

Water Quality Index and Bacteriological Assessment of Selected Sources of Drinking Water in Owerri Metropolis, Imo State, Nigeria



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ABSTRACT

Water quality assessment is essential in determining the suitability of drinking water sources for human consumption. The research aims to evaluate the Water Quality Index (WQI) and bacterial load in drinking water sources in Owerri metropolis, Imo State. Water samples were collected from selected hostels and analyzed using standard laboratory procedures. Physicochemical parameters measured included temperature (°C), pH, color (PCU), electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), turbidity (NTU), total suspended solids (mg/L), total solids (mg/L), and ammonia (NH₃) (mg/L). The results revealed that most physicochemical parameters were within World Health Organization (WHO) and Federal Ministry of Environment (FMEEnv) permissible limits, with pH (8.2-8.5), conductivity (14-157 µS/cm), and TDS (9.10-102.05 mg/L) indicating good water quality. However, bacteriological analysis showed the presence of total coliforms (up to 30 cfu/100ml) and *Klebsiella* spp. (up to 73 cfu/100ml), though *E. coli* and fecal coliforms were absent. The WQI values classified the water as generally unfit for drinking, and the detected microbial contaminants pose a potential risk to public health if not properly treated. The study recommends regular monitoring, effective water disinfection methods, and improved water storage infrastructure to prevent microbial contamination.

Keywords: Water Quality Index, Physicochemical Parameters, Bacteriological Analysis, Drinking Water and Owerri Metropolis.

1.0. INTRODUCTION

Water is not only essential for sustaining life but also plays a crucial role in human health. Access to safe drinking water is fundamental to preventing waterborne diseases and promoting overall well-being. However, the quality of drinking water can vary significantly depending on its source and the presence of contaminants [1]. Contaminated water can harbor various pathogens, chemicals, and pollutants that pose serious health risks to individuals who consume it [2]. One of the primary sources of contaminated water is environmental pollution [3, 4]. Pathogens such as bacteria, viruses, and protozoa can thrive in polluted water, leading to illnesses such as diarrhea, cholera, typhoid fever, and dysentery. Igwemmar *et al.*, [5] revealed that more than 3.4 million lives were lost annually due to contaminated water consumption caused by poor sanitation

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and affirmed that 99 percent of lives lost as a result of waterborne diseases are from the developing world.

The Water Quality Index (WQI) serves as a critical tool in assessing and monitoring the safety of drinking water [6]. It integrates multiple water quality parameters into a single numerical value, providing a standardized way to evaluate and compare the overall quality of different water sources. Parameters commonly included in WQI calculations encompass physical, chemical, and biological factors such as pH, turbidity, dissolved oxygen, biochemical oxygen demand (BOD), total dissolved solids (TDS), and the presence of pollutants like heavy metals and pesticides. By calculating WQI, researchers and policymakers can gauge the suitability of water for various uses, particularly for drinking. WQI values are typically categorized into different ranges (e.g., excellent, good, fair, poor) to communicate the level of water quality to stakeholders effectively [7]. This information is invaluable for making informed decisions regarding water treatment, resource allocation, and public health interventions aimed at ensuring access to safe drinking water.

In practical terms, communities and authorities use WQI assessments to identify sources of contamination, prioritize water quality improvement efforts, and implement remedial actions [8]. Regular monitoring of WQI helps detect changes in water quality over time, which may be influenced by factors such as seasonal variations, land use practices, industrial activities, and climate change. Such proactive measures are essential for mitigating health risks associated with contaminated drinking water and safeguarding public health on a long-term basis.

Access to safe and clean drinking water is a fundamental human right and a critical component of public health [9].

However, in many regions, drinking water sources are frequently compromised by various contaminants, posing significant health risks to local communities. Contaminants such as nitrates, phosphates, heavy metals, and pathogenic microorganisms can infiltrate these water sources, leading to a range of waterborne diseases and chronic health issues [10]. The lack of comprehensive and systematic water quality assessments exacerbates the problem. This gap in knowledge not only hampers effective water resource management but also puts the health and well-being of the local population at considerable risk. The existing water quality standards and regulations may not fully reflect the current contamination levels and emerging threats in the study area, so there is a pressing need for updated and context-specific information to guide the development of policies and interventions aimed at improving water safety. In the absence of such data, efforts to ensure safe drinking water remain fragmented and insufficient. The study will be instrumental in guiding policy decisions and regulatory frameworks aimed at ensuring safe drinking water. Policymakers can use the findings to set or revise water quality standards, develop strategies for water resource management, and allocate resources effectively. Finally, the study can serve as a model for similar assessments in other regions, particularly in areas with limited resources for water quality monitoring.

