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Safe Water, Healthy People: Public Health Risks and Quality of Public Water Sources in Selected Communities, Ilorin-South LGA, Nigeria

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ABSTRACT

Microbial contamination of public water sources continues to pose a significant threat to human health, particularly in communities that solely rely on partially treated or untreated water for household use. This study has determined the public health risk and quality of some public water sources in selected communities of Ilorin South Local Government Area, Kwara State, Nigeria.

One (1) litres of water samples were collected from six public water sources across three selected wards in Ilorin metropolis for the evaluation of the physicochemical parameters by standard methods. The Total Coliform Counts was determined using selective agar medium and isolated bacterial isolates on selective media were identified by their various biochemical features. The ability of bacterial isolates to produce biofilm was determined at optical value of 570 nm by standard quantitative microtitre plate assay.

Physicochemical analysis showed temperature ranged from 27.5–28.1°C, pH from 7.15–7.45, TDS from 237–245 mg/L, nitrite from 0.091–0.099 mg/L, turbidity from 1.59–1.65 NTU, and alkalinity from 0.018–0.021 mg/L across the three wards. Composite water sample from Akanbi III had the highest total coliform counts of 29×10^4 CFU/mL while Okaka I had the least count of 8×10^6 CFU/mL, respectively. Four bacterial genera were identified including; *Escherichia, Klebsiella, Enterobacter* and *Citrobacter* in all composite samples. *Enterobacter* sp. ($Ak10^{-5}$) was the strongest producer with an OD_{570} of 0.76, followed by *E. coli* (Ak10-3) and *Klebsiella* sp. ($BaF10^{-5}$), with OD_{570} values of 0.65 and 0.50, respectively.

The public water sources showed bacterial contamination, indicating that they are unfit for drinking. Implementing proper water treatments are required to prevent the risk of waterborne illnesses.

Keywords: Physicochemical, Water sources, Bacteria, Biofilm, Health

1.0 INTRODUCTION

Access to microbiologically safe drinking water is essential for preventing water-borne illnesses and advancing public health

(Kristanti *et al.,* 2022). Water contaminated with pathogens remains a major route for the transmission of diseases including cholera, typhoid fever, dysentery, and diarrhoea, particularly in developing nations where access to safe water and sanitation services is limited (Shayo *et al.,* 2023; Nwadike *et al.,* 2024). Children are more vulnerable due to their heightened exposure to gastrointestinal-associated pathogens and the consequent risks of illness and death (Centers for Disease Control and Prevention, 2024). The microbiological safety of drinking water is usually assessed using indicator organisms, particularly coliform bacteria, as their presence indicates potential faecal contamination and a higher likelihood of enteric pathogens in the water (Wen *et al.,* 2020; Richiardi *et al.,* 2023). Public water sources can become exposed through inadequacy in sanitation, improper or poor waste handling, infusion through sewage, and surface runoff, thereby increasing the risk of water-borne disease outbreaks (Okesanya *et al.,* 2024; WHO, 2023).

Consequently, regular microbiological monitoring of drinking water is a vital element of environmental health initiatives designed to safeguard at-risk populations (WHO, 2023). Nigeria continues to grapple with significant obstacles in delivering safe drinking water, particularly in communities where partially treated or untreated water from wells, streams, boreholes, and other public sources is consumed (Sanjo *et al.,* 2024). This exposes the households to microbial contamination and its associated health hazards (Banseka *et al.,* 2024). Poor environmental hygiene, inadequate waste disposal infrastructure, and intermittent availability of potable water further degrade water quality and amplify the prevalence of water-borne diseases (UNICEF Nigeria, 2024). This study is particularly important in Ilorin, Kwara State, where several communities face persistent shortfalls in water supply and sanitation infrastructure. Evaluating the total coliform counts, and determining specific bacteria of public health significance in selected water sources is essential in determining the microbiological safety of water used for domestic purposes (Tenebe *et al.,* 2024).

