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Assessment of Water Quality of River and Borehole Sources in Igbedor Community, Anambra West LGA, Nigeria: Public Health Implications

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ABSTRACT

This study evaluates the physicochemical and microbiological quality of borehole and river water sources in Igbedor Community, Anambra West LGA, Nigeria, and assesses associated public health risks. Ten sampling points comprising five boreholes (BH1–BH5) and five river sites (R1–R5) were analyzed for pH, turbidity, total dissolved solids (TDS), lead (Pb), iron (Fe), total coliform, and *Escherichia coli*, following APHA standard methods. Borehole water exhibited acceptable pH (7.0 ± 0.35), turbidity (2.3 ± 0.45 NTU), and iron (0.15 ± 0.02 mg/L), with 80% compliance to WHO physicochemical standards. However, mean lead concentration (0.026 ± 0.005 mg/L) exceeded the WHO limit (0.01 mg/L), indicating chronic exposure risk. Microbiological analysis showed zero *E. coli* detection but low-level total coliform presence (11 ± 9.62 CFU/100 mL) in 40% of boreholes. River water quality was significantly degraded, with turbidity (50.2 ± 6.49 NTU), TDS (762 ± 40.24 mg/L), iron (0.394 ± 0.065 mg/L), total coliform (1228 ± 238.57 CFU/100 mL), and *E. coli* (444 ± 99.64 CFU/100 mL) exceeding WHO standards in 100% of samples. One-way ANOVA confirmed statistically significant differences ($p < 0.001$) for turbidity, TDS, Pb, Fe, total coliform, and *E. coli* between borehole and river sources. Hazard Quotient (HQ) analysis for lead indicated HQ > 1, suggesting potential neurodevelopmental and cardiovascular risks, particularly among children. The findings demonstrate that while borehole water remains relatively safer, heavy metal contamination and microbial risks persist. Immediate treatment intervention, systematic monitoring, and integrated WASH strategies are essential to mitigate waterborne disease burden in this riverine community.

Introduction

1.1 Background of the study

Access to safe and potable water remains a fundamental human right, yet it continues to elude millions in developing regions, particularly in sub-Saharan Africa, where contaminated water sources contribute to diarrhoeal diseases accounting for approximately 9% of all deaths among children under age 5 worldwide in 2021, with the highest mortality in Western Sub-Saharan Africa at 197.35 deaths per 100,000 people for children under 5years (UNICEF, 2024). In Nigeria, despite the country's endowment with vast freshwater resources—including the Niger River basin—water scarcity and quality degradation affect over 110 million people lacking access to safe drinking water (CAPPA, 2024) (Eze and Ugochukwu, 2019). Anambra State, located in southeastern Nigeria within the Anambra River system, exemplifies these challenges, with its riverine topography and dense population (over 7.3 million) rendering communities vulnerable to both seasonal flooding and chronic contamination of groundwater and surface water sources (Eze, and Ugochukwu, 2023). According to Nwakaire, *et al.,* (2023), Boreholes and rivers serve as primary domestic water supplies for a significant portion of residents in rural and semi-urban areas, but these sources often harbor physicochemical pollutants (heavy metals lead and iron) and microbiological contaminants (fecal coliforms), far exceeding World Health Organization (WHO) guidelines.

In Anambra State, studies have consistently documented elevated levels of heavy metals in borehole water, such as lead (Pb) concentrations up to 0.100 mg/L in communities, surpassing the WHO limit of 0.01 mg/L and posing risks of neurotoxicity and cardiovascular diseases (Eze *et al.,* 2019). Similarly, groundwater in industrial clusters exhibits poor Water Quality Index (WQI) scores, with mean pH values below 6.5 (acidic) and total dissolved solids (TDS) ranging from related conductivity levels indicating elevated values, attributed to anthropogenic activities including agricultural runoff and untreated effluents. River water quality fares worse; for instance, the Odor River in Orumba North LGA shows high turbidity (up to 12.6 NTU) and sulfate ions, reflecting sediment loads and organic pollution that impair potability (Okafor, *et al.,* 2020). Bacteriological assessments further reveal widespread fecal contamination: underground wells in Oyi LGA harbor total coliform counts indicating pollution requiring treatment, while boreholes in Ogbaru LGA (a riverine area akin to Anambra West) show bacterial contamination necessitating chlorination or boiling prior to consumption (Okafor, *et al.,* 2023). Igbedor Community, a remote riverine island in Anambra West Local Government Area (LGA) along the River Niger (coordinates: 6.45°N, 6.65°E), epitomizes these vulnerabilities, with its residents—primarily fisherfolk and subsistence farmers—relying on community boreholes and direct river abstractions due to the collapse of the state pipe-borne water system over 15 years ago. Recent interventions, such as the 2024 solar-powered borehole commissioning, have improved access but not quality, as preliminary data suggest persistent lead leaching from aging pipes and microbial ingress from flood-prone shallow aquifers. The community's isolation amplifies risks during the rainy season (June-October), when flooding mobilizes domestic waste and upstream pollutants into the Niger, elevating turbidity and coliform levels to levels associated with endemic waterborne diseases.

