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COMPARATIVE ANALYSIS OF MICROBIAL LOAD OF AL-HIKMAH WATER SUPPLY TO MAIN HOSTELS IN ADETA AND ATERE CAMPUSES

BY

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Abstract

This study presents a comparative analysis of the microbial load in water supplied to hostels at Al-Hikmah University's Adeta and Atere campuses, Ilorin, Kwara State. Water quality is a critical public health concern, especially in densely populated university settings. Guided by the Public Health Model of Waterborne Disease Prevention and Environmental Health Risk Assessment, the study aims to assess microbial levels, compare contamination between campuses, identify specific microbial agents, and evaluate compliance with WHO standards. Employing a descriptive and comparative cross-sectional design, water samples were collected from five hostels on each campus and analyzed using the Most Probable Number (MPN) and Colony Forming Unit (CFU) methods. The total population was all hostel water sources; a purposive sampling technique was used. Findings revealed unsafe microbial levels across all samples, with Atere Hostel a showing the highest MPN (180/100ml) and Adeta Hostel B the highest CFU (65). Biochemical tests confirmed the presence of coliforms, E. coli, Staphylococcus spp., and Streptococcus spp., indicating both fecal and environmental contamination. Despite no statistically significant difference in microbial load ($p > 0.05$), the health implications are severe. The study recommends urgent water treatment, infrastructure upgrades, and routine monitoring to protect student health and ensure compliance with WHO standards.

Keywords: Microbial load, Water quality, *Escherichia coli*, Coliforms, Most Probable Number (MPN), Colony Forming Units (CFU), Waterborne pathogens, Comparative analysis

Introduction

Water is fundamental to life and essential for health, hygiene, agriculture, and industrial activities. Covering approximately 71% of the Earth's surface, water plays a central role in human civilization (Agu *et al*., 2017; Agu *et al*., 2019). Freshwater Sources Rivers, lakes, and streams are vital for consumption and daily use. However, increasing population, industrialization, and poor waste management have led to widespread pollution of these resources, threatening public health and environmental sustainability (Agu *et al*., 2021; Agu *et al*., 2023). Surface and groundwater sources are particularly vulnerable to contamination from domestic sewage, agricultural runoff, and industrial discharge. These pollutants often introduce harmful microorganisms and toxic substances into the water, making it unsafe for human use (Carpenter, 2018; Camp *et al*., 2019). Microbiological contamination is a major public health concern, especially in regions with limited access to treated water. Pathogens such as *Escherichia coli*, *Salmonella*, and *Vibrio cholerae* are commonly associated with waterborne diseases like typhoid, cholera, and gastroenteritis (Ewington *et al*., 2018; Onuoha *et al*., 2019).

Microorganisms found in natural water sources include bacteria such as *Pseudomonas*, *Micrococcus*, and *Actinomycetes* (Gebharal, 2019), some of which originate from sewage or soil and pose health risks. Groundwater sources such as wells and boreholes are also susceptible to contamination, particularly from leachate from open dump sites (Agu *et al*., 2018). Tap water, though widely used domestically, may not always be safe unless its microbial load is routinely monitored (Bonde, 2022). In institutional settings like universities, the risk of waterborne disease is amplified by population density and shared water infrastructure. Al-Hikmah University, with campuses at Adeta and Atere in Ilorin, Kwara State, serves a large student population. However, there are growing concerns regarding the quality of water supplied to the hostels, as anecdotal reports of gastrointestinal illness persist (Olusegun & Adeleke, 2020; Adewumi, 2021). Yet, no scientific study has comprehensively evaluated the microbial load in these water sources.

This study aims to assess and compare the microbial content of water supplied to the hostels in both campuses. The research will identify potential contaminants, evaluate their health implications, and determine if the water meets national and international quality standards (WHO, 2017; NAFDAC, 2019). Findings will inform university management, guide interventions, and contribute to public health strategies for safe water access in academic institutions.

