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Water Quality Assessment of River Obodo, Imiringi, Bayelsa State

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Abstract

This study provides a thorough assessment of the physicochemical and microbial water quality of River Obodo, located in the Imiringi community within Ogbia Local Government Area, Bayelsa State, Nigeria. Given the community's heavy reliance on the river for drinking, domestic use, agriculture, and fishing, assessing water quality is crucial for protecting public health and aquatic ecosystems. Water samples were collected from two ecologically significant sites during the wet season, when urban and surface runoff have the greatest impact on water chemistry and microbiology. Various parameters, including pH, temperature, conductivity, total dissolved solids (TDS), salinity, nitrate, and turbidity, were measured using in situ calibrated probes, titration, and turbidimetry methods. For microbial analysis, total heterotrophic bacteria count (THBC), total coliform count (TCC), total fecal coliform count (TFEC), and total fungal count (TFC) were quantified using standard serial dilution and selective cultivation techniques. The results revealed a slightly alkaline pH (8.0–8.5), typical tropical temperatures (~28°C), low conductivity and TDS, negligible salinity and nitrate levels, and moderate turbidity (18–19 NTU), indicating increased particulate loads due to wet season runoff and soil erosion. Microbial counts showed significant contamination, with total and fecal coliform bacteria present at concentrations (5.04–5.26 × 10^3 cfu/ml) far exceeding the zero-tolerance limits set by drinking water quality guidelines, signaling a risk of fecal pollution and potential pathogen presence. Elevated populations of heterotrophic bacteria and fungi further suggested organic contamination. These findings establish a baseline for the current water quality and highlight the need for ongoing monitoring to ensure public health and environmental sustainability in the area.

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Introduction

Water is an essential resource for sustaining life and economic activities, particularly in regions where rivers serve as primary sources of drinking water, agriculture, and aquaculture. The quality of river water is influenced by various physicochemical parameters, which determine its suitability for different uses. In Nigeria, concerns over water pollution and degradation of water bodies have intensified due to anthropogenic activities such as oil exploration, agricultural runoff, and domestic waste disposal (Obunwo *et al.,* 2022).

Water quality assessments are essential for understanding the impact of natural and anthropogenic factors on river systems. Studies by Ogbu *et al*. (2020) and Obunwo *et al.* (2022) emphasised that pollution from oil spills, industrial effluents, and agricultural runoff significantly alters the physicochemical composition of rivers in the Niger Delta, affecting aquatic biodiversity and public health. The Niger Delta, which includes Bayelsa State, has been identified as a hotspot for water pollution due to extensive oil exploration and artisanal refining (Nwankwoala and Amangabara, 2018). Rivers in the Niger Delta are characterized by fluctuations in physicochemical parameters due to seasonal variations and pollution sources.

Contaminated water sources pose severe public health challenges, particularly in rural communities where access to potable water is limited. According to Okonkwo *et al.* (2022), waterborne diseases such as cholera, typhoid, and dysentery are prevalent in regions with poor water and sanitation. The presence of heavy metals in drinking water has also been linked to long-term health issues such as cancer, reproductive disorders, and neurological impairments (Eneh *et al.,* 2021). Given the critical role of rivers in the livelihoods of communities in Ogbia LGA, assessing their physicochemical properties is essential for ensuring water safety and sustainability. The

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physicochemical analysis of river water in Ogbia LGA is vital for understanding the extent of pollution and its implications for public health and the environment. With increasing industrialisation and population growth in Bayelsa State, regular water quality assessments are necessary to monitor pollution trends and implement appropriate mitigation measures.

Materials and Methods

Study Area

The study was carried out at River Obodo, located in Imiringi community of Ogbia Local Government Area of Bayelsa State, within the Niger Delta region of Nigeria. Imiringi lies in the humid tropical climate zone, characterised by high rainfall, high relative humidity, and swampy vegetation typical of the Niger Delta ecosystem. The area experiences seasonal flooding and supports a wide range of ecological and human activities.

