and topographical aspect. In this section, we will take a quick look at the research process and the heavy metal parameters we'll be looking at.

Study Area

The Olusosun landfill in Lagos State, Nigeria, has been used since 1992 and is located in the city of Oregun. Approximately 10 km south of the Ikeja Local Government Area, Lagos Waste Management Authority (2011) estimates the landfill's area to be 42.7 hectares. (Eludoyin & Oyeku 2010). The Olusosun dumpsite is situated between latitudes 2°42′ E and 3°42′ E and longitudes 6°23′ N and 6°41′ N in the Ojota neighborhood of Lagos. Due to urbanization, the site, which was formerly outside of the city, is now inside of it. The dump facility, which is the biggest in Lagos State, gathers more than 50 percent of the waste produced. In the dumpsite, a sizable number of scavengers reside and earn a living (Aboyeji and Eigbokhan 2016).

The landfill is expected to be operational for around 20 years. Fig. 5 shows that the settlements of Ojota, Ketu, and Oregun bound the landfill. Fig. 4 presents a map showing the study area.

Due to a lack of public water, most residents in the neighbourhoods surrounding the landfill rely on private wells as a water source. Lagos State is home to over 19 million people and is growing at a 3.2 percent annual rate. The state generates much waste daily due to its large population. Approximately 40% of all waste deposits are deposited at the Olusosun Landfill site (LAWMA 2010). The Lagos

Fig. 4: Map showing the study area.

Waste Management Authority (LAWMA) manages the landfill, which accepts all types of waste in its natural state, from inorganic to organic, hazardous to non-hazardous. The landfill lacks a protective bottom liner to prevent leachate from entering groundwater. Most trash collected in Lagos is disposed of at the Lagos State Waste Management Authority's waste dumpsites (LAWMA 2010). The Olusosun Dumpsite near Ojota, the Abule-Egba Dumpsite along the Lagos-Abeokuta Expressway, and the Solous Dumpsites along the LASU Isheri Expressway are among these dumpsites. Fig. 4 presented Leachate Spring at Olusosun Dumpsite Environment, while Fig. 6 presented the map of the Lagos urban centre showing the major landfill sites.

The Olusosun dumpsite is situated between latitudes 2°42′ E and 3°42′ E and longitudes 6°23′ N and 6°41′ N in the Ojota neighborhood of Lagos. Due to urbanization, the site, which was formerly outside of the city, is now inside of it. The dump facility, which is the biggest in Lagos State and measures 42 hectares, gathers more than 50 percent of the waste produced. In the dumpsite, a sizable number of scavengers reside and earn a living (Aboyeji and Eigbokhan, 2016).The Open dump is the default option for municipal solid waste management, featuring uncontrolled trash disposal and low operational restrictions, including the environmental effects of landfills. Fig. 7 indicates scavengers sorting solid waste in the study area.

Fig. 5: Leachate spring at olusosun dumpsite environment.

