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# Physicochemical and bacteriological assessment of groundwater quality in Aduloju Area, Moniya, Ibadan, Oyo State, Nigeria

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## Abstract

Groundwater is an important source of domestic water supply in many parts of Nigeria, especially in communities where access to treated pipe-borne water is inadequate. However, contamination of groundwater resulting from poor sanitation, indiscriminate waste disposal, and environmental pollution poses serious public health concerns (WHO, 2022). This study assessed the physicochemical and bacteriological quality of groundwater from selected hand-dug wells in Aduloju Area, Moniya, Akinyele Local Government Area, Ibadan, Oyo State, Nigeria.

Two groundwater samples were collected from selected wells located at No. 24 Ekuntakoro House and Alibankudi Public well within the study area. The samples were analysed at Kappa Technologist Laboratory, Bodija, Ibadan, using standard analytical procedures recommended by APHA (2022). Physicochemical parameters analysed include colour, turbidity, pH, conductivity, total solids, total dissolved solids (TDS), calcium, iron, lead, chloride, magnesium, cadmium, zinc, chemical oxygen demand (COD), dissolved oxygen (DO), and total hardness. Bacteriological analyses including total viable count, total coliform count, total fungal count, and microbial identification were also carried out.

The results showed that most physicochemical parameters were within WHO permissible limits for drinking water. However, total solids (2010 mg/L), iron concentration (0.4 mg/L), and COD (6.5 mg/L) in Sample A exceeded WHO-recommended standards. Bacteriological analysis revealed high microbial contamination in Sample A with a total viable count of $2.7 \times 10^6$ CFUs/ml, total coliform count of $6.3 \times 10^2$ CFUs/ml, and total fungal count of $9.4 \times 10^5$ CFUs/ml. Pathogenic organisms identified include *Escherichia coli*, *Proteus* species, *Aeromonas* species, *Bacillus* species, *Pseudomonas* species, and fungal isolates such as *Aspergillus* species and *Penicillium* species. Sample B showed lower contamination levels but still contained microbial isolates.

The study concluded that groundwater from the investigated wells, particularly Sample A, is microbiologically unsafe for direct human consumption without treatment. The contamination observed may be linked to poor sanitary conditions and environmental pollution around the wells. Therefore, proper water treatment, regular groundwater monitoring, improved sanitation practices, and protection of wells from contamination are recommended to safeguard public health.

**Keywords:** Groundwater; Physicochemical Analysis; Bacteriological Assessment; Water Quality; Well Water; Ibadan.

## 1. Introduction

Water is one of the most essential natural resources required for human survival, agricultural production, industrial development, and environmental sustainability. Groundwater serves as one of the major sources of potable water in

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many developing countries due to its relative accessibility and availability (World Health Organization (WHO), 2022). In Nigeria, groundwater obtained from hand-dug wells and boreholes is widely used for domestic activities such as drinking, cooking, washing, and sanitation because of inadequate public water supply systems.

Groundwater is generally considered safer than surface water because it undergoes natural filtration through soil and rock formations before reaching aquifers. However, despite this natural purification process, groundwater quality can be adversely affected by anthropogenic activities such as poor sanitation, septic tank leakage, indiscriminate waste disposal, agricultural runoff, and industrial discharges (Egbueri, 2020). These activities introduce pollutants**,** including heavy metals, organic contaminants, and pathogenic microorganisms, into groundwater systems.

The quality of groundwater is determined by its physicochemical and microbiological characteristics. Physicochemical parameters such as pH, turbidity, electrical conductivity, total dissolved solids (TDS), hardness, and concentrations of dissolved metals are important indicators used in evaluating the suitability of water for drinking and domestic purposes (APHA, 2022). Elevated concentrations of pollutants in groundwater may pose serious health hazards to consumers.

Microbiological contamination of groundwater is one of the major public health concerns in developing countries. The presence of pathogenic organisms such as *Escherichia coli*, *Pseudomonas* species, and other coliform bacteria in drinking water indicates faecal contamination and poor sanitary conditions around water sources (Cheesbrough, 2021). Consumption of contaminated groundwater may result in waterborne diseases such as typhoid fever, cholera, diarrhoea, dysentery, and gastroenteritis.

Ibadan, the capital city of Oyo State, has experienced rapid population growth and urban expansion over the years. Consequently, many communities within the metropolis, including Moniya and its surrounding settlements, depend largely on shallow wells for water supply. In the Aduloju Area, improper waste disposal, poor drainage systems, and environmental pollution may contribute significantly to groundwater contamination.

