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Assessment of Water Pollution Around Waste Dumpsites in Bariga, Lagos, Nigeria

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ABSTRACT

This paper investigates the impact of waste dumpsites on water quality near the Bariga dumpsite. The study found that waste dumps near water bodies have significantly impacted the water quality in the Bariga area, leading to groundwater pollution through leaching. Samples were collected from boreholes and monitoring wells between May and July 2024. The results showed that the levels of EC, TDS, chloride, Fe, and Zn at the Bariga dumpsite exceeded the Nigerian Standard for drinking water quality (NSDWQ-2007). This highlights the dangers of poor construction of eco-friendly landfills and careless waste disposal in waterways, which can lead to significant groundwater pollution. The research recommends that community members avoid careless waste disposal and that the government regularly monitor water quality for household use to prevent waterborne illnesses.

Keywords: Physio-chemical parameters; Heavy metals; Water contamination; Water quality; Eco-friendly landfills; Bariga dumpsite; Environmental impact; Waterborne diseases; Monitoring wells; Waste disposal.

1. Introduction

Water is vital for life as well as for economic growth, food security, poverty alleviation, and sustainable environmental processes [1]. The continuous growth in the global population is projected to heighten the need for clean water for household activities, agriculture, and other purposes that require it. In most developing countries, the contamination of surface and groundwater resources has been worsened by inadequate sanitation systems and other factors [2-4]. Coastal areas are enclosed by water but frequently lack access to drinkable water. Most of them typically bear the brunt of uncontrolled disposal of industrial and domestic wastewater. In the coastal area of Southwestern Bangladesh, around 25% of the people do not have access to clean drinking water, even though they are close to water sources [5]. Laura et al. [6] investigated the water quality in this area and discovered that levels of arsenic, salinity, and various pollutants exceeded Bangladesh's drinking water standard and WHO guideline values. This was linked to various skin and intestinal illnesses like dysentery, fever, and diarrhea in the area [7]. They also examined different water sources in six coastal regions of Ghana, discovering that the residents heavily depend on surface water, piped water, rainwater, bottled water, and sachet water for drinking. They also confirmed the overall low water quality in the area and suggested that there could be a significant increase in the risk of childhood diarrhea and other water-related infectious diseases. The global issue of waste disposal is a major problem in developing countries, caused by population growth, economic development, urbanization, and industrialization, along with inadequate waste management approaches. Nevertheless, garbage disposal sites have been identified as a significant danger to groundwater reserves in the nation, particularly in cities like Lagos State. This statement holds especially true in locations like Bariga, Iwaya, Alaba Rago, and Ilaje, where the quality of groundwater is negatively affected by leachate from dumpsites [8-10].

Contaminated leachate from dumpsites negatively impacts soil and groundwater quality, making groundwater pollution a significant issue. This is mostly because of poorly designed leachate treatment systems, thus requiring engineered landfills. The ability to efficiently collect, process, dispose of, or recycle solid waste is often restricted by the technological and managerial resources that are available [11]. Therefore, the garbage is placed in low-lying areas like valleys, dug-out sections, or specific parts of land in residential-urban areas. Accumulating pollutants in groundwater and using it for nearby communities may have harmful effects on human health. Most Lagos State residents do not have access to piped water from the public water supply (Lagos Water Corporation) and instead rely on privately constructed boreholes and wells for groundwater. Regrettably, the groundwater quality in Lagos State is at risk due to unregulated discharge of industrial and commercial effluents, improper disposal of municipal solid waste, release of residential sewage, use of agricultural chemicals and fertilizers, salt-water intrusion, urban surface runoff, leakage from underground storage tanks and pipelines, etc.