Literature review

Water quality plays a crucial role in public health, particularly in institutional environments such as universities where high population density and shared infrastructure heighten vulnerability to waterborne diseases. According to the World Health Organization (WHO, 2023), unsafe drinking water contributes to an estimated 485,000 diarrheal deaths annually. Pathogens such as *Escherichia coli*, *Salmonella spp.*, and *Vibrio cholerae* are commonly associated with waterborne outbreaks, particularly in environments with poor sanitation and outdated infrastructure (Ercumen *et al.,* 2021; Olowoyo *et al.,* 2022). Several studies have confirmed a strong association between microbial contamination in hostel water supplies and increased gastrointestinal illness among students. For instance, Rahman *et al*. (2022) observed a 30% rise in acute gastroenteritis cases during periods of poor water quality across South Asian universities. Similarly, Nkiruka *et al.* (2023) reported that students affected by waterborne diseases missed several academic days, which negatively impacted their academic performance. Contaminants like *E. coli* serve as reliable indicators of recent fecal contamination and disease risk (Thompson *et al.,* 2022). The persistence of these pathogens is often due to factors such as biofilm formation in pipes, stagnant water in storage tanks, and proximity of water lines to sewage systems (Ramírez-Castillo *et al.,* 2020; Flemming *et al.,* 2023).

Emerging issues include the detection of antibiotic-resistant bacteria in hostel water systems, which poses treatment challenges and increases the likelihood of prolonged illness (Zhang *et al*., 2023). Some studies have identified protozoa like *Cryptosporidium* in university water supplies, which are resilient to conventional treatment and have caused chronic diarrhea in affected students (Liu *et al.,* 2022). Additionally, psychological effects of waterborne disease outbreaks, such as anxiety and depression, have been documented (Kumar & Reddy, 2024), along with heightened susceptibility among international students unfamiliar with local pathogens (Chen *et al.*, 2023). Key sources of contamination include inadequate sewage disposal, agricultural runoff, and deteriorating infrastructure. Kumar *et al.* (2021) found that over 60% of microbial contamination in South Asian cities stemmed from untreated sewage. Martínez-Santos *et al.* (2022) revealed that universities with water systems over 50 years old had significantly higher contamination levels. Seasonal variations also influence contamination levels, with stagnation during holidays exacerbating microbial proliferation in hostel plumbing (Davia *et al.,* 2024).

Waterborne illnesses such as typhoid and cholera remain prevalent in educational settings. Olanrewaju *et al.* (2024) documented a cholera outbreak in a West African university linked to contaminated storage tanks. Long-term effects of these illnesses include fatigue, reduced cognitive function, and nutrient malabsorption (Sharma & Patel, 2024; Alvarez-Bastida *et al.*, 2023). Economically, outbreaks are costly Econs and Gordon (2022) estimated a single university outbreak in the UK incurred over £500,000 in indirect costs. Standards set by WHO and national agencies such as NAFDAC and SON in Nigeria require that *E. coli* be absent in 100 ml of drinking water (WHO, 2022). However, enforcement remains inconsistent due to infrastructural and financial limitations (Rahman *et al.,* 2023; Olanrewaju *et al.,* 2024). Advances in real-time monitoring technologies have improved compliance in some institutions, offering early detection and rapid response capabilities (Salgado *et al.,* 2023).

Empirical studies across Nigeria, Ghana, India, and Pakistan consistently reveal high microbial loads in university water systems, often exceeding WHO-recommended limits (Ojo & Adeoye, 2018; Mohammed *et al.,* 2021; Kofi *et al.,* 2020; Arora *et al.,* 2023). These findings underline the urgent need for targeted investments in water infrastructure, adoption of advanced purification methods, and student education on safe water handling (Olowoyo *et al.,* 2022). The theoretical basis for addressing waterborne illnesses in universities can be grounded in the Public Health Model of Disease Prevention, which emphasizes clean water access, infrastructure hygiene, and education to reduce illness incidence (Cairncross & Feachem, 1993). Complementing this is the Environmental Health Risk Assessment model, which offers a structured method for evaluating exposure and health risks associated with environmental contamination (Covello & Merkhofer, 1993). These models support evidence-based interventions such as targeted infrastructure upgrades, routine microbial monitoring, and student health campaigns. The literature strongly supports the need for consistent water quality management in university environments. Factors such as climate change, infrastructure age, and student behavior all influence microbial contamination and the risk of disease outbreaks. Existing studies not only confirm widespread water quality issues in hostels but also provide a roadmap for intervention through upgraded systems, regulatory enforcement, and integrated health education strategies to ensure safer water for student populations.

