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Assessment of Physicochemical Parameters in Groundwater Quality in Ikere-Ekiti, Nigeria

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Abstract- Groundwater serves as the primary source of water supply for the Ikere-Ekiti community, essential for domestic, agricultural, and industrial use. The rapid population growth due to the establishment of a university has increased the demand for groundwater, putting pressure on its quality and availability. This study assesses the groundwater quality in Ikere-Ekiti through the analysis of physical and chemical parameters to determine its suitability for consumption. Water samples were collected from eight hand-dug wells across different locations and analyzed for parameters such as temperature, pH, turbidity, total dissolved solids (TDS), total hardness (TH), and electrical conductivity (EC), following standard methodologies. The results indicate that while most samples fall within acceptable limits set by the World Health Organization (WHO), some exceed permissible thresholds, particularly in turbidity, TDS, and EC, suggesting potential contamination from natural and anthropogenic sources. The findings highlight the need for continuous monitoring and proper groundwater management strategies to ensure sustainable water quality in the community.

Indexed Terms- Groundwater quality, Ikere-Ekiti, water contamination, water management, drinking water standards.

I. INTRODUCTION

Just like many regions of the world, groundwater is the major source of water supply to the Ikere community, and it is essential for human survival [1]. This source of water is basically used to meet daily demands for domestic, agricultural, and industrial purposes. The advent of the university in the community increases demand for water supplies due to the geometric increase in population, putting enormous pressure on the groundwater source, which is heavily relied on to meet their water needs. Groundwater is a very valuable resource in dry and semi-arid areas where surface water and rainfall are not regular.

The quality of groundwater in a region is determined by physical and chemical characteristics that are greatly influenced by natural phenomena such as water chemistry in the recharged area, water mixing from different sources, groundwater recharge, aquifer discharge and replenishment, water flow path, the interaction between underground water-rock mineral deposits and water, redox reactions, water retention time, ion exchange, environmental conditions, and natural features [2].

The increasing demand for water that is safe for consumption and available for domestic and agricultural use put a strain on the universe's remaining useable water resources [2]. This ongoing issue encourages stakeholders and researchers to explore a range of strategies for sensible groundwater resource management and protection [3]. Without access to surface water, the study community relied heavily on groundwater for survival, which is readily accessible through hand-dug wells.

An estimated population of over four million consumers, mainly in the developing countries, is prone to drinking contaminated groundwater [4]. The many sources of groundwater contamination revealed by studies include septic tank seepage, leachates from open dumps, industries, and agricultural waste spillovers [5-7]. Water quality reduces as a result of these contaminants entering water systems. To measure trends in groundwater quality, several tools, such as regression analysis and more elaborate parametric and non-parametric means, had been used by researchers. Long-term water quality changes adopt the use of Geographic Information Systems (GIS) and trend detection methods to solve potential groundwater quality problems. The aim of this research work is to assess groundwater quality in Ikere-Ekiti

II. METHODOLOGY

2.1 Study area

Ikere-Ekiti, a prominent town in southwestern Nigeria, is the second-largest in Ekiti State, located about 7 kilometers from Ado-Ekiti, the state capital. Geographically, Ikere-Ekiti lies between latitudes 7° 25"30' and 7°34"00' North and longitudes 5°04' 30" and 5°19'00" East, within the tropical rainforest zone with two distinct periods of rainy and dry seasons [8]. The town experiences a tropical climate, with a rainy season from April to October and a dry season from November to March. Annual precipitation averages 141.7 mm, with temperatures ranging from 21°C to 28°C. Vegetation includes tropical forests in the south and guinea savanna in the north [9]