Several studies conducted in Nigeria have reported varying degrees of groundwater contamination associated with urbanisation and poor sanitation practices (Egbueri et al., 2021; Ukah et al., 2023). Therefore, continuous monitoring and assessment of groundwater quality are essential to ensure compliance with recommended drinking water standards and protect public health.

This study was therefore carried out to assess the physicochemical and bacteriological quality of groundwater from selected wells in Aduloju Area, Moniya, Ibadan, Oyo State, Nigeria. The results obtained were compared with World Health Organization (WHO) standards for drinking water quality to determine the suitability of the groundwater for domestic consumption.

## 2. Study area

The study was carried out in Aduloju Area, Moniya, located within Akinyele Local Government Area of Ibadan, Oyo State, Nigeria. Ibadan lies within the tropical rainforest region of southwestern Nigeria and experiences distinct wet and dry seasons annually. The area is characterised by increasing residential development and dependence on groundwater sources for domestic water supply.

The residents of Aduloju Area rely heavily on hand-dug wells because of inadequate public pipe-borne water supply. Human activities such as indiscriminate refuse disposal, wastewater discharge, poor drainage systems, and septic tank seepage may contribute to groundwater pollution within the area.

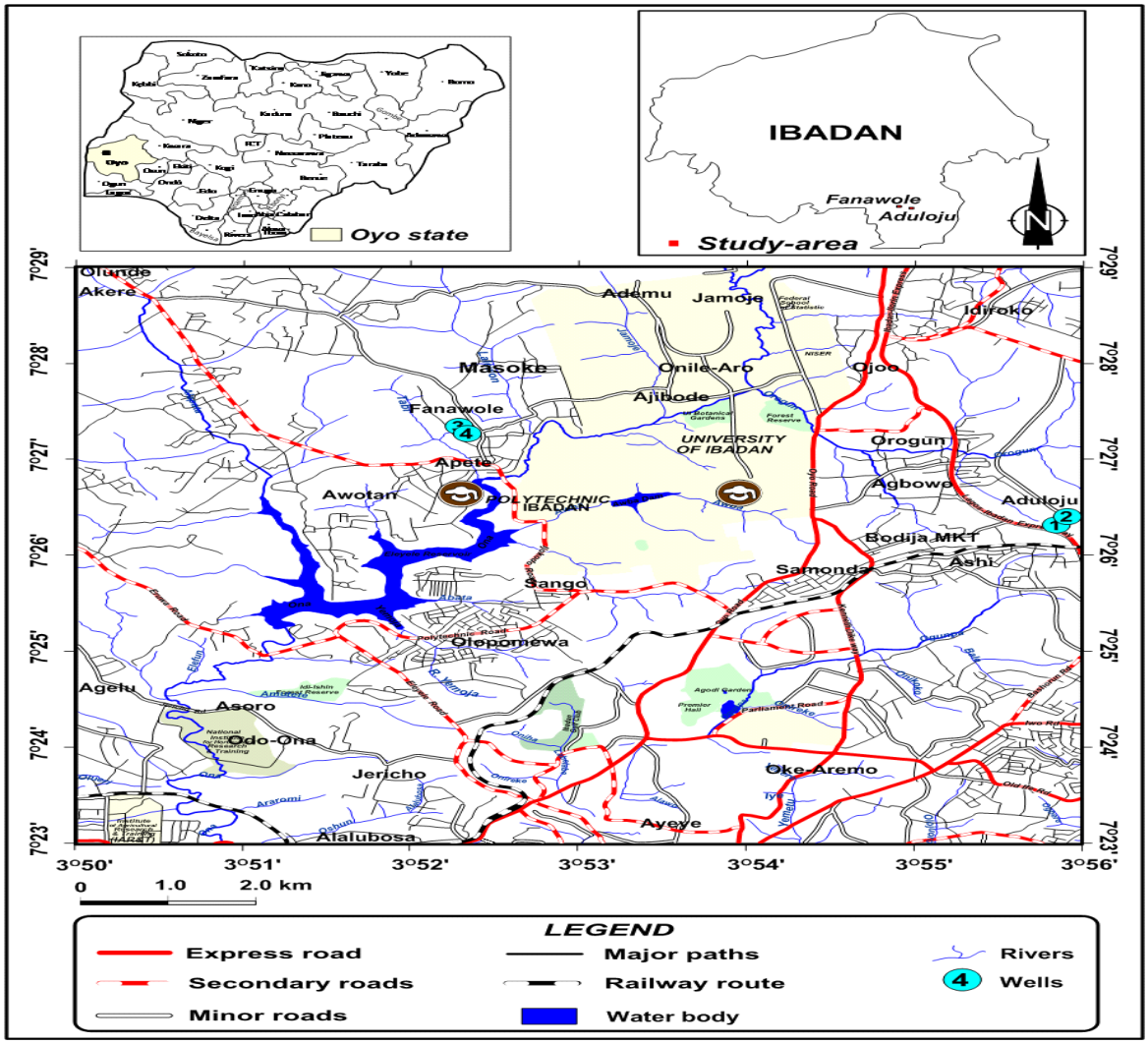


**Figure 1** Location map showing points and locations of the Aduloju Area

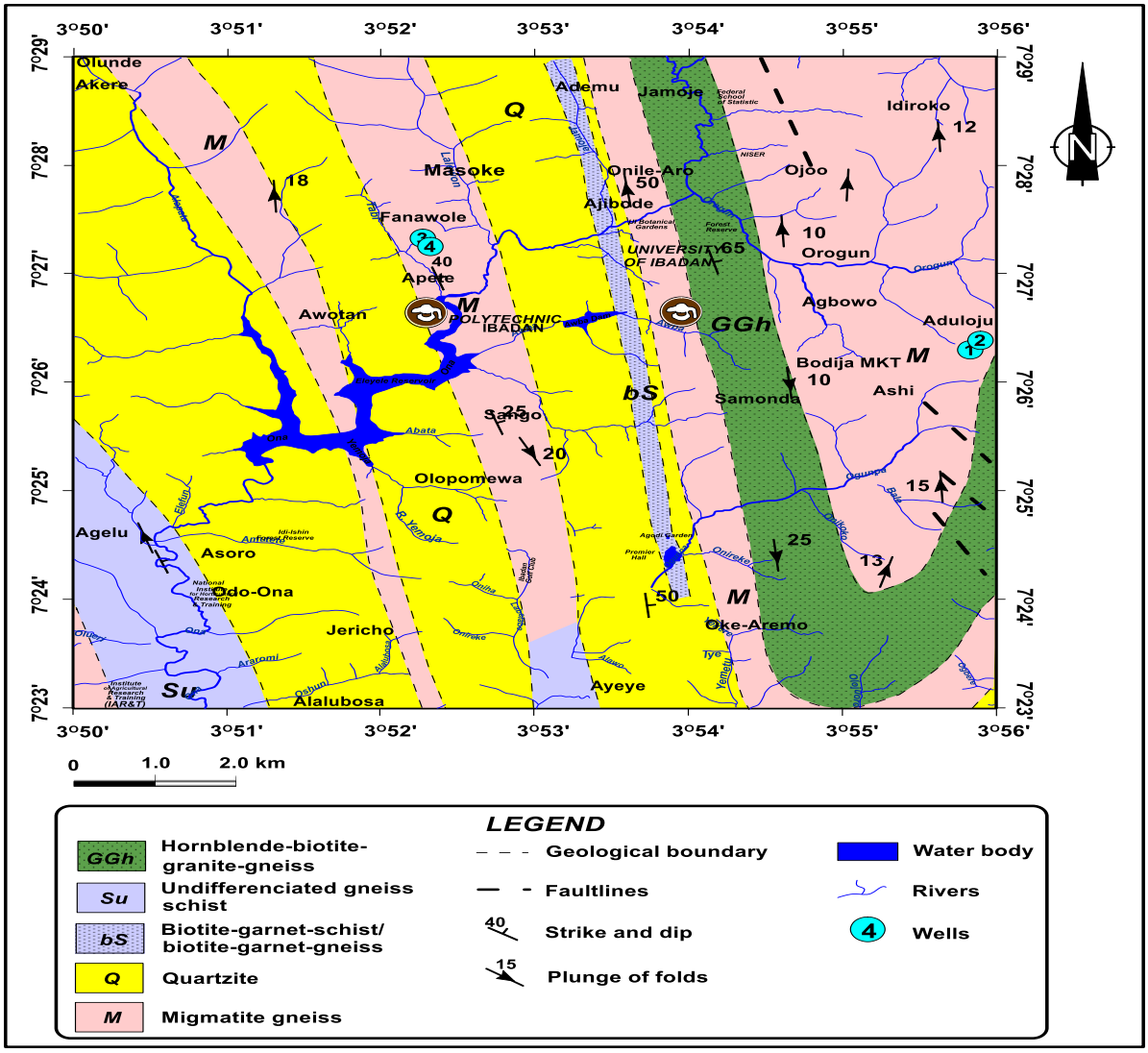


Fig.....Geological map showing the rock type that underlies the study area

**Figure 2** Geological map showing the rock type that underlies the study area.

Two hand-dug wells were selected for this study based on accessibility and regular usage by residents. The selected wells are shallow groundwater sources.