2.0. Materials and Methods

2.2 Area of Study

This study was conducted within the metropolis of Owerri, Imo State, Nigeria, located approximately at latitude 5.3895° N and longitude 6.9960° E. The area consists of multiple student hostels, each relying on various drinking water sources, including boreholes, taps, and storage tanks.

Water samples were collected from four major hostel water sources within the metropolis of Owerri. The Global Positioning System (GPS) was employed to accurately record the coordinates of each sampling location, ensuring reproducibility and precise documentation. The sampling points were selected based on frequency of use and accessibility. The GPS coordinates for the sampling locations are as follows:

- Hostel A Borehole Water Source: 5.38531° N, 6.99995° E
- Hostel B Borehole Water Source: 5.38625° N, 7.00009° E
- Hostel C Borehole Water Source: 5.38736° N, 6.99931° E
- Hostel D Borehole Water Source: 5.38531° N, 6.99996° E

The use of GPS mapping ensured spatial accuracy and provided a basis for evaluating potential environmental impacts on water quality across different hostel locations. It also assists in understanding how proximity to certain activities (e.g., waste disposal areas, cafeterias) may affect water quality, and in future studies, it will help to replicate the sampling process precisely.

2.3. Study Design

Water Quality Index and Bacteriological Assessment of Drinking Water Sources in Owerri metropolis can be classified as a community-based study, this is because it focuses on a specific community or group in a defined area, assessing health risks related to environmental factors. The population, which is the students living in the hostels, shares common drinking water sources and living conditions within the campus environment. The study base comprised various drinking water sources within these hostels, including borehole water, tap water, and storage tanks, which serve as the primary sources of potable water for students.

The focus was to assess the physicochemical and bacteriological quality of these water sources, calculate the Water Quality Index (WQI), and compare findings against World Health Organization (WHO) standards to determine their suitability for consumption. The study base was selected due to its relevance to public health concerns, given that compromised water quality can pose significant health risks to the student population.

2.3.1. Study Type

The study is best classified as a cross-sectional, descriptive study with an analytical component in the field of environmental health research.

It is cross-sectional because;

- i. data were collected at a single point in time from various water sources within Owerri metropolis, therefore there was no follow-up as it provides a snapshot of the water quality during the period of collection.
- ii. both physicochemical properties and bacteriological parameters are analyzed simultaneously to evaluate water quality.
- iii. prevalence of microbial contaminants (*E. coli*, total coliforms, etc.) in drinking water was assessed.

It is descriptive because;

- a) the study describes the characteristics of drinking water sources (e.g., pH, turbidity, TDS, microbial content).
- b) the research is observational, as it does not involve manipulating variables, rather measures and describes existing conditions.
- c) use of Standards (e.g. WHO and FMEnv.) as yardsticks for comparison to suitable water for consumption.

2.3. Materials for Water Quality Index (WQI) Testing

To assess the water quality in a school hostel, both physicochemical analysis (for Water Quality Index) and bacteriological testing (for microbiological contamination) are necessary. The following materials were used for the assessments.

2.3.1. Physicochemical Assessment

The instruments and equipment used and their purposes in the water samples include pH Meter (acidity/alkalinity), turbidity meter (to determine the cloudiness or haziness due to suspended particles), DO meter (concentration of dissolved oxygen), TDS meter (amount of dissolved salts, minerals, and metals in the water), BOD incubator (biochemical oxygen demand), conductivity meter (the electrical conductivity) and reagents for chemical testing (test for various chemicals).

2.3.2. Bacteriological Assessment

Materials needed for these analyses included sterile sampling bottles, a cooler/portable refrigerator, a membrane filtration system, most probable number test kits, a colilert test kit, nutrient agar plates, MacConkey agar, incubator and sterile pipettes.

Collected water samples were refrigerated in sterile bottles until the test were ready to be done. Membrane filtration method was done with a 100 mL of water through a sterile membrane filter. The filter was placed on the petri dish containing MacConkey agar and incubated at 37°C for 24-48 hours. Afterwards, count the number of colony-forming units (CFUs) that appear on the filter.

