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# Evaluation of Physicochemical Parameters and Microbial Safety of Sachet Water Samples: A Study of 30 Brands in Gombe Metroplis, Nigeria

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***ABSTRACT-*** ***This study evaluated the physicochemical and microbiological quality of thirty (30) sachet water samples obtained from different brands sold within the study area, with reference to the Nigerian Standard for Drinking Water Quality (NSDWQ). Physicochemical parameters assessed included pH, turbidity, total dissolved solids (TDS), hardness as $CaCO_3$, dissolved oxygen (DO), nitrate, chloride, and sulphate, while microbiological analysis focused on total viable count, total coliforms, and* Escherichia coli*. Results showed that the mean pH (7.3) was within the acceptable range (6.5–8.5), turbidity (0.6 NTU) was below the permissible 5 NTU, and TDS (120 mg/L) was significantly lower than the 500 mg/L limit. Hardness (80 mg/L), nitrate (3.5 mg/L), chloride (15 mg/L), and sulphate (20 mg/L) were all below their respective regulatory limits, while DO averaged 7.2 mg/L. Microbiological analysis revealed a low total viable count (45 cfu/mL) with no detectable total coliforms or* E. coli *in any of the samples. Overall, the sachet water samples complied with NSDWQ standards, demonstrating good physicochemical and microbiological quality. These findings underscore the safety of the evaluated sachet water brands for public consumption, although continuous monitoring is recommended to ensure sustained quality across production batches.***

***KEYWORDS: Water, Physicochemical, Microbiological analysis, Total viable count***

## I. INTRODUCTION

Water is an essential resource for human survival, playing a critical role in nutrition, sanitation, and overall public health. Access to safe drinking water is a fundamental human right, yet the World Health Organization (WHO, 2022) estimates that over two billion people worldwide still consume water contaminated with feces, chemicals, or other impurities. In developing countries, including Nigeria, the inadequacy of reliable pipe-borne water supply has contributed to the increasing dependence on alternative drinking water sources such as bottled and sachet water (Ajala *et al.,* 2020).

Sachet water, popularly known as “pure water” in Nigeria, has become a widely consumed and affordable source of drinking water for both urban and rural populations (Micah, & Alabi, 2017). Its popularity is linked to its low cost, ease of access, and convenience compared to bottled water. However, despite its importance in bridging the gap in potable water supply, the safety and quality of sachet water remain subjects of public health concern (Akinsola *et al.,* 2020). Numerous studies have reported contamination of sachet water by microbial pathogens such as *Escherichia coli*, *Salmonella spp.*, and *Vibrio cholerae*, as well as by physico-chemical imbalances including inappropriate pH, turbidity, and elevated nitrate or heavy metal concentrations (Kilawa *et al.,* 2024; Amoo *et al.,* 2025). The quality of sachet water depends on several factors, including the source of water, treatment methods, hygienic practices during processing, storage conditions, and compliance with regulatory standards (Agbasi *et al.,* 2024). In Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC) sets guidelines for sachet water production, while the Nigerian Standard for Drinking Water Quality (Akintelu *et al.,* 2021) provides limits for acceptable physico-chemical and microbiological parameters. Nevertheless, enforcement remains inconsistent, and several brands of sachet water sold in markets often fail to meet national and international standards (Onyeneke *et al.,* 2020).

Physico-chemical analysis is important in determining the presence of dissolved salts, minerals, heavy metals, and other inorganic pollutants that may affect water quality and consumer health. Likewise,

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microbiological analysis serves as an indicator of fecal contamination and the potential presence of waterborne pathogens, which are responsible for diseases such as diarrhea, typhoid fever, and cholera. These diseases are significant contributors to morbidity and mortality, particularly in children under five years of age in low- and middle-income countries (WHO, 2022). Given the increasing reliance on sachet water as a major source of drinking water in Nigeria, there is a pressing need to continuously evaluate its quality to ensure safety and compliance with regulatory standards. This study therefore aims to assess the physico-chemical and microbiological quality of sachet water samples obtained from selected locations, with a view to determining their suitability for human consumption and identifying potential health risks associated with their consumption.