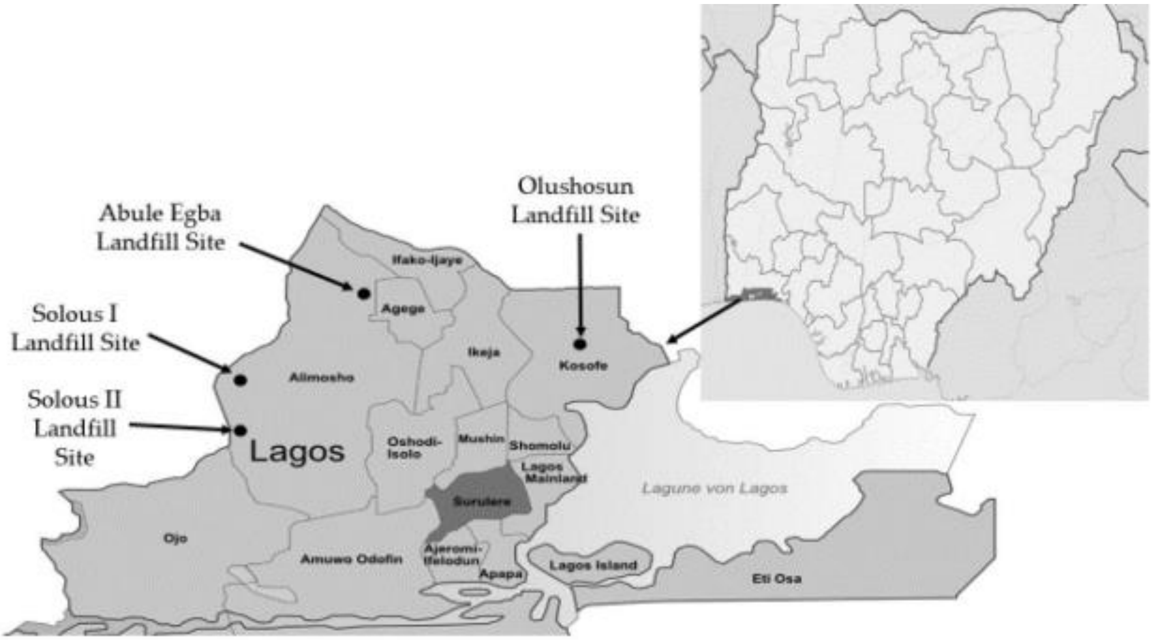


Fig. 6: Map of the Lagos urban centre showing the major landfill sites.

Fig. 7: Scavengers sorting solid waste in the study area.

Fig. 8 presented an overview of the environmental pollution and health effects associated with waste landfilling and open dumping while Fig. 9 presented the location Map of Olusosun Dumpsite in Ojota.

Climatic Condition of Study Area

There are two separate rainy seasons in the study area: one from April to July and the other from October to November. Most days in Lagos during the rainy season are cloudy or overcast. When it rains less than two days per month in August, September, December, and March, Lagos has a dry season, preceded by the Harmattan winds from the Sahara, which is greatest in December and early February. This is followed by the rainy season in April and May. The temperature ranges from 33 to 21 degrees Celsius. At an average of 32°C, the warmest month is March, while the coldest is August, at 25°C daily.

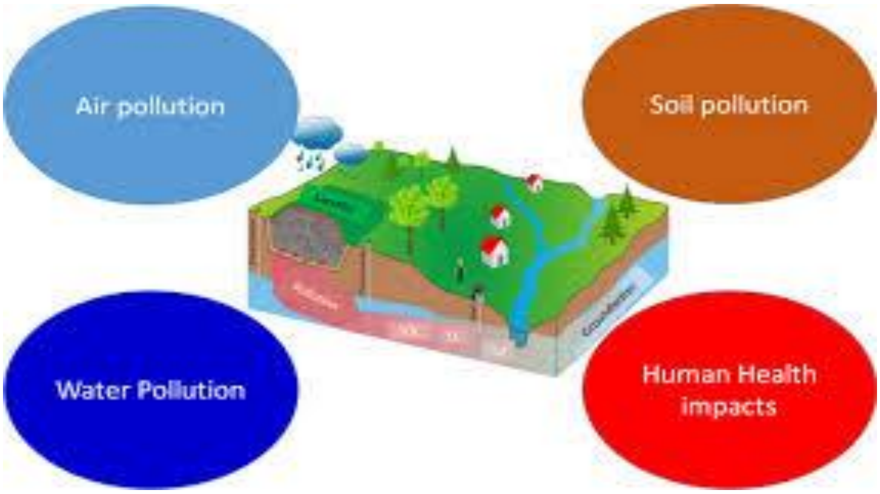


Fig. 8: An overview of the environmental pollution and health effects associated with waste land filling and open dumping.

