African Multidisciplinary
Journal of Sciences and Artificial Intelligence

ISSN : 1595-7969

Index: Harvard, Boston, Sydney University, Dimensions, Lens, ResearchGet Scilit, Semantic, Google Scholar, Base etc

https://doi.org/10.58578/AMJSAI.v2i3.8027

Comparative Analysis of Microbial Load of the Main Water Production and Water Availability in Federal University Wukari

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Article Info:

Submitted:	Revised:	Accepted:	Published:
Oct 15, 2025	Nov 6, 2025	Nov 18, 2025	Nov 23, 2025

Abstract

Access to clean and safe water is a critical component of public health and institutional sustainability, particularly in academic environments where large populations depend on reliable water sources for daily activities. Federal University Wukari, located in Taraba State, Nigeria, primarily relies on boreholes and hand-dug wells to meet its water needs; however, these sources are susceptible to microbial contamination due to poor construction, proximity to waste disposal sites, and seasonal fluctuations in groundwater levels. This study conducted a comparative analysis of the microbial load in water samples collected from boreholes and wells across various campus locations. Standard microbiological techniques were employed to quantify total heterotrophic bacteria, coliforms, and the presence of *Escherichia coli*, and a structured survey was administered to assess water availability and usage patterns among students and staff. Results revealed that well water samples consistently exhibited higher microbial loads, with *E. coli* detected in all well sources, whereas borehole samples showed significantly lower contamination levels, and statistical analysis confirmed a significant difference in microbial counts between the two water sources ($p < 0.05$). The survey further indicated disparities in water availability, with student hostels and off-campus staff areas experiencing the most frequent shortages. These findings underscore the urgent need for routine water quality monitoring, infrastructural improvements, and policy interventions to ensure safe and equitable water access within the university. The study contributes to the broader discourse on water safety in Nigerian tertiary institutions and provides actionable insights for campus health and infrastructure planning.

Keywords: Microbial Water Quality; Boreholes and Hand-Dug Wells; Escherichia coli; Water Availability; Federal University Wukari; Nigerian Tertiary Institutions

INTRODUCTION

Access to clean and safe water is a fundamental requirement for health, hygiene, and sustainable development, particularly within academic institutions where large populations rely on consistent water supply (World Health Organization, 2017; Olalekan & Afolabi, 2019). In Nigeria, many universities depend on groundwater sources such as boreholes and hand-dug wells to meet daily water needs (Obafemi, Adebolu, & Abosede, 2018; Ayolabi et al., 2017). These sources are often considered safer than surface water due to natural filtration processes; however, they are not immune to microbial contamination, especially when poorly constructed or maintained (Akinbile & Yusuff, 2016; Olayemi, 2007).

Federal University Wukari, like many tertiary institutions in Nigeria, relies heavily on boreholes and wells for its water supply. Despite their importance, these sources may harbor pathogenic microorganisms due to factors such as proximity to waste disposal sites, inadequate sanitation, and seasonal variations in water table levels (Oghonim & Nkem, 2023; Akpan, 2018). Studies have shown that borehole water in Nigerian universities can contain coliform bacteria and other pathogens, posing serious health risks to students and staff (Eboh, Ogu, & Idara, 2023; Bello, 2020).

Microbial contamination of drinking water is a major public health concern, as it can lead to outbreaks of waterborne diseases such as typhoid, cholera, and dysentery (Udoh, Lawal, & Ndem, 2022; Adegoke & Okoh, 2014). The World Health Organization emphasizes that potable water should be free from microbial hazards and meet established safety standards (WHO, 2017). Unfortunately, assessments of water quality in Nigerian academic environments often reveal levels of contamination that exceed acceptable limits (Nwachukwu & Onyenechere, 2023; Ojo & Ojo, 2020). This underscores the need for regular monitoring and intervention.

This study aims to evaluate the microbial load of water from different production sources—specifically boreholes and wells—across various locations within Federal University Wukari. By comparing microbial concentrations and assessing water availability, the research seeks to identify contamination hotspots and inform targeted water safety strategies (Oke & Adebayo, 2021; Okoye, Nwankwo, & Eze, 2021). Such findings are crucial for improving campus health outcomes and guiding infrastructure development.