Well, 1

Location: No. 24 Ekuntakoro House, Aduloju Area, Ibadan, Longitude: E3°55'50.57544"; Latitude: N7°26'18.21408". Well depth: 14.9 m, Water level: 9.6 m, Total height of water: 5.26 m

Well, 2.

Location: Alibankudi Public Well, Aduloju Area, Ibadan, Longitude: E3⁰55'52.48488, Latitude: N7°26'19.41468", Well depth: 16.6 m, Water level: 10.65 m, Total height of water: 4.46 m

## 3. Materials and methods

### 3.1. Sample Collection

Groundwater samples were collected from two selected hand-dug wells located within Aduloju Area, Moniya, Ibadan. The wells selected for the study were actively used by residents for drinking and domestic purposes. Water samples were collected into clean sterile polyethylene bottles following standard procedures recommended by APHA (2022).

Before sample collection, the bottles were rinsed thoroughly with distilled water and later rinsed with the sample water to avoid contamination. Samples for bacteriological analysis were collected in sterile containers and transported immediately in ice-packed containers to Kappa Technologist Laboratory, Bodija, Ibadan, for laboratory analyses.

### 3.2. Physicochemical Analysis

Physicochemical parameters analysed include colour, turbidity, pH, electrical conductivity, total solids, total dissolved solids (TDS), calcium ($Ca^{2+}$), iron ($Fe^{2+}$), lead ($Pb^{2+}$), chloride ($Cl^{-}$), magnesium ($Mg^{2+}$), cadmium (Cd), zinc ($Zn^{2+}$), chemical oxygen demand (COD), total dissolved oxygen (TDO), and total hardness.

The pH and electrical conductivity were determined using calibrated digital meters, while turbidity was measured using a nephelometric turbidity meter. Total solids and TDS were determined using gravimetric methods. Heavy metals were analysed using standard instrumental analytical procedures in accordance with APHA (2022).

