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(RESEARCH ARTICLE)

Antibacterial Efficacy of *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* Leaf Extracts against Bacterial Isolates from Contaminated Drinking Water Sources in Ikwo South, Nigeria

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Abstract

Introduction: The contamination of drinking water with pathogenic bacteria poses a significant public health threat, especially in rural areas of developing countries where access to treated water is limited. This study evaluated the antibacterial efficacy of *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* leaf extracts against bacterial isolates from drinking water sources in Ikwo South, Ebonyi State, Nigeria.

Methods: A total of 50 water samples from wells, boreholes, and surface sources across ten communities were analyzed using Standard microbiological techniques, yielding 53 bacterial isolates.

Results: *Escherichia coli* was the most prevalent (43.4%), followed by *Staphylococcus aureus* (22.6%), *Shigella flexneri* (18.9%), and *Klebsiella pneumoniae* (15.1%), indicating significant fecal and environmental contamination. Antibacterial activity was assessed using the agar well diffusion method. The petroleum ether extract of *F. ottoniifolia* and the ethyl acetate extract of *Z. zanthoxyloides* demonstrated concentration-dependent inhibition against all test organisms, with the highest activity observed against *S. aureus* (inhibition zones up to 19.5 mm at 100 mg/mL). Methanol extracts of both plants showed no activity. Minimum inhibitory concentrations (MICs) were lowest for *S. aureus* (12.5 mg/mL) and higher for Gram-negative isolates (25 mg/mL).

Conclusion: The findings confirm the contamination of local water sources with pathogenic bacteria and validate the traditional use of these plants, highlighting the potential of their non-polar extracts as sustainable, locally-sourced agents for water purification or complementary antimicrobial strategies in resource-limited settings.

Keywords: *Ficus ottoniifolia; Zanthoxylum zanthoxyloides*; Drinking Water Sources; *Staphylococcus aureus*; *Shigella flexneri*; *Klebsiella pneumoniae*

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1. Introduction

Water is a fundamental necessity for all living organisms. As such, the safety and purity of drinking water is paramount. When water becomes physically, chemically, or biologically contaminated, it affects all living things, including humans [1]. According to Oke *et al.* [2], one of the most demanding needs in public health in the twenty-first century, is access to potable water [2]. Being able to access clean drinking water is crucial for survival. People of all ages, especially toddlers, the elderly, and vulnerable subpopulations including those with impaired immune systems, should not drink polluted water [3]. Half of the global population have been estimated to live in potable water-shortage situations soonest [3]. Runoff from agricultural fields and animal production systems, as well as insufficient or broken sewage facilities, all add to the pollution of water sources in rural communities [2, 4, 5] like Ikwo South. Toxins, turbidity, taste, odor, color, and pathogenic bacteria must all be absent from drinking water in order to maintain a healthy condition [6].

The contamination of water sources by pathogenic microorganisms constitutes a major global health burden, particularly in rural areas of developing countries [2, 7]

In such settings, communities often rely on untreated water from boreholes, wells, rivers, and streams for drinking, cooking, and sanitation, increasing their vulnerability to waterborne diseases like diarrhea, typhoid, and dysentery [2, 7, 8]. *Salmonella typhi, Escherichia coli, Shigella* species, *Klebsiella* species and *Staphylococcus aureus* are common bacteria implicated in water-borne diseases such as diarrhea [9, 10, 11]. However, majority of communities in rural areas rely on untreated sources such rivers, streams, dams, boreholes, and wells to meet their basic needs for cooking, drinking, and sanitation [2, 8]. The contamination of water sources by pathogenic microorganisms constitutes a major global health burden, particularly in rural areas of developing countries.

These can result in human water-borne diseases such as diarrhea, which is mostly caused by microorganisms like *Salmonella typhi, Escherichia coli, Shigella* species*, Staphylococcus aureus* [2, 5, 8, 9]. Contamination often arises from agricultural runoff, inadequate sewage systems, and poor sanitation practices. The rising challenge of antibiotic resistance further complicates the treatment of bacterial infections, necessitating the search for alternative therapeutic agents. Medicinal plants, with their rich repository of bioactive compounds, represent a promising and sustainable source of new antibacterial agents. *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* are two plants used in traditional African medicine, but their efficacy against bacteria isolated from drinking water has not been extensively studied. In view of this, this study examined the distribution of bacteria isolated from drinking water sources in Ikwo South and their susceptibility pattern to *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* leaf extracts.

2. Materials and Methods

2.1. Study location

This research was carried out in Ikwo South Local Government Area of Ebonyi State, Nigeria, geographically located at latitude 6.0693° N and longitude 8.1994° E. The area is bounded by Cross River State to the east and the Abakaliki, Izzi, and Ezza local government areas. According to the National Population Commission [12], the region has an estimated population of 359,000 inhabitants and covers a land area of roughly 500 km^2. The local economy is primarily agrarian, with farming as the main occupation, although the area is also known for its rich mineral deposits. The study locations are illustrated in Figure 1.