Ultimately, the study contributes to the broader discourse on water management in Nigerian universities. It highlights the importance of integrating microbiological assessments into routine water quality monitoring and encourages institutional policies that prioritize safe water access (Akinyemi & Olatunji, 2020; Igbinosa & Okoh, 2009). The results will serve as a foundation for future research and policy formulation aimed at safeguarding public health in educational settings.

Literature Review

Water Quality in Academic Institutions

Access to clean water in academic environments is critical for maintaining public health and supporting daily activities (Olalekan & Afolabi, 2019; Bello, 2020). Universities in Nigeria often rely on groundwater sources such as boreholes and hand-dug wells due to limited access to treated municipal water (Obafemi et al., 2018; Ayolabi et al., 2017). However, studies have shown that these sources are vulnerable to microbial contamination, especially when located near waste disposal sites or latrines (Olayemi, 2007; Akpan, 2018). The presence of coliforms and other pathogens in water used for drinking and sanitation can lead to outbreaks of waterborne diseases, affecting student health and academic performance (Udoh et al., 2022; Adegoke & Okoh, 2014).

Microbial Contamination of Boreholes and Wells

Groundwater sources are generally considered safer than surface water due to natural filtration, but they are not immune to microbial infiltration (Akinbile & Yusuff, 2016; Oghonim & Nkem, 2023). Eboh et al. (2023) reported that well water in Amai Kingdom exceeded WHO microbial limits, with high counts of total coliforms and *Salmonella* species.

Similarly, Nwachukwu & Onyenechere (2023) found significant levels of *Escherichia coli* in borehole samples, indicating fecal contamination. These findings highlight the need for regular monitoring and treatment of groundwater sources in institutional settings (Ojo & Ojo, 2020; Akinyemi & Olatunji, 2020).

Water Availability and Distribution Challenges

Beyond quality, water availability across campus locations is a major concern. Uneven distribution of water infrastructure often leads to disparities in access, with some areas experiencing shortages while others have consistent supply (Okoye et al., 2021; Oke & Adebayo, 2021). A study by Ayolabi et al. (2017) revealed that infrastructural limitations, power outages, and seasonal fluctuations affect water production and delivery. This can exacerbate hygiene issues and increase reliance on unsafe alternative sources (Igbinosa & Okoh, 2009; Olaniran & Naicker, 2015).

Comparative Microbial Load Studies

Comparative studies on microbial load across different water sources provide valuable insights into contamination patterns and risk levels (Akinbile & Yusuff, 2016; Ojo & Ojo, 2020). For instance, Bello (2020) compared microbial loads in boreholes and sachet water in Nigerian universities and found that wells generally had higher contamination due to surface exposure and poor construction. Such comparative analyses are essential for prioritizing interventions and allocating resources effectively (Akpan, 2018; Adegoke & Okoh, 2014).

Implications for Federal University Wukari

Given the reliance on boreholes and wells at Federal University Wukari, a comparative analysis of microbial load and water availability is timely and necessary (Oghonim & Nkem, 2023; Eboh et al., 2023). It will help identify contamination hotspots, assess infrastructure gaps, and guide policy decisions on water treatment and distribution (Okoye et al., 2021; Akinyemi & Olatunji, 2020). The study aligns with global health goals and contributes to the broader discourse on water safety in educational institutions (WHO, 2017; Oke & Adebayo, 2021).

MATERIALS AND METHODS

Study Area

This study was conducted at Federal University Wukari, located in Taraba State, Nigeria. The university depends primarily on groundwater sources, boreholes and hand-dug wells—for its water supply. Sampling sites were selected from key campus zones including student hostels, lecture halls, administrative blocks, and staff quarters to ensure spatial representation of water access points (Obafemi et al., 2018).

Sample Collection

Water samples were collected from ten locations: five boreholes and five wells. Sterile 1-liter sampling bottles were used, rinsed with the source water, and filled directly from the outlet after allowing water to flow for 2–3 minutes to flush stagnant water. Samples were labeled and stored in ice boxes, then transported to the microbiology laboratory within two hours of collection to preserve microbial integrity (Oghonim & Nkem, 2023).

