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Physicochemical and Microbiological Assessment of Sachet Water in Dutse Urban, Nigeria

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Abstract. *The rapid increase in population has greatly intensified the requirement for safe and clean drinking water, giving rise to the widespread use of packaged sachet water, commonly known as "pure water" in Nigeria. However, issues concerning improper handling during production, distribution, and storage raise questions regarding possible contamination. This research analyzes the physicochemical and microbiological quality of sachet water in Dutse Metropolis, Nigeria, bears rising concerns over water safety and public health. Thirty (30) sachet water samples from ten popular brands were collected and analyzed for pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), total hardness, nitrite, chloride, and calcium concentration. All results showed that physicochemical parameters were within the limits set by the World Health Organization (WHO) and National Standard for Drinking Water Quality (NSDWQ). As noted, pH value was between 6.81 and 7.41, while turbidity was under the WHO suggested maximum of 5 NTU. Microbiological examination indicated the complete absence of total coliforms, Escherichia coli, and total bacterial count which shows good purification methods were applied. However, lack of heavy metal analysis poses a risk due to possible pollution from industrial effluents and agricultural runoff. The study still highlights the need for persistent surveillance and peri-regulation to warrant the safety of sachet water, primarily in metropolitan areas where the public water supply is deficient, while region possesses some encouraging findings. The results aim to assist stakeholders in evaluation assessment of sachet water while emphasizing the dire need to safeguard public health and safety.*

Keywords: *Sachet water quality, public health risks, dutse urban, drinking water standards, E. coli*

1. Introduction

Water is fundamental to sustaining life and facilitating various daily activities, including drinking, cooking, cleaning, bathing, and other domestic tasks. Beyond its role in households, water is a critical resource in industrial operations, serving as a primary component in various manufacturing, pharmaceutical, agricultural, and processing activities

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(Lawson et al., 2020). Additionally, water is vital for the growth, metabolism, and survival of all living organisms, as the human body lacks a reserve supply, necessitating continuous replenishment (Amoo et al., 2023; Amoo et al., 2021). Ideally, water intended for human consumption should be free from biological, chemical, and physical contaminants to prevent waterborne diseases and long-term health complications (Fondriest Environmental, 2022). However, despite global efforts to expand access to clean drinking water, millions of people still suffer from water scarcity, contamination, and infrastructural inadequacies. Reports suggest that nearly 90 nations are unlikely to meet the United Nations' Sustainable Development Goal (SDG) 6, which aims for universal access to safe and affordable drinking water by 2030 (Onivefu et al., 2024). This crisis is exacerbated by climate change, rapid urbanization, pollution, and inefficient water governance, making it imperative to explore alternative drinking water sources and improve water treatment technologies to ensure public health safety.

The increasing demand for potable water, combined with environmental contamination from industrial effluents, sewage disposal, and agricultural runoffs, poses a significant threat to global freshwater reserves. In regions with inadequate water treatment facilities, poor sanitation, and aging infrastructure, the quality of drinking water is often compromised, increasing the risk of waterborne diseases such as cholera, typhoid, and dysentery (UN, 2020; WHO, 2019; Ibhadode et al., 2017). Access to safe drinking water is not only essential for public health but also contributes to economic growth, education, and overall societal well-being. However, many developing nations, particularly in Sub-Saharan Africa, continue to struggle with water accessibility and quality control, resulting in a heavy dependence on alternative water sources such as boreholes, surface water, and packaged sachet water (Onivefu et al., 2024; Edet et al., 2018). The increasing reliance on sachet water, commonly known as 'pure water', has raised concerns regarding quality assurance, regulatory compliance, and potential health risks (Umoafia et al., 2023; Joseph et al., 2021).

In Nigeria, packaged sachet water has emerged as the primary drinking water source, especially in urban and semi-urban areas where public water supply systems are unreliable or nonexistent. Its affordability, accessibility, and portability make it an essential commodity, particularly for low-income populations who cannot afford bottled water or private boreholes (Muhammad & Dansabo, 2018). However, the dependence on boreholes and deep wells for sachet water production raises concerns regarding the safety of the raw water source, the effectiveness of purification methods, and the risk of post-packaging contamination. The sachet water industry, which gained prominence in the 1990s, has since expanded into one of Nigeria's fastest-growing sectors, driven by advancements in filtration, disinfection, and automated packaging technologies (Kusa & Joshua, 2023; Chiwetalu et al., 2022). However, despite these advancements, poor hygiene practices, inadequate monitoring, and the presence of counterfeit sachet water brands remain critical challenges. Research has shown that many sachet water brands contain harmful contaminants such as coliform bacteria, heavy metals, and excessive levels of nitrates, which can pose serious health risks, including gastrointestinal infections, kidney damage, and developmental issues in children.

