

Assessment Of Sachet Water Quality In Sokoto Metropolis

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ABSTRACT

Sachet water is among the alternative drinking water among the diverse users in households, industries, ministries, hospitals, schools, restaurants, markets and other places around Sokoto metropolis. Thus, this study sought to assess the presence and the level of physicochemical, heavy metals and biological parameters found in the sachet water produced and consumed in the study area. Therefore, the samples used in the study were purchased randomly from five sampling location and analyzed using standard method of analysis. The results of the study were being subjected to; analysis of variance (ANOVA), descriptive statistics and homogeneous turkey HSD analysis. The ANOVA results showed that all the physicochemical and heavy metals analysed varied significantly at 95% level of significance except chloride (0.081), alkalinity (0.087), total dissolved solids (0.204) and cadmium (1.000) respectively while the descriptive statistics and homogeneous turkey analysis showed that all the physicochemical and heavy metals analysed are within the WHO standard for drinking water except alkalinity with (365.068 mg/l), fluoride (3.245 mg/l) and nitrate (26.405 mg/l) and Fe (9.243 mg/l), Cd (0.02 mg/l) and As (7.503 mg/l) as highest concentration respectively. The biological results reveal that the total coliform bacterial load in the water samples is within the WHO standard of 0-10 MPN index of coliform in 100 cm³ of the water sample. The overall results of the study indicates that the sachet water produced and consumed in the study area are safe and suitable for consumption as more than 70% of the parameters analysed conform with WHO standard for drinking water.

Keywords: Water quality, physicochemical, heavy metals, correlation, coliform, index

1.0 INTRODUCTION

Water is an essential substance required for normal physiological and metabolic activities for human survival, which make the drinking of water inevitable. As such need for quality water for drinking among the diverse water users that is free or less harmful from biological, chemical, physical and environmental impurities are paramount. Therefore, it is necessary to determine the quality of water especially drinking water and this kind of water need to be safe or pure in order for its proper functioning in the body (Mosi et al., 2019).

Globally, more than 1 billion people do not have access to safe drinking water and the number of people without access to safe drinking water is increasing which could be attributed to increasing population growth and inability of governments to provide adequate water supply facilities to the countries (WHO 2010, 2011; Addo et al., 2020). In line with this, United nations (UN) and other countries declared access to safe drinking water as a fundamental human right and an essential step towards improving the living standards. (UN, 2007). Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still

lack access to safe water and over 2.5 billion lack access to adequate sanitation (MDG, 2010). Due to shortfall in the provision of adequate safe drinking water for the populace, the private sector i.e sachet water industry provide the populace with adequate safe drinking water. Sachet water is a phenomenon that has gained widespread use as an alternative to the insufficient provision of potable water (tap water). It is an alternative that is readily available, affordable but not without concerns about its purity (Rodríguez et al., 2023). Therefore, it is against this background that the study needs to assess the compliance status of sachet water in Sokoto metropolis with WHO standard. In order to achieve this aim physico-chemical, heavy metals and biological parameters were assessed and compared with WHO Guidelines for drinking water quality.

2.0 MATERIALS AND METHOD(S)

2.1 Study area

Sokoto metropolis is located between latitude 13°2'45.6"N and longitude 5°14'20.4"E. The State has a population of 6,391,399 people based on 2022 population projection with an average annual growth rate of 2.6% (NPC, 2022). The Metropolis covers 16 km radius away from the reference points which comprises 4 local governments areas namely; Sokoto

south, Sokoto North, Wamakko and part of Kware local governments of Sokoto State, Nigeria with local inhabitants mostly Hausa, Fulani and other groups such as, Yoruba, Igbo and migrants. The predominant language is Hausa and Fulani. Occupations of city dwellers include farming, trading, commerce, domestication of animals with a reasonable proportion of the population working in private and public sectors. Population of farmers is on the decline. (Jagaba *et al.*, 2018).

2.1.1 Sampling Locations

Five sampling locations with longitude and latitude are

designated as Kalambaina (5.192°E and 13.041°N) S₁, Kanwuri (5.198°E and 12.966°N) S₂ Gagi (5.282°E and 13.045°N) S₃, Moreh (5.273°E and 13.098°N) S₄ and UDUS Permanent site (5.239°E and 13.048°N) S₅. A total number of 15 sachet water were purchased for the analysis, three from each of the five (5) sampling locations in the study area. All the samples were labelled and transported to the laboratory prior to the commencement of the analysis. Temperature, pH and conductivity were determined by in situ (immediately at the point of collection) and the samples were stored at a room temperature.