Therefore, this study determined the public health risks and microbiological quality of public water sources from three selected wards in Ilorin South Local Government Area, Kwara State, Nigeria.

2.0 MATERIALS AND METHODS

2.1 Study Area and Design

This study was conducted in a central research institute in Ilorin South Local Government Area (LGA), Kwara State. The LGA lies within the Ilorin metropolis and includes both urban and semi-urban communities. However, persistent challenges, such as improper waste disposal, substandard drainage infrastructure, and inconsistent access to safe drinking water, increase the likelihood of waterborne illness in certain areas.

This study is laboratory-based and evaluated the microbiological safety of selected public water sources in two communities each from three wards, namely; Akanbi III, Balogun Fulani II and Okaka I in Ilorin South LGA.

2.2 Collection of Water Samples

Water samples were gathered from three wards within Ilorin South LGA. One (1) litre of water samples was collected aseptically into a sterilized sample bottles and transported to the laboratory for investigation. Samples from communities for each ward were made in a sterile container to produce a composite sample and used for subsequent physicochemical and microbiological evaluation (Table 1).

Table 1: Selected Wards and communities under study

S/N	Wards	Communities
1	Akanbi III	Tanke Oke-odo Take Iledu
2	Balogun-Fulani II	Edu Junction Ode-Balogun
3	Okaka I	Apa-Ola Labala

2.3 Physicochemical Analysis of Composite Water Samples

The composite water samples for each ward was determined for their temperature, pH, total dissolved solids (TDS), turbidity, total hardness, alkalinity, and nitrite levels, according to analytical methods of the American Public Health Association (APHA, 2005). Temperature, pH, and TDS were measured using a calibrated multi-parameter water quality meter; turbidity was determined via a calibrated nephelometric turbidimeter; total hardness and alkalinity were assessed using EDTA titrimetric and acid titration techniques, respectively; while the nitrite concentration was quantified with standard colorimetric assays.

2.4 Determination of Total Coliform in Composite Water Samples

Total coliform count was assessed after serial dilution and pour plate techniques. A stock solution of samples was prepared and serial diluted up to 10^{-7} folds. Aliquot of 1 mL from 10^{-3} and 10^{-5}diluent factors were inoculated into prepared sterile Petri dishes, followed by the addition of molten MacConkey agar. It was allowed to solidify and incubated at 37 ^{o}C for 24 hours. Colonies were counted using the colony counter and were expressed as colony-forming units per millilitre (CFU/mL). Repeated sub-culturing on freshly prepared nutrient agar was done to obtain a pure culture and pure isolates were stored on nutrient agar slants at 4 °C, for further study.

$$\text{CFU/mL} = \frac{number\ of\ colony\ counted}{volume\ of\ inoculum\ used} \times \frac{1}{Dilution\ factor}$$

2.5 Identification of Isolated Bacterial from Composite Water Samples

The pure bacterial isolates were identified by Gram staining and standard biochemical assays, including; indole production, citrate utilization, urease activity, oxidase reaction, catalase activity, and carbohydrate fermentation tests. Each test was conducted by standard microbiological protocols. Presumptive identity names of the bacterial isolates were determined using the online ABIS software.

2.6 Biofilm Production abilities of Bacterial Isolates

The potentials of the bacterial isolates to produce biofilm were determined using a standard quantitative microtiter plate method. Bacterial suspension of 0.5 McFarland was first prepared and 200 µL of it was inoculated into a 96-well polystyrene microtiter plates and incubated at 37 °C for 24–48 hours. After incubation, the broth was gently decanted, and the tubes were washed with sterile distilled water. The tubes were then air-dried for 15 minutes to fix the adherent biofilm and then stained with 0.1% crystal violet solution for 15 minutes. The stained tubes were rinsed gently with distilled water until no free stain remained. Five (5) mL of 95 % alcohol (ethanol) was added to each tube to solubilize the bound crystal violet and the solubilized dye was transferred into cuvettes for their optical density at 570 nm using a spectrophotometer. The abilities for biofilm formation were evaluated as described in a study by Omotoso *et al.* (2026).

