



Research Paper

Environmental Impact of Leachate Pollution on Groundwater Sources in Ikere Metropolis, Ekiti State, Nigeria

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Abstract

The physical, chemical, and bacteriological assessments of water samples collected from three wells situated near the landfill at Ayetoro quarters, Ikere-Ekiti, Ekiti State, Nigeria, were conducted to evaluate the extent of dumpsite pollution on the quality of groundwater in the vicinity. The borehole sites were positioned at radial distances of 20m, 50m, and 90m from the landfill site, respectively. The parameters measured included Temperature (28.17°C), pH (7.21), Conductivity (166.63µS/m), Dissolved Oxygen (0.62mg/L), Total Dissolved Solids (43.42mg/L), Total Suspended Solids (155.44mg/L), and Total Hardness (47.42mg/L). Additionally, Total Suspended Solids (155.44mg/L), Nitrate (0.62mg/L), Nitrite (0.46mg/L), Chloride (19.44mg/L), Magnesium (36.65mg/L), Calcium (10.77mg/L), Phosphate (357.73mg/L), Sulphate (272.73mg/L), and metal concentrations were analyzed. Notably, Chromium and Copper were undetectable in all analyzed samples. Most parameters indicated detectable pollution levels but remained below the limits set by the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ) for safe consumption. Bacteriological analysis indicated significant pollution across all wells. Furthermore, statistical evaluations revealed significant differences among all tested parameters at a 95% confidence level. The findings indicated minimal contamination of groundwater supplies. Nevertheless, it is crucial for the local community to receive education on appropriate waste disposal practices, and the promotion of sanitary landfills should be encouraged to avert further groundwater contamination.

1. Introduction

The problems associated with solid waste and its management have been the focus of considerable environmental attention during the last quarter of the twentieth century, as communities all over the world, have begun to recognize the hazards that its management entails. Over many decades, landfilling with municipal solid waste (MSW) has been a common practice in many countries, especially, in the developing ones. Rapid urbanization, industrialization, and population growth have been the major causes of waste generation, which invariably impose stress on the environment, leading to problems such as eutrophication of aquatic ecosystems and fish death, coral reef destruction, biodiversity loss, ozone layer depletion, and climate change. Wastes placed in landfills are subject to either groundwater underflow or infiltration from precipitation, and as water percolates through the waste, it picks up a variety of inorganic and organic compounds, flowing out of the wastes to accumulate at the bottom of the landfill. The resulting contaminated water is termed 'leachate' and can percolate through the soil. (Mor et al., 2006). Areas near landfills have a greater possibility of groundwater

contamination because of the potential pollution source of leachate originating from the nearby dumping sites. Such contamination of groundwater results in a substantial risk to local groundwater resource users and to the natural environment. Oftentimes, diseases such as typhoid fever, diarrhea, and amoebic dysentery have been associated with the consumption of waters polluted with solid or liquid wastes (Akinbile and Yusuf, 2011).

Pure and safe water is of vital importance to life, it sustains life generally. This necessitates the need to look at the level of purity of water taken by the people of Ayetoro community area of Ikere-Ekiti. The population of people in this locality is dense, and as such, heaps of waste are a common sight all over the community. Till date, there is little or no research work done on this topic in the locality, and people residing in this locality did not even know or care about the effect of leachate pollution on their groundwater sources. This research was undertaken to assess the possible impacts of leachate percolation on the groundwater quality of some wells located in proximity to a dumpsite at Ayetoro Quarters, Ikere-Ekiti, Ekiti State, Nigeria.

2. Materials and Methods

2.1 Study Area

The study areas were some wells in the vicinity of an open dumpsite located in Ayetoro community at Ikere-Ekiti, southwestern part of Nigeria. Ikere-Ekiti is one of the towns in Ekiti State. It is located between the latitude 7°30' N and longitude 5°14'E. There are two principal climate seasons namely, dry season lasting from November through March and rainy season from April to October.



Figure 1: Picture of the open dump site of Ayetoro Quarters, Ikere-Ekiti, Ekiti State.

As a result of a rapid increase in population due to creation of the state in 1996, there was increase in growth rate of houses, both residential and commercial in this metropolis with resultant indiscriminate dumping of wastes in most parts of the study area. As a result of this, the annual waste generated in this metropolis has also increased tremendously. This rapid rate of urbanization and lack of adherence to sound physical planning and developmental practices could pose threat of pollution to the groundwater resources in the study area. The wastes deposited in the open landfills are predominantly solid wastes like cans, used clothes, paper, metals, plastics, rubbers, nylons, kitchen wastes, etc. from domestic and commercial sources. Some people defecate on this site and also dead animals are often found on the dumpsite. Insects, rodents and flies which are vectors of diseases are common sights at this landfill site.

