Assessment of the Bacteriological Quality of Sachet-Packaged Water Brands in Nibo, Anambra State, Nigeria

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DOI: https://doi.org/10.51244/IJRSI.2026.1305000120

Received: 23 April 2026; Accepted: 28 April 2026; Published: 03 June 2026

ABSTRACT

Background And Objective: Access to safe drinking water remains a major public health challenge in many Nigerian communities. Sachet-packaged water, commonly called "pure water," has become the primary drinking water source for millions of Nigerians who cannot rely on municipal tap water. Despite its widespread use, concerns about the microbiological safety of sachet water is well documented. This study assessed the bacteriological quality of sachet-packaged water brands sold in Nibo, a semi-urban community in Anambra State, Nigeria, and to determine whether these products meet World Health Organization drinking water standards.

Methods: A cross-sectional descriptive design was used in the study. Twelve commonly consumed sachet water brands were purposively sampled from vendors in Nibo between April to September 2025. Samples were transported under sterile conditions to the laboratory and analysed using standard microbiological methods, including total bacterial count on nutrient agar, total coliform count on eosin methylene blue agar, and biochemical identification of bacterial isolates. Data were analysed using descriptive statistics (frequencies, percentages, means, medians, standard deviations) and one-sample t-tests with 95% wilson confidence intervals.

Results: From the 12 brands tested, 7 (58.3%) showed no bacterial growth and met WHO safety standards. However, 5 brands (41.7%) were contaminated. Among contaminated samples, total bacterial counts ranged from 30 to 110 CFU/mL (mean: 68 CFU/mL), and total coliform counts ranged from 10 to 50 CFU/mL (mean: 24 CFU/mL). Two samples (16.7%) tested positive for Escherichia coli, confirming faecal contamination. Identified bacterial species included Staphylococcus aureus (16.7%), Pseudomonas aeruginosa (16.7%), Proteus mirabilis (16.7%), Citrobacter freundii (16.7%), Klebsiella pneumoniae (8.3%), Escherichia coli (8.3%), Shigella flexneri (8.3%), and Enterobacter aerogenes (8.3%).

Conclusion and Implications for Translation: Although the majority of sachet water brands tested were safe, a substantial proportion (41.7%) contained bacteria that pose health risks, including faecal indicator organisms and opportunistic pathogens. Mean total bacterial count (68±32CFU/mL) and coliform count (24±17CFU/mL) was significantly above the acceptable limit at ($p<0.05$). People who drink these contaminated products, particularly children, elderly individuals, and immunocompromised persons, face preventable risks of diarrhoeal and other infections. Regulators should increase unannounced inspections and enforce penalties for violations.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI Volume XIII Issue V May 2026

Producers must improve hygiene practices, including regular equipment cleaning and water testing. Public health awareness campaigns should help consumers identify safer brands. Future research studies are to be conducted larger sample sizes, seasonal sampling, and antimicrobial resistance testing.

Keywords: Sachet water; bacteriological quality; coliforms; Escherichia coli; public health; Nigeria; drinking water safety

INTRODUCTION

Background of the Study

Safe drinking water is not a luxury, but a fundamental human right it is a basic necessity for human health and the prevention of diseases (WHO, 2023). Yet across the entirety of Nigeria, wholesome water is not consistently available. Many households have learned to cope by turning to alternative sources, and one of the most common is sachet-packaged drinking water, popularly known as "pure water." Walk through any market, bus stop, or neighbourhood in southern Nigeria, and one will see these small plastic sachets being sold by vendors. For a modest sum, usually less than 50 naira, anyone can buy what appears to be clean, safe drinking water (Adekunle et al 2004). However, the question of whether this water is truly safe has troubled public health researchers for years. Access to potable water remains severely constrained in many developing regions, where inadequate water supply infrastructure exposes populations to preventable waterborne infections, including cholera, typhoid fever, and diarrhoeal diseases. (WHO,2017 and UNICEF & WHO 2020).