River Obodo is an important freshwater body frequently utilized by the local population for domestic purposes such as bathing, washing, cooking, irrigation, and fishing. However, the river is always subjected to anthropogenic pressures, including small-scale farming, disposal of domestic wastes, fishing activities, and occasional oil-related operations, all of which may adversely impact water quality.

Sampling Sites

The geographical coordinates of the sampling points were recorded as follows: Obodo A (4.8812°N, 6.3256°E), Obodo B (4.8825°N, 6.3271°E). These locations were chosen for the study due to their ecological relevance, proximity to human settlements, and the potential influence of anthropogenic activities on the microbial quality of the rivers.

Sample Collection

Water samples were collected from two designated sites within the river covering only the wet season when there is increased urban runoff. Standard protocols were followed for collecting and analysing samples. Parameters measured included temperature, pH, total dissolved solids, electrical conductivity, dissolved oxygen, turbidity, salinity, and nitrate. Microbial analysis was also carried out, which measured THBC (Total Heterotrophic Bacteria Count), TCC (Total Coliform Count), TFEC (Total Faecal Coliform Count) and TFC (Total Fungal Count).

Laboratory Analysis and Procedures for Physicochemical Properties and Microbial Water Quality

Temperature was measured in situ using a calibrated thermometer or a multiparameter probe to ensure immediate and accurate readings. pH was determined using a pH meter, calibrated with standard buffer solutions (pH 4.0, 7.0, and 10.0) before measurement. Dissolved Oxygen (DO) were measured using the Winkler titration method, which involves chemical fixation of oxygen followed by titration to determine concentration. Turbidity was assessed using a turbidimeter, where water samples are analysed for light scattering caused by suspended particles. Total Dissolved Solids (TDS) and Electrical Conductivity (EC) were measured with portable conductivity meters, correlating electrical conductance with ion concentrations.

Nutrient agar (NA) was used for the isolation of total heterotrophic bacteria, MacConkey (MAC) agar was used for the isolation of total coliforms, Eosin Methylene Blue agar (EMB) for the isolation of total faecal coliforms and Potato Dextrose agar (PDA) for the isolation of total fungi (Cheesbrough, 2006). One millilitre (1mL) of Surface water samples from Obodo river was added to 9ml of normal saline solution to make a 10-fold serial dilution of up to 103. 0.1ml from 102 were inoculated in duplicates on prepared surface dry NA, MAC, EMB AND PDA agar plates respectively and incubated at 37°c for 24 hours for bacteria and 25°c for 3-5 days for fungi. The inoculated bacterial plates after 24 hours of incubation showed visible colonies, which were then counted, and discrete colonies were subcultured on freshly prepared culture plates for 24 hours to obtain pure cultures. The inoculated fungi plates after 3-5 days of incubation showed visible colonies were subcultured on freshly prepared plates for 3-5 days to obtain pure cultures. The obtained pure cultures of the isolates were stored in 10% glycerol at -14 °C in Bijou bottles (Amadi *et al*., 2014).

Data Analysis: Descriptive analysis, including means, standard deviation and ranges, was computed for all sample sites.

Results

Table 1 presents the physicochemical results of River Obodo. Both sites exhibited slightly alkaline pH values (8.0 at Obodo A and 8.5 at Obodo B). Temperatures ranged from 27.5 to 28.5°C, consistent with tropical freshwater bodies. Conductivity and total dissolved solids were low and equal (22 µS/cm and 11 mg/L, respectively), indicating low ion content. Salinity and nitrate concentrations were minimal and identical (0.01 ppt and 0.01 mg/L, respectively), reflecting freshwater conditions with limited nutrient pollution. Turbidity ranged from 18.0 NTU at Obodo A to 18.9 NTU at Obodo B, likely reflecting localised suspended solids from wet season runoff