The constant discharge of leachate into surface and groundwater presents a potential threat to the health of individuals both on and off the site through direct contact (such as dermal contact and accidental ingestion) and indirect exposure (like the release of contaminants into the air and inhalation of vapors). Additionally, these dumpsites are recognized as the origins of human-caused methane (CH_4) emissions, therefore playing a role in climate change [12]. Numerous research projects have been conducted globally, including in the region examined in this paper, focusing on the influence of waste disposal on the quality of groundwater. Longe et al. [9] noted that the leachate gathering at the bottom of the landfill can eventually seep into the groundwater, while gas emissions present possible risks to the environment and health. Coker et al. [13] demonstrated that the pH, TDS, and EC levels in water samples from around the Ojota dumpsite exceed the maximum limits set by WHO, indicating that the boreholes in that area should be abandoned. Additionally, a significant connection and effectiveness have been shown in evaluating the impact of leachate (coming from solid waste). Longe et al. [14] demonstrated that higher levels of pollutants were found mainly in the areas downstream, with no distinct trends in migration or reduction. The soil layers under the landfill are found to play a major role in the levels of contaminants in the groundwater.

Hence, the aim of this research is to evaluate the quality of groundwater near chosen dumpsites in the Bariga region of the Lagos Metropolitan Area. The Bariga dumpsite is not legal. Moreover, the research aims to evaluate the potential for exposure to certain chemical contaminants in the chosen communities caused by the dumpsites. The main objective of the research is to assess the groundwater quality using physicochemical parameters and heavy metals and to compare the results with the National Safe Drinking Water Quality Standards (NSDWQ). This study broadens our understanding of trends in groundwater contamination at unauthorized dumping sites.

1.1. Study Objectives

(i) To investigate the influence of leachate from unauthorized dumpsites on groundwater contamination.

(ii) To identify key pollutants and their sources to understand their impact on water quality in the Bariga region.

(iii) To determine how leachate migration affects groundwater quality over time and identify any significant patterns or changes in pollution levels.

(iv) To assess the health risks to communities from chemical contaminants in groundwater.

(v) To investigate how leachate from unauthorized dumpsites affects groundwater contamination.

Asian Journal of Basic Science & Research
Volume 6, Issue 3, Pages 11-19, July-September 2024

2. Material and Method

The research took place at one location in the Lagos Metropolitan Area in the southwestern region of Nigeria (Figure 1). The area is categorized as having a tropical climate, with two main seasons: wet and dry. The rainy season typically starts from April to October, while the dry season spans from October to March [15]. In the city, the average temperature is 27 oC, and it receives more than 2,000 mm of rainfall each year [16,17]. June and July have recorded the most significant amounts of rainfall. The Lagos Metropolis sits on a mostly even plain, supported by layered sedimentary rocks in the Dahomey Basin [18]. The Dahomey Basin stretches from the eastern part of Ghana to the southern edge of Nigeria, extending to the western border of the Niger Delta [19]. These deposits span from the Cretaceous to the Quaternary in age [14]. Most Cretaceous sediments come from the Abeokuta Group, while Quaternary deposits consist mainly of alluvial, lagoon, and coastal plain sand deposits [20-23].

Lagos' primary aquifer is the Coastal Plain Sand [18]. It consists of three primary areas, each divided by impermeable layers of clay [21]. A silty clay layer, up to 10 m thick, acts as a semi-permeable barrier between the top aquifer and the one below. This happens at depths ranging from 20 m to 70 m and mainly functions as groundwater [21]. The third aquifer system is found deeper within the Benin Formation, with recorded depths ranging from 118 to 166 meters below sea level [21]. The estimated hydraulic conductivity of this aquifer is around 10–3 cm/s [14].

2.1. Study site selection

Past research on water pollution from leachate moving from dumping sites has mostly concentrated on dumpsites approved by the government. This research examines the levels of chemical pollutants at an illegal dumping site. Additionally, the study aimed to examine the controls on the migration patterns of the contaminant plume, with Bariga waste disposal sites being chosen as the focus of investigation in this research.

