



MICROBIOLOGICAL QUALITY AND SANITARY RISK ASSESSMENT OF GROUNDWATER SOURCES IN EBONYI STATE, NIGERIA

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ABSTRACT

This study assessed the microbiological quality and sanitary risk of groundwater sources in Ebonyi State, Nigeria. A total of 92 groundwater samples were collected and analyzed for coliforms and total coliforms, and selected physicochemical parameters. Coliform counts ranged from 0 to 200 CFU/100 mL (mean: 27.17 ± 63.68), with a compliance level of 79.3% against the Nigerian Standard for Drinking Water Quality (NSDWQ) and WHO guidelines. Total coliforms varied from 0 to 200 CFU/100 mL (mean: 52.22 ± 78.07), showing 64.1% compliance. Turbidity varied between 0.33 and 50.4 NTU (mean: 4.14 ± 6.91) with 81.5% compliance level, TDS ranged from 18.63 to 883.1 mg/L (mean: 280.03 ± 66.95) with 96.6% compliance, EC ranged from 35.5 to 1682 (mean: 549.58 ± 327.5) with 96.6% compliance level and pH ranged from 4.0 to 8.5 (mean: 6.98 ± 0.99) with 83.7% compliance. Sanitary risk assessment based on risk factors, including proximity to latrines, waste disposal sites, flooding, and poor wellhead protection. A sanitary inspection scorecard was applied to classify risk as low, medium, or high. The risk assessment revealed 4.3% of sources as high risk, 41.3% as medium risk, and 54.4% as low risk. The findings indicate moderate contamination of groundwater sources, underscoring the need for improved source protection and community water safety interventions.

KEYWORDS: Groundwater, Microbiological quality, Coliforms, Sanitary risk

INTRODUCTION

Access to safe drinking water remains a significant challenge in developing countries, where groundwater is often the primary source for rural and peri-urban communities. In Nigeria, groundwater contributes substantially to domestic water supply; however, it is increasingly threatened by anthropogenic activities, including poor sanitation practices, inadequate waste disposal, and proximity of water sources to latrines and waste dumps (Saidu *et al.*, 2024; Odewade *et al.*, 2025).

Microbiological contamination, particularly by coliform bacteria and *Escherichia coli*, serves as a key indicator of fecal pollution and an important determinant of waterborne disease risk (WHO, 2017; NSDWQ, 2007). Studies across Nigeria have documented variable compliance levels of groundwater

microbiological quality, with evidence of fecal contamination linked to outbreaks of diarrheal diseases and other health risks (Seiyaboh *et al.*, 2020; Isukuru *et al.*, 2024).

Ebonyi State in southeastern Nigeria relies heavily on boreholes and hand-dug wells for household water needs. Despite this dependence, few systematic assessments of microbiological water quality and sanitary risks have been conducted in the state. This study therefore investigates coliform contamination and sanitary risk levels of groundwater in Ebonyi State, with a view to providing evidence-based recommendations for water safety planning.

MATERIALS AND METHODS **STUDY AREA**

Ebonyi State is located in the southeastern region

of Nigeria, between latitudes 5°40' and 6°45' N and longitudes 7°30' and 8°30' E. The state was officially created on 1st October 1996 by the military administration of General Sani Abacha, carved out from parts of Enugu and Abia States, with Abakaliki as the capital city (Okonkwo & Eze, 2019). The state derives its name from the Ebonyi River, which traverses the region.

Geography and Climate

Ebonyi covers a land area of approximately 5,935 km² and shares boundaries with Benue State to the north, Enugu State to the west, Cross River State to the east, and Abia State to the south (NPC, 2006). The climate is typically tropical, characterized by a wet season (April–October) and a dry season (November–March), with mean annual rainfall ranging from 1,600 to 2,200 mm and average temperatures between 27–30°C (NIMET, 2015). The state is drained by numerous rivers and streams, with notable surface water bodies including the Ebonyi, Cross, and Enyim Rivers.

