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Physicochemical, total and faecal coliform detection of ground water in Osubi community Delta State, Nigeria

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The presence or absence of pathogenic bacteria, indicated by coliforms, serves as a key measure of water's sanitary quality. This study assessed the physicochemical properties and the presence of total and faecal coliforms in groundwater from the Osubi community. A total of thirty groundwater samples were collected from three boreholes (designated as Locations 1, 2 and 3) within the community. The samples were promptly transported to the laboratory for analysis immediately after collection. Obtained results reveal water samples to be acidic across all borehole water samples analyzed with pH values of 6.3, 6, 5.5 and 5.7 and temperature, reaching levels of 24.2^{O}C. Presence of iron lead and cadmium was observed amongst all heavy metals present with concentrations of 0.221, 1.1225 and 0.131 mg/L, and 0.826, 0.023 and 0.008 mg/L respectively, which is basically attributed to corrosion observed within collection sites. Total coliform levels varied from 27.5 MPN/100 ml to 38 MPN/100 ml, whereas faecal coliform counts fluctuated from 0 MPN/100 ml to 26 MPN/100 ml. The observed presence of coliform bacteria and faecal coliform in groundwater samples from Osubi reveals possible leaching from septic tanks into ground water source as well as indiscriminate dumping of animal excreta at top soil surface. Consequently, the water quality index (WQI) indicates that water from all three locations is unsuitable for human consumption. The reason for this poor quality is attributed to human activities around the borehole locations as well as poor environmental practices. Hence, it is recommended that water from all borehole location should be subjected to primary water treatment processes before use as well as regular coating of water tank to prevent iron corrosion and iron contents leaching into groundwater.

Keywords: Physicochemical, bacteriological, quality, groundwater, analysis, faecal.

INTRODUCTION

Water is a naturally occurring chemical compound made up of the elements oxygen and hydrogen in a 2:1 ratio. It is crucial to human existence on Earth since water makes up around two-thirds of the human body and one to seven liters must be consumed daily to maintain proper function and avoid dehydration. (Okonkwor *et al.,* 2011; Mbaenyi-Nwaoha and Egbuche, 2012). Man's demand for water is broadly classified into three categories: household, industrial, and agricultural (Jidauna *et al.,* 2014). A reliable supply of water for various reasons significantly improves the health, social, and economic aspects of human life (Ogunnowo, 2004).

The quality of water depends on its physical, chemical, and biological characteristics, which determines its utility for different purposes (Adhikary, 2010; Vazquez *et al.,* 2005). Water fit for human consumption is referred to as potable or drinking water and should be of safe quality, which entails that it does not present any significant health risk over life time consumption (WHO, 2006). Conventional drinking water systems rely on surface water sources like rivers, streams, and lakes, as well as groundwater sources like boreholes and wells. However, there is a growing reliance on groundwater due to increased contamination of surface water, which is thought to be cleansed as it flows down the bedrock (Agwu *et al.,* 2013).

The World Health Organization (WHO) recommends a minimum daily per capita water consumption of 27 liters (WHO, 2006). However, many people make do with significantly less than 27 liters (Franceys *et al.,* 1991). This could be because around 70% of renewable water resources are either unsuitable for human use, under-developed, or unevenly distributed (Minh-Phung *et al.,* 2011). Drought, desertification, and other kinds of water scarcity are already thought to affect up to one-third of the world's population, influencing consumption and migratory patterns in many regions (Adila *et al.,* 2025; Talafre and Knabe, 2009). The growing population and need for food and other services have raised the demand for water (Rodak and Silliman, 2011). The provision of sufficient amounts and quality of water has become more difficult as a result of this rising reliance on groundwater resources (World Water Day Report (WWDR), 2011). Individuals confronting a significant water scarcity must either restrict their consumption or utilize recycled untreated water.