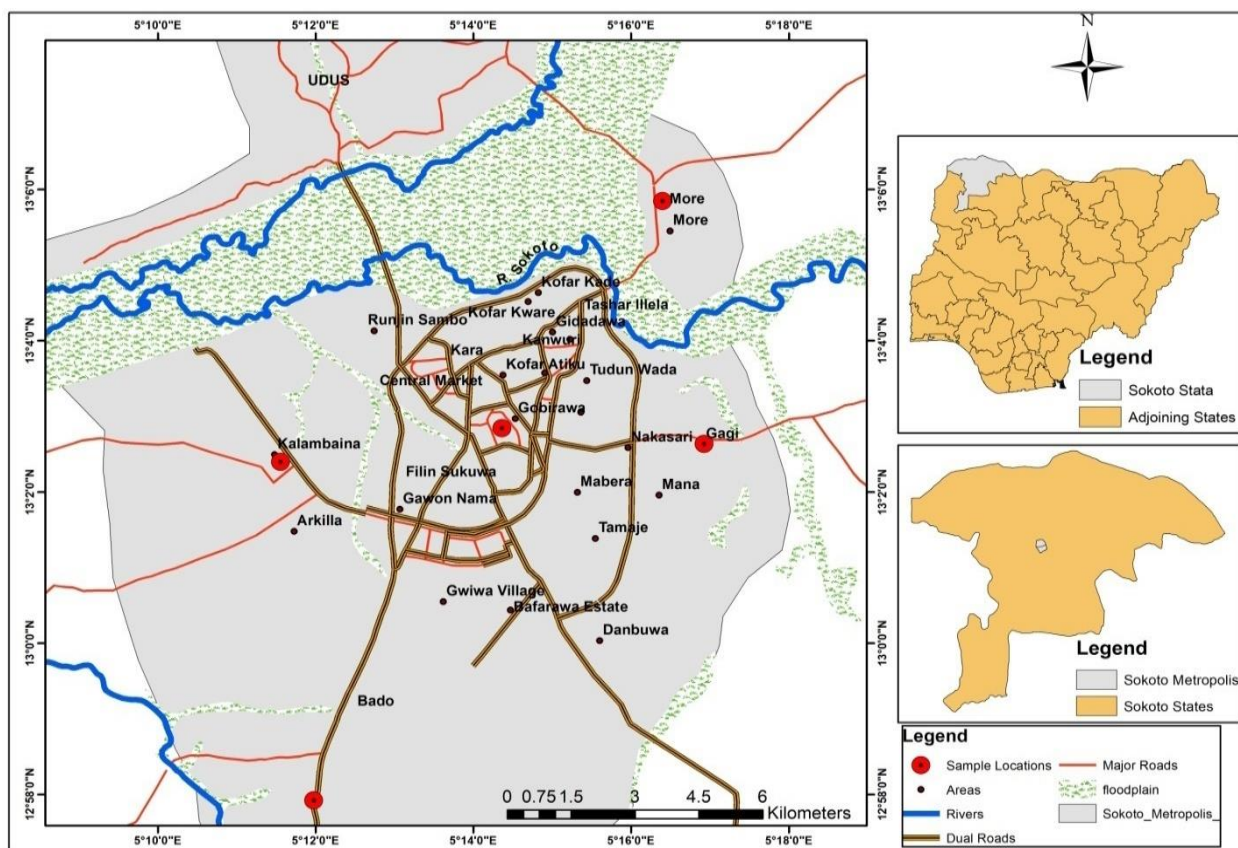


Figure 1: Map showing the study area

2.1.2 Sample Collection

2.1.3 Sachet Water

A total of Fifteen (15) sachet water samples were purchased, three (3) from each of the five (5) sampling locations of the study area (Sokoto metropolis).

2.2 Physicochemical Analysis

The physicochemical analysis was carried out to determine the physicochemical quality of the water samples in accordance to the methods of the American Public Health Association (APHA, 2005). The physicochemical parameters analysed include; Temperature, pH, Turbidity, Electrical Conductivity,

Total Dissolved Solid, Sodium, Potassium, Calcium, Magnesium, Total Hardness, Total Alkalinity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Sulphates, Nitrate, Chloride and Fluoride.

2.3 Analysis of Metals Using AAS

Atomic absorption spectroscopy (AAS) was adopted for heavy metals analysis (Umar, 2010). The principle of the method is based on nebulizing the solution of the sample into an air-acetylene flame where it is vaporized. Ions of elements were atomized. The atoms formed absorb radiation of a resonance wavelength from their respective hollow cathode lamp. The

measured absorbance is proportional to the amount of analyte in the sample solution (APHA, 2005).

2.4 Biological Analysis

The determination of the biological quality of water is essential in testing the overall quality of water samples, which involves the enumeration of bacteria of faecal origin. Standard Methods for the Examination of Total

Coliform was adopted; which is in accordance with American public health association (APHA, 2005).

3.0 RESULTS AND DISCUSSION

Table 1 below presents the analysis of variance (ANOVA) of physicochemical properties of Sachet water samples obtained from five sampling locations.

Table 1: Analysis Of Variance (Anova) Of Physicochemical Parameters Of Sachet Water