Population and Socio-Economic Activities

According to the 2006 National Population Census, Ebonyi State had a population of 2.17 million people, with current estimates exceeding 3 million (NPC, 2006). The people are predominantly Igbo, with three senatorial zones (Ebonyi North, Central, and South) and thirteen Local Government Areas. Agriculture is the mainstay of the economy, with large-scale cultivation of rice, yam, cassava, and palm produce. Ebonyi is widely regarded as the “rice basin of the South-East” due to extensive rice farming and milling activities (Ezeh & Uguru, 2015).

Natural Resources and Environmental Concerns

The state is endowed with significant mineral resources, including lead, zinc, limestone, and salt deposits. Salt mining at Uburu and Okposi dates back centuries, giving the state its nickname, the “Salt of the Nation” (Nwibo *et al.*, 2017). However, artisanal mining practices, poor waste management, and reliance on untreated surface and groundwater for domestic use have raised concerns about environmental

degradation and public health risks, particularly contamination of drinking water sources (Ugwu & Nnaji, 2020).

Sample Collection

A total of 92 groundwater samples were collected from boreholes and hand-dug wells across selected communities. Sterile sampling bottles were used, and samples were transported in ice boxes to the laboratory for analysis within 6 hours.

The procedure for sampling was adopted from USEPA (2013). A total of ninety two (92) grab groundwater samples, were collected from boreholes and hand dug wells across Ebonyi State. Global coordinates of each sampling location were recorded with the help of global positioning system (Gamin GPS 78 SC). Collection of samples from boreholes sources were accomplished by pumping the water to waste continuously for about 2 to 3 minutes, and aseptically open the sampling bottle to collect the water sample. A small space is left in the bottle to allow for mixing during inoculation. Water samples were collected separately for each analytical parameter in different container sizes as stated below:

Physicochemical analysis in one liter (1000ml) sampling bottles and for bacteriological analysis 250ml sterile sampling bottles were used, the collection was done at the depth of 20-30 cm directly into clean plastic and sampling bottles, placing them into sample transport box (cooler) containing ice pack in order to maintain the integrity of the sample collected prior to analyses for microbiological parameters within 6 hours sample holding time.

Field meters were checked and calibrated according to manufacturer's specification. Whereby, pH, electrical conductivity, total dissolved solids, and turbidity, of the water samples were measured in situ using standard methods (APHA, 2017) and compared with NSDWQ (2007) and WHO (2017) guidelines. Distributions of the sampled locations are shown in Figure 1.