The quality of groundwater receivers is affected by soil and air pollution, the disposal of domestic and industrial waste, organic materials, pathogenic microorganisms, and the use of fertilizers and pesticides in agriculture (Rashmi *et al.,* 2020; Ene *et al.,* 2010). Groundwater is one of the most significant natural resources required for human consumption, domestic services, agriculture, industry, manufacturing, and other sectors (Zeenat *et al.,* 2021; Papaioannou *et al.,* 2010).

The concentration of chemical species generally increases as groundwater traverses its flow paths below the surface (Kortatsi, 2007). Therefore, the chemistry of the groundwater may provide crucial details about the aquifers' geological past as well as the groundwater's appropriateness for residential, commercial, and agricultural uses. Groundwater chemistry is influenced by general geology, the degree of chemical weathering of various rock types, the quality of recharge water, and contributions from sources beyond water-rock interaction. Groundwater quality is complicated by these elements and how they interact (Guler and Thyne, 2004; Varquez *et al.,* 2005).

Large data sets that contain extensive information about the behavior of potable water sources and the properties of portable water could be gathered during water quality monitoring and assessment (Papaioannou *et al.,* 2010). Determining the parameters influencing home water quality and usage is crucial for the management of available water resources.

MATERIALS AND METHODS

Study area

Osubi community is located in Okpe Local Government Area, Delta State, at 05° 35′ 50″ N, 05° 49′ 10″ E. Its estimated total land area is 500 km². Its climate is tropical, with heavy rainfall from March to October for the most of the year. There are about 8,000 people living there. Since the Osubi neighborhood has experienced tremendous urbanization in recent years, the traditional water supply has become woefully inadequate, forcing the bulk of the residents to use subterranean water from boreholes. Because of its advantageous location and growing population, it is a thriving hub for trade and other economic activity. There are significant environmental issues as a result of the lack of physical design in situated markets and other business settings. There are inadequate waste management facilities in almost every town and hamlet in Nigeria.

With swampy and mangrove forests inland, the region is primarily composed of lowland, arable woods and vegetation upland. The Niger Delta Basin is home to the Oligocene Benin and Eocene Ogwashi/Asaba aquifers, based on the underlying geology of the area. Rainfall directly infiltrates aquifers, which are made up of alternating layers of silt, clay, sand, and gravel (Akpoborie *et al.,* 2011).

The following was how the Osubi community's ground water quality was evaluated:

Collection of samples and preparation

Water samples from boreholes were collected using the grab method. Thirty samples were collected from three locations in Osubi community using a plastic sampling vial and labeled appropriately. In the laboratory, each water sample were analyzed for its physical, chemical, and microbiological qualities. The average results obtained were compared to determine the quality of ground water in the Osubi community.

Determination of pH and temperature of water (ASTM 1293b)

The pH meter was first activated. The temperature probe and pH electrode were rinsed with distilled water and wiped dry with soft tissue paper. The pH electrode and probe were then immersed in a pH 4 buffer solution for calibration. After the reading stabilized, the calibration button was pressed. Subsequently, the electrode and probe were rinsed again with distilled water, dried with soft tissue paper, and placed in a pH 7 buffer solution. Once the reading stabilized, the calibration button was pressed again to complete the calibration process (Anonymous, 2002; Ademoroti, 1996).

Determination of total dissolved solids (TDS)

The total dissolved solids (TDS) meter was turned on, and the probe was rinsed with distilled water and wiped clean using a soft cloth or tissue paper. The probe was then immersed in the water samples, and the TDS measurements were recorded. Before testing additional samples, the probe was thoroughly cleaned with distilled water to avoid cross-contamination (Anonymous, 2002; Ademoroti, 1996).

Table 1. Coordinates for borehole locations.

