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ASSESSMENT OF GROUNDWATER QUALITY IN OWERRI WEST LOCAL GOVERNMENT AREA, IMO STATE, NIGERIA

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ABSTRACT

Access to clean and safe drinking water is essential for human health and well-being. However, water quality remains a critical concern in many regions, including Owerri West Local Government Area (LGA) in Imo State, Nigeria. This study assesses the physicochemical, microbial, and heavy metal contamination levels of borehole water in three communities: Redemption Estate (Obinze), Eziobodo, and Ihiagwa. Water samples were collected and analyzed using standard laboratory methods to determine parameters such as pH, turbidity, total dissolved solids (TDS), dissolved oxygen (DO), electrical conductivity, nitrate, sulfate, chloride, and microbial presence. Results revealed that while most parameters were within permissible limits set by the World Health Organization (WHO) and Federal Ministry of Environment (FMEnv), the samples showed signs of microbial contamination, particularly coliform bacteria, posing potential health risks. The presence of heavy metals such as lead in the sampled locations exceeded safe drinking water limits, raising concerns about industrial and environmental pollution. Based on the findings, the study recommends regular monitoring of borehole water, community awareness programs on water safety, and government intervention to regulate borehole drilling and water treatment practices. Improved infrastructure and filtration systems, along with strict enforcement of water quality standards, are necessary to mitigate contamination risks. The study underscores the need for sustainable water management strategies to ensure long-term access to potable water in the study area.

Keywords: **Borehole water, Owerri West, Physicochemical**

1. Introduction

Water is essential for human survival, which explains the common expression that "water is life." It is one of the most important natural resources on Earth and plays a central role in sustaining life, supporting agriculture, industry, and domestic activities Wekesa and Otieno (2022). Water is a chemical compound with the formula H_2O, made up of two hydrogen atoms and one oxygen atom held together by covalent bonds Peter-Ikechukwu et al. (2015). It exists in three states: solid, liquid, and gas, Joardar et al. (2022). About 70.9% of the Earth's surface is covered by water, yet only a small fraction is available as freshwater for human use Peter-Ikechukwu et al. (2015). Most of the Earth's water is found in the oceans, while only

a very limited percentage exists as freshwater in rivers, lakes, groundwater, living organisms, and manmade systems Peter-Ikechukwu et al. (2015). Good quality water should be colorless, odorless, tasteless, and free from pathogenic organisms and harmful contaminants, since any trace of objectionable taste, odor, or color may indicate pollution Okoro et al. (2016).

Water is vital to all living organisms and contributes significantly to the global economy. A large proportion of freshwater is used in agriculture, while the remainder is used for domestic and industrial purposes Ejepu et al. (2022). Access to safe drinking water is therefore fundamental to public health and sustainable development. However, when water becomes contaminated, it loses its suitability for human consumption and may become a vehicle for the transmission of disease and exposure to toxic substances. Globally, unsafe drinking water remains a major cause of morbidity and mortality, particularly in low- and middle-income countries. According to the World Health Organization, contaminated drinking water is responsible for diseases such as diarrhea, cholera, dysentery, typhoid, and polio, leading to an estimated 485,000 diarrheal deaths annually (WHO, 2022). Similarly, a joint report by the UNICEF and WHO indicates that billions of people still lack access to safely managed drinking water services (UNICEF & WHO, 2023).

Poor water quality is strongly associated with a wide range of adverse health outcomes. Microbial contamination, particularly by fecal coliforms, is a major contributor to gastrointestinal illnesses, especially among children under five years of age (Prüss-Ustün et al., 2019). In addition to biological contaminants, chemical pollutants such as nitrates, heavy metals (e.g., lead, cadmium), and pesticides pose serious long-term health risks. Elevated nitrate levels in drinking water have been linked to methemoglobinemia ("blue baby syndrome") in infants, while prolonged exposure to heavy metals can result in neurological disorders, kidney damage, and increased risk of cancer (WHO, 2017; Li et al., 2021). Recent studies also highlight the emerging concern of chronic exposure to low levels of contaminants, which may contribute to endocrine disruption, developmental abnormalities, and other non-communicable diseases (Saha et al., 2022).

Water used by humans is obtained mainly from two broad sources: surface water and groundwater Duru et al. (2019). Surface water includes lakes, rivers, and streams, while groundwater is obtained from wells and boreholes Duru et al. (2019). Groundwater occurs beneath the earth's surface and is mainly formed through infiltration and percolation of water into the soil and rock layers Jena (2023). It is often regarded as a relatively pure and dependable source of water because it is naturally filtered as it moves through subsurface materials Umana et al. (2022). For this reason, groundwater is widely used for drinking, agriculture, and industrial activities, especially in areas where surface water is inadequate or unavailable Sheshe and Magashi (2015). Despite this perceived purity, groundwater is not completely free from contamination. Pollution from industrial effluents, agricultural runoff, poor waste disposal, and other anthropogenic activities can degrade groundwater quality and make it unsafe for consumption, Ighalo and Adeniyi (2020). Studies have shown that groundwater contamination is increasing globally due to rapid urbanization and agricultural intensification, leading to elevated concentrations of nitrates, heavy metals, and microbial pollutants (Lapworth et al., 2017; Wu et al., 2020).

In many parts of Nigeria, including Imo State, access to clean and safe drinking water remains a major public health concern according to Civil Resource Development and Documentation Centre (2016). Population growth, urbanization, and increasing demand for potable water have led many households to depend heavily on alternative water sources such as boreholes, bottled water, and sachet water. Among

these, borehole water is commonly used because it is relatively affordable and accessible. However, borehole water may be exposed to different sources of contamination, including heavy metals, chemical pollutants, and disease-causing microorganisms. Consumption of contaminated water can result in serious health problems, including gastrointestinal infections, typhoid fever, cholera, and long-term toxic effects associated with heavy metal exposure (Adimalla & Qian, 2019; Egbueri, 2020). In areas such as Owerri West Local Government Area, inadequate infrastructure, insufficient regulation, and limited public awareness of water safety practices may further worsen the problem of unsafe water.