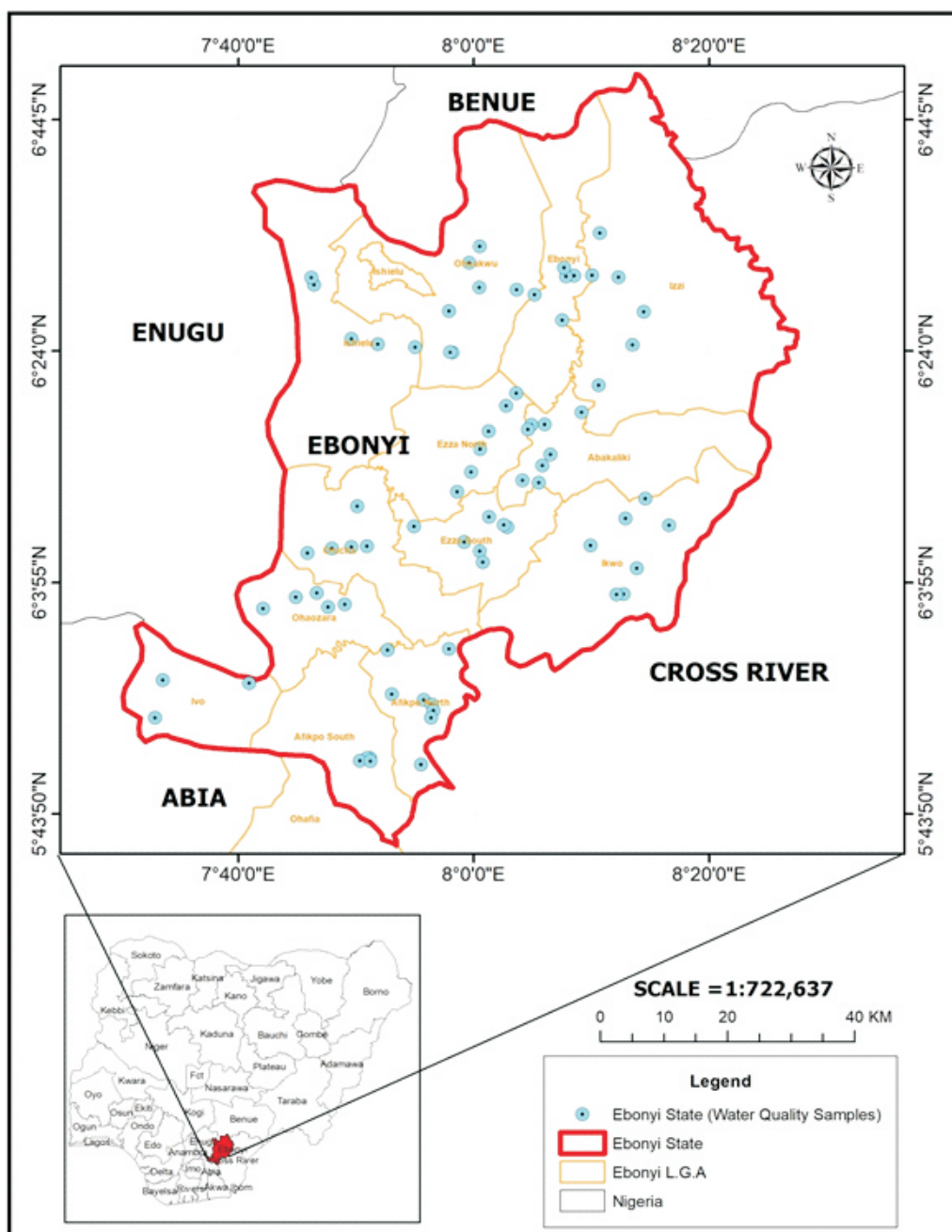


Figure.1: Map of Ebonyi State showing the sampled water points

Laboratory Analysis

Microbiological analysis

Total and fecal coliforms: Membrane filtration technique was employed in the tests for *total* and *Fecal coliforms* using Wagtech field kits. Water samples were appropriately diluted, filtered, inoculated and incubated at 37°C for *total coliforms*. For *Fecal coliforms*, 100 ml of the water samples was filtered, inoculated and incubated at 44.5°C. Plates which had characteristic yellow colonies after 14-hour incubation in each case were selected and the

colonies counted and calculated as follows using Equation 1

$$\text{cfu/100mL} = \frac{\text{No of colonies counted}}{\text{Vol. of Sample}} \times 100$$

Physicochemical analysis

Acidity and alkalinity (pH):

This was analysed onsite using Wagtech WE30200 pH meter. The water samples pH test was conducted by dipping the electrode into the water sample at about 2 – 3cm, stirred once and

reading allowed to stabilize. Calibration of the pH meter was conducted on daily basis at three points using pH 4, 7 and 10 standard solutions.

Electrical conductivity and total dissolved solids:

Electrical conductivity and total dissolved solids were determined on-site using Wagtech WE30120 conductivity/TDS meter. The testing was conducted by submerging the probe into the water sample in a plastic beaker to minimize any electromagnetic interference, stirred once and reading allowed to stabilize. Calibration of the EC/TDS meter was conducted on a daily basis using compatible EC standard solution (12.88 μ S/cm). The temperature of the water samples were measured with the EC/TDS meter, because the EC value is automatically compensated for temperature.

