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Bacteriological Quality of Selected Bottled Water Brands Produced and Sold in Okigwe, Imo State Nigeria

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Abstract

In Nigeria, bottled water is widely perceived as a premium and hygienic beverage rather than a routine household water source; however, its frequent use at social gatherings, institutional settings, and for infant feeding has raised important public health concerns about its microbiological safety.This study assessed the bacteriological quality of selected bottled water brands produced and sold in Okigwe, Imo State, Nigeria. Five bottled water brands were randomly sampled and analyzed for pH, total heterotrophic bacterial count, bacterial isolates, and antibiotic susceptibility patterns using standard microbiological techniques. The pour plate method was employed for bacterial enumeration, while bacterial identification and antibiotic susceptibility testing were conducted using conventional laboratory procedures. Cultivable bacteria were recovered from three out of the five bottled water brands analyzed. Escherichia coli and Klebsiella species were isolated from one brand, indicating faecal contamination and non-compliance with World Health Organization and Nigerian drinking water standards. Staphylococcus, Streptococcus, and Acinetobacter species were also isolated, suggesting lapses in production or post-treatment hygiene. Antibiotic susceptibility testing revealed resistance to some commonly used antibiotics, particularly among the Gram-negative isolates. The findings demonstrate that not all bottled water brands sold in Okigwe are microbiologically safe and highlight the need for stricter regulatory monitoring, improved hygiene practices by producers, and routine antimicrobial resistance surveillance in packaged drinking water.

Keywords: *Bottled water, bacteriological quality, , antibiotic resistance, Health implications Okigwe, Nigeria*

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Background to the Study

Access to safe drinking water is fundamental to public health and disease prevention. In Nigeria, bottled water is not primarily consumed as a routine household drinking-water source by the general population but is widely perceived as a premium product associated with higher socio-economic status. It is commonly served at social gatherings, ceremonies, conferences, offices, health facilities, and institutional settings, and is frequently selected for vulnerable groups such as infants and newborns due to the assumption of superior safety and purity. This perception significantly elevates the public health importance of any microbiological compromise detected in bottled water, as such products are often consumed without further treatment and are trusted for use in sensitive contexts (Edeki., 2023; Nwanisobi, 2025; World Health Organization [WHO], 2017).

However, several studies have shown that bottled water may be contaminated with pathogenic and opportunistic microorganisms, posing health risks to consumers.

Materials and Methods

This laboratory-based descriptive study was conducted on five bottled water brands produced and sold in Okigwe, Imo State, Nigeria. Samples were purchased from retail outlets and analyzed on the same day. The pour plate method was used to determine total heterotrophic bacterial count, while bacterial isolates were identified using standard microbiological techniques. Antibiotic susceptibility testing was carried out using the disk diffusion method.

Results

Table 1: Bacteriological Analysis of Bottled Water Samples

Brand	pH	Total Bacterial Count	Bacterial Isolates	Number	Percentage (%)
P1	7.2	6.9×10^3	Staphylococcus spp., Streptococcus spp.	2	40
P2	5.1	2.3×10^{-1}	Escherichia coli, Klebsiella spp.	2	40
P3	6.3	No growth	Nil	0	0
P4	8.2	2.4×10^2	Acinetobacter spp.	1	20
P5	7.3	No growth	Nil	0	0

Table 2: Antibiotic Susceptibility Pattern of Isolated Bacteria

Sample	Bacterial Isolates	Antibiotic Sensitivity Pattern
P1	Staphylococcus & Streptococcus spp.	Resistant to CTZ; sensitive to AZM, AMX, CPX, LEV, CN, CEF, RD
P2	Escherichia coli & Klebsiella spp.	Multiple resistance observed; sensitive to CN, S, OFX, AU
P4	Acinetobacter spp.	Sensitive to all antibiotics tested

Discussion

The pH values of the bottled water samples ranged from 5.1 to 8.2, indicating variability from mildly acidic to slightly alkaline conditions. P2 recorded the lowest pH value (5.1), while P4 recorded the highest (8.2).