Location	Coordinate
Location 1	N5º35'42.636", E5º49'40.30"
Location 2	N5º35'47.15", E5º49'37.90"
Location 3	N5º34'54.71", E5º48'20.95"

DETERMINATION OF TOTAL SUSPENDED SOLIDS (TSS) (ASTM1868)

Filtration Techniques

The Millipore filter paper (X mg) was initially weighed before being installed in the Total Suspended Solids (TSS) filtration assembly. The filter paper was properly positioned, and a clamp was used to secure it firmly in place. The water sample was stirred vigorously, and 250 mL of the sample was transferred into the filtration flask. Filtration was carried out using a vacuum pump. After filtration, the filter paper was dried in an oven for 30 min. It was then reweighed along with the recovered solids (Y mg). (Anonymous, 2002; Ademoroti, 1996).

$$Total\ Suspended\ Solids = \frac{(Y-X)\ x\ 1000}{sample\ volume} \qquad \text{(Eqn 1)}$$

Where;
X = weight of filter paper without solids
Y = weight of filter paper with solids.

Determination of lead, copper, iron, zinc and chromium (ASTM D6785)

The equipment was calibrated using a series of standard solutions containing lead, copper, iron, and chromium. Specific wavelengths were selected for the detection of each heavy metal: lead (283.3 nm), copper (580 nm), iron (248.3 nm), and chromium (358 nm). Between 10 and 30 mL of each water sample was measured into a conical flask. A conveyor hose pipe was then inserted into the sample and used to aspirate it into the flame. The concentrations of the target heavy metals were determined at their respective wavelengths. (Anonymous, 2002; Ademoroti, 1996).

TOTAL COLIFORM COUNTS (APHA 9222A1)

Most Probable Number (MPN) Test for Coliforms

All apparatus, materials, and growth media were sterilized using an autoclave. Three sets of five test tubes (or McCartney bottles), each containing 9 mL of MacConkey broth, were prepared. A 1 mL aliquot of the water sample was added to 9 mL of sterilized distilled water to perform a serial dilution.

From the serial dilution, 1 mL was introduced into each of the five test tubes in the first set containing MacConkey broth. Subsequently, 0.1 mL of the dilution was inoculated into the second set, and 0.01 mL into the third set. The contents of each test tube were gently agitated to mix the inoculum with the growth medium. The test tubes were then sealed and inverted before incubation.

All tubes were incubated at 37°C for 48 h. After incubation, each tube was observed for acid production, indicated by a color change, and gas production, indicating microbial growth. The number of positive tubes in each set was recorded and arranged in a standard sequence. The MPN (Most Probable Number) of coliforms per 100 mL of the original water sample was then estimated using McGrady's statistical table (Cheesbrough, 2009; Fawole and Oso, 2004).

DETERMINATION OF FAECAL COLIFORM

Detection of Fecal Coliforms Using MPN Technique

All apparatus, materials and growth media were sterilized using an autoclave. Water samples were filtered through a membrane filtration assembly, and the filter paper was carefully retrieved using sterile forceps. The filter paper was then placed on an absorbent pad and incubated at 35°C for 22–24 h.

Following incubation, an inoculating loop was used to transfer visible coliform colonies into test tubes containing a suitable broth medium. The contents of the tubes were gently agitated to ensure proper mixing, after which the tubes were sealed and inverted. The tubes were then incubated at 37°C for 24 h.

After incubation, each tube was examined for gas production, which indicated the presence of fecal coliforms. The number of positive tubes in each set was recorded and arranged in a standard format. The Most Probable Number (MPN) of fecal coliforms present in 100 mL of the original water sample was then estimated using the standard MPN statistical table (Cheesbrough, 2009; Fawole and Oso, 2004).

RESULTS AND DISCUSSION

Analysis of water samples from Osubi community gives respective results as given below. Data from each sample's location are represented as Locations 1, 2 and 3, representing water samples from three different boreholes within Osubi community (Table 1).

pH values obtained were below the allowable boundaries of 6.5-8.5 set by World Health Organization (WHO, 2006). These results obtained were in line with values obtained by Obot and Edi (2012), which reveals water samples from three different boreholes within Osubi community to be slightly acidic (Figure 1). This indicates the ability of certain metals to be dissolved into ground water. Statistical test reveals a significant difference ($p<0.05$) between pH values obtained from the boreholes sampled around Osubi community and this can be attributed to wastewater disposal around certain areas of Osubi community.