According to Prüss-Ustün et al (2019), these conditions continue to contribute substantially to the global burden of disease, particularly among children under five years of age. In Nigeria, persistent deficiencies in public water supply systems have driven a growing dependence on alternative drinking water sources. Although sachet water is widely perceived by consumers as safe due to its sealed packaging and commercial branding, accumulating evidence indicates that a significant proportion of brands fail to meet water quality and safety standards. Several studies conducted in Nigeria has found that some sachet water brands contain bacteria contaminants in drinking water, (Omalu et al, 2010; Edema et al 2011 and Ojekunle et al 2015). Some of these bacteria contaminjnants, like Escherichia coli, come from human or animal faeces and can cause diarrhoea, vomiting, and more serious illnesses. Others, like Pseudomonas aeruginosa and Klebsiella pneumoniae, are opportunistic pathogens that can infect people with weakened immune systems (WHO, 2017). The enomours public health concern is that millions of Nigerians including young children, pregnant women, and people living with HIV or other chronic conditions drink sachet water every day, often believing it to be safer than tap water. Ekwunife & Aguwa (2018) opined that while sachet water is a common source of drinking water in rural communities, it often fails to reach safe, potable standards. Despite the existence of numerous studies on sachet water quality across various Nigerian states, there remains a scarcity of location-specific data for Nibo, a semi-urban community in Anambra State. The quality of sachet water depends on many factors such as where the producer obtains the water, treatment process, whether their equipment is clean, how the sachets are sealed, and how vendors store them before sale. (Oyem et al 2014). This study was designed to fill that gap by providing local evidence that local health authorities can act upon on water quality standard

Objectives of the Study

The main objective of this study was to assess the bacteriological quality of sachet-packed water brands sold in Nibo and determine their compliance with WHO drinking water quality standards.

METHODS

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies. The STROBE checklist was used to ensure complete and transparent reporting of the study methods and findings. (Von Elm et al 2007)

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI Volume XIII Issue V May 2026

Study Design and Area

A cross-sectional descriptive study was conducted between April and September, 2025 in Nibo, a peri-urban community located in Awka South Local Government Area of Anambra State, southeastern Nigeria.

Sampling: All the 12 satchet-packaged water brands available and sold in Nibo at the time of study were included. For eachbrand, satchets were purchased from three different vendors at different locations within Nibo to ensure true representation. Each brand was analysed in triplicate.

Microbiological Analysis: Samples were transported in sterile containers a 4^0C and analysed within 6 hours of collection, as ststandard methods were followed. The total bacterial count was done by growing bacteria on nutrient agar at 37°C for 24 hours, then counting the colonies. Total coliform count was perfomed on eosin methylene blue (EMB) agar that makes coliform bacteria show up as dark colonies.

Identifying bacteria: Colonies were purified and identified using Gram staining and biochemical tests (catalase, oxidase, indole, sugar fermentation, etc.). This revealed which specific bacteria were present.

Study variables: The main outcome was bacterial contamination (counts and species). The only independent variable was the brand of water. No other factors like storage time or temperature were measured.

Quality Control: Negative control (sterile distilled water) and reference strains were used. All anakyses were perfomed in triplicate, and the mean values were reported.

Data Analysis: Data were analysed using descriptive statistics (frequency, mean, percentages, standard deviations, median and Ranges). The proportion of contamionated brands was was presented with 95% wilson confidence intervals. One- sample t-tests were used to compare mean bacterial counts against the WHO standard of 0 CFU/mLper 100 mL. All tests were two-tailed with significance set at $p<0.05$.er 100 mL.

RESULTS

Compliance with WHO Drinking Water Standards

The table below shows of the 12 sachet water brands tested, 7(58.3%) showed no bacterial growth on either nutrient agar or EMB agar. These brands complied with WHO standard of zero coliforms per 100 mL. Five (5) brands (41.7%) showed bacterial contamination and were therefore classified as non-compliant. Among these five, two brands (16.7% of the total) tested positive for Escherichia coli, which is direct evidence of faecal contamination. Table 1 summarises these findings.

Table 1. Compliance of Sachet Water Samples with WHO Standards (N = 12)

Category	frequency	percentage
Compliance (No bacteria growth)	7	58.3
Non –Compliance(contaminated)	5	41.7
Total	12	100

Total Bacterial and Coliform Counts

Among the five contaminated samples, the amount of bacteria varied considerably. Mean total bacterial counts ranged from 30 to 110 CFU/mL, with overall mean of 68±32 CFU/mL (median: 70 CFU/mL). Mean total coliform counts ranged from 10 to 50 CFU/mL, with overall mean of 24±17 CFU/mL (median: 20 CFU/mL). Table 2 provides the full descriptive statistics.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI Volume XIII Issue V May 2026

Table 2. Mean Bacterial Counts in Contaminated Sachet Water brands (n = 5)