Cultivable bacteria were isolated from three out of the five bottled water brands analyzed. P1 recorded a total bacterial count of 6.9×10^3 CFU/mL, with *Staphylococcus* spp. and *Streptococcus* spp. isolated. P2 yielded *Escherichia coli* and *Klebsiella* species, with a reported total bacterial count of 2.3×10^{-1} CFU/mL. P4 recorded a total bacterial count of 2.4×10^2 CFU/mL and yielded *Acinetobacter* species. No bacterial growth was detected in P3 and P5.

The distribution of isolates showed that *Staphylococcus* and *Streptococcus* species accounted for 40 % of the total isolates, *E. coli* and *Klebsiella* species accounted for another 40 %, while *Acinetobacter* species constituted 20 %.

Antibiotic susceptibility testing revealed varied resistance patterns. The *Staphylococcus* and *Streptococcus* isolates were resistant to ceftazidime but sensitive to multiple antibiotics including azithromycin, amoxicillin, ciprofloxacin, levofloxacin, gentamicin, ceftriaxone, and rifampicin. The *E. coli* and *Klebsiella* isolates demonstrated resistance to several antibiotics, including ceftazidime, ciprofloxacin, cefepime, ceftriaxone, and pefloxacin, while showing sensitivity to streptomycin, gentamicin, ofloxacin, augmentin, and selected cephalosporins. The *Acinetobacter* isolate was sensitive to all antibiotics tested.

The findings of this study indicate that some bottled water brands produced and sold in Okigwe do not meet established microbiological safety standards. The isolation of *Escherichia coli* from a finished bottled water product is particularly significant, as WHO guidelines clearly state that *E. coli* must not be detectable in drinking water intended for human consumption (WHO, 2017). Its presence in the P2 sample therefore represents definitive evidence of faecal contamination and a failure of water treatment or post-treatment handling processes. It shows non-compliance with WHO and Nigerian standards. The detection of opportunistic bacteria further suggests lapses in hygienic control during production or distribution.

The recovery of *Klebsiella* species alongside *E. coli* further supports the likelihood of faecal or environmental contamination. Similar findings have been reported in bottled water studies conducted in Awka, Sapele, Kwale, and Ilorin, where coliforms and opportunistic bacteria were isolated from commercially packaged water (Edeki et al., 2023; Jimoh, 2025; Nwanisobi, 2025). The isolation of *Staphylococcus* and *Streptococcus* species from P1 suggests possible contamination during bottling or handling, as these organisms are commonly associated with human skin, respiratory secretions, and poorly sanitized equipment.

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The detection of *Acinetobacter* species in P4 is also of concern, as this organism is known to survive in moist environments and has been increasingly implicated in opportunistic infections. WHO recognizes the presence of such non-faecal opportunistic bacteria in drinking water as an indicator of inadequate hygienic control, particularly in bottled and distributed water systems (WHO, 2017).

The antibiotic resistance observed among the *E. coli* and *Klebsiella* isolates aligns with recent Nigerian studies reporting resistant environmental bacteria in drinking water sources (Jimoh, 2025; Awoke et al., 2024). The presence of antibiotic-resistant bacteria in bottled water represents a potential public health threat, as it may facilitate exposure to resistant organisms and contribute to the spread of antimicrobial resistance within the community.

Public Health Implications of Microbiologically Contaminated Bottled Water

The isolation of *Escherichia coli* from a finished bottled water product has profound health implications. *E. coli* is internationally accepted as a definitive indicator of recent faecal contamination, and its presence implies the possible co-occurrence of other enteric pathogens such as *Salmonella*, *Shigella*, and pathogenic strains of *E. coli* that may not be detected during routine analysis (WHO, 2017). Consumption of water contaminated with *E. coli* has been strongly linked to acute gastroenteritis, diarrhoeal disease, vomiting, and abdominal cramps, conditions that pose a particularly severe risk to infants, newborns, and young children due to their limited physiological reserves and higher susceptibility to dehydration. In these vulnerable groups, even mild diarrhoeal illness can rapidly progress to severe dehydration, electrolyte imbalance, and, in extreme cases, death if prompt medical care is not available (WHO, 2017).