Temperature of samples were below the permissible limit set by WHO (2006) except for Location 3 (Figure 2). Statistical test reveals significant difference between water samples and this is attributed to season variation within time with which groundwater samples were obtained. The variation in water samples for various locations is attributed to weather conditions within different areas.

No measurable amount of suspended or dissolved solids was detected in the groundwater samples. This was attributed to the sanitary conditions of the borehole locations, which were free from nearby waste dumps (Figure 3). Over the years, residents of the Osubi community had maintained proper sanitation practices, particularly by ensuring adequate distance between boreholes and waste disposal sites. In contrast, Obot and Edi (2012) reported the presence of suspended and dissolved solids in groundwater samples, which was attributed to the close proximity of sampling sites to abattoir waste.

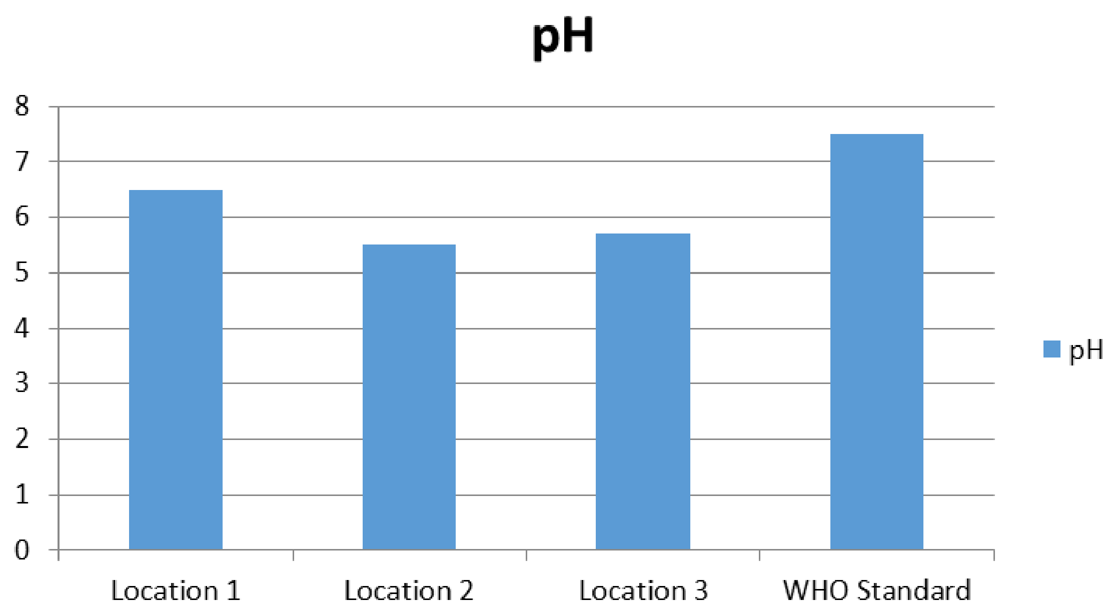

Figure 1. Showing pH values from three different borehole locations and standard values.