Against this background, there is a need to assess the quality of borehole water in Owerri West Local Government Area of Imo State. Such an assessment is important because not enough studies have been conducted on drinking water quality in this area, particularly in communities such as Eziobodo, Ihiagwa, and Redemption Estate in Obinze. Many residents rely on these water sources without adequate knowledge of their quality or the possible health risks associated with their use. This study is therefore justified by the need to generate reliable data on borehole water quality in the area, provide baseline information for future researchers, and support public awareness on the importance of safe drinking water. It will also contribute useful information for public health planning, policy formulation, and sustainable water resource management. The study focuses on the assessment of borehole water quality in the selected study area through the measurement of relevant physical, chemical, and heavy metal parameters. These include temperature, turbidity, total dissolved solids, electrical conductivity, dissolved oxygen, pH, alkalinity, chloride, sulfate, phosphate, nitrate, and total hardness. The study also covers the determination of selected trace and heavy metals such as iron, cadmium, lead, calcium, and magnesium. In addition, relationships among borehole water quality parameters within the study area will be established, and the results obtained will be compared with relevant national and international standards for drinking water quality.

The aim of this study is to assess the quality of borehole water in Owerri West Local Government Area of Imo State and to provide recommendations that will help ensure the safety and potability of drinking water in the area. To achieve this aim, the study seeks to assess the physicochemical properties of borehole water in the selected local government area, analyze the microbiological quality of the water samples, compare the measured water quality parameters with national and international standards, identify possible sources of contamination affecting the water quality, and provide recommendations for improving water quality and safeguarding public health in the study area.

2. Materials and Methods

2.1. Materials

2.1.1. Description of Imo State

Imo State is bordered by Anambra State to the north for 84 km (52 miles), Abia State to the east for about 104 km (partly in the vicinity of the Imo River), and Rivers State to the south and west for about 122 km. The state lies within latitudes 4°45'N and 7°15'N, and longitude 6°50'E and 7°25'E, with an area of around 5,100 sq km, Bedient et al. (1999).



Fig. 1.0 Map of the study state, Imo State, Nigeria
Source: Nigeria Information & Guide, n.d., map of Imo State

2.1.2 Area of Study

Borehole water from Redemption Estate, Eziobodo, and Ihiagwa in the Owerri West Local Government Area of Imo State was sampled for this study. These areas were selected because boreholes serve as their sole source of drinking water, and they have a significant population, making them suitable for the scope of the research.

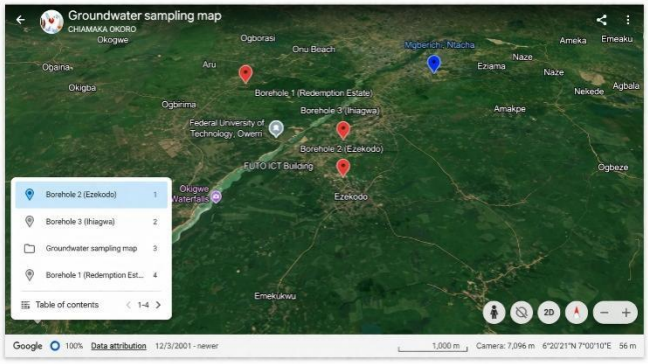


Fig. 2.0 Map showing sampling points (red)
Source: Google Earth, 2024; field data

2.1.3 Sample Collection, preservation and storage

Groundwater samples were collected using standard methods from three different households in the selected areas by allowing fresh water to flow directly from the boreholes through the taps. The sampling containers were thoroughly rinsed with the running water thereafter, the samples were collected in various containers: a 1-liter airtight plastic container for physico-chemical analysis, a 120 mL plastic container for metal

analysis (which was preserved with a 1:1 HNO_3 solution), and a 25 mL sterile container for microbiological analysis. The samples were carefully labelled, stored in an ice chest cooler, and transported to *Ebic Integrated Services Limited laboratory*, located at 23 Grafem Avenue, off Igbo-Etche Road, Port Harcourt, Rivers State, Nigeria, for analysis according to APHA (2018).

2.2 Method

2.2.1. Sterilization of materials

All the glasswares used for this experimental study which include beakers, measuring cylinders, petri-dishes, were sterilized in an autoclave at 121^{o}C for 15 minutes to avoid cross contamination of the samples.

2.2.2 Water Quality Analysis

2.2.2.1 Physical Parameters

These paremeters were analyzed in in situ to preserve their natural conditions. These include: temperature, pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), Turbidity and Dissolved Oxygen (DO) using HANNA HI 9829 Multi-parameter multimeter.

The main operating modes for HI 9829 are measurement, logging and setup. The measurement screen was configured to display measurement up to 6 simultaneous measurements by using the numbers 1-7 on the keypad while using the arrow keys to scroll through the measurements not being displayed.

Procedure: The probe was inserted to the Hanna meter and screwed up. Then the equipment was turned on by pressing the power key. The parameter button was selected by pressing the displayed key. Then parameters of interest were enabled by pressing the enable key, and then exited by pressing the ESC key. The probe/Electrode and sample beaker were rinsed with distilled water and then the sample. Exactly 2/3 of the sample was poured into the sample beaker. Then the measure key was pressed, using the up and down arrow keys to navigate to selected parameters and the reading was recorded. After recording, the meter was turned off by pressing on the power key and then the probe was unplugged. The meter was packaged and the sample beaker rinsed with distilled water, Akinnawo (2023).