The increasing dependence on packaged sachet water as a primary drinking water source in Nigeria, particularly in urban and peri-urban areas, underscores the urgent need for this study. Despite its affordability and widespread consumption, concerns persist regarding microbial contamination, chemical pollutants, and improper storage practices, which pose significant public health risks. Studies have reported instances of bacterial contamination, excessive levels of heavy metals, and non-compliance with regulatory standards, highlighting the inconsistent quality control measures within the sachet water industry. However, there remains limited data on the safety of sachet water brands in Dutse Metropolis, making it difficult to assess their compliance with National Agency for Food and Drug Administration & Control (NAFDAC), Standards Organisation of Nigeria (SON), and World Health Organisation (WHO) drinking water standards. This study is essential in bridging this knowledge gap by conducting comprehensive microbiological and physicochemical assessments to determine whether sachet water in the region meets acceptable safety benchmarks.

2. Methods

2.1. Description of the Study Area

The research was conducted in Dutse Metropolis, the capital of Jigawa State, Nigeria, which serves as the administrative, commercial, and educational hub of the state. The city's population has grown significantly beyond the 153,000 recorded by the National Population Commission (NPC, 2006) due to urbanization and infrastructural expansion. Dutse is located at 11.7011°N and 9.3419°E within the Sudan savanna belt, experiencing a semi-arid climate with distinct wet and dry seasons (NIMET, 2020). The city supports subsistence and commercial agriculture, with many residents engaged in farming and livestock rearing. It also serves a diverse population, including business owners, government officials, and students, bolstered by institutions like Federal University Dutse and Jigawa State Polytechnic (Fadare & Fasakin, 2021). Dutse's role as a trade and logistics center has driven population growth and increased reliance on packaged sachet water due to an unreliable public water supply. These factors make Dutse an ideal study area for evaluating sachet water quality and its public health implications. **Figure 1** presents a map of the research area, illustrating its geographical and infrastructural features.