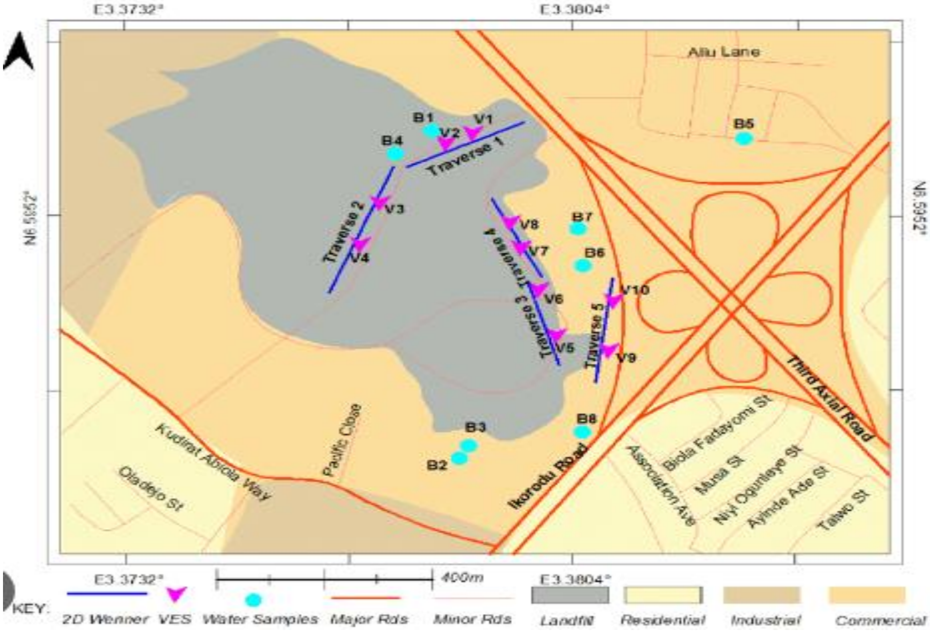


Fig. 9: Location map of olusosun dumpsite in Ojota.

Vegetation and Drainage of Study Area

For much of the territory, the state's twofold rainfall pattern creates a wetland habitat dominated by freshwater tropical rainforest and mangrove swamp forest. Extremely dry times of the year are from November to March, while rainy times are from April to September. A network of canals and waterways in the Study region covers approximately 22% of the State's geographical area.

Data Source

A combination of primary and secondary sources provided the data for this project. Direct field surveys were used to gather primary data. The information was obtained from wells close to Lagos State's biggest dumpsite, Olusosun, in Ojota, Lagos State. The research area's wells and boreholes provided the study's groundwater samples. For physicochemical characteristics and heavy metals analysis, the samples were numbered from Bh1 to Bh5 and sent to the University of Lagos. Laboratory professionals performed the tests, and the findings were gathered and analyzed. Table 1 contains information about the data points. Secondary data included information gleaned from publications such as books, papers, and journal articles. Secondary data sources include the NESREA (National Environmental Standards and Regulations Enforcement Agency), WHO, the Nigerian Standard for Drinking Water Quality (NSDWQ), and maps of Lagos State.

Collection of Samples

Over three months, groundwater samples were gathered from five unique locations, with three collected from each. The plastic bottle, which had been well-cleaned and labeled Bh1 through Bh5, was used to collect and store the samples for further analysis. After that, the samples were transferred to the University of Lagos' chemistry laboratory for assessment.

Data Analysis

All analytical techniques fulfilled the 2005 APHA standard guideline for drinkable and wastewater parameters. I tested each sample against various physical, chemical, and heavy metals criteria.

Onsite data analysis

The pH, temperature, electrical properties, and dissolved oxygen values were gathered. Dissolved oxygen concentrations were determined with a Dissolved Oxygen Meter (DOM). The pH of the sample was determined using a pH meter. The temperature was measured using a thermometer. Additionally, a conductivity/EC meter was used to assess electrical conductivity.

Offsite data analysis

An Atomic Absorption Spectrometer was used to check for metals in groundwater samples sent to the chemistry department at the University of Lagos (UNILAG) (AAS). Analyzed samples were heated and tested within six (six) days following collection. Aqua regia was used to dry the combination of water in a fume cupboard to analyze heavy metals in the water sample. For atomic absorption spectrometer (AAS) metal analysis, 25 mL of distilled water was poured and filtered through a funnel and filter paper. In addition to copper, lead, iron, calcium, chromium, manganese, magnesium, and zinc, the metals investigated were copper, lead, iron, calcium, chromium, manganese, magnesium, and zinc (Zn).

Data Evaluation

Average mean, standard deviation, tables, and various data were all part of the statistical analysis utilized to analyze the information. Each well's characteristics were compared against the distances from the landfill and the concentrations in mg.L^{-1} in a table. Each parameter's average value was obtained utilizing equation (1). The equation was used to calculate the range (2)

$$M(x) = (x1+x2+x3+\cdots.xn)/n \qquad \ldots(1)$$

$$\text{Range (R)} = \text{Highest parameter value} - \text{Lowest parameter value} \qquad \ldots(2)$$

The results are then compared to the groundwater quality of nearby environments such as Oregun, Ketu, and Ojota, as reported by Olaniyan et al. (2015) as well as the W.H.O standard and NSDWQ water quality guidelines (Oseke et al. 2021). Heavy metal poisoning of the environment and groundwater supplies, particularly in developing nations, has become a growing ecological and public health concern in recent years (Zacchaeus et al. 2020). Due to the hazardous and greenhouse gas (GHG) emissions from the direct combustion and/or decay of trash, open dumping practices significantly endanger the environment and human health (Pujara et al. 2019).