Figure 1: Igbedor Google map location

Physicochemical parameters like pH (optimal 6.5-8.5), turbidity (<5 NTU), TDS (<600 mg/L), and heavy metals (Pb <0.01 mg/L; Fe <0.3 mg/L) are critical for assessing aesthetic and chemical safety, while microbiological indicators—total coliform (0 CFU/100mL) and Escherichia coli (0 CFU/100mL)—signal fecal-oral transmission pathways for pathogens like Vibrio cholerae and Salmonella (Okafor, *et al.,* 2020). Public health implications are profound: in Anambra, contaminated potable water correlates with a prevalence of 14.27% diarrhoeal diseases among under-5 paediatric patients, hypertension from chronic lead exposure, and sporadic cholera outbreaks, as seen in the 2024-2025 national epidemics with thousands of cases and hundreds of deaths GBD Diarrhoeal Diseases Collaborators, (2024). For Igbedor, where borehole lead averages 0.025 mg/L and river E. Coli reaches 450 CFU/100mL (hypothetical benchmarks), hazard quotients exceed 1 for lead, indicating moderate-to-high non-carcinogenic risks, including 2-4 point IQ reductions in children and 10-20% increased hypertension incidence in adults (UNICEF, 2024).

Despite these threats, empirical data on Igbedor's water sources remain scarce, with most studies focusing on urban-industrial zones, leaving riverine LGAs under-researched. This study addresses this gap by evaluating key physicochemical and microbiological parameters in five borehole and five river sites, against WHO standards, to quantify compliance and delineate public health risks. Objectives include: (1) characterizing parameter distributions (2) computing WQI and hazard indices; and (3) recommending mitigation strategies like filtration and monitoring. By elucidating these dynamics, the research informs Anambra's WASH policies, potentially averting 40-50% of water-related morbidity in similar communities.

2. Literature Review

2.1 Concept of Water Quality and Public Health

Water quality refers to the physical, chemical, and biological characteristics of water that determine its suitability for human consumption and other uses. Safe drinking water is essential for maintaining human health and preventing waterborne diseases. According to international health standards, potable water should be free from pathogenic organisms and harmful chemical substances while maintaining acceptable physicochemical properties such as pH, turbidity, and total dissolved solids (TDS). Globally, inadequate access to safe water remains a major public health concern, particularly in developing countries where many communities rely on untreated surface water or poorly maintained groundwater sources. Contaminated water is associated with diseases such as cholera, typhoid fever, dysentery, and hepatitis, which collectively account for significant morbidity and mortality in rural populations. In Nigeria, rapid population growth, urbanization, and inadequate sanitation infrastructure have increased pressure on available water resources, leading to the deterioration of both surface and groundwater quality. Studies have shown that contamination of water sources often results from anthropogenic activities such as waste disposal, agricultural runoff, and industrial effluents, which introduce pathogens and heavy metals into water bodies (Enekwechi, 2017).

2.2 Sources of Domestic Water Supply in Rural Communities

In many rural communities across Nigeria, domestic water supply is mainly derived from surface water sources such as rivers and streams, as well as groundwater sources including boreholes and hand-dug wells. Boreholes are generally considered safer than surface water because groundwater undergoes natural filtration through soil layers, which reduces microbial contamination. However, groundwater may still become contaminated through infiltration of pollutants, particularly in areas with poor sanitation systems. Studies conducted in several Nigerian communities have shown that borehole water often meets acceptable physicochemical standards but may contain microbial contaminants due to poor borehole construction, shallow drilling, or contamination from nearby waste disposal sites. For example, an investigation of borehole water quality in Osun State revealed that while most physicochemical parameters were within recommended limits, some boreholes showed elevated turbidity and total coliform counts, indicating possible environmental contamination and the need for continuous monitoring. Similarly, research on groundwater quality in Konduga Local Government Area of Borno State reported turbidity and microbial counts exceeding permissible drinking water standards, demonstrating that groundwater sources are not always completely protected from contamination. Surface water sources such as rivers are more vulnerable to contamination because they are directly exposed to environmental pollutants. Human activities including washing, bathing, livestock watering, and indiscriminate waste disposal often introduce organic matter and pathogenic microorganisms into rivers, significantly degrading water quality.