3.0 RESULTS

3.1 Physicochemical properties of composite water samples

The physicochemical features of composite water samples were presented in Table 2. The temperature ranged from 27.5 °C to 28.1 °C. Composite water samples from communities in Akanbi III had the highest temperature of 28.1 °C, while the lowest temperature of 27.5 °C was determined in Balogun-Fulani I. Balogun-Fulani I had the highest pH of 7.45, while sample from Okaka I had the lowest value of 7.15.

The total dissolved solids (TDS) concentrations ranged from 237 to 245

mg/L with highest value of 245 mg/L was observed in Balogun-Fulani I and lowest value of 237 mg/L observed in Okaka I. Nitrite concentrations of 0.099 mg/L, 0.094 mg/L and 0.091 mg/L were recorded for Akanbi III, Balogun-Fulani I and Okaka I, respectively with Akanbi III having the highest nitrite concentration of 0.099 mg/L. Furthermore, Akanbi III had the highest turbidity of 1.65 NTU, followed by Balogun-Fulani I with 1.63 NTU and Okaka I with 1.59 NTU. Alkalinity values were 0.020 mg/L for Akanbi III, 0.018 mg/L for Balogun-Fulani I and 0.021 mg/L for Okaka I. Okaka I had the best alkalinity value of 0.021 mg/L, followed by Akanbi III with 0.020 mg/L, while Balogun-Fulani I had the least value of 0.018 mg/L (Table 2).

Table 2: Physicochemical Properties of the Composite Water Sample Obtained from Selected Public Water Sources

	Wards			
Parameter	**Akanbi III**	**Balogun-Fulani I**	**Okaka I**	**Unit**
Temperature	28.1	27.5	27.9	^{o}C
pH	7.39	7.45	7.15	-
Total Dissolved Solid (TDS)	240	245	237	mg/L
Nitrite	0.099	0.094	0.091	mg/L
Turbidity	1.65	1.63	1.59	NTU
Total Hardness	140	139	143	mg/L
Alkalinity	0.020	0.018	0.021	mg/L

3.2 Enumeration of Total Coliforms

The total coliform counts in composite water samples collected from Akanbi III, Balogun-Fulani II and Okaka I Wards are presented in Table 3. Akanbi III had the highest degree of coliform contamination among the wards investigated, while Okaka I had the lowest. Akanbi III consistently had the highest total coliform counts of 29×10^4 CFU/mL and 15×10^6 CFU/mL at 10^{-3} and 10^{-5} dilutions, respectively. Balogun-Fulani II had values of 21×10^4 CFU/mL and 10×10^6 CFU/mL, whereas Okaka I recorded the lowest values of 14×10^4 CFU/mL and 8×10^6 CFU/mL, respectively.

Table 3: Total Coliform Count in the composite water samples for communities in each ward on MacConkey agar

Microbiological Parameter	**Dilution Factor**	**Akanbi III**	**Balogun-Fulani II**	**Okaka I**
Total Coliform Count	10^{-3} (CFU/mL)	29×10^4	21×10^4	14×10^4
	10^{-5} (CFU/mL)	15×10^6	10×10^6	8×10^6

3.3 Identification of Isolated Bacteria from Composite Water Samples

Isolate *Escherichia coli* from $Ak10^{-3}$ produced smooth, moist, pinkish-red colonies on MacConkey agar plates and was positive for citrate, catalase, indole, glucose, lactose and sucrose, but negative for urease and oxidase; isolate from $BaF10^{-5}$ and $BaF10^{-3}$ produced large, mucoid, pink colonies and was positive for citrate, catalase, urease, glucose, lactose and sucrose, but negative for indole and oxidase. *Enterobacter* sp. was positive for citrate, catalase, glucose, lactose and sucrose but negative for indole, urease and oxidase. Isolate from water sample dilution of $Oka10^{-3}$ produced pale-pink, smooth colonies and showed positive reactions for citrate, catalase, urease, glucose and sucrose, while indole, oxidase and lactose were negative (Table 4).