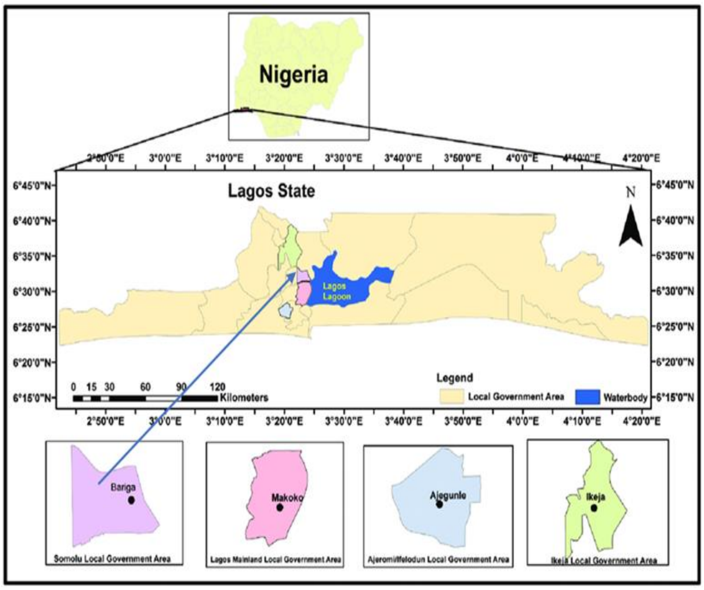

Figure 1. Site Locality Map indicating the Bariga Study Area

Bariga is located in Lagos at coordinates (6°31’54.00” N, 3°23’59.37” E). The Bariga dumpsite is an unauthorized waste disposal site located below the St Raphael Catholic Church and less than 200 meters away from the Lagos

Lagoon. The landfill is located in zones where there is a combination of residential, commercial, and industrial activities. Permission was sought from property owners to collect groundwater samples from boreholes in the two study areas. The boreholes were chosen at different distances from the sources of contamination to determine spatial patterns of the contamination plume and evaluate the risk of contaminant exposure to various end-users. Weekly groundwater samples were collected between May and July 2024. This aligns with the rainy season when the groundwater level is typically elevated. A sum of eight (8) groundwater samples were gathered near the Bariga Dumpsite. A sample of leachate from a composite surface was obtained close to the Bariga dumpsite (Figure 1).

2.2. Sampling and laboratory analysis

Before taking samples, the depth of the groundwater and the base of the well were measured with a dipping meter. The dipping meter was cleaned before each well or borehole to prevent any cross-contamination. The groundwater samples were gathered in sanitized 75-cl plastic sampling containers to reduce impurities before their use. The labels on the samples were precise, they were kept at cool temperatures, and they were tested within 5 hours of being collected to meet lab holding time requirements and preserve sample integrity.

The deep borehole samples were taken from taps at the sampling point, while the well was sampled using a plastic fetcher method until all physio-chemical parameters were stable. The sterilized sampling bottles were used to directly collect the leachate samples. Temperature, Total Dissolved Solids (TDS), salinity, and Electrical Conductivity (EC) were recorded on-site for each sampling site.

The experiment was carried out following the standard methods outlined in the 20th edition of the American Public Health Association [24]. The experiments were conducted in the Water Quality Lab at Geoearth Project Limited in Nigeria. Furthermore, samples were gathered for analysis of heavy metal concentrations, including Fe, Cu, Cr, Mn, Pb, and Zn. The benchmark for quality assessment was based on the Nigerian Standard for Drinking Water Quality [25] and the guidelines provided by the World Health Organization [26].

3. Results and Discussions

Tables 1 and 2 presented below depict the descriptive statistics analysis and summarized outcome of the measured groundwater parameters in this study. The Bariga dumpsite has a pH range of 5.4 to 7.1, with an average of 6.25, which falls below the NSDWQ standards of 6.5–8.5 for pH levels.