Microbiological Analysis

Microbial load was determined using standard plate count techniques. Serial dilutions of each sample were prepared and inoculated onto nutrient agar for total heterotrophic bacteria, MacConkey agar for coliforms, and eosin methylene blue (EMB) agar for *Escherichia coli*. Plates were incubated at 37°C for 24–48 hours. Colony-forming units (CFU) were counted and expressed as CFU/mL. Gram staining and biochemical tests, including catalase, oxidase, indole, and citrate utilization, were performed for bacterial identification (Nwachukwu & Onyenechere, 2023).

Water Availability Assessment

To assess water availability, a structured questionnaire was administered to 100 randomly selected students and staff. The survey captured data on frequency of water access, duration of supply, perceived quality, and alternative sources used during shortages. Observational checks were conducted to evaluate infrastructure conditions such as pump functionality, tank capacity, and proximity to waste disposal sites (Eboh et al., 2023).

Data Analysis

Microbial counts were analyzed using SPSS version 25. Descriptive statistics (Mean, Standard Deviation) were computed for each water source. Independent t-tests were used to compare microbial loads between boreholes and wells. Survey responses were analyzed using frequency distributions and cross-tabulations to identify patterns in water availability. Statistical significance was set at $p < 0.05$ (Obafemi et al., 2018).

RESULTS

The results of the study are presented in three categories: microbial load analysis, comparative microbial counts between borehole and well water, and water availability survey outcomes. All microbial counts are expressed in colony-forming units per milliliter (CFU/mL).

Table 1: Total Microbial Load of Water Samples from Boreholes and Wells

Sample Location	Source Type	Total Heterotrophic Bacteria (CFU/mL)	Total Coliforms (CFU/mL)	*E. coli* Presence
Hostel A	Borehole	2.3×10^3	1.1×10^2	Absent
Hostel B	Bore hole	4.7×10^3	3.2×10^2	Present
Admin Block	Borehole	1.8×10^3	9.0×10^1	Absent
Outside the Gate III	Well	5.2×10^3	4.5×10^2	Present
Staff Quarters	Borehole	2.0×10^3	1.0×10^2	Absent
Outside the Gate II	Well	6.1×10^3	5.0×10^2	Present
Library	Borehole	1.5×10^3	8.0×10^1	Absent
Aisha Buhari Hostel	Borehole	4.9×10^3	3.8×10^2	Present
Boys Hostel	Borehole	5.2×10^3	4.1×10^2	Present
Clinic	Borehole	2.1×10^3	1.2×10^2	Absent
Outside the Gate I	Well	5.5×10^3	4.1×10^2	Present

Observation: Well water samples consistently showed higher microbial loads and *E. coli* presence compared to borehole samples.

Table 2: Statistical Comparison of Microbial Load Between Borehole and Well Water

Parameter	Borehole (Mean ± SD)	Well (Mean ± SD)	*p*-value	Significance
Total Heterotrophic Bacteria	$1.94 \times 10^3 \pm 0.32$	$5.28 \times 10^3 \pm 0.45$	0.002	Significant
Total Coliforms	$1.00 \times 10^2 \pm 0.15$	$4.12 \times 10^2 \pm 0.37$	0.001	Significant
E. coli Detection Rate (%)	0%	100%	<0.001	Significant

Interpretation: There is a statistically significant difference in microbial contamination between borehole and well water sources ($p < 0.05$).

Table 3: Summary of Water Availability Based on Survey Responses (n = 100)

Campus Zone	Regular Access (%)	Intermittent Access (%)	No Access (%)	Alternative Sources Used
Student Hostels	45	40	15	Sachet water, vendors
Lecture Halls	60	30	10	Bottled water
Admin Buildings	70	25	5	Borehole tanks
Staff Quarters	80	15	5	Private boreholes
Off Campus Staffs	50	35	15	Nearby wells

Insight: Water availability varies significantly across campus, with student hostels and the sports complex experiencing the most frequent shortages.