Parameter	**Minimum**	**Maximum**	**Mean±SD**	**Median**
Total Bacterial Count (CFU/mL)	30	110	68 ± 32	70
Total Coliform Count (CFU/mL)	10	50	24 ± 17	20

Distribution of Bacterial Isolates

From the five contaminated samples, a total of 12 bacterial isolates were recovered and identified. The most frequently isolated organisms were Staphylococcus aureus (2 isolates, 16.7%), Pseudomonas aeruginosa (2 isolates, 16.7%), Proteus mirabilis (2 isolates, 16.7%), and Citrobacter freundii (2 isolates, 16.7%). The remaining four species were Klebsiella pneumoniae, Escherichia coli, Shigella flexneri, and Enterobacter aerogenes, each accounted for one isolate (8.3% each). Table 3 shows the complete distribution.

Table 3. Frequency and Percentage of Bacterial Isolates Recovered from Contaminated Sachet Water Samples

Bacterial Isolate	Frequency (n)	Percentage (%)
Staphylococcus aureus	2	16.7
Pseudomonas aeruginosa	2	16.7
Proteus mirabilis	2	16.7
Citrobacter freundii	2	16.7
Klebsiella pneumoniae	1	8.3
Escherichia coli	1	8.3
Shigella flexneri	1	8.3
Enterobacter aerogenes	1	8.3
Total	12	100

Statistical Significance

The contamination rate was 41.7% (5/12 brands). the 95% Wilson confidence interval for the true proportion of contaminated brands in Nibo was 18.4%to 68.7%. Among the contaminated brands, the mean to tal bacterial count (68±32 CFU/mL) was significantly higher than the WHO recommendation limit of 0 CFU/mL. Similarly, mean coliform count (24±17 CFU/mL) was alsso significantly above the acceptance limit ($p<0.05$)

DISCUSSION

This study found that nearly 41.7% of sachet water brands sold in Nibo are contaminated translating to more than four out of every ten brands sampled, contained bacteria contaminants including brands with feacal indicators (E coli and Shigella flexneri). While it is reassuring that the majority of brands (58.3%) were clean, the level of contamination observed is high enough to cause public health concern. For a community where many people drink sachet water daily, this represents a real and avoidable public health risk. The detection of Escherichia coli in two of the 12 brands is perhaps the most important finding of this study. E. coli does not belong in drinking water. When it appears, it tells us that faecal matter has somehow found its way into the water (WHO 2017) This could happen for several reasons.

The source water might have been contaminated from the beginning. The treatment process (such as chlorination or UV light) might have been inadequate or skipped entirely. Storage tanks or pipes might not have been cleaned properly. The plastic sachets themselves might have been sealed poorly, allowing contamination to enter after packaging. Or vendors might have stored the sachets in dirty conditions before selling them. Whatever the specific cause, the message is clear: people who drink these contaminated brands are swallowing bacteria that come from faeces. E coli can cause diarrhoea, abdominal cramps, nausea, and vomiting. In young children, elderly people, or anyone with a weakened immune system, the consequences can be more severe (Prüss-Ustün et al 2019).

Beyond E. coli, the isolation of Shigella flexneri is particularly worrisome. This bacterium causes shigellosis, a severe form of diarrhoea that can include bloody stools, high fever, and stomach cramps. Unlike some other diarrhoeal pathogens, Shigella requires only a very small number of bacteria to cause infection as few as 10 to 100 organisms can make a healthy person ill (Kotloff, et al 2018). Finding Shigella in packaged drinking water suggests serious failures in water treatment or source water protection. Staphylococcus aureus was the most common bacterium isolated, appearing in two brands. S. aureus lives naturally on human skin and in the nose. When it appears in drinking water, it often points to contamination from human hands—either during production, packaging, or vending. While S. aureus does not always cause illness when swallowed, some strains produce toxins that cause rapid-onset vomiting and diarrhoea(Tong 2015). Pseudomonas aeruginosa and Klebsiella pneumoniae belong to a group of bacteria known as opportunistic pathogens. This means they rarely cause disease in healthy people but can be dangerous for those who are already sick, hospitalised, or have weakened immune systems (In a community like Nibo, where people living with HIV, cancer patients, and malnourished children may be drinking sachet water, these bacteria pose a real threat.