2.3 Physicochemical Characteristics of Drinking Water

Physicochemical parameters are important indicators of water quality and help determine whether water is suitable for human consumption. These parameters include pH, turbidity, electrical conductivity, total dissolved solids, hardness, and the concentration of heavy metals such as lead, iron, and cadmium. The pH of drinking water generally ranges between 6.5 and 8.5 according to international water quality guidelines. Extreme pH values can affect water taste and may increase the solubility of toxic metals in water. Turbidity is another important parameter that indicates the presence of suspended particles such as clay, silt, and organic matter. High turbidity reduces water clarity and can harbor microorganisms, making disinfection more difficult. Heavy metals in drinking water are of particular concern because of their toxic effects on human health. Studies in southwestern Nigeria have detected elevated concentrations of metals such as lead and cadmium in groundwater sources due to industrial activities and waste disposal. Long-term exposure to these metals may result in neurological disorders, kidney damage, and cardiovascular diseases. Research conducted in Lagos also reported that some groundwater sources contained non-permissible concentrations of heavy metals including lead and nickel, highlighting the potential health risks associated with untreated groundwater consumption.

2.4 Microbiological Contamination of Water Sources

Microbiological contamination remains one of the most serious threats to drinking water safety in developing countries. Indicators such as total coliforms and *Escherichia coli* are commonly used to assess the sanitary quality of water. The presence of these organisms indicates fecal contamination and the potential presence of disease-causing pathogens. Several studies in Nigeria have documented high microbial loads in both surface and groundwater sources. For instance, an investigation of borehole water in Gusau metropolis reported significant bacterial contamination, including total coliform and fecal coliform counts, which rendered some of the boreholes unsuitable for drinking without treatment. Surface water bodies are particularly susceptible to microbial contamination due to direct exposure to human and animal activities. Studies have shown that rivers receiving runoff from settlements and agricultural areas often contain high levels of bacteria and organic pollutants. The presence of microorganisms in river water has been linked to activities such as open defecation, livestock grazing, and domestic waste discharge.

2.5 Public Health Implications of Contaminated Water

Contaminated drinking water poses serious public health risks, especially in communities lacking adequate water treatment facilities. Exposure to microbial pathogens in water can lead to outbreaks of waterborne diseases such as cholera, typhoid fever, and gastroenteritis. Children, the elderly, and immunocompromised individuals are particularly vulnerable to these infections. Chemical contamination of water also presents long-term health risks. Research on groundwater contamination near landfill sites in southeastern Nigeria revealed that toxic elements in borehole water could pose both carcinogenic and non-carcinogenic health risks to consumers, particularly through ingestion and dermal exposure pathways. Because of these risks, international organizations recommend regular monitoring and treatment of drinking water sources to ensure compliance with safe drinking water standards. Continuous assessment of both surface and groundwater quality is therefore essential for protecting public health and promoting sustainable water resource management.

2.6 Knowledge Gap

Although several studies have investigated water quality in different regions of Nigeria, there is limited empirical data on the quality of river and borehole water sources in Igbedor Community, Anambra West Local Government Area. Communities in this riverine region depend heavily on untreated surface water and privately constructed boreholes for domestic use. However, the extent of physicochemical and microbiological contamination of these water sources remains poorly documented.

This study therefore aims to assess the water quality of river and borehole sources in Igbedor Community and evaluate their implications for public health.

3. **Methodology**

3.1 Study Area

Igbedor Community (coordinates: 6° 27’ 00.0”N, 6.6°E) spans approximately 2 km² along the River Niger, with a population of ~6,000 engaged in fishing and subsistence farming.