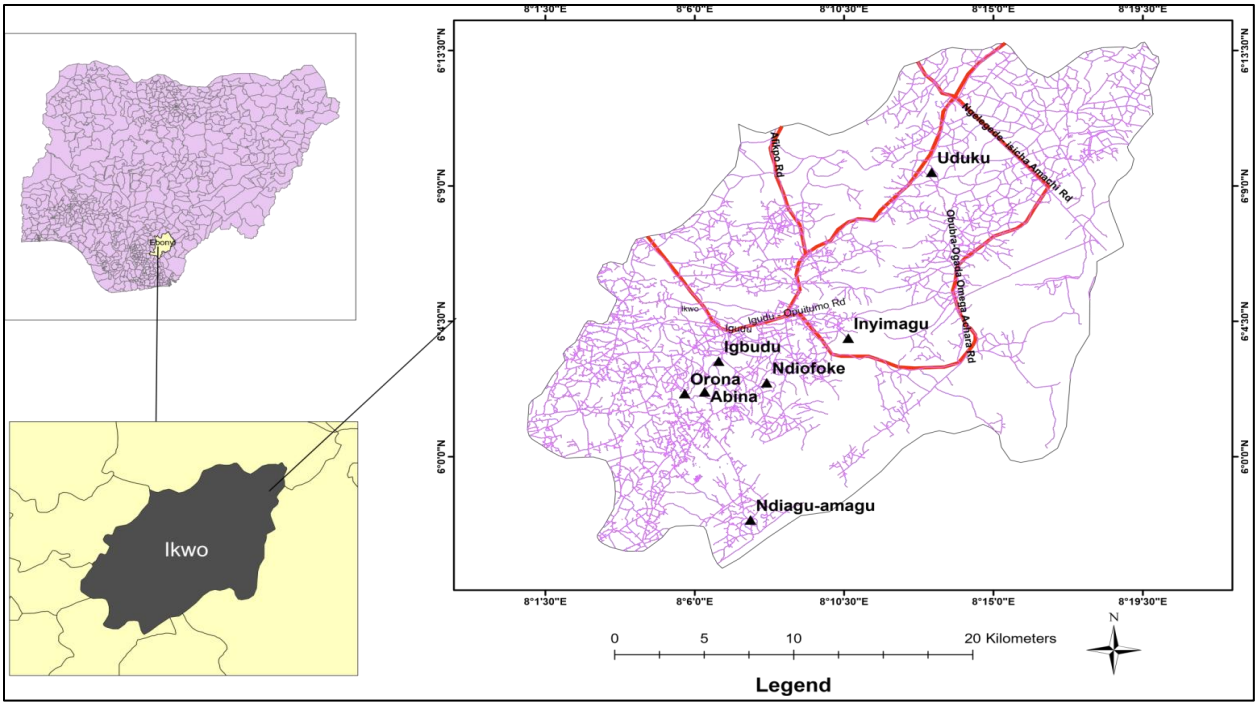

Figure 1 Map of Ikwo South with triangle shapes indicating the study areas.

2.2. Collection of Water samples

Water samples for this study were aseptically collected from a total of fifty (50) sources across ten communities, comprising ten (10) wells, thirty (30) boreholes, and ten (10) surface water sources. The communities sampled Ohataekwe, Uduku, Abina, Orona, Igbudu, Ndi-agu amagu, Ndiofoke, Agalagu-amagu, Akuna akuna, and Inyimagu were selected using a random sampling procedure in compliance with established standards for water analysis.

2.3. Bacterial Analysis and Isolation

The water samples were analyzed for the presence bacteria using method for the isolation of pure cultures as described by Iroha *et al.* [13]. For the isolation of pure bacterial colonies. In detail, all water samples was homogenized with vortex mixer (Techmel and Techmel, USA) and 100ml volume of the water samples was filtered with a 0.22 µm Millipore membrane filter (Merck, Darmstadt, Germany). The Millipore (Merck, Darmstadt, Germany) and plated onto a Plate count agar (bioMérieux, France) and incubated inverted at 37 °C in room temperature for 24 hrs. After 24 hrs of incubation, a loopful of each colonies were aseptically streaked solidified Eosin Methylene Blue (EMB) agar, MacConkey, mannitol salt agar, *Salmonella*/*Shigella* agar (bioMérieux, France) and the plates were incubated for 18-24 hrs at room temperature. Distinct colonies were sub-cultured by streaking onto fresh nutrient agar (bioMérieux, France) plates to obtain pure isolates. Further identification and characterization was performed using Vitex 2 compact 60 next-generation automated system (BIOMERIEUX, France) [14, 15]