2.2 Water Sampling

Water samples were taken from three wells near the dumpsite which were located at Ayetoro quarters within the distance of 20m, 50m and 90m radially away from the dumpsite. The well waters are used for domestic purposes like drinking, washing, bathing, etc

and also for commercial purpose like construction of buildings. Water samples were collected twice a month from March to August, 2023. At each sampling point, the appearance, and odour were observed at the spot. For each well, 1 liter of the ground water was put into sterilized polyethylene bottles. The samples were immediately taken to the Chemistry Laboratory of Federal University of Technology, Akure (FUTA) for analysis. In the laboratory, the samples were kept in a refrigerator at 4°C pending further analysis. The analysis done covered physical, chemical and bacteriological parameters of water samples from each well. The physical parameters tested include odour, taste, colour, turbidity and temperature. Chemical parameters analyzed were pH, Dissolved Oxygen (DO), Total Hardness (TH), Nitrate (NO₃), Nitrite (NO₂), Chloride (Cl), Calcium (Ca), Sulphate (SO₄), Phosphate (PO₄), Total Suspended Solid (TSS), Electric Conductivity (EC), Copper (Cu), Magnesium (Mg) and Chromium (Cr). Standard methods of analysis, APHA (1998), were adopted for all the physicochemical parameters. Heavy metals in the water samples were analyzed using atom absorption spectrophotometry (AAS) after pre-concentration (Aiyesanmi, 2006). For every batch of sample for heavy metals analysis, spiked distilled-deionized water was treated in the same manner as the samples for accuracy study, with recoveries ranging from 96.5% to 98.9%. Data generated from the monitoring programme were subjected to simple descriptive analysis.

3. Results

The temperature, turbidity, color, and odor of the samples are outlined in Table 1. All samples are without color and odor. The turbidity measurements for the samples were below the WHO and NSDWQ threshold of 5 NTU (Nephelometric Turbidity Unit), with turbidity values recorded at 0.27 NTU, 1.27 NTU, and 0.63 NTU, respectively. Elevated turbidity levels in water indicate pollution and impair the clarity of the water. The temperatures of the water samples were between 27.7°C and 28.5°C, which is below the WHO recommended range for drinking water of 35°C–40°C.

Table 2 presents the findings and comparisons of the sample parameters in relation to the World Health Organization (WHO, 2004) and the Nigerian Standard for Drinking Water Quality (NSDWQ, 2007). The pH levels of the samples varied from 6.9 to 7.63, which fall within the acceptable range established by WHO and NSDWQ of 6.5–8.5. These results confirm the alkaline characteristics of groundwater in the examined region. The chloride levels in the water from the three wells were recorded at 17.01 mg/L, 24.90 mg/L, and 17.01 mg/L, respectively, all of which are below the maximum permissible limit of 250 mg/L for chlorides in drinking water as set by WHO and NSDWQ. The total hardness (TH) of the wells situated near the dumpsite had average values of 49.87 mg/L, 68.93 mg/L, and 23.47 mg/L, which remain compliant with the WHO and NSDWQ standard of 200 mg/L. Dissolved Oxygen (DO) is an essential parameter for evaluating water quality. The average values for the samples were 0.72 mg/L, 1.00 mg/L, and 0.14 mg/L, respectively.

Table 1: Physical characteristics of the well sample

Samples	Colour	Odour	Turbidity (NTU)	Temperature(°C)
W1	Colourless	Odourless	0.27	28.5
W2	Colourless	Odourless	1.27	28.3
W3	Colourless	Odourless	0.63	27.7

Table 2: Means of physico-chemical parameters of water samples from Ayetoro Quarters, Ikere-Ekiti