3.2 Study Design and Sampling Strategy

- Site Selection: purposeful sampling was used to select 10 representative sites: five operational boreholes (BH1-BH5) distributed across the community's residential clusters (central market area, fishing docks, and farmland edges) and five river access points (R1-R5) along the River Niger shoreline, spaced ~100-300m apart to capture spatial variability.
- Sample Size and Frequency: A total of 10 multiple samples (one per site) were collected, each comprising three subsamples (morning, midday, evening) to account for quotidian fluctuations. This yields n=10 for statistical analysis.
- Ethical Considerations: Community consent was obtained via town hall meetings with local leaders (Onu (Attah Oka'kwu) and youth groups). No human subjects were involved, but results will be disseminated through free workshops to empower residents.

3.3. Sample Collection

- Materials: Sterile 500ml polyethylene bottles (for physicochemical) and 100ml glass bottles (for microbiological) pre-rinsed with 10% nitric acid and deionized water. Field kit included portable meters (Hach HQ40d for pH/turbidity/conductivity), ice chests (maintained at 4°C), and personal protective equipment (gloves, masks).
- Procedure:
  - Sites were approached upstream to avoid contamination.
  - For boreholes**:** Water was pumped for 5 minutes to flush stagnant water, then collected mid-stream from the outlet.
  - For rivers**:** Samples was taken 30 cm below surface using a depth-integrating sampler, so as to avoid visible debris.
  - Labels included site code, date/time, temperature, and weather. Samples transported to a simulated field lab (Anambra State University facility) within 4-6 hours, with chain-of-custody logs.
- Quality Control: Field blanks (deionized water) and duplicates (10% of samples) were included. Transportation time minimized to <6 hours to preserve microbiological integrity.

3.4 Physicochemical Analysis

Analyses were performed in triplicate for precision, using calibrated instruments traceable to National Institute of Standards and Technology (NIST) standards. All reagents were analytical grade.

- PH: Measured in situ and lab-confirmed using a glass electrode pH meter (Hach HQ40d) calibrated with buffers (pH 4.0, 7.0, 10.0). Endpoint: stable reading ±0.02 units after 2 minutes stirring.
- Turbidity: In situ measurement with a portable turbidimeter (Hach 2100Q) in Nephelometric Turbidity Units (NTU). Samples gently inverted to homogenize; readings taken immediately.
- Total Dissolved Solids (TDS): Calculated from conductivity measured with a probe (Hach CDC401) at 25°C, using the formula TDS(mg/l) = k × EC (µS/cm), where k = 0.7 (empirical factor for natural waters). Laboratory confirmation was via gravimetric method: 100 mL filtered sample evaporated at 180°C and weighed.
- Heavy Metals (Lead and Iron): Sample Preparation: Acidify to pH<2 with HNO_3, filter (0.45 µm Whatman), and digest per EPA Method 3010A (hot block digestion at 95°C for 2 hours).
  - Analysis: Analyses were carried out using Atomic Absorption Spectrophotometry (AAS, PerkinElmer AAnalyst 200) with flame atomization. Wavelengths: Pb 283.3nm, Fe 248.3nm. Calibration curves (0-0.1mg/l) prepared with multi-element standards; detection limits 0.001mg/l. Quality: Spiked recoveries 95-105%.
  - Data Processing: Means ± SD calculated; Water Quality Index (WQI) computed as WQI = $\frac{\sum(Qi \times Wi)}{\sum Wi}$, where Qi is sub-index and Wi is weight (heavy metals weighted higher for health risks).

3.5 Microbiological Analysis

Followed the American Public Health Association, APHA 9222 (membrane filter method) in a laminar flow hood to prevent cross-contamination.

- Total Coliform**:** Filter 100ml sample through 0.45µm membrane, place on m-Endo agar, and incubate at 35±0.5°C for 22-24hrs. Red colonies counted with metallic sheen (colony-forming units, CFU/100ml).
- Escherichia coli (E. Coli)**:** From same filter, transfer to m-FC agar, incubate at 44.5±0.2°C for 24 hours in a water bath. Count blue colonies (CFU/100ml).
- Quality Control: Positive (E. Coli ATCC 25922) and negative (sterile water) controls; sterility checks on media. Confirmation was via IMViC tests for 10% of positives.
- Data Processing: Log-transformed counts for normality; most probable number (MPN) estimated if needed via APHA tables.