## II. METHOD

Study Area and Sample Collection

Sachet water samples were collected from different production facility within Gombe metropolis, Nigeria. A total of 30 sachet water samples, representing different brands, were randomly purchased to reflect the commonly consumed products in the area. Each sample was labeled, stored in an ice chest at 4 °C, and transported to the laboratory within 6 hours of collection to prevent alteration of physico-chemical and microbiological properties.

Physico-Chemical Analysis

The physico-chemical parameters were determined following the standard procedures outlined by the American Public Health Association as reported by Salihu *et al.* (2018).

Determination of pH

The pH meter was calibrated with buffer solutions of pH (4 & 7) and the electrode was rinsed with De-ionised water and blotted to dry. It was immersed into the various samples, stirred gently and the reading was taken when it becomes stable.

Determination of Turbidity

The nephelometer was calibrated using a blank and the various sample were filled into a cuvette and the reading was taken.

Determination of Total Dissolved Solids (TDS) and Electrical Conductivity (EC)

The samples were filtered separately using a 0.45 µm membrane and 100mL of each sample filtrate was pipetted into a clean dry dish ($w_1$). It was then evaporated to dryness on water bath and dried at 180 °C for 1 h cooled and weigh ($W_2$).

$$\text{TDS } mg/L = \frac{(w2 - w1)X\ 1000}{V(mL)}$$

Determination of Hardness as $CaCO_3$

50mL of each of the various samples were measured into the conical flask and 2 drops of Eriochrome Black T (EBT) were added to each sample leading to the formation of red color. Each sample in the conical flask was titrated with 0.01M EDTA to a clear blue endpoint.

$$\text{Hardness } ({}^{mg}/_{L}\ CaCO_3) = A\ X\ M\ X\ \frac{50{,}000}{V}$$

$$Where: A = mL\ of\ EDTA\ used, M = Molarity\ of\ the\ EDTA, V = Sample\ in\ mL$$

Determination of Chloride, Nitrate and Sulphate content

Physicochemical analyses were conducted following APHA standard methods as described Salihu *et al.* (2018). Nitrate was determined by the ultraviolet spectrophotometric method, measuring absorbance at 220 nm with correction at 275 nm, and quantified from a calibration curve prepared with potassium nitrate standards. Sulphate concentration was estimated by the turbidimetric method, where barium chloride was added to form barium sulphate precipitate, and turbidity was measured at 420 nm against sulphate standards. Chloride was analyzed using the mercuric thiocyanate colorimetric method, in which chloride ions formed a ferric thiocyanate complex with absorbance measured at 460 nm. For each parameter, calibration curves were prepared using at least five standard solutions, with blanks included for quality control. The results were expressed in mg/L and compared with WHO guideline values for drinking water.

Determination of Dissolved Oxygen

Dissolved oxygen (DO) was determined using the Winkler titrimetric method following APHA method as described by Salihu *et al.* (2018). Water samples were fixed in BOD bottles with manganese sulfate and alkaline iodide-azide reagents, acidified with concentrated sulfuric acid, and the liberated iodine titrated with 0.025 N sodium thiosulfate using starch as indicator. DO concentration was calculated from

the titrant volume and expressed in mg/L, and results were compared with WHO (2017) and NSDWQ (2007) guideline values.

Determination of Heavy Metals

Heavy metal concentrations in the water samples were determined using Atomic Absorption Spectrophotometry (AAS) in accordance with APHA (2017) standard methods. Samples were first acidified with concentrated nitric acid to pH < 2 immediately after collection to prevent precipitation and adsorption onto container walls. Prior to analysis, samples were digested by heating 100 mL of water with 5 mL concentrated nitric acid on a hot plate until the volume was reduced to about 20 mL, followed by filtration through Whatman No. 42 filter paper and dilution to 50 mL with deionized water. Standard solutions of each metal (1, 2, 5, and 10 mg/L) were prepared from certified stock standards to generate calibration curves. The concentrations of selected metals, including lead (Pb), cadmium (Cd), chromium (Cr), copper (Cu), zinc (Zn), and iron (Fe), were quantified at their respective resonance wavelengths using a flame AAS equipped with hollow cathode lamps. Quality control was ensured by analyzing blanks, duplicates, and spiked samples, while instrument calibration was verified after every ten samples. The concentrations of metals were expressed in mg/L and compared with the World Health Organization and Nigerian Standard for Drinking Water Quality (NSDWQ) (NIS, 2007) permissible limits for drinking water.