2.4. Plants Collection and processing

Fresh leaves of *Zanthoxylum zanthoxyloides* and *Ficus ottoniifolia* were collected from the premises of Alex-Ekwueme Federal University, Ndufu-Alike. *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* was identified and botanical validation was performed by Dr. Udecchukwu, U.C, a botanist in the herbarium section of the Department of Biology, Alex Ekwueme Federal university, Ikwo, given a herbarium number AEFU-H-09-2025. The plant materials were washed with sterile water and air-dried at room temperature. Once dry, the leaves were ground into a fine powder using an industrial grinder. The extraction process utilized different solvents for each plant species. For each, 150 grams of the dried powder underwent a 48-hour soaking process in 500 mL of solvent: (i) Methanol extraction: Both plant species were extracted with methanol. (ii) Selective solvent extraction: *Zanthoxylum zanthoxyloides* was separately extracted using ethyl acetate, while *Ficus ottoniifolia* was extracted using petroleum ether. Following the soaking period, the mixtures were filtered using Whatman

No. 1 filter paper (Merck, Darmstadt, Germany) and a Buchner funnel to separate the solid plant residue from the liquid extract. The methanol-based filtrates were concentrated by drying in an oven at 65°C. In contrast, the filtrates containing the more volatile petroleum ether and ethyl acetate were left to evaporate at room temperature. All resulting dried extracts were stored in airtight containers [15, 16]

2.5. Preparation of Plant Extracts Concentrations

A primary stock solution was prepared for each plant by dissolving 1 gram of the respective dried extract in 10 mL of 1% dimethyl sulfoxide (DMSO). This yielded a stock solution with a concentration of 100 mg/mL. A series of serial dilutions were then prepared from this primary stock to obtain the following working concentrations of 50 mg/mL, 25 mg/mL, and 12.5 mg/mL

2.6. The antibacterial activity of plant extracts

The antibacterial activity of the *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* plant extracts was evaluated using the agar well diffusion method, following established protocols [17]. First, a bacterial suspension standardized to $1x10^6$ colony-forming units per milliliter (CFU/ml), equivalent to the 0.5 McFarland turbidity standard [14], was evenly seeded onto Petri dishes containing solidified Mueller-Hinton agar. The inoculated plates were then allowed to stand for 15 minutes to permit pre-diffusion of the bacteria into the agar. Subsequently, wells were aseptically punched into the agar using an 11 mm sterile cork borer (supertek®, U.S.A.). Each well was filled with 1 ml of a specific plant extract concentration of 100mg/ml, 50 mg/ml, 25 mg/ml and 12.5 mg/ml. Dimethyl sulfoxide (DMSO) (Thermo Fisher Scientific, U.S.A) and Ciprofloxacin (5 µg) (Oxoid, Uk) were impregnated as negative and positive control respectively. The plates were incubated at 37°C for 24 hours. After incubation, the MIC was recorded as the lowest concentration of the extract that completely inhibited visible bacterial growth and diameters of the clear inhibition zones around the wells were measured in millimeters (mm) using a metric ruler, and the results were interpreted according to standard guidelines [16, 18].

To determine the Minimum Bactericidal Concentration (MBC), a 10 µL aliquot was aspirated from each well that showed no visible growth (from the MIC test) and sub-cultured onto freshly prepared nutrient agar plates. The plates were then incubated at 37°C for 24 hours. The MBC was defined as the lowest concentration of the plant extract that resulted in no bacterial growth on the subculture, indicating a 99.9% kill rate of the initial inoculum.

2.7. Statistical Analysis

The raw data generated in the course of the study were analyzed using Statistical Package for Social Sciences (SPSS) version 26. To compare the means obtained, one-way analysis of variance (ANOVA) and Duncan were done. Then Chi-square test was also done. A *p*-value less than 0.05(<0.05) was the set significant value. Results were presented as the means and standard deviations.

3. Results

3.1. Distribution of Bacterial Isolates from Contaminated Water Sources

A total of 53 bacterial isolates were recovered from 50 water samples collected across ten communities in Ikwo South, Nigeria. The isolates were distributed among four bacterial genera, with significant variation across water source types (Table 1). Surface water sources exhibited the highest contamination (47.2%, n=25), followed by wells (36.9%, n=21) and boreholes (13.2%, n=7). *Escherichia coli* was the most prevalent isolate, accounting for 43.4% (n=23) of all bacteria recovered, and was found across all three water source types. *Staphylococcus aureus* constituted 22.6% (n=12) of isolates, predominantly from wells and surface water. *Shigella flexneri*. (18.9%, n=10) and *Klebsiella pneumoniae*. (15.1%, n=8) were also identified, with both showing notable presence in surface and well water samples. Statistical analysis using the Chi-square test revealed no significant difference in the distribution of bacterial isolates across the water sources ($p > 0.05$).