Parameter	Groups	Sum of Squares	Degree of freedom	Mean Square	F-value	Significance.
Na ⁺	Between Groups	694.800	4	173.700	6.410	0.000
	Within Groups	1084.000	40	27.100		
K ²⁺	Between Groups	22.000	4	5.500	27.500	0.000
	Within Groups	8.000	40	.200		
Ca ²⁺	Between Groups	111369.388	4	27842.347	2.820	0.038
	Within Groups	394989.424	40	9874.736		
Mg ²⁺	Between Groups	51656.239	4	12914.060	2.818	0.038
	Within Groups	183336.719	40	4583.418		
TH	Between Groups	329879.617	4	82469.904	2.969	0.031
	Within Groups	1111041.794	40	27776.045		
NO ₃ ⁻	Between Groups	1321.053	4	330.263	8.652	0.000
	Within Groups	1526.835	40	38.171		
SO ₄ ²⁻	Between Groups	11076.050	4	2769.013	6.069	0.001
	Within Groups	18249.875	40	456.247		
F ⁻	Between Groups	14.527	4	3.632	154.866	0.000
	Within Groups	.938	40	.023		
Cl ⁻	Between Groups	34803766.163	4	87266.024	2.250	0.081
	Within Groups	154672278.777	40	39239.064		
DO	Between Groups	537.281	4	134.320	7.059	0.000
	Within Groups	761.155	40	19.029		
BOD	Between Groups	168.304	4	42.076	5.670	0.001
	Within Groups	296.810	40	7.420		
Alkalinity	Between Groups	353064.097	4	88266.024	2.194	0.087
	Within Groups	1609562.572	40	40239.064		
Temp	Between Groups	103.355	4	25.839	471.700	0.000
	Within Groups	2.191	40	.055		
EC	Between Groups	753101.068	4	23563.990	2.814	0.038
	Within Groups	2676502.431	40	66912.561		
TDS	Between Groups	93438.762	4	23359.690	1.560	0.204
	Within Groups	598796.432	40	14969.911		
Ph	Between Groups	19.581	4	4.895	404.851	0.000
	Within Groups	.484	40	.012		
Turbidity (NTU)	Between Groups	6.875	4	1.719	18.577	0.000
	Within Groups	3.701	40	.093		

Key: TH = Total Hardness, EC = Electrical Conductivity

The results from the table (1) showed that the levels of all the physicochemical variables analysed varied significantly at 95% confidence limit ($P < 0.05$) across all the sampling locations except chloride (Cl⁻), alkalinity and total dissolved solids (TDS).

Table 2: Descriptive Statistics And Homogeneous Turkey Test Of Physicochemical Properties Of Sachet Water

Parameter	S ₁	S ₂	S ₃	S ₄	S ₅	WHO STD.
Na ⁺	12.333 ± 4.00000 ^a	4.667 ± 0.50000 ^b	16.667 ± 4.3589 ^a	11.667 ± 10.00000 ^b	9.333 ± 0.50000 ^a	50
K ⁺	4.666 ± 0.50000 ^a	3.0000 ± 0.00000 ^b	4.6667 ± 0.50000 ^a	3.333 ± 0.50000 ^b	4.3333 ± 0.50000 ^a	20
Ca ²⁺	89.0067 ± 21.61202 ^a	101.3656 ± 37.5870 ^b	116].7100 ± 34.727 ^a	210.392 ± 214.7771 ^b	65.7678 ± 12.59236 ^c	75-200
Mg ²⁺	60.5811 ± 14.70807 ^a	68.9678 ± 25.53372 ^b	78.1667 ± 24.81272 ^a	143.238 ± 146.1494 ^b	44.7589 ± 8.57073 ^c	30-150
TH	149.6278 ± 36.29020 ^a	146.2589 ± 57.6332 ^b	194.8767 ± 59.3782 ^a	353.631 ± 360.9266 ^b	110.5267 ± 21.16309 ^c	100-500
NO ₃ ⁻	20.1200 ± 4.88546 ^a	24.4033 ± 9.34421 ^b	26.4056 ± 8.22332 ^{ab}	12.2033 ± 1.98343 ^a	14.8656 ± 2.84877 ^c	10
SO ₄ ²⁻	15.0233 ± 3.65036 ^a	18.2153 ± 6.96890 ^b	19.3833 ± 6.1528 ^{ab}	57.4644 ± 34.87781 ^a	33.1178 ± 31.06486 ^c	400
F ⁻	3.1510 ± 0.18277 ^a	1.9353 ± 0.04872 ^b	2.9463 ± 0.03401 ^{ab}	2.0097 ± 0.22288 ^a	3.2457 ± 0.17505 ^a	1-1.5
Cl ⁻	108.1400 ± 26.25750 ^a	123.1100 ± 45.5764 ^b	139.5267 ± 44.288 ^{ab}	2310.725 ± 14.3992 ^a	79.9011 ± 15.299 ^a	200-600
DO	6.7711 ± 1.66837 ^a	9.1078 ± 0.93478 ^a	9.3344 ± 2.51853 ^b	16.8700 ± 8.65831 ^{ab}	8.9711 ± 3.19028 ^b	500
BOD	5.4956 ± .04560 ^a	5.4867 ± 1.44043 ^a	3.2144 ± 1.02096 ^b	8.4567 ± 4.82604 ^{ab}	3.12033 ± 0.19068 ^b	5.0
Alkalinity	174.862 ± 50.45204 ^a	164.3889 ± 61.1878 ^b	205.2767 ± 59.1891 ^c	365.068 ± 434.978 ^{ac}	99.6467 ± 46.86453 ^{ab}	200
Temp. ^o C	28.566 ± 0.05000 ^b	31.8778 ± 0.43525 ^a	29.1000 ± 0.08660 ^b	32.0778 ± 0.23863 ^a	29.0667 ± 0.13229 ^c	25
EC	231.4222 ± 56.18863 ^b	263.4556 ± 97.534 ^a	298.5889 ± 94.7798 ^b	547.022 ± 558.4242 ^a	170.9889 ± 32.73998 ^c	300
TDS	70.0222 ± 1.06710 ^a	134.5111 ± 65.6836 ^b	147.4333 ± 44.6758 ^c	195.9622 ± 257.816 ^{ac}	83.3111 ± 19.5839 ^{ab}	500-1500
pH	7.9011 ± 0.12464 ^b	6.9667 ± 0.13370 ^a	7.8900 ± 0.07348 ^b	6.4522 ± 0.14403 ^a	8.1944 ± 0.03005 ^c	6.5-8.5
Turbidity	1.3500 ± 0.18000 ^b	2.5667 ± 0.37772 ^a	2.0933 ± 0.35500 ^b	2.1033 ± 0.36273 ^a	2.1000 ± 0.17299 ^c	5.0