Chemical oxygen demand was determined using the dichromate reflux method, while total hardness was determined through the EDTA titrimetric method. The analytical methods adopted were consistent with standard laboratory procedures used in recent groundwater quality studies (Egbueri, 2020; Ukah et al., 2023).

### 3.3. Bacteriological Analysis

Bacteriological analyses were carried out to determine total viable count (TVC), total coliform count (TCC), and total fungal count (TFC). Standard microbiological procedures involving serial dilution, pour-plate techniques, culturing, incubation, and colony counting were employed.

Nutrient agar was used for total viable bacterial count, MacConkey agar for coliform analysis, and potato dextrose agar for fungal count. Microbial isolates were identified based on their cultural, morphological, and biochemical characteristics using standard microbiological techniques (Cheesbrough, 2021).

### 3.4. Data Analysis

The results obtained were compared with World Health Organization (WHO, 2022) permissible standards for drinking water quality to evaluate the suitability of the groundwater for domestic use.

## 4. Results and discussion

### 4.1. Physicochemical Characteristics of Groundwater Samples

**Table 1** Physicochemical Analysis of Well Water Samples

| S/N | Parameters | Unit | Sample A | Sample B | WHO Standard |
|---|---|---|---|---|---|
| 1 | Colour | Hazen units | 1.5 | 0.5 | 5 |
| 2 | Turbidity | NTU | 1.5 | 1.0 | 5 |
| 3 | pH | - | 7.6 | 6.1 | 6.5–8.5 |
| 4 | Conductivity | µS/cm | 352 | 308 | 400 |
| 5 | Total Solids | mg/L | 2010 | 1460 | 1500 |
| 6 | TDS | mg/L | 325 | 260 | 500 |
| 7 | Ca++ | mg/L | 75 | 70 | <250 |