3.2. Antibacterial Activity of Plant Extracts against *Staphylococcus aureus*

Both plant extracts demonstrated concentration-dependent antibacterial activity against *S. aureus* isolates. The petroleum ether extract of *Ficus ottoniifolia* exhibited the highest inhibitory effect, with zone diameters ranging from 16.5 to 19.5 mm at 100 mg/mL (Table 2). In contrast, the methanol extract of *F. ottoniifolia* showed no activity. Similarly, the ethyl acetate

extract of *Zanthoxylum zanthoxyloides* produced inhibition zones between 13.5 and 17.5 mm at 100 mg/mL, while its methanol extract was inactive (Table 3). The positive control (ciprofloxacin) consistently produced larger inhibition zones (24.5–28.5 mm), and the negative control (DMSO) showed no activity.

3.3. Antibacterial Activity of Plant Extracts against *Escherichia coli*

The petroleum ether extract of *F. ottoniifolia* was active against *E. coli*, with inhibition zones of 15.5–18.5 mm at 100 mg/mL and 11.5–15.5 mm at 50 mg/mL (Table 4). No activity was observed at 25 mg/mL. The methanol extract of *F. ottoniifolia* was inactive across all concentrations. For *Z. zanthoxyloides*, the ethyl acetate extract showed moderate activity against *E. coli*, with zones of 11.5–14.5 mm at 100 mg/mL and 9.0–12.5 mm at 50 mg/mL, while the methanol extract was inactive (Table 5).

3.4. Antibacterial Activity of Plant Extracts against *Shigella flexneri* and *Klebsiella pneumoniae*.

Both plant extracts also exhibited antibacterial effects against *Shigella flexneri*. and *Klebsiella pneumoniae*., though with generally smaller inhibition zones compared to those for *S. aureus* and *E. coli*. The petroleum ether extract of *F. ottoniifolia* inhibited *Shigella flexneri* with zones of 12.5–15.0 mm at 100 mg/mL (Table 6), while the ethyl acetate extract of *Z. zanthoxyloides* produced zones of 11.5–12.5 mm at the same concentration (Table 7). Against *Klebsiella pneumoniae*., *F. ottoniifolia* petroleum ether extract showed zones of 11.5–14.5 mm at 100 mg/mL (Table 9), and *Z. zanthoxyloides* ethyl acetate extract yielded zones of 11.0–13.5 mm (Table 8). Methanol extracts of both plants were inactive against these pathogens.

3.5. Minimum Inhibitory Concentration (MIC) of Active Extracts

The MIC values for the most effective extracts are summarized in Tables 10 and 11. The petroleum ether extract of *F. ottoniifolia* exhibited the lowest MIC against *S. aureus* (12.5 mg/mL), while for *E. coli*, *Shigella flexneri*., and *Klebsiella pneumoniae*., the MIC was 25 mg/mL. Similarly, the ethyl acetate extract of *Z. zanthoxyloides* showed an MIC of 12.5 mg/mL against *S. aureus* and 25 mg/mL against the Gram-negative isolates.

Table 1 The distribution of bacterial isolates in water samples from different water sources.

Isolates	Borehole (%)	Well (%)	Surface water (%)	Total (%)	*P-value*
S.aureus	0(0.0)	6(28.6)	6(25.0)	12(22.6)	0.741*ns*
E.coli	5(71.4)	8(38.1)	10(40.0)	23(43.4)	
Shigella flexneri	1(14.3)	4(19.1)	5(20.0)	10(18.9)	
Klebsiella pneumoniae.	1(14.3)	3(14.3)	4(16.0)	8(15.1)	
Total isolates	7(13.2%)	21(36.9%)	25(47.2%)	53(100)	

Key: X^2 value 3.522 ;ns-no significant difference in distribution of isolates in the respective sources (p>0.05) .

Table 2 Zones of inhibition in mm of various concentration of the petroleum ether and methanol extract of *Ficus ottoniifolia* against *Staphylococcus aureus.*

	Petroleum ether extract				**Methanol extract**			**Control**	
ISOLATES	**100mg/ml**	**50mg/ml**	**25mg/ml**	**12.5mg/ml**	**100mg/ml**	**50mg/ml**	**25mg/ml**	**DMSO**	**CIP**
1	19.50±0.71^{b}	18.50±0.71^{c}	14.50±0.071^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.00±1.41^{a}
2	18.50±0.71^{b}	14.50±0.71^{c}	12.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.00±1.41^{a}
3	19.00±0.71^{b}	15.50±0.71^{c}	12.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.50±0.71^{a}
4	19.00±1.41^{b}	15.50±0.71^{c}	14.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.00±1.41^{a}
5	19.50±1.41^{b}	16.50±0.71^{c}	15.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±2.12^{a}
6	16.50±0.71^{b}	14.50±0.71^{c}	12.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
7	17.50±0.71^{b}	15.50±0.71^{c}	13.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
8	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.00±1.41^{a}
9	18.50±0.71^{b}	14.00±1.41^{c}	0.00±0.00^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.00±1.41^{a}
10	19.00±1.41^{b}	16.50±0.71^{c}	14.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.00±1.41^{a}
11	19.50± .71^{b}	15.50±0.71^{c}	13.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71^{a}
12	18.50±2.12^{b}	15.50±0.71^{c}	13.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.50±0.71^{a}