Beyond faecal indicators, the recovery of opportunistic bacterial species such as *Klebsiella* and *Acinetobacter* from bottled water presents additional health risks. *Klebsiella* species are well-documented causes of urinary tract infections, pneumonia, septicaemia, and neonatal infections, particularly in settings where exposure occurs through contaminated fluids or medical environments. Their presence in bottled water intended for direct consumption suggests environmental or faecal contamination and introduces a potential pathway for community-acquired infections, especially among infants, pregnant women, and immunocompromised individuals (Jimoh, 2025; Awoke et al., 2024). *Acinetobacter* species, once regarded as low-virulence environmental organisms, have emerged globally as significant opportunistic pathogens associated with respiratory tract infections, bloodstream infections, and meningitis, particularly in neonates and hospitalized patients. Detection of *Acinetobacter* in bottled water therefore raises concerns about its use in homes, clinics, and offices where such water may be consumed by vulnerable persons (Awoke et al., 2024; WHO, 2017).

The isolation of *Staphylococcus* and *Streptococcus* species from bottled water further underscores the public health implications of poor production hygiene. These organisms are commonly associated with human skin, nasal passages, and respiratory secretions, and their presence in bottled water is indicative of contamination during bottling, handling, or storage. Although not classical waterborne pathogens, ingestion of water contaminated with these organisms may contribute to throat infections, skin infections, and opportunistic systemic infections, particularly among individuals with compromised immunity. Importantly, their detection signals broader hygienic failures in the production environment, increasing the likelihood that other pathogenic microorganisms could also contaminate the product (Edeki et al., 2023; WHO, 2017).

An additional and critical public health implication of the findings relates to antimicrobial resistance. The antibiotic susceptibility patterns observed among the *E. coli* and *Klebsiella* isolates indicate resistance to several commonly used antibiotics. The presence of antibiotic-resistant bacteria in bottled water is of particular concern because drinking water is consumed directly and frequently by diverse population groups. Exposure to resistant organisms through bottled water may facilitate the colonization of the human gut with resistant bacteria and contribute to the horizontal transfer of resistance genes within the community. In Nigeria, where antimicrobial stewardship remains a challenge and self-medication with antibiotics is common, such exposure may exacerbate the existing burden of antimicrobial resistance and compromise the effectiveness of first-line treatments for common infections (Awoke et al., 2024; Jimoh, 2025& Shehu,2025**)**.

The public health implications of these findings are further amplified by the social contexts in which bottled water is consumed. Bottled water is routinely distributed at large gatherings such as weddings, funerals, conferences, and religious events, where a single contaminated batch may be consumed by many individuals within a short period. This creates the potential for clustered cases of gastrointestinal illness that may go unrecognized or unreported, particularly if symptoms are mild or delayed. Additionally, the use of bottled water for preparing infant feeds or administering medications to newborns increases the risk of severe health outcomes when contamination occurs, given the heightened vulnerability of this population group (WHO, 2017).

In summary, microbiological contamination of bottled water in Okigwe has implications that extend beyond individual consumer risk to broader public health concerns, including infant health, community transmission of opportunistic and faecal pathogens, and the environmental spread of antibiotic-resistant bacteria. These findings reinforce the necessity for strict regulatory oversight, routine microbiological testing, and improved hygienic practices in bottled water production to ensure that products marketed as premium and safe do not become inadvertent vehicles for disease transmission.

This study demonstrates that some bottled water brands produced and sold in Okigwe, Imo State, are microbiologically unsafe. The presence of *E. coli* constitutes a clear violation of WHO and Nigerian drinking water standards, while the detection of other opportunistic bacteria reflects lapses in production hygiene. The observed antibiotic resistance among certain isolates further underscores the public health implications of consuming contaminated bottled water.

Recommendations

1. Regular microbiological surveillance of bottled water brands in Okigwe should be strengthened by regulatory agencies.
2. Bottled water producers should improve source water protection, treatment efficiency, and bottling-line sanitation.

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3. Routine antibiotic susceptibility testing of waterborne isolates should be incorporated into environmental health monitoring to support antimicrobial resistance surveillance.

Public health education should also be intensified to inform consumers that bottled water is not inherently free from microbiological risks.

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