Due to a lack of infrastructure at these dumpsites, there is a high risk of leachate contaminating the groundwater within the dumpsites, especially during the rainy season. The quality, volume, and sensitivity of the groundwater that receives the leachate, as well as the leachate's concentration and flow, the landfill's hydrogeological setting, the level of protection provided by the landfill, and the quality, quantity, and sensitivity of the groundwater that receives the leachate all play a role in how polluted the leachate can be. Because of the vast spectrum of chemical compounds that may be present in landfill leachate, groundwater within the dumpsites may be unfit for drinking and other household purposes. Several common contaminants can be discovered

Table 1: Site description of sample locations.

S/n	Sample code	Street name	Distance [m]	Source of sample	North	East
1.	Bh_1	Moshalasi Street	610m	well	06°35′27.69″	003°22′19.48″
2.	Bh_2	Anisere Close	500m	well	06°35′23.13″	003°22′21.75″
3.	Bh_3	Kudirat Abiola Way	300m	Borehole	06°35′23.86″	003°22′30.67
4.	Bh_4	Ayinde Street	875m	Borehole	06°35′26.12″	003°23′26.79″
5.	Bh_5	Niyi Ogunleye Street	378m	Borehole	06°35′19.26″	003°23′24.76″

Source: Fieldwork 2022

in municipal solid waste (MSW). Because groundwater may be affected, particularly regarding how garbage is disposed of at LAWMA dumpsites, various studies have been conducted to see how these dumpsites influence groundwater quality in the surrounding areas. Flows into lakes and base flows into rivers from groundwater, as part of the hydrologic cycle, help maintain surface water systems by supporting inflow needs for surface water. Maintaining sensitive ecosystems' biodiversity and habitats often depends on these flows (Tharme 2003). Groundwater contamination can be transferred to surface water via the hydrologic cycle, impacting aquatic organisms' health and quality.

RESULTS AND DISCUSSION

Water samples were used to assess the landfill's impact on the area's groundwater quality. Tables and figures are used to displaying the information clearly and concisely.

Physical Parameters

Each sampling point's physical and chemical properties were found to comply with World Health Organization (WHO) standards in terms of appearance, odour, and turbidity. There was evidence of pathogens, such as active microorganisms, with temperatures ranging from 25.7 to 26.4°C below the recommended range of 35-40°C (Akinbile & Yusoff 2011, Jaji et al. 2007). Table 2 presented the physical parameters of water in the study area.

Chemical Parameters

According to W.H.O, NESREA, and NSDWQ standards,

Table 2: Physical Parameters of Water in Study Area.

Physical Parameter	Temperature [°C]	Appearance	Electrical Conductivity	Total Dissolve Solid	Odour	Turbidity (NTU)
W.H.O Standard	35 – 40	Colourless	1000	500	Odourless	5NTU
Bh1	26.4	Colourless	110.6	70.3	Odourless	Clear
Bh2	26.3	Colourless	119.3	92.3	Odourless	Clear
Bh3	25.7	Colourless	205.6	96.6	Odourless	Clear
Bh4	25.9	Colourless	150.6	63.3	Odourless	Clear
Bh5	25.6	Colourless	118.6	71.6	Odourless	Clear

Table 3: Chemical parameters in the study area.

	pH	Total Hardness [mg.L^{-1}]	Chloride [mg.L^{-1}]	Nitrates [mg.L^{-1}]	Phosphate [mg.L^{-1}]	Sulfates [mg.L^{-1})	Dissolved Oxygen [mg.L^{-1}]
NSDWQ	6.5 - 8.5	Not Stated	250	50	Not Stated	100	5.0
W.H.O Standard	6.5 - 8.5	100	250	10	5	250	Not Stated
NESREA	6.5 – 8.5	150	200	50	Not Stated	100	Not Stated
Bh$_1$	5.61	32.3	64.2	1.83	1.40	3.68	4.69
Bh$_2$	6.36	52.6	70.7	1.04	0.44	0.74	5.01
Bh$_3$	6.30	51.3	23.1	4.86	0.33	12.63	8.46
Bh$_4$	6.91	103.6	45.8	2.09	0.12	0.22	3.21
Bh$_5$	6.48	93.3	65.4	0.07	0.40	2.03	4.61

Table 4: Heavy metal concentration in the study area.