Key: Isolate 1-12: represents *Staphylococcus aureaus* isolates from different water samples.; DMSO:Dimethyl-sulphoxide (Negative control); CIP:Ciprofloxacin (Positive control); *Means values represented in rows with different letters differ statistically from each other at P<0.05

Table 3 Zones of inhibition in mm of various concentration of ethyl acatate and methanol extract of *Zanthoxylum zanthoxyloides* against *Staphylococcus aureus*

	Ethyl-acetate extract				**Methanol extract**			**Control**	
Isolates	**100mg/ml**	**50mg/ml**	**25mg/ml**	**12.5mg/ml**	**100mg/ml**	**50mg/ml**	**25mg/ml**	**DMSO**	**CIP**
1	15.50±0.71^{b}	13.50±0.71^{c}	11.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
2	14.50±0.71^{b}	12.50±0.71^{c}	10.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.00±1.41^{a}
3	13.50±0.71^{b}	11.50±0.71^{c}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
4	16.50±0.71^{b}	14.50±0.71^{c}	12.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±2.12^{a}
5	14.50±0.71^{b}	12.50±0.71^{c}	10.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±1.41^{a}
6	14.50±0.71^{b}	12.50±0.71^{c}	10.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.00±0.71^{a}
7	17.50±0.71^{b}	15.50±0.71^{c}	13.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
8	15.50±0.71^{b}	13.50±0.71^{c}	12.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.00±1.41^{a}
9	16.50±0.71^{b}	14.00±1.41^{c}	11.50±0.71^{d}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
10	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
11	15.50±0.71^{b}	13.50±0.71^{c}	11.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.00±1.41^{a}
12	14.50±0.71^{b}	12.50±0.71^{c}	10.50±0.71^{d}	0.00±0.00^{e}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}

Key: Isolate 1-12: represents *Staphylococcus aureus* isolates from different water samples.; DMSO:Dimethyl-sulphoxide(Negative control); CIP:Ciprofloxacin(Positive control); *Means values represented in rows with different letters differ statistically from each other at P<0.05

Table 4 Zones of inhibition in mm of various concentration of the petroleum ether and methanol extract of *Ficus ottoniifolia* against *Escherichia coli*

	Petroleum ether extract			**Methanol extract**			**Control**	
Isolates	100mg/ml	50mg/ml	25mg/ml	100mg/ml	50mg/ml	25mg/ml	DMSO	CIP
1	17.50±0.71^{b}	14.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.00±1.41^{a}
2	16.50±0.71^{b}	14.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
3	00.00±0.00^{b}	00.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71^{a}
4	15.50±0.71^{b}	13.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.00±1.41^{a}
5	16.50±0.71^{b}	12.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.50±0.71^{a}
6	17.50±0.71^{b}	13.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.00±1.41^{a}
7	15.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
8	18.50±0.71^{b}	15.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71^{a}
9	17.50±0.71^{b}	14.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
10	00.00±0.00^{b}	00.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
11	15.50±0.71^{b}	12.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
12	16.50±0.71^{b}	13.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
13	15.50±0.71^{b}	12.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.50±0.71^{a}
14	00.00±0.00^{b}	00.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.00±1.41^{a}
15	16.50±0.71^{b}	14.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71a
16	17.50±0.71^{b}	14.50±2.12^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71a
17	17.50±0.71^{b}	14.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.00±1.41^{a}
18	15.50±0.71^{b}	13.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.50±0.71^{a}
19	17.50±0.71^{b}	15.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.00±1.41^{a}
20	15.50±0.71^{b}	13.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
21	16.50±0.71^{b}	14.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71^{a}
22	17.50±0.71^{b}	14.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71a
23	16.50±0.71^{b}	13.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71a

Key: Isolate 1-23: Represents *Escherichia coli* isolates from different water samples.; DMSO: Dimethyl-sulphoxide(Negative control); CIP: Ciprofloxacin(Positive control); *Means values represented in rows with different letters differ statistically from each other at P<0.05

Table 5 Zones of inhibition in mm of various concentration of the ethyl- acetate and methanol extract of *Zanthoxylum zanthoxyloides* against *Escherichia coli*

	Ethyl- acetate extract			**Methanol extract**			**Control**	
Isolates	100 mg/ml	50 mg/ml	25 mg/ml	100 mg/ml	50 mg/ml	25 mg/ml	DMSO	CIP
1	12.50±0.71^{b}	09.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.50±0.71^{a}
2	13.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
3	11.50±0.71^{b}	09.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
4	13.00±1.41^{b}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.00±1.41^{a}
5	13.50±0.71^{b}	09.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
6	11.50±0.71^{b}	09.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
7	12.50±0.71^{b}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
8	13.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
9	11.50±0.71^{b}	09.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
10	12.50±0.71^{b}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
11	13.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.50±0.71^{a}
12	12.50±0.71^{b}	10.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71^{a}
13	11.50±0.71^{b}	09.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
14	13.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
15	12.50±0.71^{b}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
16	13.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71^{a}
17	14.50±0.71^{b}	12.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.00±1.41^{a}
18	13.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
19	00.00±0.00^{b}	00.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
20	13.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
21	12.50±0.71^{b}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
22	13.00±1.41^{b}	09.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}
23	12.50±0.71^{b}	09.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}