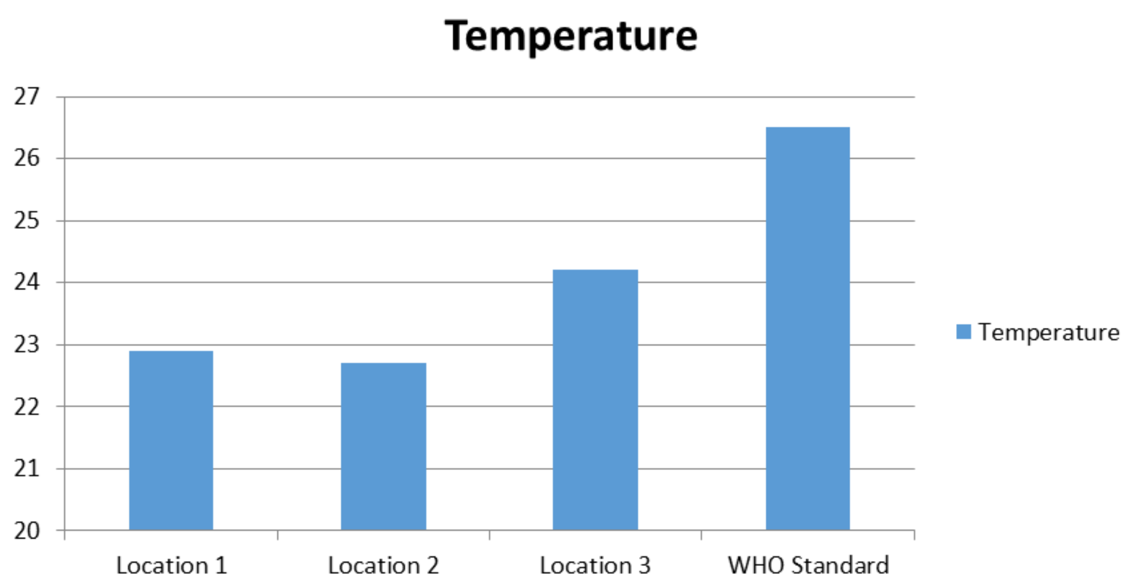

Figure 2. Showing temperature values from three different borehole locations and standard values.

The presence of heavy metals in water was recognized as a major contributor to various health issues, including cancer, and rendered the water unsuitable for both agricultural and domestic use. Zinc, as a heavy metal, imparted an undesirable astringent taste to water at concentrations exceeding 3 mg/L. The presence of iron in the water samples indicated the dissolution of exposed steel and metallic materials, which had likely percolated into the groundwater. The detection of lead, cadmium, and chromium was attributed to contamination from electronic waste, including batteries, paint cans, photocopy chemicals, used lubricants, and emissions from incineration activities conducted around the sampling locations.

The results obtained indicated the presence of iron, lead, and cadmium in the water samples (Figure 4), aligning with the findings of Ofomola (2015), who reported iron concentrations in boreholes within the Osubi community reaching up to 0.03 mg/L. Similarly, Okoro *et al.* (2017) documented iron levels as high as 0.6 mg/L. This presence was attributed to the exposed steel towers of water tanks. Visual inspection during analysis revealed that parts of the