Variables	Mean std	Range	CV%	WHO standard
PH	7.21 ^e + 0.37	6.91-7.63	5.19	6.5-8.5
EC	166.63 ^{bc} + 20.81	143.33-183.33	12.49	300
Temperature	28.17 ^e + 0.41	27.70-28.50	1.48	30°C – 40°C
DO	0.62 ^e + 0.43	0.14-1.00	70.75	NS
TSS	155.44 ^{cd} + 62.68	95.21-220.32	40.33	500
TDS	43.42 ^{de} + 7.75	35.07-50.10	17.63	500
TH	47.42 ^{de} + 22.82	23.47-68.93	48.14	200
Ca	10.77 ^b + 3.72	6.46-12.92	34.64	75
Cl	19.44 ^e + 4.20	17.01-24.29	21.63	250
Mg	36.65 ^{de} + 19.5	17.01-56.01	53.21	NS
NO ₂	0.46 ^e + 0.24	0.19-0.65	52.22	13
NO ₃	0.62 ^e + 0.09	0.54-0.73	15.89	50
PO ₄	357.73 ^a + 203.09	195.12-585.37	56.77	NS
SO ₄	272.73 ^{ab} + 121.21	151.52-393.94	44.44	200

Table 3: Bacteriological parameter of the well water samples and comparison Standards for drinking water.

Samples	Bacteria constituent	Water sample result	Variance
W1	Total coliform bac.	1.5	+0.7
	<i>Escherichia coli</i>	1.4	+0.6
W2	Total coliform bac.	1.3	+0.5
	<i>Escherichia coli</i>	1.2	+0.5
W3	Total coliform bac.	1.0	0.2
	<i>Escherichia coli</i>	1.0	0.0

Calcium concentrations are significantly lower than the 75mg/L benchmark set by WHO and NSDWQ for drinking water. The measured levels range from 6.46 to 12.92mg/L, while the total dissolved solids (TDS) were found to be between 35.07 and 50.10mg/L, both of which are below the WHO and NSDWQ threshold of 500mg/L. Nitrate levels in the wells fluctuate between 0.54 and 0.73mg/L, which is under the WHO guideline of 50mg/L. Nitrite concentrations vary from 0.19 to 0.54 mg/L, also falling short of the WHO and NSDWQ limit of 3mg/L. Sulphate (SO₄) levels in the wells are recorded at 151.52, 272.73, and 393.94mg/L, with values for W{1} and W{2} exceeding the permissible limits of 200 mg/L and 250 mg/L as per WHO and NSDWQ standards. This suggests potential sulphate toxicity, which may lead to gastrointestinal irritation (Abdurafiu et al., 2011). Electrical conductivity (EC)

serves as a crucial metric for assessing the quantity of dissolved substances in water. The conductivity of the well samples ranged from 143 µS/cm to 183 µS/cm, which is below the WHO and NSDWQ standard of 300µS/cm. Phosphate concentrations in the samples were recorded at 292.68, 585.37, and 195.12 mg/L, as detailed in Table 2. The total suspended solids in the well samples ranged from 95.21 mg/L to 220.32 mg/L, which are also below the WHO and NSDWQ threshold of 500 mg/L. No metals were detected in the tests conducted, indicating the absence of toxic waste in all samples.

Statistical analysis (ANOVA, $P \geq 0.05$) presented in Table 3 indicated that there were significant differences among the chemical parameters. Through the application of Duncan's Multiple Range Test, it was determined that the means of phosphate, sulphate, electric conductivity, total suspended solids, and total

hardness exhibited significant differences. However, the mean values for total hardness, total dissolved solids, temperature, and magnesium did not show significant differences at the 5% level of significance. Similarly, chlorine, calcium, pH, nitrate (NO₃), dissolved oxygen, and nitrite (NO₂) also did not demonstrate significant differences. Table 3 illustrates the bacteriological characteristics of the tested well water samples. The detection of *Escherichia coli* indicated a high concentration of thermotolerant coliform bacteria, exceeding one in all analyzed samples, which suggests faecal contamination from human waste originating from the dumpsite.

4. Discussions

The quality of groundwater is influenced by various factors, including the chemical composition of aquifers, the climatic conditions during their formation, and the volume of water present in the aquifer along with its circulation rate. Additionally, the activities of microorganisms, temperature, and pressure contribute to the chemical properties of groundwater. Aquifers possess permeability because the particles that constitute them, such as gravel or sand, are not densely packed, allowing for spaces between them. Water and leachates flow through these spaces (Ibiyemi, 2001).