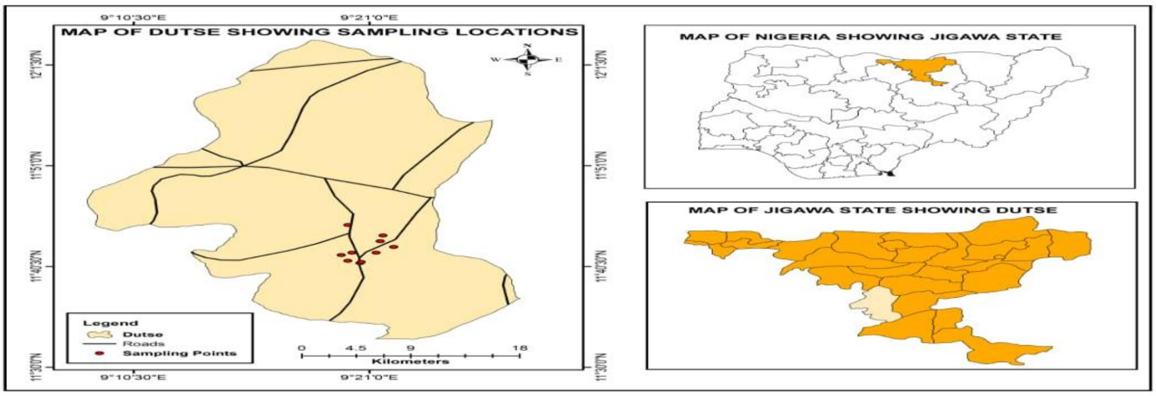

Figure 1. Map of the Dutse showing the sampling point

2.2. Collection of Sachet Water Samples

To evaluate the quality of sachet water in Dutse Metropolis, Jigawa State, Nigeria, the study collected a total of 30 sachet water samples from ten popular local brands in September 2024, during the rainy season. These samples were gathered using a stratified random sampling approach from various retail outlets, roadside vendors, and market stalls to ensure a diverse representation of available products. Three sachets were collected from each brand, and the brands were anonymized with coded labels (B_A-B_J) for objectivity. The coded brands included Shemar's Water (B_A), Family Water (B_B), BIG-IUA (B_C), Puri-Pack Water (B_D), Risala Water (B_E), Layla Water (B_F), FUD Classic Water (B_G), Umaz Water (B_H), Salsabil Water (B_I), and Wasila Water (B_J). A 250 mL sample was aseptically drawn from each sachet and stored in sterile polyethylene containers. To prevent any microbial contamination during transport, the samples were placed in ice-cooled storage bags and delivered to the Water Board Treatment Plant Laboratory in Birninkudu within one hour for immediate analysis. While this study did not explore seasonal variations or the effects of storage conditions, it provides a valuable overview of sachet water quality at the time of sampling.

2.3. Determination of Physicochemical Properties of the Water Samples

The physicochemical analysis of sachet water samples was carried out following standardized protocols from Adeleye et al. (2022), AWWA (2017), APHA (2012), and Okareh et al. (2018). Key water quality parameters such as pH, temperature, total hardness, turbidity, electrical conductivity (EC), nitrite concentration, total alkalinity, calcium, chloride, and total dissolved solids (TDS) were measured using specific instruments to ensure accuracy and reproducibility. pH was measured with a Pocket Pro pH Tester (HANNA HI 98107), temperature was recorded using a ThermoWorks ThermaPen 4 digital thermometer, and total hardness was determined with an Extech 475460 digital hardness meter. A HACH 2100P portable turbidimeter was used to assess turbidity, while EC was measured with a YSI ProDSS laboratory multi-parameter meter. Nitrite concentration was analyzed using a Thermo Scientific GENESYS 10S UV-vis spectrophotometer. Calibration procedures for each instrument were performed following the manufacturer's guidelines to ensure measurement accuracy, and detection limits for each instrument were adhered to as per standard protocols. The calibration procedures and detection limits are essential for validating data accuracy, ensuring reliable results for the study. Although Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) are crucial water quality indicators, they were not included in this analysis due to the study's focus on parameters that are more commonly used for monitoring sachet water quality in the study area. The exclusion of COD and BOD was based on the assumption that the sachet water samples analyzed are intended for immediate consumption and are subject to regular purification processes, which may make these parameters less relevant for this specific study.

2.4. Microbiological Examination of the Water Samples

The microbiological quality of sachet water samples was assessed following methodologies from Chiwetalu et al. (2022) and WHO (2012), employing conventional culture-based methods. The study examined total bacterial count (TBC), total coliform count (TCC), and the presence of *Escherichia coli* (E. coli) as indicators of microbial contamination and potential health risks. For TBC, 1 mL of each sample was aseptically transferred into sterile Petri dishes, mixed with nutrient agar, and incubated at 35°C for 24 hours before colony enumeration using a digital counter. TCC was determined using the multiple-tube fermentation technique with MacConkey broth, incubated at 37°C for 48 hours. Acid production, gas formation, or turbidity in the broth indicated coliform presence. Positive coliform samples were streaked onto Eosin Methylene Blue (EMB) agar and incubated at 44.5°C for 24 hours, with metallic green colonies confirming *E. coli* contamination.

2.5. Data Presentation

The results from physicochemical and microbiological analyses were systematically organized and presented in tables and graphical formats for clarity and comparability. The mean values of physicochemical parameters (pH, turbidity, TDS, total hardness, etc.) and microbiological counts (TBC, TCC, and E. coli detection) were evaluated against established standards by the National Standard for Drinking Water Quality (NSDWQ, 2007) and the World Health Organization (WHO, 2022). Brands that exceeded permissible limits were flagged as non-compliant, highlighting potential public health risks.