Key: Isolate 1-23: Represents *Escherichia coli* isolates from different water samples.; DMSO: Dimethyl-sulphoxide(Negative control); CIP: Ciprofloxacin(Positive control); *Means values represented in rows with different letters differ statistically from each other at P<0.05

Table 6 Zones of inhibition in mm of various concentration of the petroleum ether and methanol extract of *Ficus ottoniifolia* against *Shigella flexneri*.

	Ethyl- acetate extract			**Methanol extract**			**Control**	
Isolates	**100 mg/ml**	**50 mg/ml**	**25 mg/ml**	**100 mg/ml**	**50 mg/ml**	**25 mg/ml**	**DMSO**	**CIP**
1	14.50±0.71^{b}	11.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	22.50±0.71^{a}
2	13.50±0.71^{b}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
3	12.50±0.71^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	22.50±0.71^{a}
4	13.00±1.41^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
5	14.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	23.50±0.71^{a}
6	13.50±0.71^{b}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.00±1.41^{a}
7	13.00±1.41^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
8	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
9	15.00±1.41^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
10	13.00±1.41^{b}	12.00±1.41^{b}	0.00±0.00^{c}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	23.50±0.71^{a}

Key: Isolate 1-10: Represents *Shigella* species isolates from different water samples.; DMSO: Dimethyl-sulphoxide(Negative control); CIP: Ciprofloxacin(Positive control); *Means values represented in rows with different letters differ statistically from each other at P<0.05

Table 7 Zones of inhibition in mm of various concentration of the ethyl-acetate and methanol extract of *Zanthoxylum zanthoxyloides* against *Shigella flexneri*.

	Ethyl- acetate extract			**Methanol extract**			**Control**	
Isolate	100 mg/ml	50 mg/ml	25 mg/ml	100 mg/ml	50 mg/ml	25 mg/ml	DMSO	CIP.
1	11.50±0.71^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	23.50±0.71^{a}
2	12.50±0.71^{b}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
3	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	22.50±0.71^{a}
4	12.00±1.41^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
5	12.50±0.71^{b}	10.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	23.50±0.71^{a}
6	11.50±0.71^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}

7	0.00±0.00[b]	0.00±0.00[b]	0.00±0.00[b]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	23.50±0.71[a]
8	11.50±0.71[b]	9.50±0.71[c]	0.00±0.00[d]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71[a]
9	11.50±0.71[b]	9.50±0.71[c]	0.00±0.00[d]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71[a]
10	12.50±0.71[b]	10.50±0.71[c]	0.00±0.00[d]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.00±1.41[a]

Key: Isolate 1-10: Represents *Shigella* species isolates from different water samples.; DMSO: Dimethyl-sulphoxide(Negative control); CIP: Ciprofloxacin(Positive control); *Means values represented in rows with different letters differ statistically from each other at P<0.05

Table 8 Zones of inhibition in mm of various concentration of the ethyl acetate and methanol extract of *Zanthoxylum zanthoxyloides* against *Klebsiella pneumoniae*.

	Petroleum ether extract			**Methanol extract**			**Control**	
Isolates	100 mg/ml	50 mg/ml	25 mg/ml	100 mg/ml	50 mg/ml	25 mg/ml	DMSO	CIP
1	0.00±0.00[b]	0.00±0.00[b]	0.00±0.00[b]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71[a]
2	11.00±1.41[b]	11.00±1.41[b]	0.00±0.00[c]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71[a]
3	13.50±0.71[b]	11.50±0.71[c]	0.00±0.00[d]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.00±1.41[a]
4	11.00±1.41[b]	10.00±1.41[b]	0.00±0.00[c]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71[a]
5	11.50±0.71[b]	9.50±0.71[c]	0.00±0.00[d]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	23.50±0.71[a]
6	13.00±1.41[b]	11.00±2.82[b]	0.00±0.00[c]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71[a]
7	0.00±0.00[b]	0.00±0.71[b]	0.00±0.00[b]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71[a]
8	11.50±0.71[b]	9.50±0.71[c]	0.00±0.00[d]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	23.50±0.71[a]

Key: Isolate 1-8: Represents *Klebsiella* species isolates from different water samples.; DMSO: Dimethyl-sulphoxide(Negative control); CIP: Ciprofloxacin(Positive control); *Means values represented in rows with different letters differ statistically from each other at P<0.05

Table 9 Zones of inhibition in mm of various concentration of the petroleum ether and methanol extract of *Ficus ottoniifolia* against *Klebsiella pneumoniae*