| | | | | | |
|---|---|---|---|---|---|
| 8 | Fe++ | mg/L | 0.4 | 0.2 | 0.3 |
| 9 | Pb++ | mg/L | 0.03 | 0.02 | 0.1 |
| 10 | Cl– | mg/L | 36.4 | 15.0 | 250 |
| 11 | Mg++ | mg/L | 30 | 25 | <50 |
| 12 | Cd | mg/L | 0.01 | - | 0.05 |
| 13 | Zn++ | mg/L | 0.50 | 0.15 | 0.5 |
| 14 | COD | mg/L | 6.5 | 2.6 | 5 |
| 15 | DO | mg/L | 3.7 | 3.2 | --- |
| 16 | Total Hardness | mg/L | 82.0 | 76.5 | 100–150 |

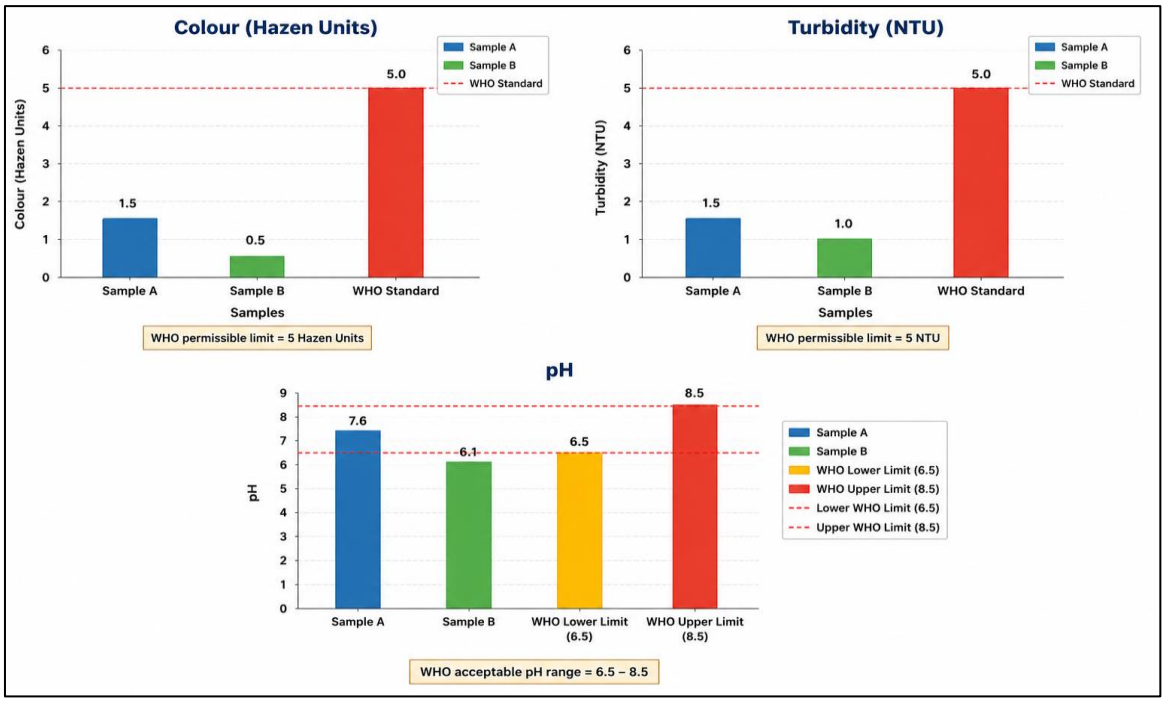


**Figure 3** Bar charts showing colour, turbidity and pH of Sample A and Sample B compared with WHO Standard

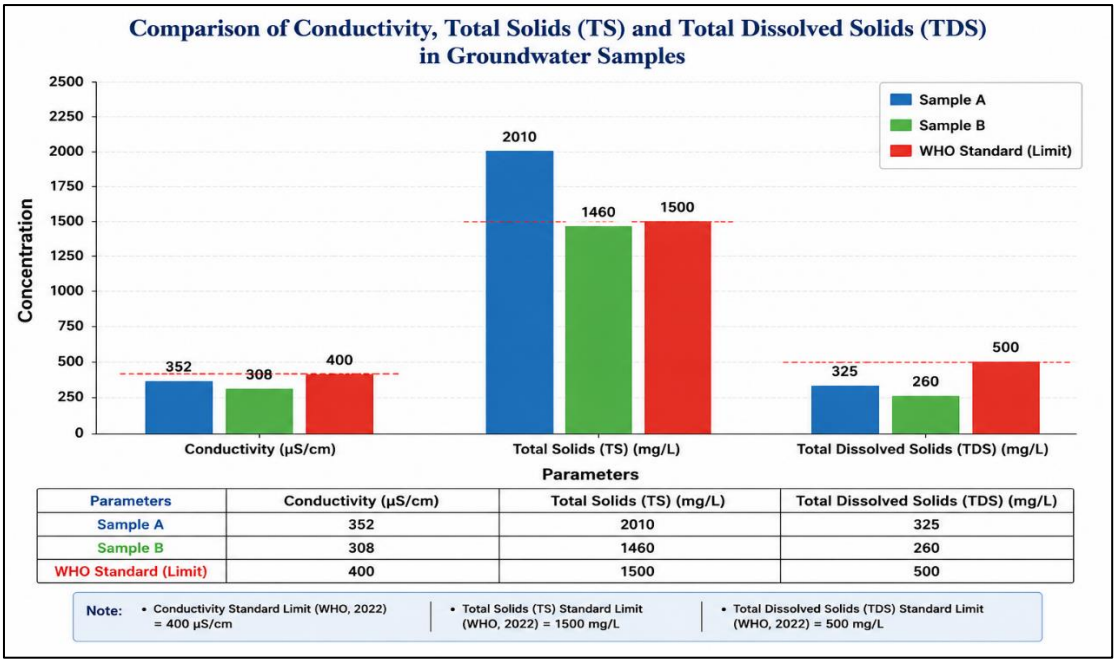


**Figure 4 C**onductivity, total solids and total dissolved solids of Sample A and Sample B compared with WHO Standard

The colour and turbidity values obtained from both groundwater samples were within WHO permissible limits, indicating relatively clear water with low suspended particles (WHO, 2022).

The pH value of Sample A (7.6) was within the WHO recommended range of 6.5–8.5, indicating neutral to slightly alkaline water. However, Sample B recorded a pH value of 6.1, which is slightly acidic and below WHO standards. Acidic groundwater may increase corrosion of metallic pipes and dissolution of metals into water (Ukah et al., 2023).

Electrical conductivity values for both samples were within WHO permissible limits, suggesting moderate ionic concentrations in the groundwater. Total dissolved solids values also complied with WHO standards, indicating acceptable levels of dissolved substances in the water.

However, total solids concentration in Sample A (2010 mg/L) exceeded the WHO permissible limit of 1500 mg/L. Elevated total solids may result from infiltration of runoff, organic matter, and environmental pollutants into the groundwater system (Egbueri et al., 2021).