Our findings are remarkably consistent with previous studies across Nigeria. Omalu and colleagues found that 45% of sachet water samples in Minna, Niger State, were contaminated with coliforms (Omalu et al 2010). Edema et al 2011 reported contamination in 38% of samples from southwestern Nigeria and Ojekunle et al 2015 found that 42% of sachet water brands in Ogun State failed safety tests. Our finding of 41.7% contamination sits right in the middle of this range and also mirror challenges faced across the global south, where sachet water is a primary drinking source. Studies in Kumasi and Accra Ghana have consistently detected to tal and feacal coliforms in factory- bagged sachets (Ekwunife et al 2010 and Obiri-Danso et al 2003). Addo et al 2009 further confirm that sachet water oftern fail to meet international standard due to poor handling and inadequate treatment. The consistency in our findings suggests that the problem is not limited to one factory, one city, or one state. Contaminated sachet water appears to be a nationwide issue, rooted in weak regulation, poor enforcement of existing standards, and gaps in the knowledge and practices of small-scale producers. In Nigeria, responsibility for regulating sachet water falls primarily to the National Agency for Food and Drug Administration and Control (NAFDAC). NAFDAC requires producers to register their brands and submit to periodic inspections. In practice, however, many producers operate without meaningful oversight. Some may not even know the basic hygiene requirements for safe water production. Others may know but cut corners to save money (Dada,2009)

Strengths and Limitations of the Study

Strengths: This study provides data on sachet water bacteriological quality specifically for Nibo, Anambra State, filling an important geographic gap in the literature. The use of standard microbiological methods following Cheesbrough's protocols ensures that the findings are comparable with other studies from Nigeria and beyond (Cheesbrough, 2006). The study also followed the STROBE reporting guideline for cross-sectional studies, which enhances transparency and completeness of reporting (von Elm et al 2007).

Limitations: Although the study included all available brands (12 brands), and each was tested in triplicate, the study was conducted at a single time point. Seasonal variations and long term batch consistency were not assessed.

Recommendations for future studies: Future research should include larger sample sizes, seasonal sampling to capture temporal variations, antimicrobial resistance testing, molecular characterisation of isolates, and source-tracking studies to identify specific points of contamination along the production and distribution chain.

CONCLUSION AND IMPLICATIONS FOR TRANSLATION

This study set out to answer a simple question about the wholesomeness of sachet water sold in Nibo, Anambra state. More than half of the brands of sachet water tested were clean and met WHO water quality standards. And nearly 42% were contaminated, and some of those contained bacteria that come directly from faeces, which is a serious health concern to the community and public health of Anambra State.

The presence of E. coli and Shigella flexneri in satchet-packaged drinking water is a failure of multiple systems: water treatment, quality control, regulation, and public protection. Until these systems are strengthened, people who drink sachet water will continue to face preventable health risks.

Implications for translation to public health practice:

For a public health professional, the numbers in this study are not just statistics. They represent real risks for real people. Imagine a mother buying sachet water for her young child. She believes she is giving the child something clean and safe. But if that sachet comes from one of the contaminated brands we identified, she may unknowingly be giving her child bacteria that cause diarrhoea. In a country where diarrhoeal disease is already a leading killer of children under five, this is unacceptable. (Prüss-Ustün et al 2019)

The risk is not the same for everyone. A healthy adult with a robust immune system might drink contaminated water and experience no symptoms, or only mild discomfort. But for the very young, the very old, pregnant women, and people with chronic illnesses, the same water could lead to hospitalisation. This is why drinking water standards exist to protect the most vulnerable members of society.

We believe the evidence from this study is clear enough to justify immediate action. Not more studies, not more delaysaction. Regulators need to inspect producers more frequently and enforce penalties for violations. Producers need to improve their hygiene practices, starting with the basics: clean source water, proper treatment, clean equipment, and regular testing. Consumers need to be informed so they can choose safer brands and demand better from producers.

RECOMMENDATIONS:

Infrastructure and source regulation: there should be standardized bore hole construction enforced by regulators like EHO and NAFDAC,

NAFDAC and the state health ministry should inspect sachet water facilities more often, test products quarterly, and ensure that environmental buffers are considered when siting production facilities. And then publish the results.

Producers: Use basic food safety systems, test water regularly for bacteria, clean equipment weekly, and train staff on hand hygiene.

Consumers: Check for a valid NAFDAC number, avoid damaged or dirty sachets, and report illness after drinking water to a clinic.

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