Mean values in rows with different superscript are significantly different (P<0.05) using Tukey HSD

Key: TH = Total Hardness, EC = Electrical Conductivity, WHO = World Health Organisation

Descriptive statistics of physiochemical parameters concentration in (parts per million) of sachet water samples from five sampling locations are presented in table 2. Sodium concentration in the water sample analysed ranged between 4.667 ± 0.500 to 16.667 ± 4.3589 mg/l with the average of 10.933 mg/l which falls within the WHO Standard of 20 mg/l. This result however, fluctuated from one sampling location to the other to which may have been caused as a result of microbial degradation in the water sample. The presence of cation in sachet beyond tolerable level has significant health implication. The concentration of potassium obtained for the study was within the range of 3.000 -4.667 mg/l with an average value of 3.999 mg/l. The value tends to slightly decrease and increase from one sampling location to the other but is still within the WHO standard for drinking water. According to Rodríguez et al., 2023 potassium level in water increases when the micro-organism dies. The

findings of the study showed the presence and active nature of the micro-organism in the water samples.

Calcium is the 5th most abundant element in the earth crust, thus very important for human cell physiology. About 95% of calcium in human body is stored in bones and teeth. High deficiency of calcium in humans may cause rickets, poor blood clotting, bones fracture e.t.c and exceeding limit of calcium produced cardiovascular diseases (WHO, 2017). According to WHO standards, its permissible level in drinking water is 75-200 mg/l. In this study, a range of 65.767 – 210.392 mg/l of calcium was observed which indicates that the calcium level in sachet water analysed was below the WHO limit in all the sampling locations except S₄ which was found with recorded value above the WHO standard. This is in line with the low level of calcium reported for sachet water in Abaraka and Warri, Nigeria (Bazaanah et al., 2023).

The values concentration for magnesium for all the samples analysed ranged from 44.758 mg/L to 143.238 mg/L which are within the limit (30-150 mg/L) described by WHO for quality drinking water. A slight significant difference was observed in the samples between and within the study areas. Total hardness which measures the concentration of multivalent metallic cations (majorly Ca²⁺, Mg²⁺) in

water; can serve as source of dietary Calcium and Magnesium to the body (Alexander *et al.*, 2019). As indicated in; (Table 2), S₄ sampling location has the highest TH value (353.6311 mg/L) which is quiet below the recommended limit prescribed by WHO. However, all other sampling locations have values which are within the 100-500 mg/L recommended by WHO. However, in a similar study conducted in Ondo

state, all samples have values which are within the 100-500 mg/L recommended by WHO (Akinsola *et al.*, 2020).

The result shown in Table 2 depicts that the values (12 – 26 mg/L) obtained in all the samples met the requirement of 20 mg/L described by WHO for nitrate concentration in drinking water. However, Nitrate was detected in all the sampling location except S₅ with concentration beyond the 20 mg/L described by WHO for Nitrate concentration in drinking water. The presence of nitrates in a water sample could be due to inorganic fertilizers, plants and animal decomposition and wastes which may have percolated the soils over time (Amosah *et al.*, 2023). The high values of nitrate as shown in Table 2 could be due to the fact that soluble particles that are chemical in nature could be well distributed in the body of the water and possibly interact with the water molecules in a form that storage for days may not have significantly affected the concentration in the body of water.

Sulphate (SO₄²⁻) occurs naturally in water as a result of leaching from gypsum and other common minerals, Discharge of industrial waste and domestic sewage tend to increase its concentration. The concentration of Sulphate (SO₄²⁻) in the water samples from all the sampling location was very low compared to WHO limit of 400mg/l for drinking water as the highest and lowest concentration ranged from 57.464 to 15.023 mg/l observed in S₄ and S₁ sampling location respectively.

Fluoride (F⁻) inhibits enzymes that breed acid-producing bacteria whose acid eats away tooth enamel. Excessive fluoride intake leads to loss of calcium from teeth matrix, aggravating cavity formation throughout life rather than remedying it and so causing dental fluorosis. Severe, chronic and cumulative overexposure can cause the incurable crippling of skeletal fluorosis (Srivastava *et al.*, 2020). The probable source might be during weathering and circulation of water in rocks and soil. Fluorine is leached out and dissolve in water. The concentration of each sampling site varies depending on the type of rock from which it originates. The average concentration in the water samples are higher than the WHO acceptable range of 1-1.5 mg/l for drinking water as the highest and lowest concentration ranged from 3.245 to 1.935 mg/l respectively see (Table 2). This could be attributed to the type of filters used as some of them are ineffective in removing fluoride and a very good example of such filter is carbon activated filter.