Table 1: Physicochemical Parameters of River Obodo

Parameter	Obodo A	Obodo B	Mean	Std Dev	Min.	Max.
pH	8.0	8.5	8.25	0.35	8.0	8.5
Temperature (^{0}C)	28.5	27.5	28.0	0.71	27.5	28.5
Conductivity (µS/cm)	22	22	22	0	22	22
TDS (mg/L)	11	11	11	0	11	11
Salinity (ppt)	0.01	0.01	0.01	0	0.01	0.01
Nitrate (mg/L)	0.01	0.01	0.01	0	0.01	0.01
Turbidity (NTU)	18.0	18.9	18.45	0.64	18.0	18.9

Table 2 shows the microbial population of the River Obodo. Total Heterotrophic Bacterial Count (THBC) values were slightly higher at Obodo B (5.23 ×10³ cfu/ml) than Obodo A (5.04 ×10³ cfu/ml). Total coliform counts ranged narrowly from 5.04 to 5.10 ×10³ cfu/ml, while total faecal coliform counts varied from 5.08 to 5.26 ×10³ cfu/ml. Fungal counts were moderately high (4.74 ×10³ cfu/ml at Obodo A and 4.60 ×10³ cfu/ml at Obodo B). These microbial levels suggest the presence of organic pollutants, possibly from domestic or agricultural sources.

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Table 2: Microbial Counts (x10^{3}cfu/ml) of Water Samples from River Obodo

Parameter	Obodo A	Obodo B	Mean	Std Dev
THBC	5.04	5.23	5.14	0.13
TCC	5.10	5.04	5.07	0.04
TFEC	5.08	5.26	5.17	0.13
TFC	4.74	4.60	4.67	0.10

Table 3 presents the table of physicochemical parameters when compared to the WHO and NESREA Standards. The limit for pH is 6.5 – 8.5, which is the same as the NESREA limits. The limit for temperature is not specified in the WHO and NESREA limits. Conductivity limit is <1000 in both standards. TDS is <1000 in both standards. Salinity, Nitrates and Turbidity is <5, ≤50 and ≤5 in both standards, respectively.

Table 3: Compare Physicochemical Parameters with WHO and NESREA Standards

Parameter	Observed Range	WHO limit	NESREA limit	Compliance
pH	8.0-8.5	6.5-8.5	6.5-8.5	Compliant
Temperature (^{0}C)	27.5-28.5	No specific limit	No specific limit	Acceptable
Conductivity (µS/cm)	22	<1000	<1000	Compliant
TDS (mg/L)	11	<1000	<1000	Compliant
Salinity (ppt)	0.01	No limit	<0.5	Compliant
Nitrate (mg/L)	0.01	≤50	≤50	Compliant
Turbidity (NTU)	18.0-18.9	≤5	≤5	Non-compliant

Table 4 presents the microbial population as compared to their WHO and NESREA limits. THBC has a WHO limit of <0.5 cfu/100ml and <1.0 cfu/100ml. TCC has a limit of 0 cfu/100ml for both WHO and NESREA. TFEC has a limit of 0 cfu/100ml in both standards. TFc limit was not specified, but should be absent in portable water.

Table 4: Compare Microbial counts with WHO and NESREA Standards

Parameters	Observed range	WHO	NESREA	Complance
THBC (x10^3cfu/ml)	5.04-5.23	<0.5 cfu/100ml	<1.0 cfu/100ml	Non-compliant
TCC(x10^3cfu/ml)	5.04-5.10	0 cfu/100ml	0 cfu/100ml	Non-Compliant
TFEC(x10^3cfu/ml)	5.08-5.26	0 cfu/100ml	0 cfu/100ml	Non-compliant
TFC(x10^3cfu/ml)	4.60-4.74	Not specified (should be absent in potable water)	Not specified (should be absent in potable water)	Non-compliant

Discussion

The alkaline pH values align with previous studies reporting pH ranges of 7.8-8.5 in less acidic Niger Delta waters during the wet season (Ezekiel et al, 2023). Temperature ranges reflect the tropical climate and influence dissolved oxygen availability, which in turn affects aquatic life sustainability. Low conductivity and TDS values reflect minimal ionic pollution, likely from limited industrial effluents. However, moderate turbidity suggests runoff contribution typical in wet seasons characterised by soil erosion and particulate matter influx. The physicochemical parameters indicate that River Obodo during the wet season exhibits slightly alkaline, warm, low-salinity freshwater with moderate turbidity influenced by runoff. The relatively stable water quality between the two sites highlights similar environmental stressors affecting both locations.