Methodology

This study employed a descriptive and comparative cross-sectional design to evaluate the microbial load in hostel water supplies across two campuses (Adeta and Atere) of Al-Hikmah University, Ilorin, Kwara State. The design allowed for systematic collection and analysis of microbial data and comparison between different environmental and infrastructural contexts. Descriptive analysis characterized the microbial profile, while comparative analysis identified differences in contamination levels between campuses (Creswell, 2014; Leedy & Ormrod, 2019). The research was conducted on Adeta and Atere campuses of Al-Hikmah University, both located in Ilorin, Nigeria. Adeta Campus is situated in the city center and is potentially exposed to urban pollutants, while Atere Campus lies in a semi-rural area, likely affected by unregulated water sources. Both campuses accommodate a large student population, and hostel water quality plays a critical role in student health. Water samples were collected from five hostels (Hostels A–E) on each campus using sterile techniques. The materials used included: sterile sample bottles, gloves, pipettes, petri dishes, methylated spirit, hydrogen peroxide, conical flasks, and culture media such as MacConkey agar. Water filters and other microbiological tools were employed for sample preparation and laboratory testing.

Two main microbiological techniques were used: **Most Probable Number (MPN) Method**: 100ml water samples were distributed into sterile broth in volumes of 50ml, 10ml, and 5ml. After 48 hours of incubation at 37°C–44°C, acid and gas production in lactose-containing media was used to estimate coliform density using a probability table. **Membrane Filtration Technique**: Water was filtered through a membrane which was then incubated on lactose broth pads. Coliform colonies were counted to determine the presumptive *E. coli* count per 100ml.
Bacteria were further identified using standard procedures including Gram staining, catalase and coagulase tests, lactose fermentation, and motility assays.

Sterile sampling kits were used to ensure the integrity of collected samples. Microbial testing methods were reviewed and validated by experts from the Department of Environmental Health Sciences. A pilot test confirmed reliability and consistency. Both MPN and membrane filtration methods follow APHA (2017) standards. Standardized sampling protocols were employed. All samples were collected under similar conditions, and laboratory analyses involved controls and repeat testing to ensure consistency. Inter- and intra-rater reliability was ensured through repeated testing by multiple technicians.

Descriptive statistics such as means and standard deviations summarized microbial load across campuses. Comparative analyses used t-tests and chi-square tests to evaluate significant differences in MPN and CFU values

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between Adeta and Atere hostels. Permission for water sampling was obtained from university authorities, and all procedures were carried out in accordance with environmental health safety protocols.

The selected methods ensured a robust comparison of microbial water quality between two distinct campus environments. Both MPN and membrane filtration are internationally accepted techniques for microbial water quality analysis, allowing for data reliability and relevance to public health standards, particularly those set by WHO.

Results and Discussion

Summary of Laboratory Results

Water samples were collected from five hostels each in the Adeta and Atere campuses (Hostels A–E). The samples were analyzed for microbial load using the Most Probable Number (MPN) method and colony-forming units (CFU). The biochemical characteristics of isolates were also determined. Table 4.1 summarizes the MPN and CFU values for each hostel at both campuses.

Table 1: ***Summary of MPN and CFU Values***

Hostel	Campus	MPN/100ml	CFU
A	Adeta	5	13
A	Atere	180	25
B	Adeta	5	65
B	Atere	90	15
C	Adeta	2	45
C	Atere	35	20
D	Adeta	8	62
D	Atere	7	14
E	Adeta	5	52
E	Atere	9	36

The table shows bacteria levels in hostel water from Adeta and Atere campuses. MPN (Most Probable Number) detects harmful coliforms, while CFU (Colony Forming Unit) shows the total number of bacteria. Atere Hostel A had the highest MPN with 180/100ml, while Adeta Hostel A had just 5/100ml. In contrast, Adeta Hostel B had a high CFU of 65, compared to 15 in Atere. Overall, Atere hostels had more fecal contamination, while Adeta hostels had higher total bacteria. Both campuses had unsafe water, which may cause illness if not treated, showing the urgent need for purification and better sanitation.

Microbiological Characteristics

Microbiological tests were conducted to determine the presence of specific contaminants. The distinctive properties of isolates identified in the water samples are presented in tables below:

Table 2: ***Distinctive Properties of Isolates in Water for Adeta Hostels***

Hostel	Isolate	Gram Staining Reaction	Catalase	Coagulase	Lactose	Motility
A	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative

A	Coliform	Negative	Negative	Negative	Positive	Positive
B	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative
B	Coliform	Negative	Negative	Negative	Positive	Positive
C	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative
C	Coliform	Negative	Negative	Negative	Positive	Positive
D	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative
D	Coliform	Negative	Negative	Negative	Positive	Positive
E	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative
E	Coliform	Negative	Negative	Negative	Positive	Positive

The table shows the types of bacteria found in water from Adeta hostels. Two main types were detected: *Staphylococcus/Streptococcus* and coliforms. The *Staphylococcus/Streptococcus* bacteria were Gram-positive, lacked movement, and could break down certain substances but not lactose. The coliform bacteria were Gram-negative, could move, and could ferment lactose, a sign of fecal contamination. These findings suggest that the water is unsafe for drinking, as it contains harmful bacteria that can cause illnesses like diarrhea and infections. This indicates poor water quality and highlights the need for treatment and better hygiene practices to protect students' health.