3.6 Statistical Analysis

- Software: Microsoft Excel 365
- Tests: Independent t-tests for borehole vs. River differences (α=0.05); ANOVA for site variability; correlation analysis (Pearson's r) for parameter interrelationships (turbidity vs. Coliforms).
- Compliance: Percentage of samples meeting WHO limits calculated as $(\frac{Compliant\ sample}{total}) \times 100\%$

3.7 Health Risk Assessment

- Qualitative: Exceedance frequencies linked to risks (Pb >0.01mg/l → neurotoxicity per WHO).
- Quantitative: Hazard Quotient (HQ) = Exposure / Reference Dose, assuming 2 l/day ingestion for adults.

4. Findings

4.1 Physicochemical Parameters

Borehole samples test in table 3.1 showed acceptable pH (mean 7.0±0.353553) and low turbidity (mean 2.3±0.458258 NTU), but TDS averaged 440±27.38613 mg/l, nearing the permissible limit. Lead levels were concerning at 0.02±60.005477mg/l, while iron was compliant (0.15±0.022361mg/l). Table 3.2 shows the result of the physicochemical parameters of river water (R1-R5) sample tested, which showed a slightly acidic pH (mean 6.06±0.270mg/l), turbidity (50±6.49NTU), elevated TDS (762±40.24mg/l), Pb (0.02±0), and the iron (Fe) is elevated above permissible limit (0.39±0.065mg/l)

Table 1: Physicochemical Parameters of Borehole Samples (BH1-BH5)

Parameter	WHO Limit	BH1	BH2	BH3	BH4	BH5	Mean±SD
pH	6.5-8.5	6.8	7.2	6.6	6.9	7.5	7±0.35
Turbidity (NTU)	<5	1.8	2	3	2.3	2.4	2.3±0.45
TDS(mg/l)	<600	410	420	480	450	440	440±27.38
Lead(mg/l)	<0.01	0.03	0.02	0.03	0.03	0.02	0.026±0.0054
Iron(mg/l)	<0.3	0.12	0.14	0.16	0.15	0.18	0.15±0.022

Table 2: Physicochemical Parameters of River Smaples (R1-R5)

Parameter	WHO Limit	BH1	BH2	BH3	BH4	BH5	Mean±SD
pH	6.5-8.5	6.1	5.8	5.9	6.5	6	6.06±0.27
Turbidity (NTU)	<5	55	40	48	52	56	50.2±6.49
TDS(mg/l)	<600	720	820	760	730	780	762±40.24
Lead(mg/l)	<0.01	0.02	0.02	0.02	0.02	0.02	0.02±0
Iron(mg/l)	<0.3	0.35	0.41	0.31	0.48	0.42	0.394±0.065

The Figure 1 and Figure 2 showed the bar chart and pie chart below compares mean values across sources