Table 1. Physio-chemical parameters values from Bariga dumpsite

Descriptive Stat.	pH	EC	Salinity	TDS	Calculated Hardness	Total Hardness	Chloride
		(uS/cm)	(ppt)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Minimum	5.4	633	188	483	54	51	233
Maximum	7.1	4210	6430	3982	163	602	3241
Mean	6.25	2421.5	3309	2232.5	108.5	326.5	1737
NSDWQ	6.5-8.5	1000	NV	500	NV	150	250

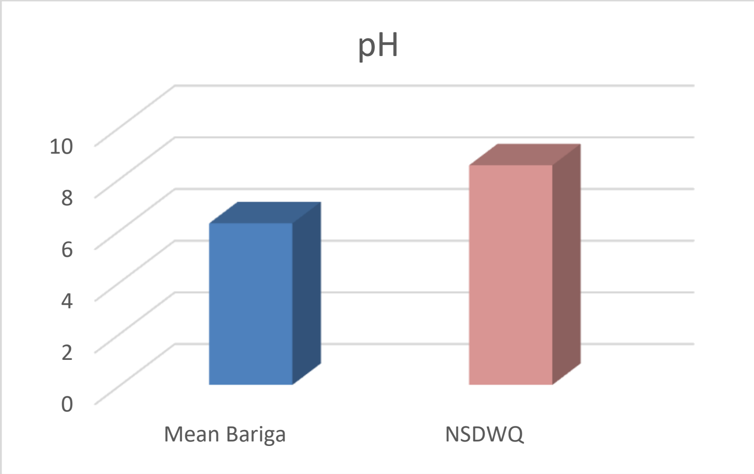

Figure 2. Showing the Mean pH of Bariga dumpsites

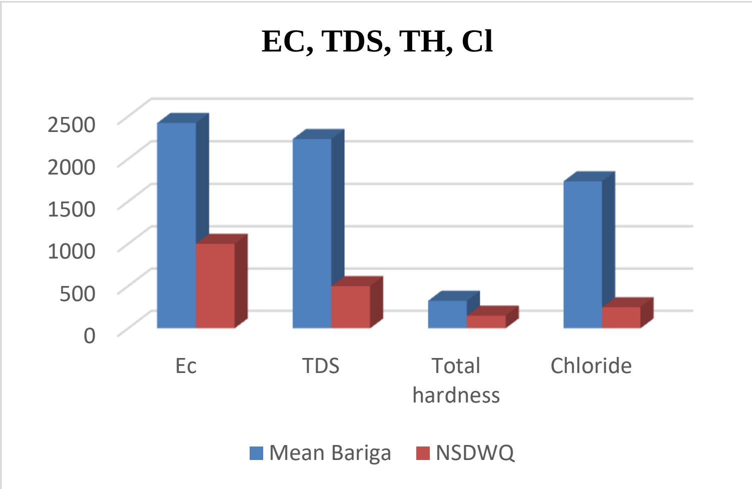

Figure 3. Showing the EC, TDS, TH, Cl of Bariga dumpsites

Table 2. Heavy metals values from Bariga Dumpsite

	Chromium (Cr)	**Copper (Cu)**	**Iron (Fe)**	**Manganese (Mn)**	**Lead (Pb)**	**Zinc (Zn)**
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
BAR 1	0.0021	0.021	0.40	0.078	0.092	3.38
BAR 2	0.012	0.016	0.36	0.019	0.004	4.42
BAR 3	0.022	0.007	0.49	0.087	0.002	3.67
BAR 4	0.031	0.034	0.38	0.059	0.007	3.56
BAR 5	0.041	0.011	0.29	0.018	0.0051	5.52
BAR 6	0.005	0.81	0.58	0.037	0.017	4.31
BAR 7	0.003	0.59	0.39	0.049	0.028	6.25
BAR 8	0.019	0.78	0.68	0.028	0.003	5.1
(NSDWQ)	0.05	1	0.3	0.2	0.01	3

The findings from the average pH values of the Bariga dumpsite indicate a slightly acidic concentration when compared to the NSDWQ standards. The Bariga dumpsite has water quality that meets NSDWQ standards based on Table 1, although it is slightly acidic. However, the levels of EC, TDS, TH, and chloride exceed the permissible limit for standards, indicating groundwater contamination due to increased dissolved ions in the water, as shown in