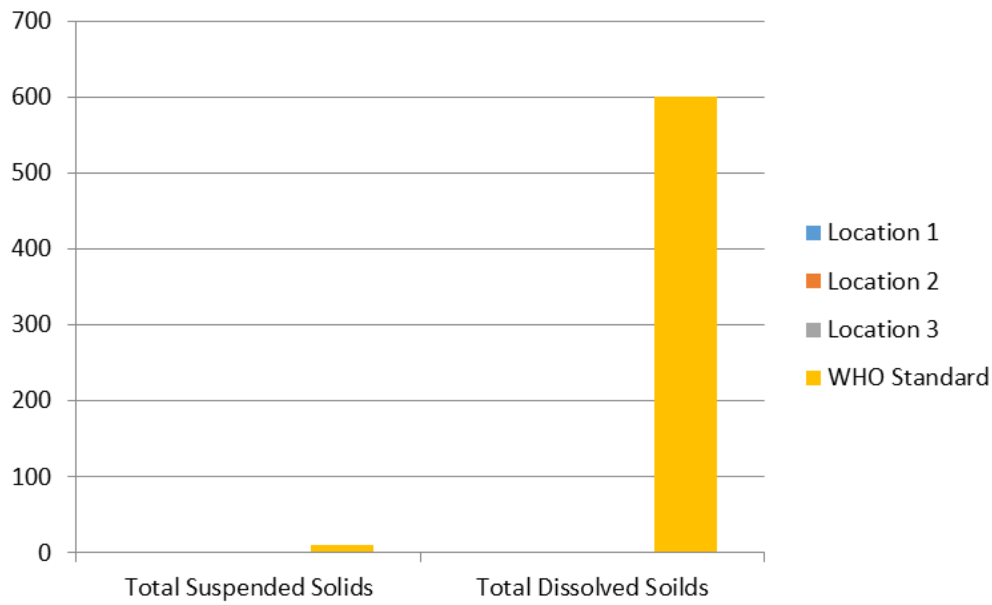

Figure 3. Showing total suspended solids and total dissolved solids values from three different borehole locations and standard values.

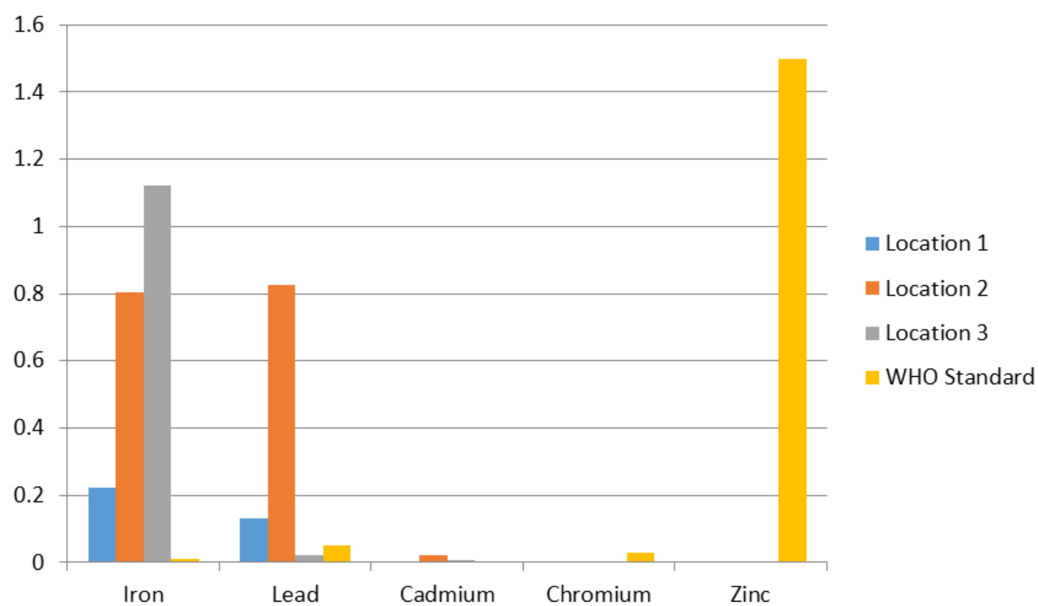

Figure 4. Showing heavy metals values from three different borehole locations and standard values.

tower structures were rusted and exposed to water flow, leading to infiltration of rust-contaminated water into the ground surrounding the base of the tanks.

Statistical analysis revealed a significant difference in iron concentrations among the boreholes, which was attributed to variations in the extent of tower exposure and the pH of the water. Borehole Location 3 recorded the highest iron content, likely due to its acidic pH, which facilitated greater metal dissolution.

Lead was detected in all sampling locations, a result linked to the proximity of auto-mechanic workshops and improper disposal of hazardous domestic waste, such as used batteries and electronic materials. Cadmium was found in two sampling locations and was associated with the presence of dry cell batteries, ceramic waste, and poorly disposed lubricants. These findings were consistent with the report by Ugwoha and Emete (2015), which noted that such waste materials contribute to leachate formation,