Table 4: Colonial and Biochemical features of isolated Bacteria from the Composite Water Sample

Isolates	Gram reaction (on MacConkey)	Citrate	catalase	Indole	Urease	Oxidase	Glucose	Lactose	Sucrose	Presumptive Identity
$Ak10^{-3}$	-ve, smooth, moist, pinkish red	+	+	+	-	-	+	+	+	*Escherichia coli*
$BaF10^{-5}$	-ve, large, mucoid, pink	+	+	-	+	-	+	+	+	*Klebsiella* spp.
$Ak10^{-5}$	-ve, smooth, ferment lactose	+	+	-	-	-	+	+	+	*Enterobacter* sp.
$Oka10^{-3}$	-ve, pale pink and smooth	+	+	-	+	-	+	-	+	*Citrobacter* sp.
$BaF10^{-3}$	-ve, mucoid, pink	+	+	-	+	-	+	+	+	*Klebsiella* sp.
$Oka10^{-5}$	-ve	+	+	-	+	-	+	-	+	*Citrobacter* sp.

Key: $Ak10^{-3}$- Akanbi III; $BaF10^{-5}$- Balogun-Fulani II; $Oka10^{-3}$- Okaka I

3.4 Potential of Bacterial from Composite samples to produce Biofilms

The biofilm assay demonstrated that the bacterial isolates differed considerably in their biofilm-producing capacities (Table 5). Isolate from Ak10-5 (Enterobacter sp.) had the highest biofilm-producing ability, while Oka10-3 (Citrobacter sp.) showed the least potential. The two Klebsiella isolates showed OD570 values of 0.50 and 0.22, while the two Citrobacter isolates had 0.19 and 0.23. Enterobacter sp. (Ak10-5) was the strongest producer with an OD570 of 0.76, followed by E. coli (Ak10-3) and Klebsiella sp. (BaF10-5), with OD570 values of 0.65 and 0.50, respectively. Citrobacter sp. (Oka10-5), Klebsiella sp. (BaF10-3), and Citrobacter sp. (Oka10-3) were weak producers, recording OD570 values of 0.23, 0.22, and 0.19, respectively.

Table 5: Abilities of Bacterial Isolate for biofilm production

Sample code	Presumptive Identity	Optical value (OD_{570})	Group
$Ak10^{-3}$	*Escherichia coli*	0.65	Moderate
$BaF10^{-5}$	*Klebsiella* sp.	0.50	Moderate
$Ak10^{-5}$	*Enterobacter* sp.	0.76	Strong
$Oka10^{-3}$	*Citrobacter* sp.	0.19	Weak
$BaF10^{-3}$	*Klebsiella* sp.	0.22	Weak
$Oka10^{-5}$	*Citrobacter* sp.	0.23	weak

4.0 DISCUSSION

Variation in temperature among the three wards suggests that the samples were exposed to similar environmental conditions at the time of collection. Temperature is an important water-quality parameter since it influences chemical reactions and microbial activity in water. The values indicate that the water samples were generally within the neutral to slightly alkaline range. The difference in composite samples among the wards suggests that there was no substantial variation in the acidity or alkalinity of the water samples. The lower TDS indicated a slightly lower concentration of dissolved substances. The result from this study also aligns with Kulmedov (2026) who demonstrated that microbiological degradation can occur within water distribution systems even when physicochemical qualities appear acceptable.

The lower nitrite concentration recorded in Okaka I may indicate a lower level of nitrogenous contamination relative to the other two wards. The relatively low

turbidity values indicate that the water samples contained comparatively low levels of suspended particles. Among the three wards, Okaka I had the clearest water based on the measured turbidity. It has been reported that although several physicochemical parameters of sachet and bottled water met safety criteria, bacterial contamination persisted, highlighting the necessity for regular microbiological screening (Kadi and Aleru-Obogai, 2026).