Parameters	Chromium [mg.L^{-1}]	Copper [mg.L^{-1}]	Iron [mg.L^{-1}]	Lead [mg.L^{-1}]	Manganese [mg.L^{-1}]	Magnesium [mg.L^{-1}]	Chloride [mg.L^{-1}]	Zinc [mg.L^{-1}]
NSDWQ	0.05	1	0.3	0.01	0.2	0.2	0.25	3.0
W.H.O Standard	0.05	2	0.1	0.01	0.4	0.4	1.5	Not Stated
NESREA	Not Stated	0.5	0.6	0.01	0.2	0.05	200	3
Bh$_1$	0	0	0.03	0.04	0.12	2.66	64.2	0.09
Bh$_2$	0	0	0.79	0.04	1.77	12.62	70.7	0.09
Bh$_3$	0	0	0.24	0.04	0.72	14.12	23.1	0.07
Bh$_4$	0	0	0	0.03	0	0.64	45.76	0.20
Bh$_5$	0.01	0.05	0.61	0.04	1.08	3.59	65.36	0.13

Table 5: Descriptive Statistics of water parameters in the study area.

S/N	PARAMETERS	MEAN	RANGE	STANDARD DEVIATION
1.	Calcium (Ca)	72.38	144.51	56.954
2.	Copper (Cu)	0.01	0.05	0.018
3.	Chromium(Cr)	0	0.04	0.010
4.	Manganese (Mn)	0.74	1.97	0.651
5.	Magnesium (Mg)	6.73	14.18	5.340
6.	Lead (Pb)	0.04	0.01	0.005
7.	Iron(Fe)	0.33	0.79	0.316
8.	Zinc (Zn)	0.12	0.13	0.045
9.	pH	6.33	1.76	3.116
10.	Total Dissolved Solids (TDS)	78.82	36	52.362
11.	Hardness	70.63	76	27.542
12.	Nitrates	2.46	4.81	1.636
13.	Dissolve Oxygen (DO)	5.20	5.25	6.753
14.	Sodium	1.98	3.13	1.041
15.	Potassium	21.072	73.266	26.228

the average concentration of chemical parameters is shown in Table 3. Samples of groundwater containing heavy metal concentration are shown in Table 4. Table 5 also presents descriptive statistics of water parameters in the study area.

pH: The groundwater's pH was somewhat acidic because of low amounts of metal pollutants (below 7). pH is one of the environmental parameters that influence the movement of pollutants. Toxic metals and nutrients can be released into the groundwater when acidity (low pH) is present in the water. When acidity is reduced (raising pH), some nutrients become insoluble and inaccessible to plants. In soil with a pH > 7.5, calcium binds phosphorus, making it less accessible to plants (Lake et al. 2000). WHO and NSDWQ recommend a pH range of 6.5–8.5 for drinking water. An acidity level that is slightly below normal indicates that water is not safe to consume. The pH of the lowest sample was found at Bh1, where it was 5.6.

Dissolved Oxygen: Water quality is closely tied to the concentration of dissolved oxygen (DO). According to the NSDWQ, the oxygen levels in groundwater samples from selected locations Bh1, Bh4, and Bh5 were within the acceptable limit of 5.0 $mg.L^{-1}$; however, samples from Bh2 and Bh3 exceeded this threshold. Drinking water quality is not regulated in DO. When DO levels fall below 5 $mg.L^{-1}$, aquatic organisms are under stress, causing them to die.

Total Dissolved Solids: Table 4 shows that TDS levels in the samples were below the WHO recommendation of 500 $mg.L^{-1}$ and the NSDWQ allowable limit of 1000 $mg.L^{-1}$. According to the data, metals had been dissolved in the groundwater by dissolved chemical components.

Chromium: There were no significant differences in Chromium (Cr) concentrations between the sampling locations, as indicated in Table 4. Mean Cr concentrations are within the acceptable range of 0.05 $mg.L^{-1}$. Chromium compounds are classified as harmful or non-toxic depending on the metal's oxidized state. Even though chromium (III) is an important element that can be hazardous in large amounts, chromium (VI) compounds have been related to lung cancer. Chromium aids insulin in its role in blood sugar regulation. Diabetes, infertility, and heart disease have been related to a shortage of this metal (Al Osman 2019).

Nitrates: According to the WHO, NESREA, and NSDWQ, nitrate concentrations in groundwater samples were below the maximum allowed levels of 50 $mg.L^{-1}$ and 10 $mg.L^{-1}$, respectively. The high nitrate concentration of groundwater in landfills can be transferred to surface water, resulting in eutrophication. In addition, human red blood cells' capacity to carry oxygen can be hampered by water with high nitrate concentrations.