The Chlorine level for all the sachet water is above the maximum allowable concentration (MAC) set by

WHO (Table 2). Increase in chloride concentration in conventional water treatment plant could be due to the amount of free chloride after chlorination. Elevated chlorine levels can cause great aesthetic problems (strong taste and odour) and if organic matter is present, can result in the creation of trihalomethanes, which are potentially carcinogenic with target organs including liver and the kidney (Srivastava *et al.*, 2020). This result disproportionate the findings of Akinsola *et al.* (2020) who reported Chloride concentration of (14 – 56 mg/L) obtained in all the samples which met the requirement of 100-200 mg/L described by WHO for chloride concentration in drinking water.

Dissolved oxygen (DO) measures the amount of oxygen freely available in water, Table 2 showed that the average DO ranges from 6.771 to 16.870 mg/l which was very low compared to WHO limit of 500 mg/l. The average concentration of BOD fluctuated between 3.120 and 8.456 mg/l which is above the WHO limit of 5.0 mg/l for drinking water. This suggests that the concentration of BOD in the water samples do not conform with WHO standard except S₃ and S₅ sampling location. High BOD in water is a clear indication of pollution and contamination. Water samples with BOD less than 5.0 mg/l is considered safe (NSDWQ, 2007).

Alkalinity is a measure of the acid-neutralizing capacity of water. It is due to the presence of carbonate (CO₃²⁻), bicarbonate (HCO₃⁻), and hydroxyl (OH⁻) anions. However, borates, phosphates, silicates, and other bases also contribute to alkalinity if present (Wilson, 2010). The result obtained for all the sampling locations are within the WHO acceptable limit except for S₄ sampling location with recorded concentration of (365.0689 mg/L) which is above the recommended limit (200 mg/L). The high total alkalinity values observed in S₄ may be due to deposits or contamination during treatment. In a similar study, the results obtained for all the sachet water samples are within the WHO acceptable limit 200 mg/L. (Akinsola *et al.*, 2020).

Temperature is a measure of the average thermal energy of a system. The temperatures for all the sachet water samples analysed are within the range of 28.5667 ± 0.05000 to 32.0778 ± 0.23863 with average value of 30.1378. The mean temperature obtained from this study is reasonably above the WHO standard of 25 °C. According to Rodríguez *et al.*, 2023 temperatures within this range are conducive for optimal growth for mesophyll bacteria including human pathogens; hence this temperature has the potential to enhance the growth of micro-organism thereby promoting the

development of unpleasant odour and taste in water. The higher the temperature of water, the lower the level of dissolved oxygen as well as survival rate of microorganisms. Conductivity is an important water quality parameter of controlling and monitoring water treatment as it gives the idea about ionisable materials in water (Alexander *et al.*, 2019). It affects all aspects of water treatment and suitability of specific application (Ogundipe, 2015). The result in table 2 reveals that all the analysed sachet water samples possess EC values ranging from $170.9889 \pm 32.739 \mu\text{s/cm}$ to $547.0222 \pm 558.424 \mu\text{s/cm}$ which is within the acceptable limit of $300 \mu\text{s/cm}$ described in the manual for drinking water quality by WHO except S₄ sampling location. There is a huge significant difference in the means of the samples between the study areas. However, literature has expressed that long term consumption of treated water with $\text{EC} > 40 \mu\text{s/cm}$ can lead to high probability of fracture in children, pregnancy disorder, diuresis and increased tooth decay (Opafola *et al.*, 2020).

Total Dissolved Solid (TDS) is a measure of the total amount of dissolved substances in the water sample. According to Edokpayi *et al.*, 2018 high levels of TDS can lead to gastro-intestinal irritation and stains to fabric. Drinking water containing TDS levels above 500mg/L usually has a strong taste (Apau *et al.*, 2014) and generally indicates hard water, which can cause scale buildup in pipes, valves and filters (Nsiah and Boakye, 2015). As seen in Table 2, the TDS (Total Dissolved Solid) obtained for the analyzed samples ranges from $(70.0222 - 195.9622 \text{ mg/L})$ which are far below the WHO reference standards. This is in agreement with Akinsola *et al.* (2020) who reported TDS (Total Dissolved Solid) obtained for the

analyzed sachet water samples ranges from $(42.0 - 247.0 \text{ mg/L})$ which are quiet within the WHO reference standards.

pH is an important parameter used to ascertain water quality. It is also an essential parameter required for evaluating the acid-base balance of water (Amosah *et al.*, 2023). pH of different brands of sachet water analysed ranged from 6.40 to 8.10 with an average value 7.48. The pH obtained for the study falls within the WHO recommended range of 6.50-8.50. This is in line with Akinsola *et al.* (2020) who reported all the samples analysed has values within the recommended limit (6.5-8.5) prescribed by the WHO standard for quality drinking water whereas the mean turbidity values for all the sachet water are below the standard set by the WHO which is 5 NTU and also within the range of 1.3-2.5 NTU. This could be attributed to the fact that, Sachet water passed through series of filters during production to remove the suspended clay particles, trace elements and suspended solids. Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. This does not support the findings of Akinsola *et al.* (2020) who reported turbidity not detected in all brands of sachet water analysed in Owo, Akure and Ondo state, Nigeria.