2.2.2.2 Chemical Parameters

- **Total Suspended Solids (TSS):** Determined by the gravimetric method (APHA 2540 D), involving filtration of a homogenized sample through a pre-weighed glass fiber filter, followed by drying at 103-105 °C to constant weight.
- **Alkalinity**: Measured by titrimetric method (APHA 2320 B) using standard acid with phenolphthalein or methyl orange indicators, depending on sample pH.
- **Total Hardness:** Determined by EDTA titrimetric method (APHA 2340 C) at pH ~10 using Eriochrome Black T indicator to detect the endpoint.
- **Nitrate (NO_3^-):** Analyzed by the brucine colorimetric method (EPA 352.1), with absorbance measured at 410 nm after acid digestion and heating.

- **Sulphate (SO_4^{2-}):** Determined by turbidimetric method (APHA 4500-SO_4^{2-} E), measuring absorbance at 420 nm after $BaCl_2$-induced turbidity formation.
- **Phosphate-Phosphorus (PO_4^{3-}):** Measured using the vanadomolybdophosphoric acid colorimetric method (APHA 4500-P C) at 470 nm.
- **Chloride (Cl^-):** Determined by argentometric titration (APHA 4500-Cl^- B) using silver nitrate with potassium chromate indicator.
- **Metals (Cd, Ca, Fe, Pb, Mg)**: Analyzed using Atomic Absorption Spectrophotometry (AAS) after acid digestion (APHA 3030 F/G).

2.2.2.3 Microbiological Analysis (Fecal and Total Coliforms):

These were determined using the membrane filtration technique [22]., where water samples were filtered through a 0.45 µm membrane, cultured on selective Chromocult agar, incubated at 22 °C and 37 °C, and colonies (30 - 300 CFU) were enumerated based on characteristic color change.

3. Results and Discussion

3.1 Result

Table 1.0 Result of groundwater samples.

Parameter	Unit	Method	Sample Id			Drinking Water Standard Limit	
			BH1	BH2	BH3	FMEnv	WHO
pH	–	APHA 4500-H^+	6.64	6.75	6.79	6.5-8.5	6.5-8.5
Color	TCU	APHA 2120 B	1.00	1.00	1.00	15	15
Odor	TON	APHA 2150 B	1.00	1.00	1.00	3.5	3.5
Temp.	°C	APHA 2550-B	27.80	27.60	27.70	<35	25
E.C.	µs/cm	APHA 2510-B	98.70	73.80	68.30	NS	NS
DO	mg/L	APHA 4500-O	2.90	3.20	2.70	NS	NS
TDS	mg/L	APHA 2540-C	49.20	36.50	34.10	500	600
TSS	mg/L	APHA 2540-D	<0.01	<0.01	<0.01	30	NS
Turbidity	NTU	APHA 2130-B	<0.01	<0.01	<0.01	5.0	5.0
SO_4^{2-}	mg/L	APHA 4500-SO_4^{2-}	<0.01	<0.01	<0.01	500	250
Cl^-	mg/L	APHA 4500-Cl^--B	<0.01	<0.01	<0.01	250	250-300
Hardness	mg/L	APHA 2320-B	87.97	77.20	75.50	200	200
NO_3^-	mg/L	APHA 4500-NO_3^-E	0.337	0.469	0.166	50	50
Alkalinity	mg/L	APHA 2320-B	4.00	6.00	4.00	NS	NS
PO_4^{3-}	mg/L	APHA 4500P-B	<0.01	<0.01	<0.01	NS	NS
Fe	mg/L	APHA 3111-B	1.761	1.253	0.440	1.0	1-3
Cd	mg/L	APHA 3111-B	<0.01	<0.01	<0.01	0.01	0.003
Pb	mg/L	APHA 3111-B	0.310	0.367	0.356	0.05	0.01
Ca	mg/L	APHA 3111-B	19.852	16.711	16.029	NS	NS
Mg	mg/L	APHA 3111-B	9.567	9.100	8.857	NS	100
Total coliform	Cfu/mL	APHA 9221-B	28	39	75	NS	NS
Faecal coliform	Cfu/mL	APHA 9221-E	0	0	0	0	0

3.2. Discussion

3.2.1 Characteristics of Groundwater in the studied environment

The physical, chemical, metal, and microbiological properties of borehole samples collected at the study area were determined. Summary of the groundwater laboratory result is presented in table 4.1 above and the results are discussed below.

- **pH**: The pH of water determines the solubility that can be dissolved in the water and biological availability of chemical constituents such as nutrients and heavy metals. Most mineral waters have pH of 6 to 9 and unless there are natural or anthropogenic influences adding acidity or basicity, the pH of water remains reasonably constant [23]. The pH of groundwater depends largely on the buffering/attenuating capacity of the overlying soil and the effects of surrounding. Groundwater pH mean value recorded for all the sampled location was 6.82. This value signifies the absence or low amount of dissolved soluble substances in the water as well as biological and chemical constituents such as nutrients and heavy metals present in the groundwater. Essentially, the pH is determined by the amount of dissolved carbon dioxide (CO_2), which forms carbonic acid in water. Present investigation was similar with reports made by another researchers' study *(Edimeh et al. 2011; Aremu et al. 2011).*