For the most probable number (MPN), serial dilutions were done on the water sample, and later diluted into tubes with Lauryl Tryptose Broth.

They were incubated and examined for gas production and color change, which were indicative of bacterial growth. Statistical tables were used to calculate the most probable number of bacteria present in the sample.

For Colilert test, the Colilert reagent was added to the water sample according to the kit instructions and incubate at 37°C for 48 hours. A sample colour change to yellow indicated the presence of total coliforms, and when it fluoresces under UV light, indicated the presence of *E. coli*.

For Bacterial Count, the number of CFUs or MPN were compared with the permissible limits for drinking water as set by WHO or FMEnv. standards.

For safety evaluation, water was considered safe for drinking if the sample contained no coliforms or *E. coli* per 100 mL. Thereafter, the results were compared with the WQI and bacteriological results against the WHO or local regulatory standards to evaluate the safety of the drinking water.

2.4. Data Analysis and Calculation of WQI

Statistical tools were used to analyze the collected data, and the results were compared with WHO and FMEnv. permissible limits. Graphical representations were employed to visualize spatial variations in water quality across different hostels. After finding the values for the parameters, the calculation of WQI followed up. The formulae to calculate WQI are detailed below

1. Unit weight (W_n) factors for each parameter was calculated by using the formula below

$$W_n = \frac{k}{S_n}$$

where k is a constant focus which can be determined by:

$$k = \frac{1}{\sum(\frac{1}{S_n})}$$

S_n = Standard desirable value of the parameter or maximum permissible limit of the parameter.

On summation of all selected parameters unit weight factor (W_n) = 1

Table 2: Results from hostel A

Parameter	Standard Limit (S_n)	Mean $\pm$ SE	$1/S_n$	$W_n = K/S_n$	Ideal Value (V_n)	$Q_n = (V_n/S_n) \times 100$	$W_n \times Q_n$
Temperature (°C)	30	28.80 $\pm$ 0.00	0.03333	0.07343	0	0	0.00000
pH	8.5	8.20 $\pm$ 0.00	0.11764	0.25915	7	80	20.72960
Color (PCU)	15	0.011 $\pm$ 0.00	0.06667	0.14685	0	0	0.00000
Electrical Conductivity (EC)	1000	14.00 $\pm$ 0.00	0.00100	0.00220	0	1.4	0.00308
Total Dissolved Solids (TDS)	500	9.10 $\pm$ 0.00	0.00200	0.00441	0	1.82	0.00807
Dissolved Oxygen (DO)	7.5	23.00 $\pm$ 0.00	0.13333	0.29371	0	306.67	90.07116
Biological Oxygen Demand (BOD)	5.0	10.00 $\pm$ 0.05	0.20000	0.44056	0	83	36.56648
Turbidity (NTU)	5.0	2.80 $\pm$ 0.00	0.20000	0.44056	0	56	24.67136
Total Suspended Solid (mg/L)	<10	30.90 $\pm$ 8.20	0.20100	0.46056	0	48	20.1473
Total Solids (mg/L)	1000	40.00 $\pm$ 28.28	0.00100	0.00220	0	4.0	0.00881
Ammonia (NH ₃) (mg/L)	0	0.07 $\pm$ 0.00	—	—	0	—	—

$$WQI = \frac{\sum W_n \times Q_n}{\sum W_n} = 135.5; \sum 1/S_n = 0.45397; K = 2.20279; \sum W_n = 1; \sum W_n \times Q_n = 135.49$$

3.1.2. Physiochemical and Bacteriological Analysis of Borehole Water from Hostel B

Hostel B recorded that temperature (28.80 $\pm$ 0.00°C), pH (8.50 $\pm$ 0.00), Total Solids (40.00 $\pm$ 28.28 mg/L) and **Turbidity** (2.80 $\pm$ 0.00 NTU) were within acceptable limits while color (0.011 $\pm$ 0.00 PCU), EC (14.00 $\pm$ 0.00 μ S/cm) and TDS (9.10 $\pm$ 0.00 mg/L) recorded extremely low concentrations and DO (23.00 $\pm$ 0.00 mg/L) had very high concentration. Ammonia (0.08 $\pm$ 0.00 mg/L) was detected in minimal amounts while TSS (25.50 $\pm$ 4.60 mg/L) and BOD (9.00 $\pm$ 0.05) exceeded permissible limits as shown in Table 3.