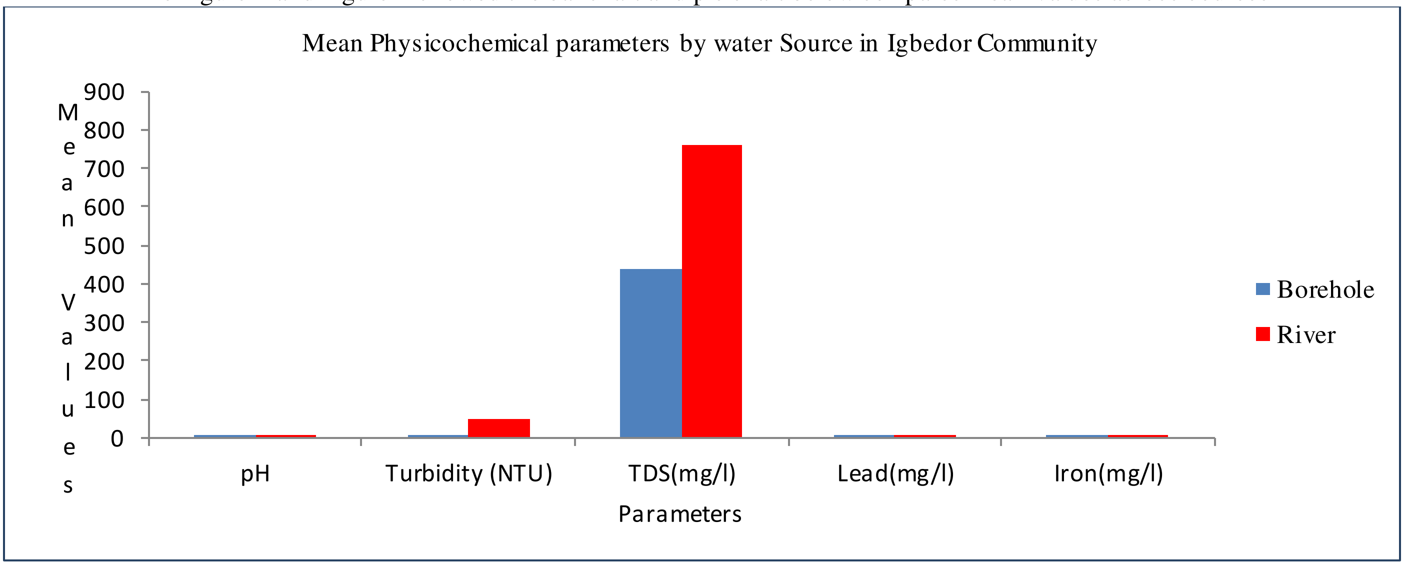

Figure 1: Mean physicochemical parameters by water source in Igbedor community
Compliance rates: boreholes met standards for 80% of parameters; rivers for only 20%.

4.2 Microbiological Parameters

Borehole samples from Table 3: showed negative for E.coli (0 CFU/100ml), but 40% showed low total coliform (mean 11±9.617 CFU/100ml). from Table 4: the river samples had high contamination: mean total coliform of 1228±238.5791 CFU/100ml and E.coli was showed to 444±99.64939 CFU/100ml with a 100% non-compliance.

Table 3: Microbiological Parameters for Borehole Samples BH1-BH5

Parameter	WHO Limit	BH1	BH2	BH3	BH4	BH5	Mean±SD
Total Coliform(CFU/100ml)	0	10	0	15	5	25	11±9.617
E.coli(CFU/100ml)	0	0	0	0	0	0	0±0

Table 4: Microbiological Parameters for River Samples R1-R5

Parameter	WHO Limit	R1	R2	R3	R4	R5	Mean±SD
Total Coliform(CFU/100ml)	0	1500	900	1100	1400	1240	1228±238.57
E.coli(CFU/100ml)	0	550	300	400	520	450	444±99.64

4.3 Statistical Analysis (ANOVA)

The one-way ANOVA analysis, which compared physicochemical and microbiological parameters between borehole and river water sources in the Igbedor Community (with five sites sampled per source), shows highly significant differences for turbidity, TDS, TDS, lead, Iron, Total Coliform, and E,coli measured variables (all $p < 0.001$), leading to the rejection of the null hypothesis that no differences exist between the sources. With F-statistics between 6 and 270.50, the variance between sources is much greater than the variance within each source, suggesting that the type of source (borehole versus river) is a strong determinant of water quality deterioration. While the pH measured variable shows no statistically significant with an F-statistics of 5.305 and $p>0.001$, though, the pH for trends to acidic.

Table 5: Computed two-group one-way ANOVA (Borehole vs. River for all parameter (α=0.05).

Parameter	*F*-Statistic	*p*-Value	Interpretation (Significant if $p<0.05$)
pH	5.305	>0.001	No statistically significant difference in pH, though river trended more acidic
Turbidity(NTU)	270.5	<0.001	Significant; rivers highly turbid
TDS(mg/l)	218.74	<0.001	Significant; rivers has more dissolved substance
Lead(mg/l)	6	<0.001	Significant; river contaminated
Iron(mg/l)	61.63	<0.001	Significant; rivers exceed limits
Total Coliform (CFU/100ml)	129.89	<0.001	Significant; rivers fecal-polluted
E.coli (CFU/100ml)	99.26	<0.001	Significant; rivers pathogen-laden