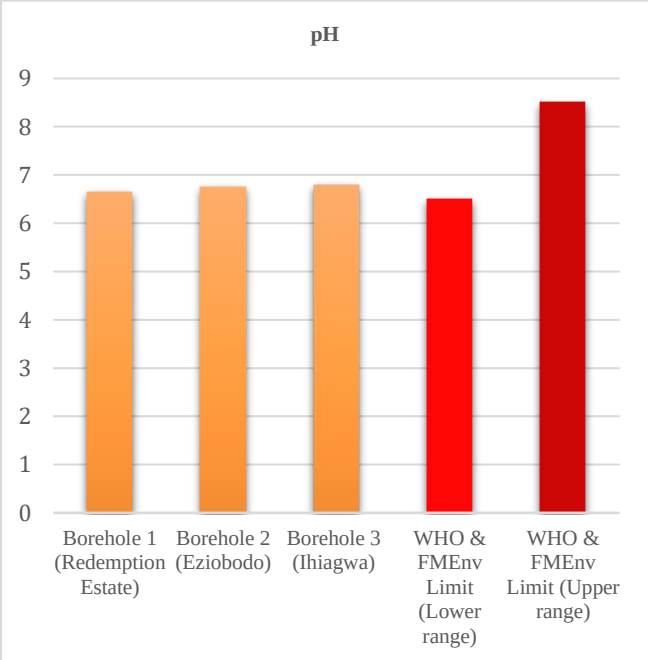


Fig. 3.0: Distribution of pH

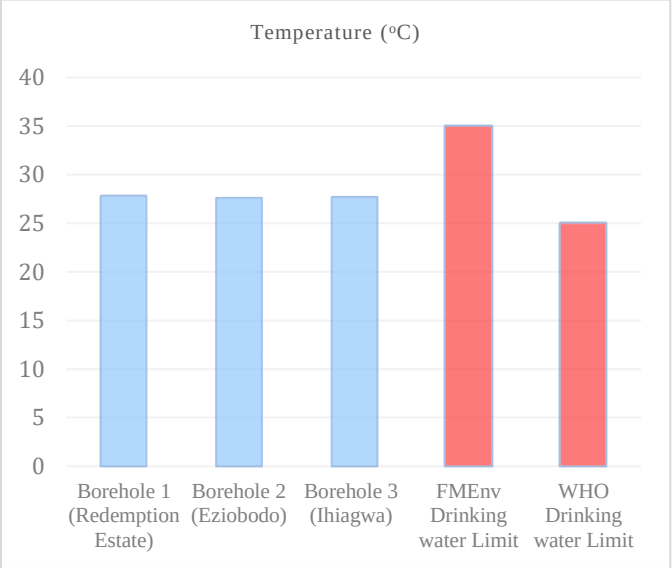


Fig. 4.0: Distribution of Temperature

- **Temperature**: High water temperature enhances the growth of microorganisms and may increase taste, odour, colour and corrosion problems. The temperature of the water samples within the study area was in the range of 27.60 - 27.80 ^{o}C with Redemption estate being the highest. This agreed with the Federal Ministry of Environment (FMEnv) Standard for drinking water Lu et al. (2022).

- **Dissolved Oxygen (DO)**: The DO concentration of the groundwater samples collected were relatively low as the amount of oxygen is not affected by microorganisms, chemicals, or pollutants within the study area. DO of the groundwater samples ranged from 2.70 - 3.20 mg/L.

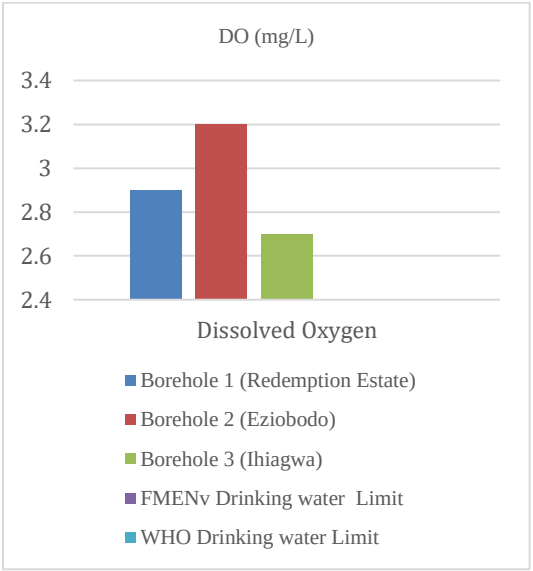


Fig. 5.0: Distribution of Dissolved Oxygen

- **Turbidity**: Groundwater turbidity values recorded were all <0.01 NTU in all sampled locations. Hence compliance with FMEnv turbidity limit was due to the absence of fine silt particles in the sample collected as presented in *figure 6.0* below.

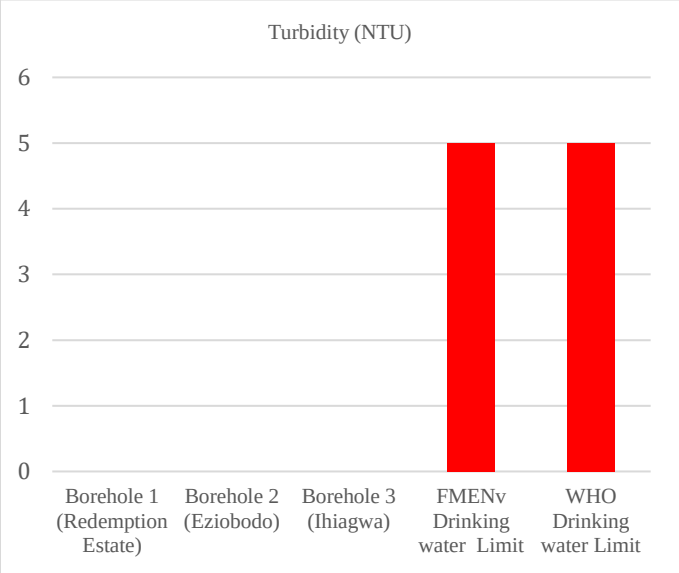


Fig. 6.0: Distribution of Turbidity

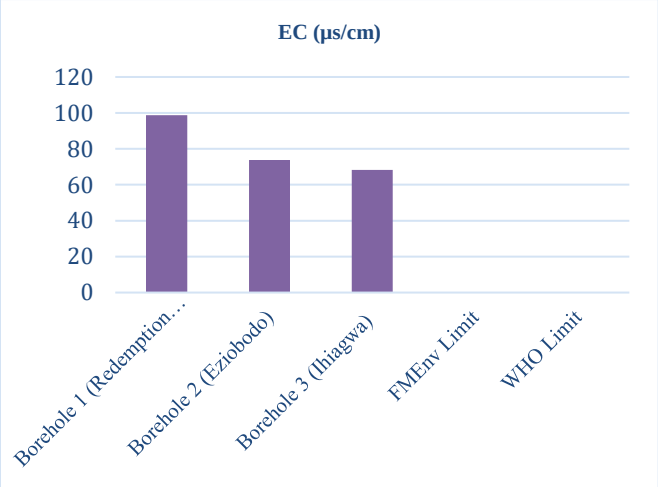


Fig. 7.0: Distribution of E.C.