HEAVY METAL PROPERTIES

Four (4) essential micronutrient nutrients (Mn, Fe, Cu and Zn) alongside with five (5) toxic heavy metals (As, Cr, Pb, Co and Cd) was studied or determined. Large dose of these metals is known to have adverse contribute to the taste of water and further lead to acute or chronic health condition (Alexander *et al.*, 2019).

Table 3: Analysis Of Variance (Anova) Of Heavy Metals Of Sachet Water

Metas		Sum of Squares	Degree of frrdom	Mean Square	F-value	Significance
Zn	Between Groups	0.015	4	0.004	15.224	0.000
	Within Groups	0.010	40	0.000		
Cd	Between Groups	0.000	4	0.000	0.000	1.000
	Within Groups	0.000	40	0.000		
Fe	Between Groups	521.719	4	130.430	4.404	0.005
	Within Groups	1184.556	40	29.614		
Cu	Between Groups	0.001	4	0.000	6.000	0.001
	Within Groups	0.001	40	0.000		
Ni	Between Groups	0.000	4	0.000	4.667	0.003
	Within Groups	0.001	40	0.000		
As	Between Groups	23.082	4	5.771	34.861	0.000
	Within Groups	6.621	40	0.166		
Co	Between Groups	0.007	4	0.002	25.286	0.000
	Within Groups	0.003	40	0.000		
Pb	Between Groups	0.001	4	0.000	8.667	0.000
	Within Groups	0.001	40	0.000		

Mn	Between Groups	0.483	4	0.121	5.127	0.002
	Within Groups	0.942	40	0.024		
Cr	Between Groups	0.001	4	0.000	4.000	0.008
	Within Groups	0.003	40	0.000		

The results from the table (3) showed that the levels of all the heavy metals analysed varied significantly at 95% confidence limit ($P < 0.05$) across all the sampling locations except cadmium (Cd).

Table 4: Descriptive Statistics And Homogeneous Turkey Hsd Test Of Heavy Metals Of Sachet Water

	S1	S2	S3	S4	S5	WHOSTD
Metals						
Zn	0.0433 ± 0.00500 ^a	0.0267 ± 0.0100 ^a	0.0333 ± 0.00500 ^b	0.0767 ± 0.03279 ^b	0.0300 ± 0.00000 ^a	15
Cd	0.0200 ± 0.00000 ^b	0.0200 ± 0.0000 ^c	0.0200 ± 0.00000 ^b	0.0200 ± 0.00000 ^a	0.0200 ± 0.00000 ^b	0.003
Fe	0.6233 ± 0.10000 ^a	0.6067 ± 0.0400 ^b	0.5367 ± 0.1175 ^{ab}	9.2433 ± 12.1629 ^c	1.2567 ± 0.32821 ^a	0.3
Cu	0.0033 ± 0.00500 ^a	0.0000 ± 0.0000 ^b	0.0033 ± 0.0050 ^{ab}	0.0100 ± 0.00866 ^c	0.0000 ± 0.00000 ^a	1.0
Ni	0.0100 ± 0.00000 ^a	0.0033 ± 0.0050 ^c	0.0067 ± 0.0050 ^{ac}	0.0067 ± 0.00500 ^b	0.0100 ± 0.00000 ^a	0.02
As	5.6133 ± 0.71500 ^b	7.4600 ± 0.4763 ^c	6.7533 ± 0.1261 ^{ac}	7.5033 ± 0.26782 ^b	7.3667 ± 0.04359 ^{ab}	0.01
Co	0.0300 ± 0.01500 ^a	0.0500 ± 0.008 ^{ab}	0.0133 ± 0.005 ^{ac}	0.0233 ± 0.00500 ^b	0.0200 ± 0.00000 ^c	0.05
Pb	0.0133 ± 0.00500 ^b	0.0133 ± 0.0050 ^a	0.0167 ± 0.0050 ^{ab}	0.0100 ± 0.00000 ^c	0.0200 ± 0.00000 ^b	0.01
Mn	0.0267 ± 0.00500 ^a	0.1333 ± 0.0132 ^a	0.0267 ± 0.0050 ^{ab}	0.2933 ± 0.34253 ^c	0.0333 ± 0.01323 ^a	0.05
Cr	0.0200 ± 0.00000 ^a	0.0200 ± 0.000 ^{ac}	0.0200 ± 0.0000 ^{ab}	0.0333 ± 0.02000 ^c	0.0200 ± 0.00000 ^a	0.05

Mean values in rows with different superscript are significantly different ($P < 0.05$) using Tukey HSD

As shown in Table 4, metals such as Zinc, Copper, chromium, lead, cobalt and nickel were detected with concentration levels within the recommended WHO standard in all the sachet water analyzed in the study area, which further indicate that the water samples in the study areas are free from this heavy metal contamination capable of causing chronic health challenges. However, copper was not detected in S₂ and S₅ sampling locations while Mn was found present with concentrations within the stipulated limit except in S₂ and S₄ sampling locations of the study area.