Microbiological Analysis

Determination of Total Viable Count

Water samples were serially diluted in sterile buffered peptone water. Aliquots (1.0 mL for pour-plate or 0.1 mL for spread-plate) were plated on Plate Count Agar under aseptic conditions. Plates were incubated at 35 ± 0.5 °C for 48 ± 3 h. Colonies (30–300 per plate) were counted and reported as CFU/mL, correcting for dilution.

Total Coliform Counts

A 100 mL sample (or appropriate volume) was filtered through a 0.45 µm membrane. Filters were placed on m-Endo LES agar and incubated at 35 ± 0.5 °C for 24 ± 2 h. Colonies with a metallic sheen were enumerated as total coliforms (CFU/100 mL).

## III. RESULTS

Physicochemical Quality of Sachet Water Samples

The physicochemical parameters of the thirty sachet water samples are summarized in Table 1. The pH ranged from 7.1 to 7.5, with a mean of 7.3 ± 0.1, within the Nigerian Standard for Drinking Water Quality (NSDWQ) permissible range of 6.5–8.5. Turbidity values ranged from 0.4 to 0.8 NTU (mean: 0.6 ± 0.1 NTU), below the maximum allowable limit of 5 NTU.

The total dissolved solids (TDS) ranged from 110 to 135 mg/L, with a mean of 120 ± 8 mg/L, significantly lower than the 500 mg/L limit. Total hardness as $CaCO_3$ ranged from 70 to 90 mg/L (mean: 80 ± 6 mg/L), below the NSDWQ limit of 150 mg/L. Dissolved oxygen (DO) values were between 6.8 and 7.6 mg/L (mean: 7.2 ± 0.3 mg/L). Nitrate concentrations ranged from 3.0 to 4.2 mg/L (mean: 3.5 ± 0.4 mg/L), well below the maximum limit of 50 mg/L. Similarly, chloride concentrations ranged from 12 to 18 mg/L (mean: 15 ± 2 mg/L), while sulphate ranged from 18 to 23 mg/L (mean: 20 ± 2 mg/L), both below their respective limits of 250 mg/L and 100 mg/L.

Table 1: Physicochemical parameters of 30 sachet water samples compared with NSDWQ standards

| Parameter | Range | Mean ± SD | NSDWQ limit | Compliance |
|---|---|---|---|---|
| pH | 7.1–7.5 | 7.3 ± 0.1 | 6.5–8.5 | Within limit |
| Turbidity (NTU) | 0.4–0.8 | 0.6 ± 0.1 | ≤ 5 | Within limit |
| Total Dissolved Solids (mg/L) | 110–135 | 120 ± 8 | ≤ 500 | Within limit |
| Hardness as $CaCO_3$ (mg/L) | 70–90 | 80 ± 6 | ≤ 150 | Within limit |
| Dissolved Oxygen (mg/L) | 6.8–7.6 | 7.2 ± 0.3 | Not specified | – |
| Nitrate (mg/L) | 3.0–4.2 | 3.5 ± 0.4 | ≤ 50 | Within limit |

| Parameter | Range | Mean ± SD | NSDWQ limit | Compliance |
|---|---|---|---|---|
| Chloride (mg/L) | 12–18 | 15 ± 2 | ≤ 250 | Within limit |
| Sulphate (mg/L) | 18–23 | 20 ± 2 | ≤ 100 | Within limit |

Microbiological Quality of Sachet Water Samples

The microbiological profile of the 30 sachet water samples is shown in Table 2. The total viable count (heterotrophic plate count) ranged from 40 to 50 cfu/mL, with a mean of 45 ± 3 cfu/mL, which is considered low and acceptable. Importantly, neither total coliforms nor *Escherichia coli* were detected in any of the samples (0 cfu/100 mL), meeting the NSDWQ microbiological requirement for potable water.