Total coliform count observed in the present study exceeds the World Health Organization's recommended limit for water safety. The presence of coliform bacteria suggests possible faecal contamination and elevates the risk of waterborne disease transmission, particularly in areas where water remains untreated. The result from this study corroborate with the study by Okpanachi *et al.* (2026), who reported the detection of coliforms contamination in well, borehole, tap, and sachet water sources across Biu Metropolis, Nigeria, and emphasized the serious public health implications of unsafe drinking water. Furthermore, Dissasa (2025) reported similar coliform levels above recommended thresholds, thereby linking contamination to inadequate hygiene practices and the presence of enteric bacterial pathogens. However, Olaoye and Onilude (2009), reported microbial contamination in sachet-packaged drinking water sold in western Nigeria, despite its marketed suitability for human consumption.

The relatively high total coliform counts observed across the three wards indicate the presence of coliform bacteria in the examined water samples. Total coliforms are commonly used as indicators of the sanitary quality of water. Their presence may indicate contamination arising from environmental sources, inadequate protection of water sources, poor handling, or deficiencies in water treatment and distribution. Additional indicators such as faecal coliforms or *Escherichia coli* provide better evidence of faecal pollution. It is important to note that contamination should be interpreted against the applicable WHO and Nigerian drinking-water microbiological standards, since drinking water are particularly expected to contain no detectable *E. coli* in a specified 100-mL sample.

Four genera of bacteria of public health importance were identified from all the composite water samples, namely; *Escherichia coli*, *Klebsiella* sp., *Enterobacter* sp., and *Citrobacter* sp. Their presence confirms bacteriological contamination of the sampled public water sources. Okpanachi *et al.* (2026) and Dissasa (2025) also characterized and identified some of these bacteria from contaminated water sources and confirmed their roles as key indicator of faecal pollution. Similarly, previous study by Olaoye and Onilude (2009), detected *E. coli* in sachet drinking water, and Seiyaboh *et al.* (2019) identified it among bacterial contaminants in groundwater from Bayelsa State, Nigeria. The presence of *Klebsiella* sp. in this study is consistent with report by Kadi and Aleru-Obogai (2026) who documented *Klebsiella* species in drinking or environmental water samples. The presence of *Escherichia coli*, *Klebsiella* sp., *Enterobacter* sp., and *Citrobacter* sp. raises concerns about the possible existence of enteric pathogens capable of transmitting water-borne diseases.

The relatively strong biofilm production potential observed in *Enterobacter* sp. is important since biofilm formation can enhance bacterial persistence on surfaces and may contribute to resistance to environmental stresses and antimicrobial treatment. Biofilm formation as an important factor have been identified and associated with persistence (Surgers *et al.,* 2019). The moderate biofilm production observed in *E. coli* and *Klebsiella* sp. also indicates their capacity to establish surface-associated microbial communities. Research on *Enterobacter cloacae* has also demonstrated that biofilm formation is influenced by environmental and culture conditions, reflecting that biofilm

production is dependent on the conditions under which the organisms are grown (Singh *et al.,* 2026). The ability to produce biofilms is important because biofilms can provide a protected environment in which microorganisms can attach to surfaces and persist under environmental stresses (Singh *et al.,* 2026).

Conclusion

The public water sources in selected wards in Ilorin South Local Government Area were relatively unsafe with the detection of microbial contaminants. The isolation of enterbacteriaceae including; *Escherichia*, *Klebsiella*, *Enterobacter* and *Citrobacter* is significant for water safety. Bacterial isolates showed potential to produce biological film at different quantifiable rate significant to protect the bacteria. This result indicates unsafe microbiological quality and highlights the necessity for proper treatment of public water sources before use for consumption. Therefore, periodic assessments of public water quality are advised to minimize exposure to microbial contaminants and waterborne illnesses.

Declaration of Data Availability: The data that are used in this research are available upon request from the corresponding author through (first author)

Declaration by Authors

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