- **Electrical Conductivity (EC):** Conductivity is the ability of a solution to permit the flow of electrical current. It varies with the number and type of ions in the solution. The conductivity in water is proportional to the concentration of dissolved solids, which in most cases are commonly inorganic salts. Pure water is not a good conductor of electric current but rather, it is a good insulator. Increase in ions concentration enhances the electrical conductivity of water. The higher the salinity of water, the higher its conductivity Cormick and Belizán (2019). The conductivity of the surface water analyzed was between the range of 68.30 µS/cm to 98.70 µS/cm. with Redemption estate being the highest. This was in agreement with the fact that Redemption estate had the highest TDS since the amount of dissolved solid in water determines EC. This value shows that the borehole

water had less ionized particles and was in compliant with the NIS standard of 1000 µS/cm for drinking water quality as presented in figure 7.0

- **Total Dissolved Solid (TDS):** Total Dissolved Solid (TDS) of water is the difference between the Total Solid (TS) and the Suspended Solid (SS). Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc. These minerals produced un-wanted taste and diluted color in appearance of water. This is the important parameter for the use of water. The water with the results showed that the Total Dissolved Solid of the sampled groundwater was relatively low with the values recorded as 34.10 mg/L, 36.50 and 49.20 mg/L for Redemption estate, Eziobodo and Ihiagwa when compared with the FMEnv and WHO standards of 500 mg/l and 600 mg/l for drinking water. This condition is an indication that the groundwater body was not inundated with substances emanating from land areas and farming activities going on within the communities and also there has been little or no salt water intrusion or seepage of minerals into the water as presented in figure 8.0. High values of TDS in groundwater are generally not harmful to human beings, but high concentration of these may affect persons who are suffering from kidney and heart diseases.

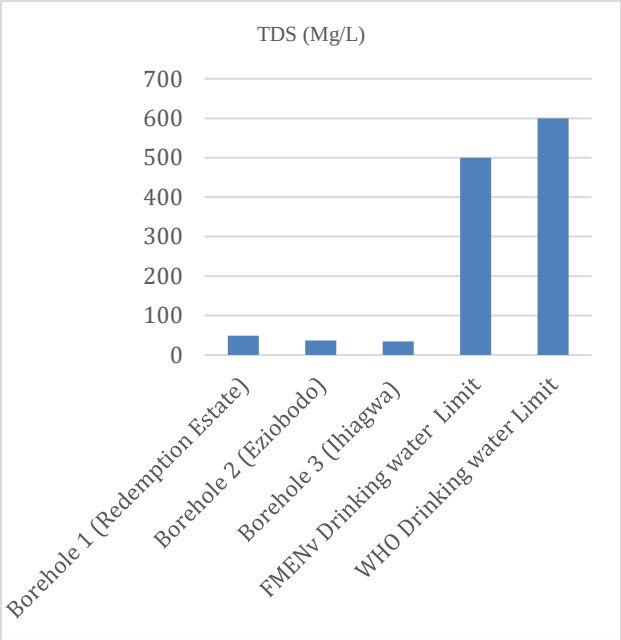


Fig. 8.0: Distribution of TDS

Total Suspended Solid (TSS): The results showed that the Total Suspended Solids of the sampled Groundwater were relatively low with values recorded as <0.01 for all sample locations which is in compliance with the FMEnv as presented in figure 9.0.

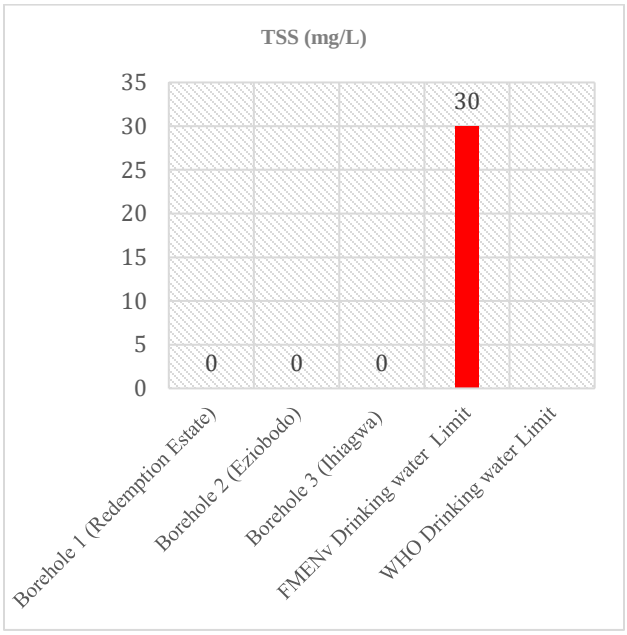


Fig. 9.0: Distribution of TSS

- **Total Hardness**: Total hardness of Water hardness is the total calcium and magnesium ion attention in a water sample and is expressed as the attention of calcium carbonate. The measure and subsequent control of water hardness is essential to prevent scaling and clogging in water pipes. Groundwater samples were in compliant with FMEnv drinking water standard limit of 200 mg/$CaCO_3$L for water hardness. The values recorded were 75.50, 77.20 and 87.97 mg/$CaCO_3$L as presented in figure 10.0. This is an indication that the water is not hard and can be recommended for domestic use.