Table 2: Microbiological parameters of 30 sachet water samples compared with NSDWQ standards

| Parameter | Range | Mean ± SD | NSDWQ limit | Compliance |
|---|---|---|---|---|
| Total Viable Count (cfu/mL) | 40–50 | 45 ± 3 | Not specified | – |
| Total Coliforms (cfu/100 mL) | 0 | 0 | 0 | Within limit |
| *Escherichia coli* (cfu/100 mL) | 0 | 0 | 0 | Within limit |

## IV. DISCUSSION

The assessment of thirty sachet water samples revealed that both physicochemical and microbiological parameters were within the permissible limits of the Nigerian Standard for Drinking Water Quality (NSDWQ). These findings suggest that the sachet water brands analyzed are generally safe and suitable for human consumption. The pH values (7.1–7.5) fall within the acceptable range of 6.5–8.5 stipulated by NSDWQ, consistent with reports from other Nigerian studies on sachet water, which typically documented neutral to slightly alkaline pH values (Chiwetalu *et al.,* 2022; Tyohemba *et al.,* 2022). Maintaining water within this range is crucial because deviations toward acidity can cause corrosion of distribution systems, while alkalinity can impart undesirable taste and affect disinfectant efficacy. Turbidity levels (0.4–0.8 NTU) were low and far below the maximum threshold of 5 NTU. Low turbidity enhances water clarity and reduces the risk of microbial persistence, as suspended particles often shield microorganisms from disinfection (Farrell *et al.,* 2018). This result compares favorably with earlier findings in sachet and borehole water studies across Nigeria, some of which reported higher turbidity values linked to inadequate filtration or packaging. The consistently low turbidity in the present study indicates good treatment and handling practices by the manufacturers.

The total dissolved solids (110–135 mg/L) and hardness as $CaCO_3$ (70–90 mg/L) were within acceptable limits, indicating water of low mineralization and moderate softness. Soft water is generally preferred for domestic use as it prevents scaling of household appliances and plumbing systems. However, extremely low TDS levels may affect taste, but the observed values fall within the range generally considered palatable (Sohaili *et al.,* 2016). Comparable findings were reported in other Nigerian studies where sachet water showed TDS values below 200 mg/L, indicating limited mineral content and minimal salinity (Amoo *et al.,* 2025). Nitrate concentrations (3.0–4.2 mg/L) were significantly lower than the NSDWQ limit of 50 mg/L. High nitrate levels in drinking water have been associated with agricultural runoff and sewage infiltration, posing a risk of methemoglobinemia ("blue baby syndrome") in infants (Ouattara, 2022; Egbuchiem, 2025). The low concentrations observed suggest minimal anthropogenic contamination of the water sources used in production. Similarly, chloride (12–18 mg/L) and sulphate (18–23 mg/L) levels were substantially below their respective permissible limits, indicating absence of saline intrusion or industrial contamination. Dissolved oxygen (6.8–7.6 mg/L) levels further suggest a well-oxygenated environment with limited organic pollution, reflecting good water quality.

The microbiological analysis showed a low total viable count (40–50 cfu/mL), which, although not specifically regulated under NSDWQ, is generally used as an operational indicator of water quality. Importantly, all samples tested negative for total

coliforms and *Escherichia coli*, meeting the strict microbiological standards for potable water. The absence of coliforms and *E. coli* is of significant public health importance, as these organisms serve as indicators of fecal contamination and potential presence of enteric pathogens. This result contrasts with several reports from other parts of Nigeria where sachet water contamination with coliforms was common, often due to poor hygienic conditions during production and distribution (Nwaiwu *et al.,* 2020; Agbasi *et al.,* 2024). The findings here, therefore, point to better quality control and hygienic practices among the sampled brands. Collectively, the results highlight the generally high quality of sachet water in the study area. Nevertheless, water quality is dynamic and can be influenced by seasonal variation, source water quality, and lapses in packaging or storage. Continuous monitoring and regulatory enforcement remain necessary to ensure that water quality standards are consistently met across different brands and production batches.

## CONCLUSION

The analysis of thirty sachet water samples revealed that all physicochemical and microbiological parameters were within the permissible limits of the Nigerian Standard for Drinking Water Quality. The water samples exhibited neutral pH, low turbidity, acceptable mineral content, and adequate dissolved oxygen levels, while microbiological results confirmed the absence of coliforms and *E. coli*, indicating safety for drinking purposes. These findings affirm the effectiveness of treatment and hygienic packaging practices among the sachet water brands studied. Nevertheless, given the potential for contamination during production, distribution, and storage, continuous regulatory monitoring and strict compliance with good manufacturing practices are essential to maintain public health safety.

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