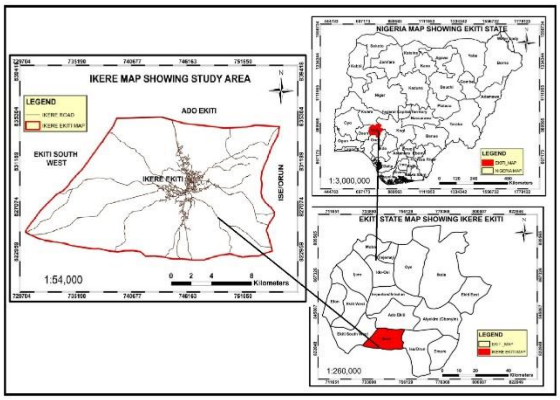

Figure 1: Map of the study area

2.2 Groundwater sample collection

Groundwater samples were obtained from 8 dug wells at different locations within the study area as shown in Table 1. Before processing, the samples were collected in pre-washed polyethylene (PE) bottles (1 liter). The sample bottle was rinsed with the water sample at the point of collection. To avoid contamination and the effects of light and temperature, these sample bottles were sealed and stored at a constant temperature of 4 ∘C and were transferred to the laboratory for analysis to establish the overall quality of the water in each of the samples. Every sample was assessed for a number of characteristics (alkalinity, turbidity, TH, TDS, EC, Zn2+, Pb2+, Fe2+, Mn2+, Ca2+, Cu2+, Na+, Cl-, SO42-, and NO3-) to measure the optimal drinking water quality and were related to World Health Organization [10] approved guidelines

Table 1: Details of sample

Sample Location	Sample Designation
EWE NLA (7049N, 5020E)	S1
EWE NLA (7051N, 5021E)	S2
NITEL (7049N, 5021E)	S3
NITEL (705N, 5021E)	S4
IDI-ISIN (70493N, 5.21E)	S5
IDI-ISIN (70495N, 5015E)	S6
MOSHOOD (70489N, 5024E)	S7
MOSHOOD (70479N, 5023E)	S8

2.3 Sample water analysis

The temperature and pH tests were performed at the location of samples taken with calibrated standard instruments and adopting the standard protocols and procedures of the American Society for Testing and Materials (ASTM) standard instruments [11]. Sample temperature was measured with a thermometer on-site. A pH meter was used to measure the pH of the water samples. Before collecting the data, the pH meter was calibrated with two standard solutions (pH 4.0 and 6.86). After dipping the pH sensor in the water sample and keeping it for a few minutes to get a stable reading, the result of each sample was recorded. To eliminate cross-contamination across samples, the probe was cleaned with deionized water after each analysis. The APHA [12] methods adopted for analyses of water samples are presented in Table 2.

Table 2: Analytical methods used for determination of Physico-Chemical parameters

Parameter	Analytical Method
Temperature	Thermometer
pH	Potentiometry
Turbidity	Colorimetric
Electric Conductivity	Electrometric
Total Dissolved Solids	Gravimetry
Total Hardness	Titrimetric
Alkalinity	Titrimetric
Sulphates	Turbidity
Chloride	Titrimetric
Nitrate	Spectrophotometry
Manganese	Colorimetric
Iron	Colorimetric
Copper	Spectrometry
Lead	Spectrometry
Zinc	Spectrometry
Sodium	Flame Photometry

III. RESULTS AND DISCUSSIONS

Assessing the quality of groundwater is a very important task because it is a major factor that determines the suitability for domestic and industrial consumption. Thus, the physical and chemical properties of groundwater in Ikere-Ekiti are examined for the water quality parameters.

A. Physical parameters

Table 3 shows the results of physical parameters of groundwater in Ikere-Ekiti; it was observed that the temperature ranges from 27.0°C to 30.0°C. Although the WHO does not provide a direct standard for water temperature, it is noted that water temperatures above 25°C may affect taste, accelerate chemical reactions, and influence microbial growth. The temperature recorded for the samples may not directly impact health but could influence water palatability and the efficiency of disinfection processes. The pH values of groundwater tests range from 6.40 to 7.30, which implies that all samples fall within the WHO guideline except S6 and S8 (6.40), which are slightly below the lower limit, indicating slightly acidic water.