3. Results and Discussion

3.1. Physicochemical Analyses of the Sampled Sachet Water

While the study thoroughly assessed key physicochemical and microbiological parameters of sachet water, it did not include the analysis of heavy metals such as Pb, Cd, and Hg, or crucial indicators like COD and BOD. Although the study region lacks industrial areas, heavy metals can still enter water through agricultural runoff. COD and BOD are important for assessing organic contamination and oxygen depletion, which can impact water quality and health. The decision to omit these parameters was based on the focus on factors directly related to the safety and consumability of sachet water. However, including heavy metals, COD, and BOD in future studies would provide a more comprehensive picture of water quality and potential long-term risks. In this study, several physicochemical parameters, including pH, temperature, turbidity, electrical conductivity, and microbial contamination, were analyzed and compared to international standards like WHO and NSDWQ, ensuring a solid evaluation of water safety.

3.1.1. Temperature Analysis (°C) of Sachet Water Samples

Water temperature is a critical parameter in assessing drinking water quality, as it influences several physicochemical and biological processes. In this study, the recorded temperature of ten sachet water brands ranged between 26.0°C and 27.1°C (**Table 1**), exceeding the WHO recommended limit of 25°C for neutral pH drinking water. Elevated temperatures in potable water can accelerate microbial activity, enhance chemical reaction rates, and decrease dissolved oxygen levels, all of which may compromise water quality. Findings from this study are consistent with results reported by Umoafia et al. (2023) and Junior *et al.* (2021), though slightly higher than those recorded by Milkiyas et al. (2011) and Patil et al. (2012). The impact of increased water temperature extends beyond microbial growth, as it can alter the solubility of gases and minerals, influence corrosion rates in distribution systems, and intensify taste, odor, and color variations (Adesakin et al., 2020). Additionally, temperature fluctuations affect the effectiveness of disinfection processes, particularly for chlorine-based treatments, which become less effective at higher temperatures. Monitoring and controlling water temperature is vital for maintaining chemical equilibrium and microbiological safety, particularly in sachet water production, storage, and distribution.

Table 1. Comparison of mean values of physicochemical analyses of the sampled sachet water with allowable standards

Parameter	NSD	WHO	B_A	B_B	B_C	B_D	B_E	B_F	B_G	B_H	B_I	B_J
Temperature (°C)	AMB	NSS	26.4	26.0	26.6	26.8	27.1	26.9	27.0	26.5	27.3	27.1
pH	6.5-8.5	6.5-8.5	7.01	6.98	7.11	7.41	7.01	6.81	6.88	7.41	7.24	7.06
EC (µs/cm)	1000	1000	264	224	104	163	154	233	270	261	131	207
TDS (mg/L)	NA	1000	424	224	401	109	180	271	338	461	255	192
Turbidity (mg/L)	5	5	1.33	2.92	2.40	1.36	2.30	3.09	2.11	1.48	2.00	1.07
T. Hardness (mg/L)	15	15-500	17	25	20	29	41	28	37	30	24	44
Nitrite (mg/L)	0.20	NA	0.06	0.00	0.00	0.01	0.01	0.10	0.00	0.00	0.00	0.00
Chloride (mg/L)	250	250	32	14	14	53	17	22	18	21	28	14
Calcium (mg/L)	7	30	8.60	12.90	9.70	10.2	14.8	12.2	11.8	13.3	10.5	16.1
T. Alkalinity (mg/L)	150	NA	26.7	84.3	29.1	33.9	80.5	92.1	33.1	29.4	29.1	28.2

NA: not available; B_A: brand A; *NTU: Nephelometric turbidity unit; NSD: Nigeria standard for drinking water quality*

3.1.2. pH Values of Sachet Water Samples

The pH of drinking water is a crucial parameter that affects its chemical stability, taste, and interaction with various contaminants. The pH level influences corrosion rates in distribution systems and plays a vital role in determining the solubility and bioavailability of metals and minerals in water. In this study, the mean pH values of all sachet water samples fell within the WHO and NSDWQ recommended range of 6.5 – 8.5 (**Table 1**), ensuring their suitability for consumption. Maintaining a balanced pH level is essential, as deviations from this range can lead to negative health implications and infrastructure damage. Highly acidic water with pH values less than 6.5 can corrode pipes, leaching toxic metals like lead and copper, while highly alkaline water with pH values greater than 8.5 may cause an unpleasant taste and reduce disinfection efficacy. Previous studies on sachet water in Nigeria have reported similar pH values ranged from 6.5 - 6.9 in Calabar (Umoafia et al., 2023), 6.9 - 7.0 in Enugu (Chiwetelu et al., 2022), 7.0 - 7.03 in Port Harcourt (Lawson et al., 2020), 6.5 - 8.4 in Ilorin (Sule et al., 2017), and 6.0 - 7.54 in Abeokuta (Taiwo et al., 2012). These consistent findings reinforce the importance of regulatory oversight in ensuring water safety. Routine monitoring and adherence to quality standards help prevent the risks associated with improper pH levels. The implementation of buffering agents or adjustments in purification methods can be employed by water manufacturers to maintain optimal pH, thereby ensuring both consumer safety and infrastructure longevity.