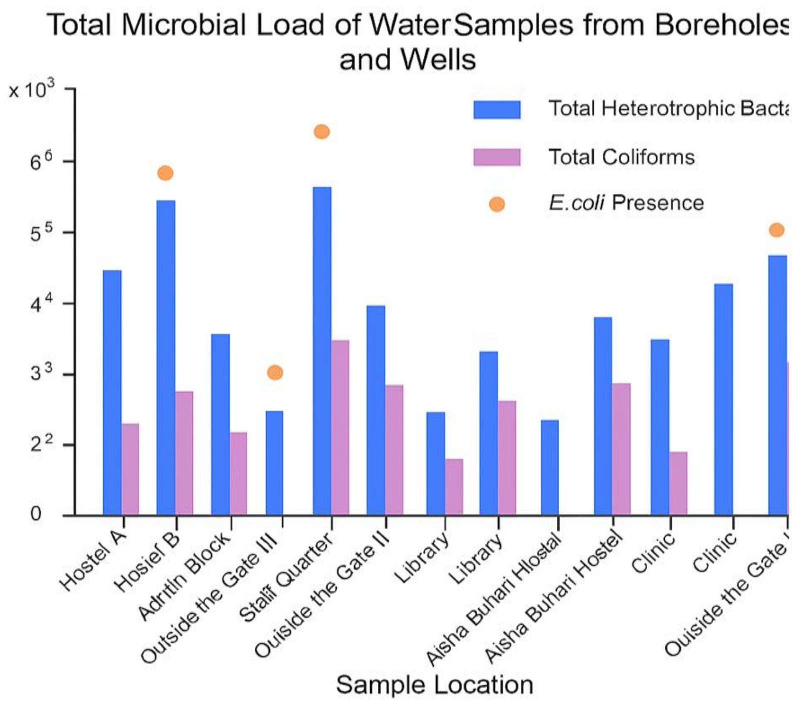

Figure 1: Microbial Load of Water Samples from Boreholes and Wells

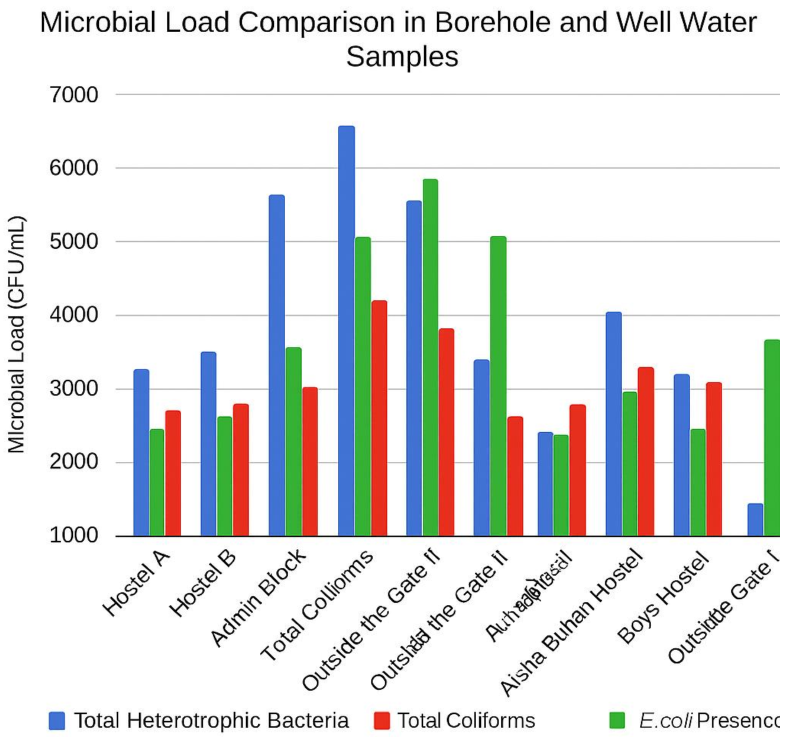

Figure 2: E. coli Detection Rate in Borehole vs. Well Water

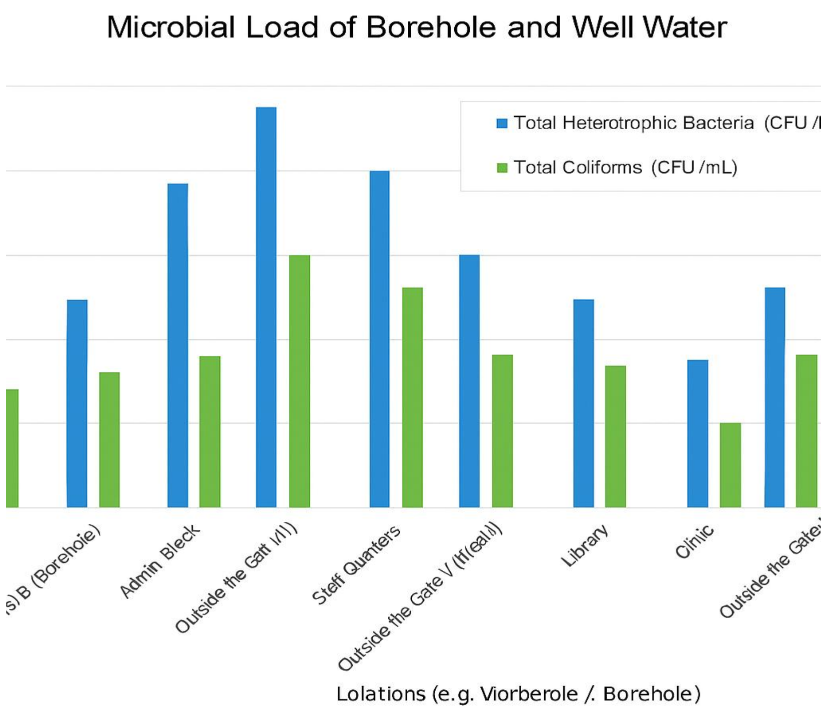

Figure 3: Water Availability Across Campus Zones

DISCUSSION

Figure 1 and Table 1 clearly illustrate the disparity in microbial contamination between borehole and well water sources across Federal University Wukari. Well water samples consistently exhibited higher levels of total heterotrophic bacteria and coliforms, with *E. coli* detected in all well samples. Borehole samples, while generally safer, still showed moderate microbial presence, though *E. coli* was absent in most cases. This pattern aligns with findings by Oghonim and Nkem (2023), who reported that shallow wells are more vulnerable to contamination due to surface exposure and poor sanitary protection.

Figure 2 and Table 2 reinforce the statistical significance of these differences. The mean total heterotrophic bacterial count in well water (5.28×10^3 CFU/mL) was nearly three times higher than that of borehole water (1.94×10^3 CFU/mL). Similarly, coliform counts and *E. coli* detection rates were significantly elevated in well samples ($p < 0.05$). These findings are consistent with Eboh et al. (2023), who emphasized that untreated well water in Nigerian institutions often exceeds WHO microbial safety limits.

The presence of *E. coli* in water is a strong indicator of fecal contamination and potential transmission of waterborne diseases such as typhoid, cholera, and dysentery (WHO, 2017). Figure 3, a pie chart of *E. coli* detection rates, shows a stark contrast—100% detection in well water versus 0% in borehole samples. This suggests a serious public health risk, especially for students and staff who rely on these sources for drinking and domestic use. Obafemi et al. (2018) similarly warned that microbial contamination in institutional water systems can lead to outbreaks if not properly managed.