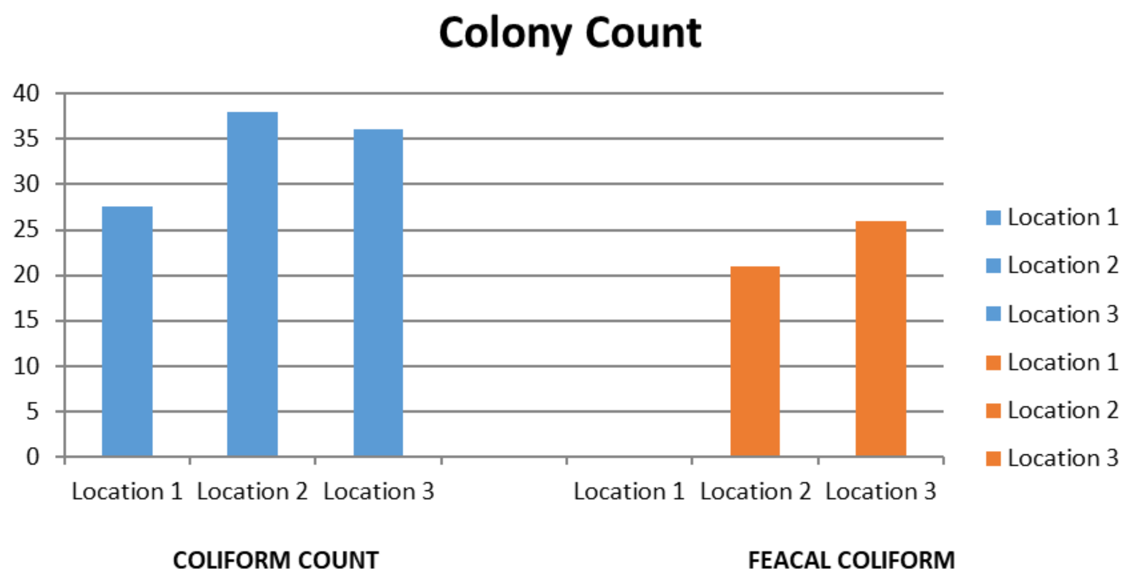

Figure 5. Showing colony count values from three different borehole locations and standard values.

thereby contaminating groundwater sources.

Colony count results indicated the presence of bacterial colonies in the groundwater samples, likely due to the leaching of waste materials into the aquifer. The presence of bacteria in water is known to pose serious health risks, including dysentery, cholera, and diarrhea.

Similar findings were reported by Obot and Edi (2012), who documented high coliform counts in groundwater and attributed these to leaching from a nearby abattoir. Although no abattoir was observed near the sampling locations in this study, the close proximity of septic tanks to boreholes raised concerns about potential contamination sources (Figure 5).

Statistical analysis revealed no significant difference in colony counts across the three borehole sample locations, suggesting that microbial load was influenced primarily by the anthropogenic activities surrounding each site. The presence of coliform and faecal coliform bacteria in groundwater samples from Osubi suggested possible contamination from septic tank leakage and the indiscriminate disposal of animal excreta on the surface soil (Figure 5).

These findings were consistent with the study by Orogu *et al.* (2017), who reported the detection of *Escherichia coli* in borehole and well water samples from other regions in Nigeria. Such contamination renders groundwater unsafe for human consumption due to the pathogenic nature of the microorganisms involved.

Conclusion

The results obtained indicated the presence of micro-organisms in the water samples at levels exceeding permissible standards, along with detectable concentrations of heavy metals such as iron, lead, and cadmium. Based on these findings, it was concluded that ground-water from the study area was highly polluted and unfit for human consumption. This contamination was likely the result of years of continuous environmental pollution. The poor water quality was attributed to anthropogenic activities surrounding the borehole locations, as well as inadequate environmental management practices.

Groundwater is generally considered a reliable source of fresh water due to its typically high quality and minimal treatment requirements. However, it remains highly susceptible to contamination from human activities.

In light of the conclusions drawn, the following recommendations were made:

I. Water from all borehole locations should undergo primary treatment processes before use.
II. Regular coating and maintenance of water tank towers should be implemented to prevent rusting and the leaching of iron into groundwater.
III. Septic tanks should be sited at safe distances from boreholes to minimize the risk of microbial contamination through leaching.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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