The turbidity of the samples S1, S3, S4, and S7 meets the WHO standard (3-5 NTU). While Samples S2 (6 NTU), S5 (18 NTU), S6 (10 NTU), and S8 (9 NTU) exceed the standard, indicating potential contamination, poor filtration, or sediment presence. All samples tested are within the acceptable ranges of WHO's Total Dissolved Solids (TDS), with sample S5 recording the highest value (642.86 mg/L). Sample S6 (357.14 mg/L) and S8 (321.4 mg/L) show moderate levels, possibly indicating the influence of mineral dissolution or contamination, which can significantly impact water quality by altering taste and odour [13]. The acceptable threshold of TDS in drinking water is 500 mg/l to 1000 mg/l [14]. TDS more than the permissible limit can cause gastrointestinal problems.

The observed range of total hardness of the water sampled is 2.83-22.96 mg/L, which means that all the samples are well below the threshold, indicating soft water, which is desirable for domestic use and drinking. Samples S3 (3400 µS/cm), S1 (2600 µS/cm), S2 (2500 µS/cm), S4 (2600 µS/cm), and S8 (2600 µS/cm) exceed the limit of electrical conductivity (EC), suggesting significant mineral content or contamination from agricultural, industrial, or geogenic sources. Samples S5 (1100 µS/cm) and S7 (2100 µS/cm) are closer to acceptable levels.

Table 3. Physical parameters of groundwater in Ikere-Ekiti

Code Bar	Temp. ºC	Turbidity NTU	Total Dissolved Solids Mg/l	Total Hardness Mg/l	Electrical Conductivity Us/cm
S 1	27.00	5.00	178.57	6.38	2600.00
S 2	28.50	6.00	214.29	7.65	2500.00
S 3	29.00	4.00	142.86	5.10	3400.00
S 4	30.00	3.00	107.14	3.83	2600.00
S 5	28.00	18.00	642.86	22.96	1100.00
S 6	29.00	10.00	357.14	12.76	2300.00
S 7	30.00	5.00	178.57	6.38	2100.00
S 8	28.50	9.00	321.40	11.5	2600.00

B. Chemical parameters

The chemical parameters analysis was divided into two; heavy metals and non-heavy metals. Table 4 revealed the results for heavy metals in the groundwater of the sampled location. It was observed that most samples (S1: 2.25 mg/L, S3: 1.53 mg/L, S6: 0.56 mg/L, S8: 0.94 mg/L) are within acceptable limits for zinc except for sample S5 (7.8 mg/L), which exceeds the limit, indicating potential contamination. Similarly, Sample S5 (0.1 mg/L) significantly exceeds the guideline for lead, which is concerning due to lead's toxicity and its potential to cause severe health effects, including developmental issues in children. Samples S1, S2, and S6 meet the guideline (0.01 mg/L), while lead was not detected in samples S3, S4, S7, and S8. The iron level in groundwater for samples S1, S2, S6, and S8 (0.02–0.08 mg/L) is within acceptable limits. Sample S5 (0.4 mg/L) exceeds the iron limit, which could cause staining of laundry, plumbing, and an unpleasant metallic taste. Samples S1 (0.6 mg/L), S5 (0.9 mg/L), and S8 (0.7 mg/L) exceed the limit of manganese, while samples S2, S3, S4, and S7 (0–0.2 mg/L) are within acceptable limits. Calcium levels vary significantly, with S5 (10.42 mg/L) being the highest. While this does not pose health risks, higher levels contribute to water hardness, which can affect household appliances. Copper was not detected (N.D.) in any samples, indicating no immediate risk from this parameter.

Table 4: Summary Result of the Heavy-metals test carried out on the well water Samples

Code Bar	Zinc	Lead	Iron	Manganese	Calcium	Copper
S 1	2.25	0.01	0.03	0.6	2.13	N.D
S 2	0.00	0.01	0.02	0.00	2.77	N.D
S 3	1.53	0.00	0.00	0.00	1.49	N.D
S 4	0.00	0.00	0.00	0.00	0.85	N.D
S 5	7.8	0.1	0.4	0.9	10.42	N.D
S 6	0.56	0.01	0.04	0.4	5.32	N.D
S 7	0.00	0.00	0.00	0.2	2.13	N.D
S 8	0.94	0.00	0.08	0.7	4.68	N.D