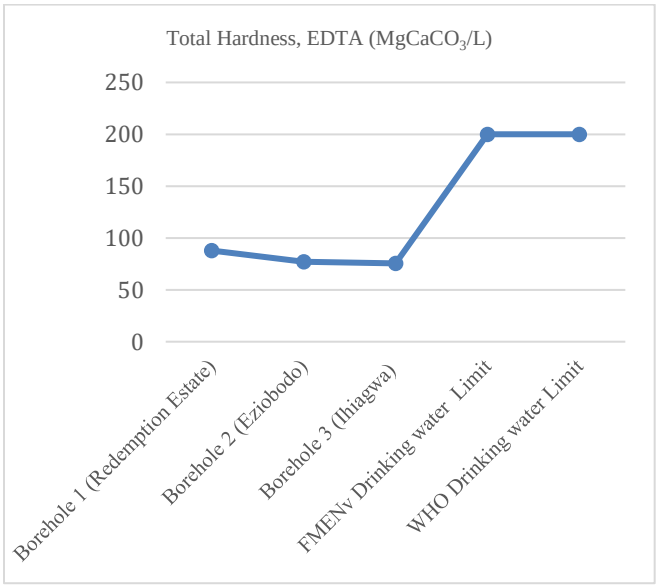


Fig. 10.0: Distribution of Total Hardness

- **Total Alkalinity**: total alkalinity represents the quantity of base present in water. The presence of bicarbonates, carbonates, phosphates, hydroxides, *etc.* causes an increase in alkalinity level De Filippi and Sappa (2023)**.** Alkalinity in this study was in the range of 4.0 - 6.0 mg/L, Eziobodo being the highest and these values were all in compliance with WHO 50 mg/l permissible limit for drinking water quality.

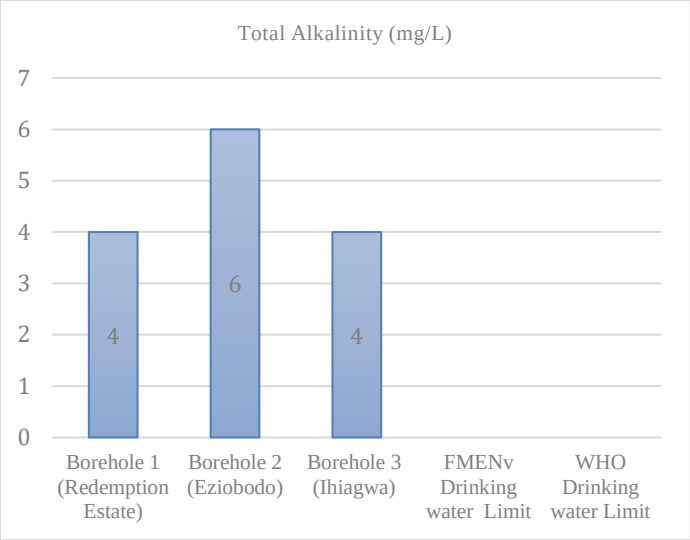


Fig. 11.0: Distribution of Total Alkalinity

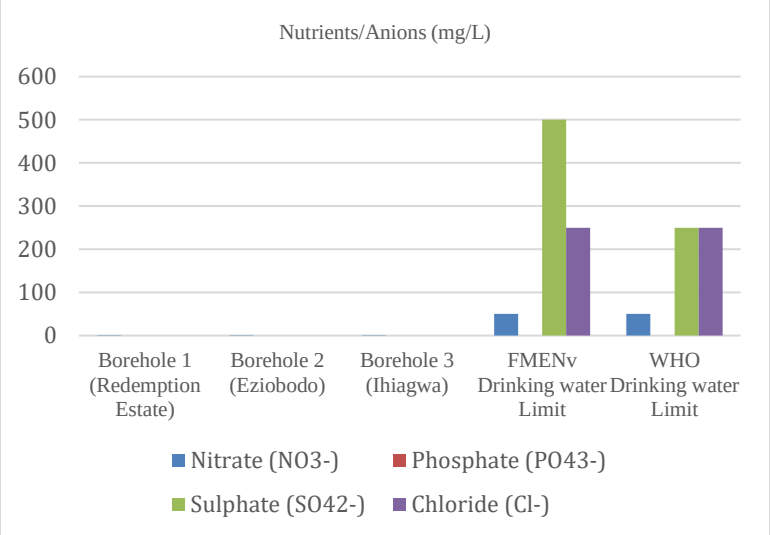


Fig. 12.0: Distribution of Nutrients/Anions

- **Nitrate (NO_3^-):** the nitrate concentration in groundwater water is normally low but can reach high levels as a result of leaching or runoff from agricultural land or contamination from human or animal wastes as a consequence of the oxidation of ammonia and similar sources Edimeh et al. (2011). High nitrate concentrations have detrimental effects on infants less than 3.6 months of age. Nitrate toxicity comes from the body's natural breakdown of nitrate to nitrite. This leads to "blue baby disease" which threatens the oxygen carrying capacity of the blood around the body Aremu et al. (2011).

Nitrate is an essential ingredient of plant nutrition. It is however regarded as an indicator of pollution in public water supply. Nitrate was in the range of 0.166 - 0.469 mg/L, Eziobodo being the highest. Nitrate in the water sample was relatively low and below WHO limit of 50 mg/L as shown in fig. 12.0 below.