Metals like Zinc, Copper, chromium, lead, cobalt and nickel can serve as dietary supplement if present within the WHO tolerable limit. The concentrations detected for Zn, Cu and Ni in all the water samples in the study area shown in Table 4 are less than 15 mg/l, 1 mg/l mg/L and 0.02 mg/L for zinc, copper and nickel respectively, as prescribed by WHO standard for drinking water. This implies that the samples are acceptable as they pose no risk to human health. However, water containing zinc at concentrations in excess may appear opalescent and develop a greasy film on boiling. Although drinking-water seldom contains zinc at concentrations above 0.1 mg/L,

levels in tap water can be considerably higher because of the zinc used in older galvanized plumbing materials (Perveen et al., 2023). Lead is found at concentration not greater than 0.01 mg/L and cobalt was found present at concentrations less than the recommended 0.05 mg/L described by WHO for all the water samples except S₂ sampling location with concentration of 0.05 mg/l. This implies that there is no significant health risk in the samples in comparison to permissible standard used.

Consequently, Cadmium, Arsenic and Iron concentrations for all the sachet water analyzed exceeds the maximum allowable concentrations described WHO standard for drinking water and as a result, consumers in Sokoto metropolis are exposed to chronic health risk from these metals toxicity. High concentrations of Cadmium, Arsenic and Iron can affect the acceptability of drinking water, and should be given adequate priority during production (WHO, 2010). Alexander *et al.* (2019) reported that large doses of the aforementioned metals cause diseases such as kidney damage, liver cirrhosis, lethargy, gastrointestinal disorder, headache, sleeplessness and leg weakness.

Table 5: Total Coliform Count Result

Sampling Sites	Coliform Count/100 MPN
S1	0
S2	10
S3	0
S4	0
S5	10

High microbial loadis attributed to poor sanitation in the water treatment process or ineffectiveness in the water treatment process. Consequently, WHO recommends 0- MPN/100 ml for treated water. To further assess the safety of sold product within the study areas and on the sachet water brands. The presence of coliform indicates the risk of water-borne diseases (Alexander *et al.*, 2019). As shown in Table 5, All the water samples in the study area analyzed are within the WHO limit of 0 MPN/100 ml for treated water except S₂ (10 MPN/100mL) and S₅ (10 MPN/100mL) and violates the 0 MPN/100mL described by WHO thus making it unfit for consumption. Hence potential risk is associated with the consumption of such treated water. Moreover, no coliform was detected in 3 sampling location of the study area which is S₁, S₃ and S₄. This indicates the quality and safety of this sold water product as they are exactly to the zero-specification laid down by WHO for treated water.

4.0 CONCLUSION

The assessment of Sachet water quality in Sokoto metropolis showed that the water samples had up to 70% quality compliance with WHO. The analysis of variance (ANOVA) results showed that all the physicochemical variables and heavy metals analyzed were significantly different at 95% level of significant except Alkalinity, Chloride (Cl⁻), Total Dissolved Solid (TDS) and cadmium (Cd) respectively. The descriptive statistics and homogeneous turkey HSD test results showed all the physicochemical and heavy metals parameters analysed are within the WHO maximum allowable concentration except Alkalinity, Nitrate (NO₃⁻) and Fluoride (F⁻) and Iron (Fe), Arsenic (As) and Cadmium (Cd). However, the biological result revealed that the total coliform bacteria was absent in all the sampling locations except S₂ and S₅ with recorded concentration of 10 MPN/100ml of the water sample which is quiet beyond the WHO limit of treated water but within the WHO limit of untreated drinking water like; well and borehole water. Hence, sachet water in the study area is considered safe and suitable for drinking and other domestic purposes.

REFERENCES

Addo HO, Amegah KE, Xonam TA, (2020). Consumer

preference and quality of sachet water sold and consumed in the Sunyani Municipality of Ghana. *Biomed Res Int*. 2020;2020:1. <https://doi.org/10.1155/2020/3865895>