N.D; Not Detected

All samples show very low levels of concentration of all the non-heavy metals tested (sodium, sulfate, chloride, and nitrate) as seen in Table 5 when compared with the WHO standards displayed in Table 6 below, posing no health risks, risk of salinity or aesthetic concerns, or taste issues. Sample S7 (120.70 mg/L) and Sample S5 (8.40 mg/L) shows the highest concentration of chloride and nitrate respectively, though still well below the safe limit, indicating no immediate concerns. Chloride exists naturally in the form of sodium and potassium salts. The presence of chlorides for all the samples tested could be as a result of chloride-containing soils and rock undergoing leaching, which later got in contact with underground water [15]. Also, sewage effluents discharged by residents that found their way into underground water could lead to the presence of chloride in groundwater [16]. Highly concentrated waste containing nitrogen compounds can be oxidized to nitrate, and percolating the soil adjacent to the groundwater is a possible cause of nitrate detection in some of the samples' locations. Major health implications of excess nitrate in water are hypertension in adults [17] and methaemoglobinaemia in babies [18]. The total alkalinity results show that all samples are within the acceptable range, suggesting good buffering capacity to resist pH changes.

Table 5: Summary Result of the Non-Heavy metals test carried out on the well water Samples

Code Bar	pH	Sodium	Sulphate	Chloride	Nitrate	Alkalinity
S 1	7.20	0.45	4.00	86.40	3.00	115.20
S 2	7.30	0.00	0.00	109.50	0.00	116.80
S 3	6.50	0.00	2.00	91.00	1.75	104.00
S 4	6.90	0.00	0.00	75.90	0.00	110.40
S 5	6.60	0.84	9.00	99.00	8.40	105.60
S 6	6.40	0.30	1.00	76.80	0.75	102.40
S 7	7.10	0.21	0.00	120.70	0.00	113.60
S 8	6.40	0.48	2.00	70.40	1.37	102.40

Table 6: WHO [10] standards for groundwater quality parameters

Parameters	Maximum Acceptable Concentration (WHO, 2011)
pH	6.5 – 8.5
Electrical Conductivity	2500 µS/cm
Turbidity	5 NTU
Total Dissolved Solid	1000 mg/L
Total Hardness	500 mg/L
Zinc	3 mg/L
Lead	0.01 mg/L
Iron	0.3 mg/L
Manganese	0.1 mg/L
Calcium	75 mg/L
Copper	2.0 mg/L
Sodium	200 mg/L
Sulphate	250 mg/L
Chloride	250 mg/L
Nitrate	45 mg/L
Alkalinity	100 mg/L

CONCLUSION

The present study examined groundwater samples from different locations in Ikere-Ekiti for some physico-chemical parameters, which include pH, alkalinity, total dissolved solids, total hardness, electrical conductivity, zinc, lead, iron, manganese, calcium, copper, sodium, sulphates, chloride, and nitrate. The samples generally meet WHO standards for most parameters tested. Elevated electrical conductivity and high conductivity were observed in several samples, suggesting contamination or mineral leaching. Samples S1 and S8 show elevated manganese levels beyond WHO guidelines, which may cause aesthetic and operational issues. Lead contamination in S5 is of significant concern, as lead is highly toxic even at low concentrations and requires urgent remediation. The groundwater's non-heavy metals parameters mostly comply with WHO standards. Slight acidity in a few samples (S6, S8) warrants monitoring, but overall, the water is suitable for drinking without significant health risks. This analysis suggests that while some samples meet WHO standards, significant contamination in S5 and isolated issues in other samples indicate the need for remedial action to ensure safe drinking water.

Simple treatment methods, such as filtration, are highly recommended for all groundwater to reduce turbidity, manage contamination levels, and demineralize to address conductivity, and TDS are necessary before the water is suitable for drinking. Regular monitoring is essential to ensure compliance with WHO standards. Also, it is important to ensure that there are no groundwater contamination sources, like industrial waste, agricultural runoff, or sewage leaks, contributing to deviations in the physicochemical parameters.

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