- **Sulphates (SO_4^{2-}):** Sulphate occurs predominantly as calcium sulphate (Gypsum). Sodium and magnesium sulphate are readily soluble in water but calcium sulphate is less soluble. sulphates occur naturally in numerous minerals and are used commercially, principally in the chemical industry. They are discharged into water in industrial wastes and through atmospheric deposition; however, the highest levels usually occur in groundwater and are from natural sources Standards Organisation of Nigeria (2015) as shown in fig. 12.0 below. The result for sulphate were all <0.01. The sulphate concentration was relatively low and were within the FMEnv 500 mg/l and WHO 250 mg/l standard limits for drinking water. The existing data do not identify a level of sulfate in drinking-water that is likely to cause adverse human health effects. The presence of sulphate in drinking-water may also cause noticeable taste and may contribute to the corrosion of distribution systems Ogbeifun et al. (2019) shown in fig. 12.0 below
- **Phosphate (PO_4^{3-}):** phosphate enter water ways from human, animal waste and other sources like phosphorus rich bedrock, industrial effluents, fertilizer run-off, laundry and cleaning. Phosphates in water increase the tendency of troublesome algae to grow in the water. This causes eutrophication or over fertilization as it chokes up the water ways and uses up large amounts of oxygen Ichu et al. (2024). Phosphate was <0.001mg/L. This implies that the phosphate level in the water is very low as shown in fig. 12.0 below.
- **Chloride (Cl^-):** Chloride in drinking-water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt and saline intrusion. The main source of human exposure to chloride is the addition of salt to food, and the intake from this source is usually greatly in excess of that from drinking-water Bedient et al. (1999)**.** In this study, Cl^- was <0.001mg/L which was below the 250 mg/L to 300 mg/L permissible limit for WHO and Federal Ministry of Environment. Excessive chloride concentrations increase rates of corrosion of metals in the distribution system, depending on the alkalinity of the water. This can lead to increased concentrations of metals in the supply Bedient et al. (1999). Chloride concentrations in excess of about 250 mg/L can give rise to detectable taste in water shown in fig. 12.0 above.

Metals

- **Iron (Fe):** Fe is one of the most abundant metals in the Earth's crust. It is found in natural fresh waters at levels ranging from 0.5 to 50 mg/L. Iron may also be present in drinking-water as a result of the use of iron coagulants or the corrosion of steel and cast-iron pipes during water distribution Ogbeifun et al. (2019). The range of iron concentration in this study is 0.440 - 1.761 mg/L, Redemption estate being the highest. Iron stains laundry and plumbing fixtures at levels above 0.3 mg/L; there is usually no noticeable taste at iron concentrations below 0.3 mg/L, and concentrations of 1 - 3 mg/L can be acceptable for people drinking anaerobic well water, Adaji et al. (2021).
- **Cadmium (Cd):** Cd is released to the environment in wastewater, and diffuse pollution is caused by contamination from fertilizers and local air pollution. Contamination in drinking-water may also

be caused by impurities in the zinc of galvanized pipes and solders and some metal fittings. Food is the main source of daily exposure to cadmium. Smoking is a significant additional source of cadmium exposure, Standards Organisation of Nigeria (2015). In this study, Cd was <0. 001.Cadmium value was relatively low and in compliance with WHO and Federal Ministry of Environment permissible limit for drinking water. Cadmium accumulates primarily in the kidneys and has a long biological half-life in humans of 10 - 35 years. There is evidence that cadmium is carcinogenic by the inhalation route.

- **Lead (Pb):** Lead toxicity also referred to as lead poisoning, can be either acute or chronic. Acute exposure leads to loss of appetite, headache, hypertension, abdominal pain, renal dysfunction, weariness, insomnia, arthritis, hallucinations and dizziness. Acute exposure is obtained at place of work and in some manufacturing industries which make use of lead. Chronic exposure of lead can result in mental retardation, birth defects, psychosis, autism, allergies, dyslexia, weight loss, hyperactivity, paralysis, muscular weakness, brain damage, kidney damage and probably death Adaji et al. (2021). Pb is a general toxicant that accumulates in the skeleton. Infants, children up to 6 years of age and pregnant women are most susceptible to its adverse health effects Standards Organisation of Nigeria (2015). Lead was in the range of <0.310 - 0.367 mg/L, Eziobodo being the highest. The results from this study show that lead contamination was above WHO and FMEnv permissible limit of 0.01 and 0.05 mg/L.
- **Calcium (Ca):** Calcium is the fifth most abundant element in the earth's crust and is crucial for human cell physiology and bones. Approximately 95% of calcium in the human body is stored in bones and teeth, and a high calcium deficiency can lead to rickets, poor blood clotting, bone fractures, and other health problems, Ezeama and Achonye (2023). The WHO permissible range for calcium in drinking water is 7 5mg/l. In the study areas, results show that the concentration of calcium ranges from 16.029 - 19.852 mg/L, Redemption Estate being the highest.