Table 3: ***Distinctive Properties of Isolates in Water for Atere Hostels***

Hostel	Isolate	Gram Staining Reaction	Catalase	Coagulase	Lactose	Motility
A	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative
A	Coliform	Negative	Negative	Negative	Positive	Positive
B	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative
B	Coliform	Negative	Negative	Negative	Positive	Positive
C	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative
C	Coliform	Negative	Negative	Negative	Positive	Positive
D	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative
D	Coliform	Negative	Negative	Negative	Positive	Positive
E	*Staphylococcus spp/Streptococcus spp*	Positive	Negative	Positive	Negative	Negative

VOL. 4, NO 2, DECEMBER, 2024
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E	Coliform	Negative	Negative	Negative	Positive	Positive

The table shows the bacteria found in water from Atere hostels. Like Adeta, two main types were identified: *Staphylococcus/Streptococcus* and coliforms. The *Staphylococcus/Streptococcus* bacteria were Gram-positive, did not move, and could not ferment lactose. Coliforms, which are indicators of fecal contamination, were Gram-negative, lactose-fermenting, and motile. These results suggest the presence of disease-causing germs in the water, especially from fecal sources, making it unsafe for drinking. If not treated, this water could lead to infections and stomach-related illnesses among students, highlighting the urgent need for water purification and sanitation improvements on campus.

Analysis of MPN Values between Adeta and Atere Hostels

To determine if significant differences exist between the microbial loads of the two campuses, a Chi-square (χ^2) test was performed for each corresponding hostel (A–E) based on MPN values.

Table 4: ***Chi-Square Test for MPN Values between Adeta and Atere Campuses***

Hostel	Adeta MPN	Atere MPN	Chi-Square	p-value	Significant ($p < 0.05$)
A	5	180	0.00	1.0000	No
B	5	90	0.00	1.0000	No
C	2	35	0.00	1.0000	No
D	8	7	0.00	1.0000	No
E	5	9	0.00	1.0000	No

Although the numerical difference in MPN values appears substantial (especially for Hostels A–C), the chi-square test does not indicate statistical significance ($p > 0.05$) due to the small sample size and simplified contingency format. Therefore, no statistically significant difference was detected in MPN values between Adeta and Atere hostels based on this test.

Table 5: ***Comparative MPN Interpretation Based on WHO Standards***

Hostel Pair	MPN (Adeta)	MPN (Atere)	WHO Max Standard (0/100ml)	Interpretation
A	5	180	0	Atere Hostel A is grossly polluted
B	5	90	0	Atere Hostel B is polluted
C	2	35	0	Atere Hostel C exceeds acceptable limits
D	8	7	0	Both exceed acceptable limits
E	5	9	0	Both exceed acceptable limits

Based on WHO guidelines (0 detectable E. coli per 100ml), all hostels exhibit contamination. However, Atere Hostels A, B, and C show significantly higher MPNs, placing them in the “grossly polluted” category, particularly Hostel A with 180 MPN/100ml, suggesting high health risk potential.

Comparative CFU (Colony Count) Analysis

Table 6: ***Comparison of CFU Counts between Campuses***

Hostel Pair	CFU (Adeta)	CFU (Atere)	Interpretation
A	13	25	Slightly higher in Atere
B	65	15	Significantly higher in Adeta
C	45	20	Higher in Adeta
D	62	14	Higher in Adeta
E	52	36	Higher in Adeta

Interestingly, while Atere Hostels show higher MPN (more coliform presence), Adeta Hostels show consistently higher CFU counts, indicating greater bacterial population density. This contrast suggests that although pathogenic coliforms are more prevalent in Atere, non-coliform or opportunistic bacteria may be more abundant in Adeta.

Biochemical Characterization of Isolates

The isolates from both campuses exhibited similar biochemical properties are summarized in the table below:

Table 7: ***Biochemical Characterization of Isolates from Adeta and Atere Campuses***

Isolate Type	Gram Staining	Catalase	Coagulase	Lactose Fermentation	Motility
Staphylococcus/ Streptococcus spp.	Positive	Negative	Positive	Negative	Negative
Coliforms	Negative	Negative	Negative	Positive	Positive

These findings confirm the presence of both pathogenic *cocci* and coliform *bacilli*, capable of causing a range of infections including gastroenteritis, diarrhea, and skin infections. These biochemical traits confirm the presence of harmful bacteria in the water, highlighting health risks such as diarrhea and other infections for students exposed to contaminated sources.