3.1.3. Turbidity (NTU) of Sachet Water Samples

Turbidity is a measure of the clarity of water, determined by the presence of suspended particles such as silt, clay, organic matter, and microbial contaminants. High turbidity levels can reduce the effectiveness of water disinfection processes, as suspended particles may harbor bacteria and viruses, shielding them from disinfection agents. The turbidity levels of the sachet water sample in this study ranged from 1.07 to 3.09 NTU, which falls well within the WHO guideline limit of 5.0 NTU for drinking water (**Table 1**). These values indicate that the sachet water samples maintain acceptable clarity and are free from significant particulate contamination. Studies in various Nigerian cities have shown similar findings. Umoafia et al. (2023) reported turbidity levels between 0.41 and 0.99 NTU in sachet water samples, demonstrating efficient filtration methods used in production. However, Milkiyas et al. (2011) reported higher turbidity values in some regions, likely due to inadequate filtration and poor handling. Maintaining low turbidity levels is crucial for water safety, as excessive particulate matter can compromise disinfection efficacy and consumer perception. Clear water is generally preferred over turbid water, as high turbidity can indicate contamination or insufficient treatment. Turbidity can result from poor storage, compromised packaging, or ineffective filtration methods.

3.1.4. Electrical Conductivity (µS/cm) of Sachet Water Samples

Electrical conductivity (EC) is an essential indicator of the dissolved ion concentration in water, which determines its ability to conduct electricity. The presence of dissolved salts, such as sodium, calcium, chloride, and sulfate, directly influences EC levels, making it a useful parameter for assessing mineralization and water purity. In this study, the EC values for all sachet water brands ranged between 104 and 270 µS/cm, remaining well within the WHO and NSDWQ permissible limit of 1000 µS/cm (**Table 1**). These values indicate that the sachet water contains an optimal level of dissolved ions, ensuring good taste and mineral balance without exceeding safe consumption thresholds. Low EC values suggest effective purification processes, such as reverse osmosis and deionization, which remove excess dissolved salts. However, extremely low EC levels (<50 µS/cm) may indicate excessive demineralization, potentially leading to a lack of essential minerals needed for electrolyte balance and metabolic functions. On the other hand, excessively high EC values may result from industrial effluents, agricultural runoff, or natural mineral deposits, potentially causing taste alteration, scaling in pipes, and adverse health effects (Junior et al., 2021). Research by Chiwetalu et al. (2022) on sachet water samples in Enugu recorded EC values between 120 and 290 µS/cm, aligning with the findings of this study. Regular monitoring of EC levels is essential for ensuring optimal drinking water quality, particularly in urban areas where industrial and domestic pollutants may alter water composition.

3.1.5. Total Dissolved Solids (TDS) in Sachet Water Samples

TDS levels provide insight into the degree of water mineralization and overall quality. In this study, the TDS values ranged from 109 to 461 mg/L, is in concord within the WHO guideline limit of 1000 mg/L (**Table 1**), indicating that the sachet water samples exhibit low mineralization and high purity. Studies by Chiwetalu et al. (2022) and Adedire et al. (2021) corroborate these findings, highlighting the efficiency of reverse osmosis and advanced filtration techniques employed in sachet water production. While high TDS levels

(>500 mg/L) can lead to an unpleasant taste and scaling in plumbing systems, excessively low TDS (<100 mg/L) can make water taste flat and unpalatable, depriving consumers of essential minerals needed for hydration and metabolic functions. Maintaining optimal TDS levels is crucial for ensuring safe drinking water while preserving beneficial mineral content. WHO (2012) suggests that ideal drinking water should contain moderate TDS levels ranged from 150 – 500 mg/L, so as to balance purity and essential mineral intake.