2. Sub-index for each parameter were computed by multiplying the normalized value by its weight.

$$Sub\ index = \left(\frac{Observed\ value - Minimum\ value}{Maximum\ value - Minimum\ value} \right) \times 100$$

The range of values depended on the specific water quality standard used (e.g., WHO standards for drinking water).

3. Sum the sub-indices to get the overall WQI.

$$WQI = \sum (Weight\ of\ parameter \times Sub-index)$$

$$= \sum W_n Q_n \text{ where } Q_n \text{ is the sub-index}$$

Table 1: Interpretation of WQI

The final WQI value typically ranges from 0 to 100, (Brown et al.)

WQI Range	Water Quality Status
0 - 25	Excellent
26 - 50	Good
51 - 75	Poor
76 - 100	Very Poor
Above 100	Unfit

3.0. Results and Discussion

3.1. Results

3.1.1. Physiochemical and Bacteriological Analysis of Borehole Water from Hostel A

Hostel A recorded that temperature (28.80 $\pm$ 0.00°C), pH (8.20 $\pm$ 0.00), **Turbidity** (2.80 $\pm$ 0.00 NTU) and Ammonia (0.07 $\pm$ 0.00 mg/L) were within acceptable limits while color (0.011 $\pm$ 0.00 PCU), EC (14.00 $\pm$ 0.00 μ S/cm), Total Solids (40.00 $\pm$ 28.28 mg/L) and TDS (9.10 $\pm$ 0.00 mg/L) recorded extremely low concentrations and DO (23.00 $\pm$ 0.00 mg/L) had very high concentration. Ammonia (0.07 $\pm$ 0.00 mg/L) was detected in minimal amounts while TSS (30.90 $\pm$ 28.28 mg/L) and BOD (10.00 $\pm$ 0.05) exceeded permissible limits as shown in Table 2

Table 3: Results from Hostel B

Parameter	Standard Limit (S _n)	Mean ± SE	1/S _n	W _n = K/S _n	Ideal Value (V _n)	Q _n = (V _n /S _n) × 100	W _n × Q _n
Temperature (°C)	30	28.80±0.00	0.03333	0.07343	0	0	0.00000
pH	8.5	8.50±0.00	0.11764	0.25915	7	100	25.91500
Color (PCU)	15	0.011±0.00	0.06667	0.14685	0	0	0.00000
Electrical Conductivity (EC)	1000	14.00±0.00	0.00100	0.00220	0	1.40	0.00308
Total Dissolved Solids (TDS)	500	9.10±0.00	0.00200	0.00441	0	1.82	0.00807
Dissolved Oxygen (DO)	7.5	23.00±0.00	0.13333	0.29371	0	306.67	90.07116
Biological Oxygen Demand	5.0	9.00±0.05	0.20000	0.46756	0	76	36.03468
Turbidity (NTU)	5.0	2.80±0.00	0.20000	0.44056	0	56.00	24.67136
Total Suspended Solid (mg/L)	<10	25.50±4.60	0.18700	0.51160	0	48	20.1473
Total Solids (mg/L)	1000	40.00±28.28	0.00100	0.00220	0	4.00	0.00881
Ammonia (NH ₃) (mg/L)	0	0.08±0.00	—	—	0	—	—

$$WQI = \frac{\sum W_n \times Q_n}{\sum W_n} = 139.4; \sum 1/S_n = 0.45397; K = 2.20279; \sum W_n = 1; \sum W_n \times Q_n = 135.49$$

3.1.3. Physiochemical and Bacteriological Analysis of Borehole Water from Hostel C

Hostel C recorded that temperature (27.90±0.00°C), pH (8.30 ± 0.00), Total Solids (40.00±28.28 mg/L), BOD (4.15±0.07 mg/L) and Turbidity (2.80±0.00 NTU) were within acceptable limits while color (0.015±0.00 PCU), EC (157.00±0.00 µS/cm) and TDS (9.50±0.00 mg/L) recorded extremely low concentrations and DO (23.00±0.00 mg/L) had very high concentration. Ammonia (0.10±0.00 mg/L) was detected in minimal amounts while TSS (30.90±28.28 mg/L) exceeded permissible limits as shown in Table 4.