The observed low temperature serves as an indicator of foreign bodies' presence. This is evident from the correlation table results, which show a highly significant correlation between TDS and temperature. Elevated temperatures indicate the presence of active microorganisms and suspended particles, leading to increased temperature. Although the chloride levels in the water samples were below the WHO and NSDWQ thresholds, their presence suggests pollution, necessitating treatment prior to use. Chloride concentrations exceeding 250mg/l can impart a detectable taste and have corrosive effects on various domestic and industrial equipment. High chloride levels in water are often regarded as an indicator of pollution and are considered a tracer for groundwater contamination (Loizidou et al., 1993). Elevated chloride levels indicate the presence of weathered silicate-rich rocks beneath the overburden and leaching from soil due to infiltration from landfills and other human activities. (Igbinosa et al., 2009).

Hardness is defined as the interaction with soap and the formation of scale, which elevates the boiling point of water and its pH level, yet it does not pose any negative health risks to humans. The hardness observed in water samples may result from the leaching of Calcium and Magnesium ions into the groundwater (Srinivasamoorthy et al., 2009). Total hardness values exceeding 200mg/l do not have any detrimental effects on human health; however, they indicate the presence of calcium and magnesium deposits. These ions hinder the formation of lather with soap, thus impacting the economic management of water resources. Nitrate, recognized as the most

oxidized form of nitrogen compounds, is frequently found in both surface and groundwater as it is the final product of the aerobic breakdown of organic nitrogenous materials. Typically, unpolluted natural waters contain only trace amounts of nitrate. This finding aligns with the research of Adeyemo et al. (2002), who noted that nitrate concentrations ranging from 0.1mg/l to 10mg/l are considered natural in groundwater. Nitrate is a crucial component of fertilizers and is essential for agricultural productivity. Following rainfall, various amounts of nitrate are transported from agricultural fields into adjacent water bodies and the groundwater table through processes such as infiltration, percolation, and seepage. Additionally, nitrates enter waterways from leaking septic systems, leachate from landfills, and runoff from livestock manure, animal waste, and emissions from vehicle exhausts.

Nitrites have a relatively short lifespan as they are rapidly transformed into nitrates by airborne bacteria. These nitrites interact directly with haemoglobin in human blood, resulting in the formation of methaemoglobin, which impairs the capacity of blood cells to carry oxygen. This condition poses a significant risk to infants under three months old, leading to a disorder known as methaemoglobinemia, commonly referred to as "blue baby" disease. Water containing nitrate concentrations above 1.0mg/l is unsafe for human consumption, particularly for infants (Akinbile and Yusof, 2011). Akinbile and Yusof (2011) indicate that nitrate levels below 1.00mg/l suggest oxygen depletion; this indicates that W1 and W3 have experienced oxygen depletion and must be treated prior to consumption. Comparable findings were documented by Jaji et al. (2007) and Igbinosa et al. (2009). Phosphate sources include laundry activities involving detergents, agricultural runoff from phosphate fertilizers, and processing plants where phosphates are utilized as food additives (Ademoroti, 1996). This explains why W1 exhibits the highest phosphate concentration, although it does not meet WHO standards.

The elevated levels of *E. coli* and total coliform bacteria exceed the water quality standards set by the WHO. Significant treatment of water from these wells is necessary before it can be safely consumed domestically. Disinfection of wells, along with other treatment methods such as chlorination, sedimentation, and filtration, is essential to render the water potable and suitable for household use (Akinbile and Yusof, 2011).

5. Conclusions

The findings of this research indicate that the leachate produced from landfill sites exerts a negligible effect on the groundwater quality in the area. The site's soil stratigraphy, which is primarily composed of clay, appears to have played a crucial role in the low concentrations or complete absence of contaminants, particularly heavy metals, in the groundwater samples.

The findings revealed extremely inadequate sanitation and detrimental impacts on the health of both humans and animals if the nearby well waters were utilized for household purposes. Due to the elevated levels of bacteriological contamination found in water samples from these wells, health issues including typhoid fever, diarrhea, and worm infestations are likely to occur if this water is ingested in its current condition. The detection of *Escherichia coli* and total coliform bacteria signifies microbial pollution of the groundwater resulting from human activities.

The presence of some contaminants, even though below the WHO permissible limits in the groundwater samples, is an indication that in the absence of a leachate collection system, the uncontrolled accumulation of leachates over time at the landfill base may become a significant threat to the groundwater quality. Thus, the findings obtained in this study have shown that groundwater supplies of the study area is good for drinking and domestic purposes after treatment, however, there is need to improve on waste management practices and construction of properly engineered sanitary landfills to curtail the pollution of groundwater sources.

6. Statements and Declarations

Ethical Approval: Not applicable

Conflict of Interest: No conflict of interest

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