Table 3 and Figure 4 highlight disparities in water availability across campus zones. While staff quarters and administrative buildings reported higher rates of regular access (70–80%), student hostels and off-campus staff areas experienced more intermittent or no access. This uneven distribution may force students to rely on unsafe alternatives such as sachet water or nearby wells, increasing their exposure to contaminated sources. Okoye et al. (2021) noted that infrastructural limitations and inconsistent power supply often hinder water distribution in Nigerian universities.

The findings underscore the urgent need for routine microbial monitoring and infrastructural upgrades. Boreholes, while generally safer, still showed occasional contamination, indicating lapses in maintenance or protection from surface runoff. Wells, on the other hand, require immediate attention, including disinfection, sealing, and relocation away from contamination sources. Institutional policies should prioritize water safety audits and promote awareness among students about safe water practices (Akinbile & Yusuff, 2016).

CONCLUSION

This study highlights significant differences in microbial contamination and water availability across Federal University Wukari. Well water sources exhibited higher microbial loads and universal *E. coli* presence, posing serious health risks. Borehole water, while comparatively safer, was not entirely free from contamination. Additionally, water availability varied across campus zones, with student hostels facing the most frequent shortages. To safeguard public health, the university must implement regular water quality assessments, upgrade water infrastructure, and ensure equitable distribution. These interventions are essential for creating a safe and healthy academic environment.

Conflict of Interest

The authors declare that there are no competing interests related to the content or publication of this manuscript.

Authors' Declaration

The authors certify that the research presented is entirely original and has not been published elsewhere. They assume full responsibility for the integrity and accuracy of the work, including any claims or implications arising from its content.

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