Table 4: Physiochemical results from Hostel C

Parameter	Standard Limit (S _n)	Mean ± SE	1/S _n	W _n = K/S _n	Ideal Value (V _n)	Q _n = (V _n /S _n) × 100	W _n × Q _n
Temperature (°C)	30	27.90±0.00	0.03333	0.07343	0	0	0.00000
pH	8.5	8.20±0.00	0.11764	0.25915	7	80	20.72960
Colour (PCU)	15	0.015±0.00	0.06667	0.14685	0	0	0.00000
Electrical Conductivity (EC)	1000	157.00±0.00	0.00100	0.00220	0	1.40	0.00308
Total Dissolved Solids (TDS)	500	102.50±0.00	0.00200	0.00441	0	1.82	0.00807
Dissolved Oxygen (DO)	7.5	14.90±0.00	0.13333	0.29371	0	306.67	90.07116
Biological Oxygen Demand	5.0	4.15±0.05	0.20000	0.44056	0	83	36.56648
Turbidity (NTU)	5.0	2.80±0.00	0.20000	0.44056	0	56.00	24.67136
Total Suspended Solid (mg/L)	<10	28.40±6.50	0.22110	0.32056	0	43	22.1543
TSS (mg/L)	<10	9.50±0.00	0.19660	0.62150	0	55	24.4823
Total Solids (mg/L)	1000	102.00±28.28	0.00100	0.00220	0	4.00	0.00881
Ammonia (NH ₃) (mg/L)	0	0.10±0.00	—	—	0	—	—

$$WQI = \frac{\sum W_n \times Q_n}{\sum W_n} = 136.5; \sum 1/S_n = 0.45397; K = 2.20279; \sum W_n = 1; \sum W_n \times Q_n = 135.49$$

3.1.4. Physiochemical and Bacteriological Analysis of Borehole Water from Hostel D

Hostel C recorded that temperature (27.90±0.00°C), pH (8.30 ± 0.00), Total Solids (40.00±28.28 mg/L), BOD (4.15±0.07 mg/L) and Turbidity (2.80±0.00 NTU) were within acceptable limits while color (0.015±0.00 PCU), EC (157.00±0.00 µS/cm) and TDS (9.50±0.00 mg/L) recorded extremely low concentrations and DO (23.00±0.00 mg/L) had very high concentration. Ammonia (0.10±0.00 mg/L) was detected in minimal amounts while TSS (30.90±28.28 mg/L) exceeded permissible limits as shown in Table 5.

Table 5: Physiochemical results from Hostel D

Parameter	Standard Limit (S _n)	Mean ± SE	1/S _n	W _n = K/S _n	Ideal Value (V _n)	Q _n = (V _n /S _n) × 100	W _n × Q _n
Temperature (°C)	30	29.15±0.25	0.03333	0.07343	0	0	0.00000
pH	8.5	8.40±0.00	0.11764	0.25915	7	93.33	24.18724
Color (PCU)	15	0.0015±0.0005	0.06667	0.14685	0	0	0.00000
Electrical Conductivity (EC)	1000	16.00±0.00	0.00100	0.00220	0	1.60	0.03520
Total Dissolved Solids (TDS)	500	10.40±0.00	0.00200	0.00441	0	2.08	0.00917
Dissolved Oxygen (DO)	7.5	19.70±0.00	0.13333	0.29371	0	262.67	77.14792
Biological Oxygen Demand (BOD)	5.0	6.65±0.05	0.20000	0.44056	0	133.00	58.59448
Turbidity (NTU)	5.0	3.40±0.00	0.20000	0.44056	0	68.00	29.95808
Total Solids (mg/L)	1000	17.00±1.00	0.00100	0.00220	0	1.70	0.00374
TSS (mg/L)	<10	10.10±0.00	0.16650	0.45330	0	65	28.7435
Ammonia (NH ₃) (mg/L)	0	0.09±0.00	—	—	0	—	—

$$WQI = \frac{\sum W_n \times Q_n}{\sum W_n} = 189.9; \sum 1/S_n = 0.45397; K = 2.20279; \sum W_n = 1; \sum W_n \times Q_n = 189.94$$

3.1.5. Microbial contamination

The Total Coliform Count recorded 4 cfu/100mL, 4 cfu/100mL, 4 cfu/100mL and 30 cfu/100mL for hostel A, B, C and D respectively. Total Fungal Count detected at 2 cfu/100mL, 3 cfu/100mL, 1 cfu/100mL and 9 cfu/100mL for hostels A, B, C and D respectively. Total Fecal Coliform (cfu/100mL): Recorded as 0 was recorded for Hostel A, B, and C and 70 cfu/100mL for Hostel D. *Klebsiella* spp. (cfu/100mL): Detected at 20 cfu/100mL, 17 cfu/100mL, 4 cfu/100mL, and 0 cfu/100mL for hostels A, B, C and D respectively. *E. coli* Count (cfu/100mL) recorded 0 cfu/100mL in all hostels. WQI scale for hostels A, B, C and D recorded 135.5, 139.4, 136.5 and 189.9.