Lead: All of the samples had Lead levels that were over the acceptable limit. In each case, the WHO and NSDWQ allowable limit of 0.01 $mg.L^{-1}$ were exceeded by an average of 0.004 $mg.L^{-1}$. Children are particularly at risk from Lead's potentially detrimental effects on their health (Payne 2008). In the samples, lead concentrations weren't high enough to represent a significant health hazard.

Copper: All groundwater samples from the five locations analyzed were within the WHO and NSDWQ standards. Despite this, it has persisted and is completely safe to consume. The liver and kidneys can be damaged by copper toxicity, resulting in death. It can induce dizziness, nausea, vomiting, and diarrhoea, among other symptoms.

Iron: It was found that the concentrations of Bh2 and Bh5 were greater than the WHO limit of 0.3 mg.L^{-1} at 0.79 mg.L^{-1} and 0.61 mg.L^{-1}. Table 4 shows the average iron content to be 33 micrograms per litre. Discolouration and staining are possible when washing textiles in water with high iron content.

Comparison of Present Results with Previous Studies

Table 6 shows that the metal pollutants reported in samples by Olaniyan et al. (2015) were likewise discovered in this research. Nitrogen, Zinc, and Chromium levels were greater in his research, though. These metal pollutants were reported to have 26.0, 0.15, and 0.03 mg.L^{-1} values, respectively, whereas this research revealed amounts of 2.46, 0.12, and 0 mg.L^{-1}. Because of this, seasonality significantly affects how groundwater is polluted, as shown by the results. A shallow water table during the rainy season can contribute to groundwater pollution, whereas a deep-water table is more common during the dry season. Although Olaniyan et al. (2015) results were more accurate, the trash created by paint and plastic firms in Ojota, Ketu, and Oregun communities impacts groundwater pollution more than those identified in this study.

CONCLUSIONS

During a visit to the study area, it was discovered that there were insufficient facilities and that the waste disposal method employed was open dumping, which does not necessitate special oversight. Residents in this neighborhood have to rely on sachet water for their drinking water, while water for domestic use is provided by water trucks. A lot of pollution comes from the dump, making the environment unpleasant. According to the presence of leachate ponds, the landfill is responsible for this region's groundwater pollution. Residents in this area cannot breathe clean air because of the landfill, which contributes to air pollution.

In Lagos city, where adequately constructed waste facilities are lacking, insufficient solid waste management is a significant environmental issue. Leachates from municipal solid waste dumps are a major contributor to groundwater contamination in urban areas. The pH values of the groundwater samples taken near the dumpsite were generally low, with 84.58 percent falling below the World Health Organization recommended range of 6.5 to 8.5 for drinking water.

Table 6: Descriptive statistical analysis of water quality parameters in previous research.

Parameters [mg.L^{-1}]	Current Study		Olaniyan et al. (2015)	
	Mean	Range	Mean	Range
pH	6.33	1.76	5.63	0.38
DO	5.20	5.25	0.59	0.21
Nitrates (NO_3)	2.46	4.81	26.0	56.75
Iron (Fe)	0.33	0.79	0.56	2.34
Zinc (Zn)	0.12	0.13	0.15	0.22
Chromium (Cr)	0	0.04	0.03	0.09
Manganese (Mn)	0.74	1.97	0.27	0.30

According to the results of this study, the concentrations of various water parameters, such as dissolved oxygen (DO), iron (Fe), lead (Pb), manganese (Mn), and magnesium (Mg), were slightly higher than the WHO, NESREA, and NSDWQ permitted levels of 5.02 mg.L^{-1}, 0.33 mg.L^{-1}, 0.04 mg.L^{-1}, 0.74 mg.L^{-1}, and 6.73 mg.L^{-1}.

RECOMMENDATIONS

i. Based on the result obtained from this study, groundwater quality monitoring should be encouraged as a continuous process.
ii. Because seasons (dry and rainy) play a major role in the contamination level of water parameters, proper and appropriate treatment should be done according to seasonal variation.
iii. Even though some heavy metal concentrations in the study area are still within WHO, NESREA, and NSDWQ standard limits, investigations and further monitoring should be conducted regularly to assess the concentrations of heavy metals in groundwater.
iv. People should be educated about the negative impact of heavy metal concentrations on humans and plants.
v. The government should provide adequate and functional disposal facilities for appropriate refuse collection and disposal.
vi. Soil should be used to cover the daily waste collected to reduce air pollution in the study area.
vii. Proper remediation techniques should be utilized to prevent leachates from landfill and dump sites from further contaminating the groundwater.

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