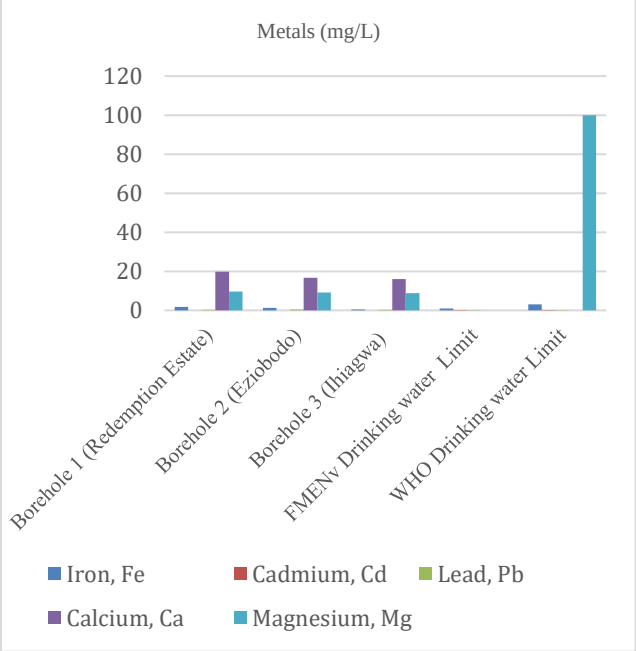


Fig. 13.0: Distribution of Metals

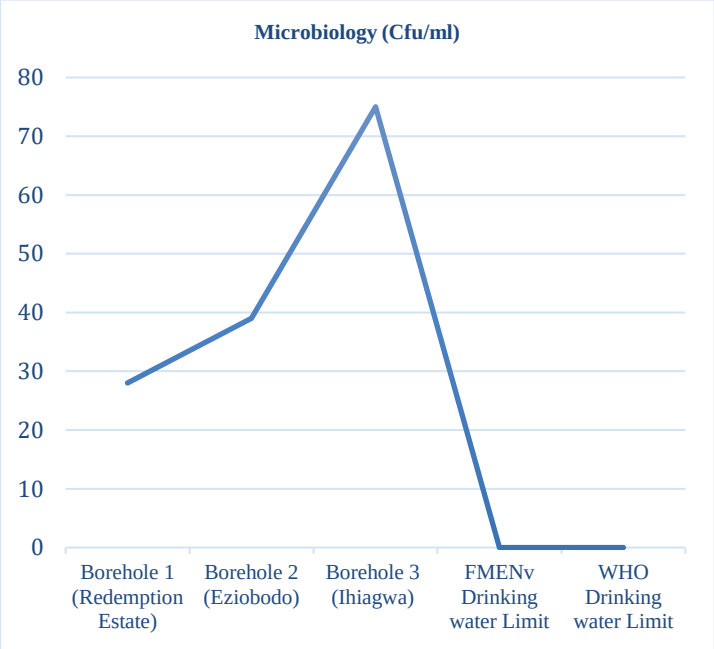


Fig. 14.0: Distribution of Microbiology

- **Magnesium (Mg):** Magnesium is a naturally occurring component of water and the eighth most prevalent element in the earth's crust. It is present in minerals like dolomite, magnetite, and others and is necessary for the healthy operation of living things. About 25 g of magnesium are found in the human body, with 60% of that being found in bones and 40% in muscles and tissues Meride and Ayenew (2016). The WHO recommends that the permissible limit of magnesium that can be present in water is 50 mg/L. Magnesium levels in the studied locations ranged from 8.856 - 9.567 mg/L, Redemption Estate being the highest. The findings show that the magnesium concentration was below the WHO and FMEnv permissible limit.

Microbial Analysis: The main indicator bacteria for the existence of pathogenic microorganisms in drinking water is the total coliform group. It is a key indicator of whether water is fit for human consumption. The presence of other harmful bacteria or organisms is quite likely if coliforms are detected in significant quantities in the water. The WHO drinking water regulations require the absence of total coliform in public drinking water supplies. In this study, all sampling sites were not detected of faecal coliform bacteria whereas all drinking water samples collected from Owerri West LGA and analyzed for total coliform bacteria showed significant growth which ranged from 28 to 75 cfu/mL as shown (Fig. 14.0). According to Adaji et al. (2021) risk associated in this drinking water is a high risk (28-75 cfu/mL) because low risk is classified from 1-10 cfu/ml. According to the study, all water sampling sites in Owerri West LGA did not meet world health organization standards for drinking water guideline.

4. Conclusion and Recommendations

4.1: Conclusion and Recommendations

This study assessed the quality of borehole water from Redemption Estate (Obinze), Eziobodo, and Ihiagwa in Owerri West LGA, Imo State, Nigeria, using standard physicochemical, microbiological, and heavy-metal analyses. The results show that most physicochemical parameters, including alkalinity, total hardness, nitrate, sulfate, phosphate, and chloride, were within the permissible limits of applicable drinking-water standards. However, deviations were observed in key safety indicators. Lead (Pb) exceeded acceptable limits, and total coliform bacteria were detected in all sampled locations, although faecal coliform was not detected. These findings indicate that, despite generally acceptable physicochemical quality, borehole water in the study area presents potential public-health risks due to heavy-metal contamination and microbiological quality concerns. Therefore, borehole water from the sampled communities should not be assumed safe for direct consumption without appropriate treatment and routine monitoring.

4.2: Recommendations

i. A need to establish a scheduled borehole-water testing program (e.g., quarterly) covering physicochemical parameters, total coliform/E. coli, and priority metals (especially Pb), with results shared publicly in the communities.

ii. Until consistent compliance with drinking water standard is confirmed, households and vendors using borehole water within the area should apply disinfection (e.g., chlorination/UV) and filtration before drinking, with clear guidance on safe storage to prevent re-contamination.

iii. Where Pb is above limit, apply lead-removal treatment (e.g., appropriate adsorption/filtration media) and investigate plumbing and fittings (e.g., old metallic components) that may leach metals into water.

iv. Improve borehole construction and protection measures: proper wellhead sealing, raised aprons, drainage away from the borehole, and maintaining safe distances from septic tanks, soakaways, refuse dumps, and flood-prone areas.

v. Promote sanitary handling during water collection and transport (clean containers, covered storage, routine cleaning) to reduce microbial contamination introduced after abstraction.

vi. Local authorities should enforce water-quality compliance for borehole owners and water vendors, including registration, periodic inspection, and corrective action plans where standards are exceeded.

vii. Implement community education on waterborne disease risks, interpretation of test results, and practical steps for household-level treatment and safe storage.

viii. Conduct expanded sampling across seasons (dry vs. rainy) and more boreholes to confirm trends, identify contamination hotspots, and better trace likely sources of Pb and microbial contamination.

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