3.2 Discussion

Overall, hostels A–C show good physico-chemical quality (within guidelines) except for elevated BOD and TSS; hostel D recorded high faecal coliforms and coliforms, indicating contamination, despite otherwise acceptable chemistry (pH, turbidity, etc.). The hostel values (8.2–8.5) fell within WHO/NSDWQ limits.

The recorded temperatures (28–29°C) were typical of tropical groundwater. The Ghana Bole study noted temperature above WHO norms even when other parameters were within limits [11]. Bayelsa's studies seldom report temperature as exceeding the 30°C guideline [12]; the hostel waters ($\leq 29.2^\circ\text{C}$) comply with the standard. Odu *et al.* [13] reported pH 9.79–11.13 for wells/boreholes which were above WHO limits. Zige *et al.* [12] recorded pH 6.2–7.1 (neutral) in Bayelsa, Nigeria. While Bowan *et al.*, [11] reported all sampled borehole pH within WHO limits except for outliers. Thus, hostel A–D pH agrees with most values in coastal Nigeria (6–8). Variations arise from geology, sanitation, and hydrogeology. For example, the exceedingly alkaline pH (9.8–11.1) in Rivers State boreholes likely reflects local geology or contamination (limestone or cement grouting) [13], which was not present at the hostel site.

All hostels had essentially zero color and low turbidity (≤ 3.4 NTU), well below the WHO guideline (5 NTU). This matches most borehole studies, which typically report low turbidity (< 5 –10 NTU) for protected groundwater. Zige *et al.* [12] reported turbidity within WHO limits. Occasional turbidity issues arise when boreholes are poorly constructed or near disturbed sites; as reported by Nzenwa *et al.*, [14] turbidity above limits in some locations in Imo State. The hostel results show good clarity, consistent with many studies of rural boreholes.

Hostels A, B, and D have very low EC (14–16 $\mu\text{S}/\text{cm}$) and TDS (9–10 mg/L), except C, which had higher EC (157 $\mu\text{S}/\text{cm}$) and TDS (102 mg/L). All are far below NSDWQ (TDS ≤ 500 mg/L) and WHO (≤ 1000 mg/L) limits. Regional boreholes in the Niger Delta often have low to moderate salinity [15].

Oparaocha *et al.*, [16] reported all physicochemical parameters (including TDS/EC) within WHO limits. Bole district boreholes had acceptable physicochemical values except temperature. Groundwater often has lower DO than surface water; the hostel DO values (14.9–23.0 mg/L) are unusually high (saturation at 25°C is ~ 8 –9 mg/L). This likely reflects measurement or labeling issues. BOD, however, was elevated in hostels A, B, D (9–10 mg/L), exceeding the 5 mg/L guideline. This indicates organic pollution. By contrast, Aremu *et al.* [17] found BOD negligible, which suggested low values. High BOD in hostel A/B/D could be attributed to local contamination like surface runoff, organic residues not seen in the cleaner commercial boreholes of other studies.

The unusually high DO in some hostel samples may be methodological, that is, ambient equilibration, or due to highly aerated recharge.

The hostels' TSS (10–31 mg/L) often exceeded the limits of 10 mg/L. Hostels A to C had notably high TSS (25–31 mg/L), whereas D was 10.1 mg/L. Elevated TSS suggests particulate intrusion. Borehole study in Abuja reported low suspended solids in protected wells [17]. The high TSS in A–C may reflect near-surface contamination or less frequent cleaning. High BOD/TSS in some hostels suggests surface runoff or sewage infiltration – possibly from nearby hostels, farm runoff, or leaking septic systems. Total solids (TS) were high only in C (102 mg/L); otherwise, it is low, which is consistent with low EC/TDS. Hostels had 0.07–0.10 mg/L of NH_3 content, which is below acceptable limits (1.5 mg/L for WHO and 0 mg/L for NSDWQ) for any ammoniacal N as a test parameter. In a study conducted by Akpoveta *et al.*, [18], physicochemical parameters determined for borehole water used in the vicinities of Benin, Edo State, and Agbor, Delta State, of Nigeria were found to fall within the WHO/SON maximum permitted limit for potable water except for calcium and manganese.