Discussion of Findings

The findings of this study confirm significant microbial contamination in the water supplied to hostels across both Adeta and Atere campuses of Al-Hikmah University. This aligns with the first objective of the study, which aimed to determine the microbial load in the water supply. All water samples tested positive for microbial presence, indicating a potential health risk to the hostel residents. Notably, Atere Hostel A recorded a Most Probable Number (MPN) of 180/100ml, far exceeding acceptable safety limits. This is consistent with the findings of Olanrewaju *et al*. (2023), who reported that water sources in Nigerian university hostels often surpass microbial safety thresholds due to poor infrastructural maintenance and environmental contamination.

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The second objective, which involved comparing microbial content between the two campuses, revealed notable differences. While Atere hostels showed higher MPN values, indicating more severe fecal contamination, Adeta hostels exhibited higher Colony Forming Units (CFU), suggesting a greater general bacterial load. For example, Adeta Hostel B recorded a CFU of 65 compared to 15 in Atere Hostel B. This trend may be attributed to factors such as biofilm formation or stagnation in poorly maintained water systems. These findings are supported by Martínez-Santos *et al*. (2022), who observed elevated microbial loads in aged water distribution networks due to persistent bacterial growth in stagnant water pipelines.

The third objective was to identify the specific microbial contaminants present. Biochemical characterization revealed the presence of *Staphylococcus spp., Streptococcus spp*., and coliforms, with lactose-fermenting, motile coliforms strongly indicating the presence of *Escherichia coli* (*E. coli*). *E. coli* is a key indicator of fecal pollution and is associated with gastrointestinal illnesses such as diarrhea and typhoid. These findings are in line with those of Rahman *et al*. (2022), who found similar microbial contaminants in university hostel water systems, linking them to outbreaks of gastroenteritis. The identification of *Staphylococcus and Streptococcus spp.*, further suggests the risk of infections through both ingestion and dermal exposure, such as during bathing or washing.

Concerning the fourth objective, which was to assess water quality against the World Health Organization (WHO) standards, the results revealed that none of the water samples complied with the WHO requirement of zero detectable *E. coli* per 100ml. The detection of *E. coli* in all tested samples indicates a serious breach of safety protocols in water treatment. These findings corroborate those of Olowoyo *et al*. (2022), who reported that hostel water systems in Nigerian institutions often fail to meet microbial safety standards due to inadequate disinfection, poor infrastructure, and lack of routine monitoring.

This study demonstrates that students in both Adeta and Atere campuses are exposed to health hazards through contaminated water. While the nature of contamination differs between campuses Atere showing more fecal contamination and Adeta displaying broader bacterial proliferation the risk to student health remains significant and warrants immediate institutional intervention.

Conclusion

This study confirms that hostel water at both Adeta and Atere campuses of Al-Hikmah University is microbiologically unsafe, posing a serious health risk to students. All samples contained harmful bacteria, including coliforms, which are indicative of fecal contamination and associated with illnesses such as diarrhea and typhoid. Contamination patterns differed across campuses: Atere showed higher fecal contamination, likely due to environmental or sewage infiltration, while Adeta had a broader bacterial presence, possibly linked to poor storage and aging infrastructure. None of the water samples met WHO safety standards, highlighting the urgent need for institutional intervention.

Recommendations

Based on the findings, the following actions are recommended:

I. The university should implement chlorination or UV purification of water supplied to all hostels.
II. Establish a water monitoring unit to conduct monthly microbial assessments and ensure compliance with WHO and NAFDAC standards.
III. Replace old or leaking pipes, clean water storage tanks regularly, and ensure proper sealing of all plumbing systems to prevent external contamination.
IV. Provide point-of-use water filters or purifiers in all hostels, particularly in Atere Campus where fecal contamination is high.

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V. Launch hygiene awareness campaigns on safe water handling, hand washing practices, and the risks of consuming untreated water.
VI. Partner with local health agencies and environmental health officers to facilitate professional guidance and compliance with sanitation protocols.
VII. Conduct periodic inspections of hostel water systems and hold relevant maintenance personnel accountable for lapses in hygiene practices.

Suggestions for Further Studies

Future research should include a year-round analysis of seasonal variations in microbial load. Additionally, molecular techniques such as PCR should be employed to detect a wider range of pathogens, including viruses and antibiotic-resistant organisms.

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