Asian Journal of Basic Science & Research
Volume 6, Issue 3, Pages 11-19, July-September 2024

Table 1 and Figures 2 and 3. This may be linked to the proximity of the Bariga area to the lagoon. Oyedele and Momoh's research on seawater intrusion in freshwater aquifers in a lagoon suggested that the salinity issue could be caused by the upward flow of water and salts from groundwater [27]. Seas, oceans, and lagoons have a major impact on coastal aquifers. The inundation of a barrier by seawater influx, as reported by Mafimisebi (2024), is a possible cause of subsurface salinity that does not take a long time geologically, where the impact of tsunamis on groundwater quality was evaluated. They wanted to understand how groundwater salinization occurs, suggesting that when seawater infiltrates the surface due to waves measuring 4 to 7 meters high, it carries dissolved salts that become trapped in the soil. The salts carried in by the powerful waves seep into the ground, and when the initial rains of the year come, the salts that have been absorbed trickle down to the underground water source, polluting it. The elevated chloride levels in the groundwater indicate pollution from the lagoon. This also heightens the water's corrosive potential, impacting infrastructure and the quality of drinking water, ultimately leading to mortality and harm to aquatic plants and animals due to stream acidification in the surrounding area. This research also indicated a small amount of heavy metal (Fe and Zn) pollution in the groundwater near the Bariga landfill site. Table 2 displays high levels of iron (Fe) and zinc (Zn) compared to other heavy metals, particularly in the boreholes and wells of the Bariga dumpsite, exceeding the acceptable limits. This means the groundwater near the Bariga landfill is not suitable for drinking. The primary reason could be attributed to its proximity to the lagoon and surface runoff, which may have a detrimental impact on an individual's health.

4. Conclusions

The contamination of groundwater sources is becoming more of a problem due to the indiscriminate disposal of solid waste, discharge of wastewater, and potentially harmful storm water run-off, putting the quality of drinking water at risk and jeopardizing the progress made to improve global access to clean water. The physico-chemical parameters in groundwater samples near the Bariga dumpsite exhibit a notable departure from the NSDWQ standards. Some factors that may be responsible for that observation include the uncontrolled nature of the waste, the amount of solid waste being deposited, and the proximity of the area to a lagoon. The elevated chloride levels in groundwater quality indicate contamination from sewage origins. This also enhances the water's corrosive potential, impacting infrastructure, water quality, and ultimately mortality and aquatic ecosystems due to stream acidification in the vicinity.

In the study area, the groundwater samples were found to have slightly acidic pH levels. This could be due to the high population density and commercial activities in those regions. A different type of groundwater pollution may result from the heavy metals (Fe and Zn) present in the Bariga dumpsite. It is clear from this research that poorly designed, eco-friendly landfills and haphazard waste disposal in waterways can result in significant groundwater contamination, endangering human health and the environment. A combined effort from both community members and the government is needed to prevent uncontrolled waste disposal and establish effective waste management.

The following suggestions should be taken into consideration to avoid any waterborne diseases in the future around Bariga community in Lagos, Nigeria: (i) Firstly, the local communities and Lagos State Government need to design and maintain eco-friendly landfills to prevent uncontrolled waste disposal at the Bariga dumpsite; (ii) Soon, the

Asian Journal of Basic Science & Research
Volume 6, Issue 3, Pages 11-19, July-September 2024

local communities and Lagos State Government need to strengthen and enforce waste disposal regulations; (iii) Thirdly, the Lagos State Government needs to raise awareness and involve the Bariga community in proper waste disposal practices; (iv) Lastly, the Lagos State Government needs to invest in continuous monitoring and remediation of groundwater contamination in the Bariga community.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The author declares no competing financial, professional, or personal interests.

Consent for publication

The author declares that he consented to the publication of this study.

Authors' contributions

Author’s independent contribution.

Availability of data and material

Supplementary information is available from the author upon reasonable request.

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