Iron concentration in Sample A (0.4 mg/L) exceeded the WHO permissible limit of 0.3 mg/L, while Sample B remained within acceptable limits. Elevated iron concentrations may originate from geological formations and anthropogenic contamination and may cause staining, unpleasant taste, and discolouration of water (WHO, 2022).

Lead, cadmium, chloride, calcium, magnesium, and zinc concentrations were within permissible limits, indicating minimal heavy metal contamination. Similarly, total hardness values indicate moderately hard water suitable for domestic use.

The COD value of Sample A (6.5 mg/L) exceeded the WHO-recommended limit of 5 mg/L, indicating the presence of oxidisable organic pollutants and poor sanitary conditions around the water source (Ukah et al., 2023).

### 4.2. Bacteriological Characteristics of Groundwater Samples

**Table 2** Bacteriological Analysis of Well Water Samples

| Parameters | Sample A | Sample B | WHO Standard |
|---|---|---|---|
| Total Viable Count (CFUs/ml) | $2.7 \times 10^6$ | $6.9 \times 10^2$ | $1.5 \times 10^2$ |
| Organisms Identified | Bacillus spp; Pseudomonas spp., Flavobacterium sp | Bacillus spp | No Pathogen |
| Total Coliform Count (CFUs/ml) | $6.3 \times 10^2$ | Nil | Nil |
| Organisms Identified | Aeromonas sp; E. coli; Proteus sp | - | No Faecal Coliform |
| Total Fungal Count (CFUs/ml) | $9.4 \times 10^5$ | $7.3 \times 10^2$ | $1.0 \times 10^2$ |
| Organisms Identified | Aspergillus spp; Penicillium spp., Geotrichum sp., | Aspergillus spp., Rhizopus sp. | No Pathogen |