- Alexander P, Bwatanglang I. B. and Daniel J. (2019), Assessment of Physicochemical and Bacteriological Parameters of Borehole and Hand Dug Well Water in Michika and Environs, Adamawa State, Nigeria, *Microbiology Research Journal International*, 28(6): 1-11, DOI: 10.9734/mrji/2019/v28i630148.
- Amosah J, Lukman T, Atanga RA. (2023). Portable water sources in rural communities the experience of Togmaa community in the Wa West District. *Am J Arts Hum Sci*. 2:8–14. <https://doi.org/10.54536/ajahs.v2i1.1158>.
- Apau, J., Acheampong, A. and Bepule, V. (2014). Physicochemical and Microbial Parameters of Water from Hand-Dug Wells from Nyamebekyere, a Suburb of Obuasi, Ghana. *International Journal of Science and Technology*, Vol. 3(6), pp. 1 - 5.
- APHA (2005). "Standard methods for the examination of water and waste water". 21st Edition, Washington D.C.
- Bazaanah P, Mothapo RA. (2023). Sustainability of drinking water and sanitation delivery systems in rural communities of the Lepelle Nkumpi Local Municipality, South Africa. *Environ Dev Sustain..* <https://doi.org/10.1007/S10668-023-03190-4>.
- Edokpayi JN, Rogawski ET, Kahler DM, Hill CL, Reynolds C, Nyathi E, Smith JA, Odiyo JO, Samie A, Bessong P, Dillingham R. (2018). Challenges to Sustainable Safe Drinking Water: A Case Study of Water Quality and Use across Seasons in Rural Communities in Limpopo Province, South Africa. *Water (Basel)*. 10(2):159. doi: 10.3390/w10020159. Epub . PMID: 30595910; PMCID: PMC6310213.
- Ibrahim M.D, Umaru M., Akinsoji A. A, (2015) Qualitative Assessment of Sachet and Bottled Water Marketed in Bauchi Metropolis, Nigeria, *Chemical and Process Engineering Research*, Vol.37.
- Jagaba, M. A., Sirajo, A. I. and Abubakar, A. (2018). Assessment of the Causes and Problems Associated With Urban Sprawl in Sokoto Metropolis. *International Journal of Innovative Social Sciences & Humanities Research*. 6(1):42-47.
- Mosi L, Adadey SM, Sowah SA, Yeboah C. (2019). Microbiological assessment of sachet water pure water from five regions in Ghana. *AAS Open Res*. 1:12. <https://doi.org/10.12688/aasopenres.12837.2>.
- National Population Commission (NPC, 2022). Population Census Data, Nigeria, Federal Republic of Nigeria Official Gazette, National and State Provisional Total Census, Printed and Published in Federal Government Printer, Lagos, 21(94).

- Nsiah, J.J. and Boakye, E. (2015). Assessment of the Quality of Water from Hand-Dug Wells in Shama Ahanta West Metropolitan Assembly: Western Region of Ghana. *International Journal of Science and Technology*, Volume 5 (9), pp. 1 -7.
- Nwankwoala, H.O. and Nwagbogwu, C.N. (2012). Characteristics and quality assessment of groundwater in parts of Akure, South-Western Nigeria. *Journal of Environmental Science and Water Resources*, 1(4): 67 - 73.
- Ogundipe, O.A (2015). Evaluation of physicochemical and microbial properties of some sachet and bottled water sold in Akure, Ondo State. A final year project submitted to the department of chemistry, Federal University of Technology, Akure. Pp 1 – 15.
- Oluwaseun A. Akinsola, Tolulope O. Oyewumi, Benjamin A. Adegola and Patience O. Okpe (2020). Quality Assessment of Selected Sachet Water Brands Marketed in Owo, Akure and Ondo Areas of Ondo State, Nigeria. *Research Journal of Pure Science and Technology* E-ISSN 2579-0536 P-ISSN 2695-2696. DOI:10.13140/RG.2.2.22829.00481.
- Opafola OT, Oladepo KT, Ajibade FO, David AO. (2020). Potability assessment of packaged sachet water sold within a tertiary institution in southwestern Nigeria. *J King Saud Univ Sci.*;32:1999–2004. <https://doi.org/10.1016/j.jksus.2020.02.004>.
- Perveen S, Amar-UI-Haque. (2023). Drinking water quality monitoring, assessment and management in Pakistan: a review. *Heliyon*.. <https://doi.org/10.1016/j.heliyon.2023.e13872>.
- Rodríguez-Izquierdo E, Alvarado-Velázquez J, García-Meneses PM. (2023). Inequality, water accessibility, and health impacts in Chiapas, Mexico. *Reg Environ Change*. 23:23. <https://doi.org/10.1007/s10113-022-01993-1>.
- Sohonou, M. Vissin, E. W. Sintondji, L. O. Houssou, C. S, Agbossou, K. E. Etorh, A. P. (2017). Physico chemical And Microbiological Qualities of Water From Wells Drillings And Tanks used As Drinking Water In The Municipality Of Allada (Benin, West Africa). *European Scientific Journal*. 13(15) 1857 – 7881. DOI: <https://doi.org/10.19044/esj.2017.v13n15p69>.
- Srivastava S, Flora SJS. (2020). Fluoride in drinking water and skeletal fluorosis: a review of the global impact. *Curr Environ Health Rep*. 7:140–6. <https://doi.org/10.1007/s40572-020-00270-9>.
- United Nations Development Programme (UNDP) (2016). Human development report 2006: Beyond scarcity: Power, Poverty and the Global Water Crisis. United Nations, New York, NY.
- United Nations Millennium Development Goal (2011), Assessing progress in African towards the Millennium Development Goals. MDG, Report New York.
- WHO (2010): Progress on Sanitation and Drinking water: 2010 Update. World Health Organization, Geneva, Switzerland.
- WHO (2011): Drinking Water: Equity, Safety and Sustainability. World Health Organization, Geneva, Switzerland.
- WHO and UNICEF (2004.) Joint Monitoring Programme for Water Supply and Sanitation; Meeting the MDG Drinking Water and Sanitation Target: A Mid-Term Assessment W.H.O Geneva.
- Wilson C.P., (2010). Water quality notes: Alkalinity and Hardness; University of Florida IFAS Extension: Publication No. SL 332 (www.edis.ifas.ufl.edu/topic_series_water_quality_notes) Retrieved 4th July, 2019.
- World Health organization (WHO) (2017). Guidelines for drinking water quality, WHO Press.