	Petroleum ether extract			**Methanol extract**			**Control**	
Isolates	100 mg/ml	50 mg/ml	25 mg/ml	100 mg/ml	50 mg/ml	25 mg/ml	DMSO	CIP
1	14.50±0.71[b]	11.50±0.00[c]	0.00±0.00[d]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71[a]
2	13.00±0.71[b]	10.50±0.71[c]	0.00±0.00[d]	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71[a]

3	13.50±0.71^{b}	11.00±1.41^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	28.50±0.71^{a}
4	11.50±0.71^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	25.50±0.71^{a}
5	13.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	24.50±0.71^{a}
6	11.50±0.71^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71^{a}
7	11.50±0.71^{b}	9.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	26.50±0.71^{a}
8	13.50±0.71^{b}	11.50±0.71^{c}	0.00±0.00^{d}	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	27.50±0.71^{a}

Key: Isolate 1-8: Represents *Klebsiella* species isolates from different water samples; DMSO: Dimethyl-sulphoxide(Negative control); CIP: Ciprofloxacin(Positive control);*Means values represented in rows with different letters differ statistically from each other at P<0.05

Table 10 Minimum inhibitory concentration of petroleum ether extract of *Ficus ottoniifolia* leaf against the test isolates.

Test isolates	Frequency	MIC(mg/ml)
Escherichia coli	23	25
Staphylococcus aureus	12	12.5
Shigella flexneri	10	25
Klebsiella pneumoniae	8	25

Key: 23: Represents twenty-three isolates of *Escherichia coli* from different the drinking water samples; 12: Represents twelve isolates of *Staphylococcus aureus* from different the drinking water samples; 10: Represents ten isolates of *Shigella* species from the different drinking water samples; 8: Represents eight isolates of *Klebsiella* species from the different drinking water samples

Table 11 Minimum inhibitory concentration of ethyl acetate extract of *Zanthoxylum zanthoxyloides* leaf against the test isolates.

Test isolates	Frequency	MIC(mg/ml)
Escherichia coli	23	25
Staphylococcus aureus	12	12.5
Shigella flexneri	10	25
Klebsiella pneumoniae	8	25

Key: 23: Represents twenty-three isolates of *Escherichia coli* from different the drinking water samples; 12: Represents twelve isolates of *Staphylococcus aureus* from different the drinking water samples; 10: Represents ten isolates of *Shigella* species from the different drinking water samples; 8: Represents eight isolates of *Klebsiella* species from the different drinking water sample

4. Discussion

This study evaluated the antibacterial efficacy of *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* leaf extracts against bacterial isolates from drinking water sources in Ikwo South, Nigeria. The results reveal significant bacterial contamination across all water sources sampled, with surface water exhibiting the highest contamination (47.2%), followed by well water (36.9%) and borehole water (13.2%). This distribution is consistent with studies conducted in similar rural settings, where surface water is more vulnerable to environmental and anthropogenic pollution due to runoff and poor sanitation practices [8, 12].

Our study isolated *Escherichia coli*, *Klebsiella pneumoniae, Shigella flexneri, Staphylococcus aureus* and have been isolated from groundwater sources [5,7, 19, 20], and these organisms amongst other factors have led to several water-borne. In most rural communities, wells and boreholes water sources are close to public toilets in various compounds. This can contaminate underground water bodies with enteric microorganisms [5,7, 21]. Unsafe drinking water and unsanitary circumstances enhance the risk of different health hazards like typhoid fever, shigellosis. According to the literatures, WHO estimated that 60% of all deaths due to diarrhea in low- and middle-income countries are attributable to inadequate drinking water (35%), sanitation (31%) and hygiene (12%) [22].

The most frequently isolated bacterium was *Escherichia coli* (43.4%), which is a widely recognized indicator of faecal contamination in water [3, 7, 23]. This finding aligns with studies by Yang *et al*. [23], who also reported *E. coli* as the predominant isolate in contaminated drinking water sources of rural households in Ghana, Malawi, Mozambique, Niger, Rwanda, Uganda, and Zambia [23]. The presence of *E. coli* in drinking water signals a high risk of waterborne diseases such as diarrhoea and gastroenteritis, particularly in vulnerable populations [7, 23].

Other significant isolates included *Staphylococcus aureus* (22.6%), *Shigella flexneri* (18.9%), and *Klebsiella pneumoniae* (15.1%). The isolation of *Shigella* is particularly concerning, as it is a known causative agent of dysentery. This finding aligns with reports from similar studies in Nigeria [5, 9, 11, 24], and contrasts with others, such as the work by Aboh *et al*. [25] in Nigeria, which reported an absence of *Shigella* in well water samples. The prevalence observed in this study is higher than the 0.24% incidence of *Shigella* species identified by Nguendo-Yongsi *et al*. [26] among Enterobacteriaceae from drinking water, and also exceeds the 22% contamination rate reported in a Pakistani study [27]. However, it is lower than rates documented in other regional studies, such as 40% reported by Mian *et al*. [28] in Pakistan and 63.3% by Faisal *et al*. [29] in Afghanistan. The confirmed prevalence of *Shigella* species in the studied water samples likely results from poor sanitation, the mixing of sewage effluents with drinking water sources, and fecal contamination. The comparatively higher incidence in this study may be attributable to the specific sampling of wells and boreholes sites, including surface water sources where sewage mixes with freshwater, highlighting the direct impact of environmental fecal pollution on water quality. The presence of *Klebsiella pneumoniae*, though less prevalent, indicates possible environmental and faecal contamination [7].