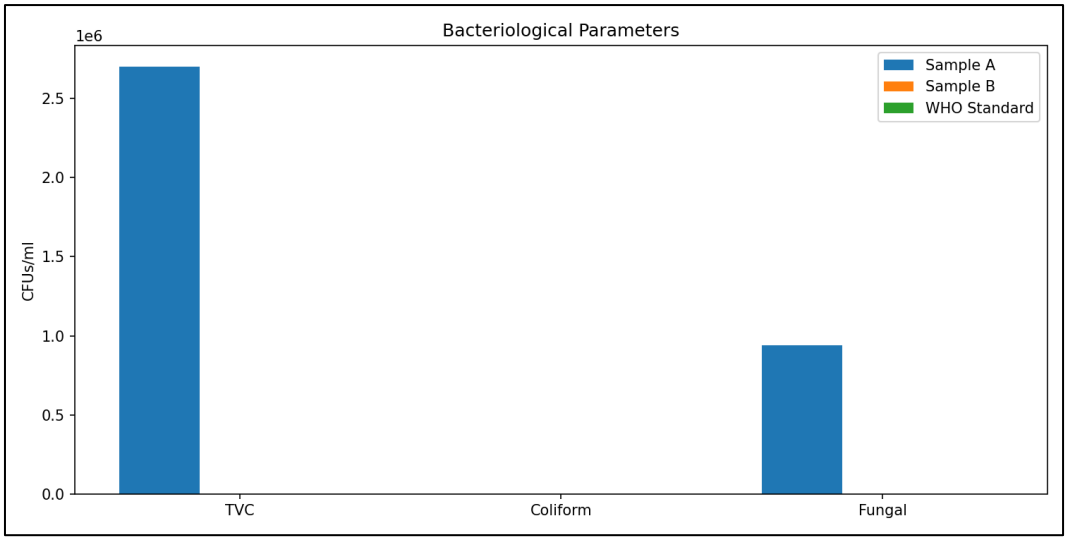


**Figure 5** Bar chart showing bacteriological parameters

The bacteriological analysis revealed significant microbial contamination in the groundwater samples, particularly in Sample A. The total viable count recorded in Sample A exceeded WHO permissible limits, indicating poor microbial quality of the groundwater.

The presence of *Escherichia coli* in Sample A indicates faecal contamination of the well water and suggests possible infiltration of sewage or human waste into the groundwater source (WHO, 2022).

Other bacterial isolates identified include *Pseudomonas* species, *Proteus* species, *Aeromonas* species, *Flavobacterium* species, and *Bacillus* species. These organisms are associated with environmental contamination and poor sanitary conditions around water sources (Cheesbrough, 2021).

The total fungal counts recorded in both samples exceeded WHO permissible limits. Fungal isolates identified include *Aspergillus* species, *Penicillium* species, *Geotricum* species, and *Rhizopus* species.

Although Sample B showed comparatively lower microbial contamination, the presence of microbial isolates indicates that the groundwater is not entirely safe for direct human consumption without treatment.

## 5. Conclusion

This study assessed the physicochemical and bacteriological quality of groundwater from selected wells in Aduloju Area, Moniya, Ibadan. The physicochemical analysis showed that most parameters were within WHO permissible limits for drinking water. However, elevated total solids, iron concentration, and chemical oxygen demand were observed in Sample A.

The bacteriological analysis revealed significant microbial contamination, particularly in Sample A, where coliform bacteria and pathogenic organisms such as *Escherichia coli* were detected. The findings indicate faecal contamination and poor sanitary conditions around the wells.

Based on the results obtained, the groundwater from the investigated wells is not entirely safe for direct human consumption without treatment.

### *Recommendations*

Well water should be adequately treated through boiling, chlorination, or filtration before consumption. Regular monitoring and assessment of groundwater quality should be carried out to ensure compliance with WHO drinking water standards. Proper sanitary practices should be maintained around the wells to prevent contamination from refuse dumps and wastewater. Wells should be properly covered and protected from direct environmental exposure. Public health awareness programmes should be organised to educate residents on safe water handling and sanitation practices. Government agencies should enforce regulations on environmental sanitation and waste disposal within the study area.

## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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