The presence of moderate coliform and faecal coliform bacteria is indicative of potential faecal contamination, raising concerns about the safety of the water for drinking and domestic use without treatment. Such microbial presence aligns with reported public health challenges in rural Niger Delta communities relying on untreated surface water (Okonkwo et al., 2022). The fungal counts also reflect natural aquatic microbiota, but could increase from organic pollution. The WHO and NESREA guideline range of 6.5 to 8.5 aims to ensure water is neither too acidic nor too alkaline, protecting pipes from corrosion, reducing metal leaching, and maintaining aquatic life health. River Obodo's pH values (8.0 and 8.5) fall within this range, indicating acceptable alkalinity that is unlikely to cause equipment damage or harm aquatic organisms. Turbidity limits restrict suspended particles that reduce water clarity. High turbidity can provide a medium for microbial growth and shield pathogens from disinfection. Both WHO and NESREA set 5 NTU as the maximum for safe drinking water. Observed turbidity of 18.0-18.9 NTU in River Obodo exceeds this, likely due to wet season runoff carrying sediments. This elevates health risks and reduces treatment efficiency, underscoring the need for sediment control and treatment before use. Nitrate is regulated due to its capacity to cause methemoglobinemia (blue baby syndrome), particularly in infants. The 50 mg/L limit set by WHO and NESREA reflects levels considered safe for long-term consumption. River Obodo's nitrate levels (0.01 mg/L) are well below this threshold, indicating minimal agricultural or sanitary contamination regarding nitrogen. Microbial Indicators (Total and Faecal Coliforms = 0 cfu/100 mL). Zero coliform presence is mandated to assure the absence of faecal contamination and waterborne pathogens. River Obodo's microbial loads (5.04-5.26 $\times 10^3$ cfu/ml) far exceed this safe standard, implying direct contamination from domestic wastes or agricultural runoff. This represents a critical public health concern necessitating urgent interventions, including improved sanitation and water treatment.

WHO and NESREA standards serve as essential benchmarks to assess potable water safety. In the Niger Delta's wet season, elevated turbidity and microbial contamination driven by flooding, runoff, and anthropogenic pollution are common challenges. Thus, while River Obodo meets chemical quality criteria, microbial compliance failure signals contamination risks for local populations relying on untreated surface water. Regular monitoring following these standards is vital to detect seasonal or episodic pollution and implement early control measures. The standards also guide infrastructural improvements (e.g., filtration) needed to safeguard public health.

Conclusion

River Obodo in Imiringi, Bayelsa State, exhibits moderately good physicochemical quality during the wet season, characterised by a slightly alkaline pH and low dissolved solids, except for turbidity. These findings suggest that chemical pollutants are likely minimal, as evidenced by low salinity, nitrate, and dissolved solids levels. However, the microbiological quality is poor, with high levels of coliforms and heterotrophic bacteria, indicating significant faecal contamination that poses serious health risks for those dependent on river water. The presence of elevated microbial contamination, particularly faecal indicators, highlights the potential health hazards for communities using this water. High turbidity often correlates with microbial contamination, as suspended

particles can harbour bacteria and interfere with disinfection processes. This study emphasises the urgent need for interventions, including improved sanitation, pollution control, and the implementation of effective water treatment technologies before consumption. Ongoing monitoring and pollution mitigation efforts are essential to protect water quality and public health in the region. A comparison with the WHO and NESREA guidelines reveals that while the chemical quality of River Obodo water is acceptable, its microbiological safety is a concern. The high turbidity and bacterial contamination underscore the critical need for integrated environmental management, sanitation enhancements, and water treatment to reduce the risk of waterborne diseases.

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