3.1.6. Total Hardness (mg/L) of the Water

The total hardness of the sachet water samples in this study ranged from 17 to 44 mg/L (**Table 1**), which is well below the WHO and NSDWQ recommended limits for drinking water hardness, set at 500 mg/L and 150 mg/L, respectively. This finding is in agreement with those of Umoafia et al. (2023), who reported similarly low hardness levels in sachet water samples from their study area. However, the values of total hardness obtained in this study were lower than those reported by Okeola et al. (2021) and Chinenye and Amos (2017), who recorded higher levels due to variations in water sources and mineral content. The results were, however, slightly higher than those recorded by Adedire et al. (2021), who observed a hardness ranged of 10 to 29 mg/L in another region of Nigeria. The relatively low hardness values in this study may be attributed to efficient water treatment processes, including ion-exchange softening or reverse osmosis, employed by sachet water manufacturers to reduce mineral deposits. While drinking water with moderate hardness contributes essential minerals like calcium and magnesium, excessive hardness can lead to scaling in pipes and appliances. Conversely, extremely soft water may cause corrosion in plumbing systems and leach heavy metals, making it crucial to maintain balanced hardness levels (WHO, 2022).

3.1.7. Calcium Level (mg/L) of the Water

The calcium concentrations in the analyzed sachet water samples varied from 8.60 to 16.1 mg/L (**Table 1**). These findings contrast with those of Onivefu et al. (2024), who recorded significantly lower calcium levels (2.10 - 4.8 mg/L), and Airaodion et al. (2019), who documented even lower concentrations (0.4 - 0.09 mg/L) in sachet water from different regions. In contrast, Yusuf et al. (2015) found higher calcium levels, ranging from 2.1 to 48.58 mg/L, in sachet water samples from Zaria. Despite these variations, all reported values remain below the WHO (2022) guideline limit of 200 mg/L for safe drinking water. Calcium levels in drinking water are highly dependent on the water source, treatment process, and packaging material (Onivefu et al., 2024). The findings of this study indicate that the sachet water brands sampled provide moderate calcium levels, which are beneficial for human health, particularly in bone formation, muscle contraction, and cardiovascular function (WHO, 2022). However, excessive calcium in drinking water can contribute to scaling in plumbing and industrial equipment, and at extremely high concentrations, may increase the risk of kidney stone formation. Thus, maintaining an optimal calcium concentration in drinking water is essential for both health and infrastructure sustainability (Sharma et al., 2017).

3.1.8. Nitrite Level (mg/L) of the Sample Water

The nitrite levels in most sachet water samples from Dutse urban were generally low, indicating minimal contamination from sources like agricultural runoff, sewage, or industrial effluents. These contaminants are common sources of nitrites in water, but the results suggest the water is largely free from significant organic contamination. The nitrite levels ranged from 0.00 mg/L to 0.10 mg/L (**Table 1**), all well below the WHO guideline of 0.20 mg/L, with most brands showing negligible nitrite presence. Only one brand, BA, had a slightly higher level of 0.06 mg/L, but it still complied with WHO standards. While nitrites can pose health risks, particularly in infants and pregnant women, the low levels observed here suggest minimal concern. Higher nitrite concentrations can lead to issues like methemoglobinemia and gastrointestinal disturbances (WHO, 2022; Popoola *et al.,* 2019). The slightly elevated levels in one brand may point to potential issues with filtration or microbial activity during storage, but overall, the sachet water quality in Dutse appears to meet the required safety standards, with effective treatment methods like chlorination and activated carbon filtration suggested to further reduce any risk.