Turbidity: was measured using Wagtech WE30140 Potalab Turbidimeter. The turbidity measurement was conducted by placing the meter on a flat surface, filling a clean sample vial to mark, placing in a sample well and covering the vial with light shield cap. The

display reading was recorded as sample turbidity. Calibration of the turbidity meter was conducted on daily basis using Cal 1: 800NTU; followed by Cal 2: 100NTU; then Cal 3: 20NTU and; finally, Cal 4: 0.02NTU standards.

Sanitary Risk Assessment

Each water source was inspected for risk factors, including proximity to latrines, waste disposal sites, flooding, and poor wellhead protection. A sanitary inspection scorecard was applied to classify risk as low, medium, or high (WHO, 2017).

Data Analysis

Descriptive statistics (mean, range, standard deviation) were computed, and compliance levels determined as the proportion of samples meeting guideline values.

Results and discussions:

Tables 1 and 2 contain the results of the microbiological and physicochemical parameters respectively, while Table 3 contains the result of the sanitary risk assessment.

Table 1: Microbiological parameters

S/ N	Parameter	Number Of Sample	Min	Max	Mean	Std. Deviation	Guideline Value (NSDWQ, 2007 and WHO,201 7)	Compliance (%)
1	Coliform(cfu/100 mL)	92	0	200	27.17	63.68	0	79.3
2	Total coliform (cfu/100mL)	92	0	200	52.22	78.07	10	64.1

Table 2: Physicochemical Parameters

S/N	Parameter	Number Of Sample	Min	Max	Mean	Std. Deviation	Guideline Value (NSDWQ,2007 and WHO,2017)	Compliance (%)
1	Turbidity	92	0.33	50.4	4.14	6.91	5	81.5
2	TDS	92	18.63	883.1	280.03	166.95	500	94.6
3	EC	92	35.5	1682	549.58	327.2	1000	94.6
3	pH	92	5.0	8.5	6.98	0.99	6.5-8.5	83.7

Table3: Sanitary Risk Assessment

Risk Category	% of Source
High Risk	4.3%
Medium Risk	41.3%
Low Risk	54.4%

The results in table 1 and 3 respectively show that while a majority of groundwater sources in Ebonyi State meet microbiological standards, a substantial proportion remain at risk of contamination. The observed non-compliance with coliform and total coliform standards is consistent with previous findings in other parts of Nigeria (Seiyaboh *et al.*, 2020; Saidu *et al.*, 2024).

High standard deviations in microbial counts suggest localized contamination events, possibly linked to seasonal flooding or proximity to fecal sources. Physicochemical results, table 2 show that most sources met turbidity, EC and TDS guidelines level, but some exceeded acceptable limits. The high turbidity values in some areas may be due to surface runoff, poor well construction, or organic matter. TDS exceeded 1000mg/L in a few samples, possibly from minerals dissolution or anthropogenic pollution.

Sanitary risk assessment revealed that infrastructural and environmental conditions strongly influenced water quality outcomes. This underscores the importance of integrating sanitary inspection with routine microbial

monitoring.

Compared with WHO (2017) guidelines, the compliance levels observed are moderate, indicating a public health concern. Previous studies in Sokoto, Bayelsa, and Katsina States have shown similar levels of fecal contamination linked to diarrheal disease outbreaks (Odewade *et al.*, 2025; Isukuru *et al.*, 2024).

Conclusion

This study reveals moderate microbiological contamination of groundwater sources in Ebonyi State, with only 64.1% and 79.3% of samples meeting *total coliform* and *fecal coliform* standards respectively, while compliance levels were higher for turbidity (81.5%), EC (94.6%), TDS (94.6%) and pH (83.7%). Sanitary risk assessment revealed that more than 45% of water sources fall within medium to high-risk categories. Sanitary risk assessments further highlight infrastructure and environmental risk factors. The findings call for community-based water safety plans, improved well construction, and public health education to minimize groundwater contamination risks.

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