The hostels showed clear contamination patterns; hostels A–C had low total coliform counts (4 cfu/100mL each) with no fecal coliforms, whereas Hostel D had 30 total coliforms and 70 fecal coliforms per 100 mL. *Klebsiella* was found in A (20), B (17), C (4) but not D; *E. coli* was absent in all samples. Under WHO/NSDWQ, any coliform should be 0 in 100 mL. Thus, all hostel waters fail microbial standards (NSDWQ oddly allows ≤ 10 cfu/mL for total coliform, but WHO requires 0 cfu/100mL). Some studies have reported faecal indicators in boreholes. In Bayelsa, Zige *et al.* [12] found no fecal coliform in most boreholes but did isolate *E. coli* (17.9%) and *Klebsiella* (35.7%) in the total bacterial load, concluding the water was unsafe. Similarly, Ghana's Bole district saw *E. coli* and total coliform “far above” WHO limits in all sampled boreholes [11]. The study in Fako, Cameroon, noted detectable coliforms in almost all water sources (surface and groundwater) with seasonal spikes in contamination [19]. However, Yusuf *et al.*, [20] reported that all the borehole water sampled in Offa and Erin-Ile in Kwara State and in Ilesa and Osogbo in Osun State, Nigeria, was free of *E. coli*. The hostels' pattern of low coliform in A to C and high contamination in D is in line with some findings that unprotected boreholes often harbour bacteria. Hostel D's contamination likely stems from proximity to waste or pipeline leaks, echoing observations that poor sanitation (pit latrines, dumpsites) degrades borehole water quality.

In short, our hostels' physico-chemical trends (neutral pH, low TDS/EC/turbidity) are broadly consistent with other Niger Delta borehole studies, whereas the microbial contamination (especially fecal coliforms in D) mirrors the common theme of faecal pollution found in many regional water sources. Commercial boreholes (with regular maintenance) can have very low microbial loads, implying that our hostel boreholes may lack similar upkeep [13]. Seasonal differences between wet vs dry seasons also affect coliform counts, as seen in Cameroon [11].

4.0. Conclusion and Recommendation

4.1. Conclusion

The hostel borehole waters are chemically similar to other Niger Delta boreholes (neutral to slightly alkaline pH, low TDS/EC), but their elevated BOD and coliforms (especially at Hostel D) highlight potential sanitary issues common in the region.

Many studies underscore that while groundwater often meets chemical standards, microbial safety is a frequent problem requiring treatment or better protection.

4.2. Recommendation

Based on the findings from this study from Owerri metropolis, the following are recommended;

1. Effective Disinfection Methods: Implement chlorination, ultraviolet disinfection, and boiling (short-term) to significantly reduce microbial contamination, ensuring safe drinking water.

2. Regular Water Quality Monitoring: Conduct quarterly physicochemical and bacteriological assessments, use real-time sensors for early detection, and maintain a water quality database to track trends and prevent unnoticed contamination.

3. Proper Siting of Water Sources: Ensure boreholes and wells are located at least 50–100 meters uphill from potential contamination sources, supported by hydrogeological surveys to minimize pollution risks.

4. Agricultural Practice Control: Establish buffer zones, apply fertilizers and pesticides responsibly, use biological pest control, and manage manure application to prevent agricultural runoff from contaminating water sources.

5. Proactive Surveillance Systems: Develop integrated surveillance strategies combining disinfection, monitoring, and siting best practices to sustain long-term water safety and protect public health.

Conflict of Interest: The authors declare that there is "No conflict of interest" regarding the publication and outcomes of this research. All procedures and analyses were conducted solely in pursuit of scientific knowledge and transparency.

Author's Contribution

OOMT: Writing, Data collection, analysis and writing.

OSG: Conceptualization, Formal analysis, drafting of the manuscript, data analysis, review, editing and supervision.

EEA: Formal analysis, drafting of the manuscript, data analysis, review, and editing.

NEO: Data analysis, writing, review, and editing.

ACU: Writing, review, and editing.

NJC: Conceptualization, study design, review, and editing

MTC: Study design, review, and editing

All authors should read and approve the final manuscript.

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