3.1.9. Chloride (mg/L) of the Water

Chloride is a crucial anion in drinking water that contributes to the water's taste and overall quality. The chloride levels in the sachet water samples in this study ranged from 14.00 to 53.00 mg/L (**Table 1**), is well within the NSDWQ and WHO permissible limits of 250 mg/L for safe drinking water. These results align with previous studies by Onivefu et al. (2024) and Alex et al. (2015), who reported chloride concentrations of 12.8 - 28.3 mg/L and 3.28 - 34.5 mg/L, respectively, in sachet water samples from different regions. The chloride levels detected in this study indicate that the sampled sachet water brands are free from excessive salinity, which can alter taste and cause corrosion in plumbing systems. According to Adeyeye et al. (2017), the human body requires approximately 81.7 mg/L of chloride daily, with minors needing a lower intake of around 45 mg/L. Excessive chloride intake may pose health risks to individuals with sodium chloride metabolism disorders, such as those with hypertension or congestive heart failure (WHO, 2022). However, for healthy individuals, the levels recorded in this study are safe for consumption.

3.1.10. Total Alkalinity (mg/L) of the Sampled Water

The total alkalinity of the sachet water samples in this study ranged from 26.7 to 92.0 mg/L (**Table 1**), which falls well within the WHO and NSDWQ allowable limits of 500 mg/L and 250 mg/L, respectively. These values are notably higher than those recorded by Onivefu et al. (2024) and Unegbu et al. (2017), who reported alkalinity levels ranging from 3.71 to 9.02 mg/L and 9 to 19 mg/L, respectively. The variations in alkalinity levels across different studies can be attributed to differences in the water source, mineral composition, and treatment processes used by sachet water manufacturers. Alkalinity in drinking water is primarily derived from the presence of bicarbonates, carbonates, and hydroxides, which help maintain pH stability and buffer against acidification (WHO, 2022). While moderate alkalinity is beneficial in neutralizing acidity and preventing pipe corrosion, excessively high levels can lead to adverse effects such as gastrointestinal irritation and hair fiber swelling (Popoola et al., 2019). Prior studies, including those by Lawson et al. (2020) and

Sharma et al. (2017), have highlighted the importance of monitoring alkalinity levels to ensure the long-term safety of drinking water.

3.2. Microbiological Analysis

The microbiological analysis of the sachet water samples showed no presence of total coliforms, *Escherichia coli*, or total bacterial count, indicating that the water met the microbiological safety standards, which suggests that current purification and packaging practices are effective. This aligns with findings from previous studies, such as Chiwetalu et al. (2022) and Ekwunife et al. (2010), which also reported no microbial contamination in sachet water from different regions. However, while the absence of bacteria is reassuring, it's important to note the limitations of conventional culture-based methods used in this study. These methods can sometimes lead to false negatives, particularly if samples were pre-treated or if hard-to-culture organisms were present. This means that some potential contaminants could have been overlooked. For example, Alli et al. (2011) found pathogenic microorganisms, including protozoan parasites, in sachet water from southwestern Nigeria, highlighting that water quality can vary across regions. These differences point to the need for ongoing monitoring and stricter regulatory enforcement to ensure consistent microbiological safety across all areas.

Table 2. Comparison of mean values of microbiological analyses of the sampled sachet water with allowable standards

Parameter	NSD	WHO	B_A	B_B	B_C	B_D	B_E	B_F	B_G	B_H	B_I	B_J
TBC (cfu/mL)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TCC (cfu/100mL)	10.0	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. coli (cfu/mL)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Conclusions

The physicochemical and microbiological assessments of the sachet water in the Dutse Metropolis showed that most of the parameters were within reasonable limits set by the World Health Organization (WHO) and the National Standard for Drinking Water Quality (NSDWQ), indicating good water quality. The study suggests that the purification processes are quite effective, as pH, turbidity, electrical conductivity, total dissolved solids, total hardness, nitrite, chloride, and calcium levels were all within acceptable limits. Also, there were no total coliforms or Escherichia coli which indicates that treatment and packaging processes are working well in achieving microbiological safety. The assessment omitted considerations of heavy metal analysis, which is a significant gap and concern due to the possibility of pollution from agricultural runoff. Subsequent studies should include these parameters to better understand the essence of water quality and its impact on health. Moreover, active monitoring together with the enforcement of regulations is necessary to ensure the safety of sachet water in urban settings where public water supply systems are dysfunctional. As previously mentioned, this study reveals how important it is to observe and maintain standard operational procedures in the sachet water industry to protect the health and safety of the people in Dutse or any other place of a similar nature.

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Conflicts of Interest

We, authors of this article, solemnly declare that we have no conflict of interest.

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