Both *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* extracts exhibited concentration-dependent antibacterial activity against all tested isolates. The petroleum ether extract of *F. ottoniifolia* demonstrated superior activity compared to the ethyl acetate extract of *Z. zanthoxyloides*, particularly against *Staphylococcus aureus*, with inhibition zones up to 19.5 mm at 100 mg/ml. These findings are consistent with studies by Oshomoh and Idu. [30], who highlighted the antibacterial potential of *Z. zanthoxyloides*, and newer research by Raphaël *et al*. [31], who reported its efficacy against *Klebsiella pneumoniae* while de A Gonzaga *et al*. [32] demonstrated that stem bark extracts from *Zanthoxylum* species strongly inhibited the growth of several pathogens; *S. aureus, S. epidermidis, K. pneumonie, S. Setubal,* and *E. coli* with respective MIC values of 1.06, 1.06, 3.12, 3.12, and 1.06 µg/ ml, 1.06, 3.12, 1.06, 3.12, and 3.12 µg/ ml, and 12.5, 6.25, 6.25, 6.25, and 12.5 µg/ ml. Such investigations into antimicrobial activity are often guided by traditional medicinal uses. *Z. zanthoxyloides* is widely employed across parts of Asia including China and Korea and in African countries such as Uganda, Nigeria, and Ghana for managing microbial infection [33, 34, 35, 36, 37, 38]. It has also been documented as a chewing stick and a remedy for oral infections and toothaches [39], suggesting specific activity against oral pathogens. This ethnobotanical relevance underscores the species' potential as a source of antimicrobial agents.

Notably, methanol extracts of both plants showed no activity, suggesting that the bioactive compounds are non-polar and better extracted with solvents such as petroleum ether and ethyl acetate. This observation aligns with phytochemical extraction principles, where solvent polarity significantly influences the recovery of antimicrobial compounds [15, 16, 40].

The minimum inhibitory concentrations (MICs) for *S. aureus* were as low as 12.5 mg/ml for both plant extracts, whereas Gram-negative bacteria required higher concentrations (25 mg/ml). This trend is commonly observed in plant-based

antimicrobial studies, as Gram-negative bacteria possess an outer membrane that limits penetration of bioactive compounds [16, 18].

The high level of bacterial contamination in drinking water sources in Ikwo South underscores the urgent need for community-based water treatment interventions. The demonstrated efficacy of *F. ottoniifolia* and *Z. zanthoxyloides* extracts suggests they could be integrated into low-cost, culturally acceptable water purification strategies, especially in rural communities with limited access to conventional water treatment facilities.

The strengths of this study include its direct public health relevance to a resource-limited setting and the application of standardized bacteriological and phytochemical methods, which enhance the reliability and comparability of the findings. The use of solvent-specific extractions provided insight into the polarity of bioactive compounds, while automated bacterial identification (VITEK® 2) ensured accurate characterization. This work validates the traditional use of *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* and highlights their potential as sustainable, locally available options for water purification. However, the study has limitations. The *in vitro* assessment of crude extracts does not guarantee efficacy, safety, or stability in real-world applications. The agar well diffusion method may underestimate the activity of poorly diffusing compounds, and the limited solvent range may not fully capture extractable phytocompounds. Furthermore, the study was geographically and temporally restricted, and the observed MICs were higher than those of conventional antibiotics, suggesting a role as complementary rather than standalone agents. Future studies should focus on compound isolation, toxicity evaluation, and field-based application trials.

5. Conclusion

This study confirms that drinking water sources in Ikwo South are contaminated with pathogenic bacteria, predominantly *Escherichia coli*, posing a significant public health risk. The presence of faecal coliforms highlights the urgent need for improved water sanitation and hygiene practices in the community. *Ficus ottoniifolia* and *Zanthoxylum zanthoxyloides* leaf extracts exhibit promising antibacterial activity against waterborne isolates, particularly *Staphylococcus aureus* and coliforms. The non-polar extracts (petroleum ether and ethyl acetate) were more effective than methanol extracts, indicating the lipophilic nature of the active compounds. These plants could serve as sustainable, locally available options for water purification or as complementary treatments for bacterial infections, especially in resource-limited rural areas. Further studies are recommended to isolate and characterize the active compounds, assess their safety, and develop practical applications such as herbal disinfectants or water treatment solutions.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest

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