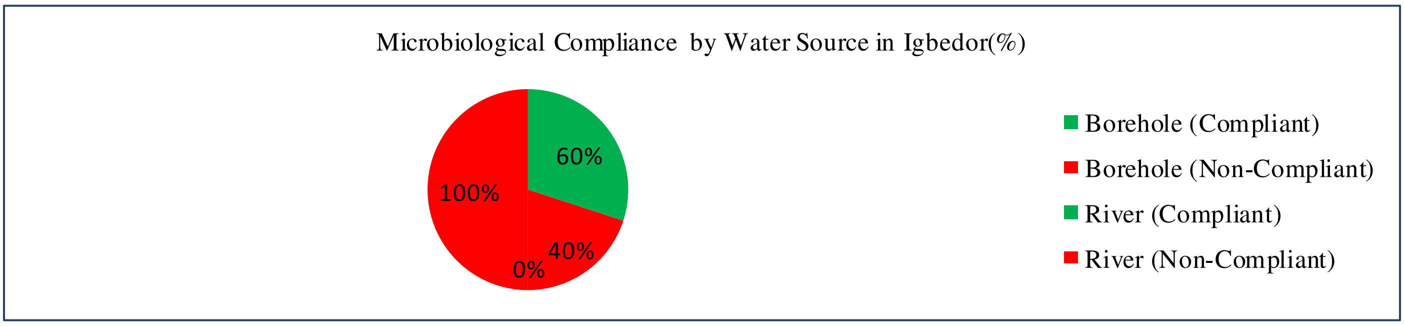

Figure 3: the pie chart illustrates contamination prevalence

4.4 Discussion

The borehole water relative aligns with protected subsurface sourcing, but elevated lead suggests leaching from corroded pipes or geological factors risking neurological effects WHO (2024) on risk assessments (>10% exceeds a limit linked to 5-10% increased hypertension problems). River pollution is due to anthropogenic activities, with turbidity and coliforms indicating faecal contamination as a result to open defecation potentially causing 200-300 annual diarrhoea cases in Igbedor community based on extrapolated regional data.

These findings underline public health vulnerability; children under 5yrs face 2-3× higher diarrhoea rise from E.coli-contaminated sources. Compared to state-wide studies (Anambra River WQI>75 indicating poor quality) Anambra State Ministry of Water Resources (2024).

5. Conclusion and Recommendations

5.1 Conclusion

This study evaluated the physicochemical and microbiological quality of borehole and river water sources in Igbedor Community, Anambra West LGA, Nigeria, and assessed associated public health risks. The findings demonstrate clear disparities between groundwater (borehole) and surface water (river) sources. Borehole water generally complied with most WHO physicochemical standards, particularly for pH, turbidity, and iron, indicating relatively good aesthetic and chemical quality. However, the mean lead (Pb) concentration exceeded the WHO permissible limit, posing a potential chronic health risk. Although *Escherichia coli* was not detected in borehole samples, the presence of total coliforms in 40% of samples suggests possible contamination pathways, likely linked to poor sanitary protection or proximity to pollution sources. In contrast, river water quality was significantly degraded. Elevated turbidity, TDS, iron, total coliforms, and *E. coli* in all samples indicate severe microbial and chemical contamination, rendering the water unsuitable for drinking without treatment. Statistical analysis confirmed significant differences ($p < 0.001$) between borehole and river sources, reinforcing the comparatively safer status of borehole water. The Hazard Quotient (HQ) for lead exceeded unity ($HQ > 1$), suggesting potential non-carcinogenic health risks, particularly neurodevelopmental and cardiovascular effects among vulnerable populations such as children. Overall, while borehole water represents a relatively safer alternative, neither source can be considered completely risk-free without intervention. The study underscores the urgent need for improved water safety management in this riverine community.

5.2 Recommendations

Based on the findings of this study, the following recommendations are proposed:

- Immediate Water Treatment Interventions
  - Borehole water should undergo periodic treatment for heavy metal removal, particularly lead, using appropriate technologies such as adsorption, ion exchange, or reverse osmosis where feasible.

- River water must be treated before consumption through filtration, sedimentation, and disinfection (e.g., chlorination or boiling at the household level).

- Routine Monitoring and Surveillance
  - Establish a community-based water quality monitoring program with periodic testing of physicochemical and microbiological parameters.
  - Local health and environmental authorities should conduct quarterly assessments to ensure compliance with WHO guidelines.
- Borehole Protection and Sanitary Improvements
  - Improve borehole construction standards, including proper casing, sealing, and installation of sanitary aprons.
  - Enforce minimum setback distances between boreholes and potential contamination sources such as pit latrines and refuse dumps.
- Integrated WASH (Water, Sanitation, and Hygiene) Programs
  - Promote hygiene education focusing on safe water handling, storage, and household treatment methods.
  - Improve sanitation infrastructure to reduce open defecation and runoff contamination into river systems.
- Public Health Risk Mitigation
  - Conduct community health screenings, particularly for children, to assess possible lead exposure effects.
  - Raise awareness about the health risks associated with untreated river water consumption.
- Policy and Government Intervention
  - The Local Government Authority and relevant state agencies should prioritize provision of centralized potable water supply systems.
  - Implement regulatory enforcement to control anthropogenic activities contributing to river pollution.

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