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Assessment of Physicochemical and Elemental Properties of some Sachet Water sold in selected Communities in Abuja Metropolis, Nigeria

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Abstract
Samples of 10 brands of sachet water were purchased from selected communities in Abuja, the Federal Capital Territory, Nigeria and analyzed for their physicochemical and elemental properties using standard analytical methods. The parameters determined include temperature, turbidity, total suspended solids, total dissolved solids, dissolved oxygen, electrical conductivity. Also determined were calcium, magnesium, lead and zinc ions as well as chloride, nitrate, nitrite and sulphate ions. All the parameters analyzed for were within the recommended limits set by the World Health Organization (WHO) and the Standard Organization of Nigeria for safe drinking water except lead, with values of 0.3 mg/L and 2.63 mg/L in S2 and S3 respectively instead of the <0.01 mg/L recommended by WHO. The results indicated that the water samples were safe for human consumption except the samples with elevated values of lead. The two brands of sachet water with high level of lead should be withdrawn from circulation and further investigation on the source of lead in the water be carried out. There should also be further treatment during the production process to avoid lead poisoning of the unsuspected public.
Keywords: Physicochemical Properties, Turbidity, Dissolved Oxygen, Sachet Water, Chloride

Introduction

Water is one of the most essential natural resources on earth but portable water is not readily available to man. About one billion people do not have access to clean drinking water and approximately 2.6 billion do not have access to improved sanitation services while 1.4 million children under the age of 5 die yearly due to lack of access to clean water and adequate sanitation especially in Sub-Saharan Africa and Asia [1][2]. Nigeria as the most populous country in Africa with a population of over 200 million also faces major water challenges. In 2019, about 60 million Nigerians were living without access to safe drinking water and 80 million without access to improved sanitation facilities thus, necessitating the need for increased awareness to safe drinking water in Nigeria [3]. This justifies earlier observations that not all water is portable for use by man due to contamination by harmful metallic elements and microbial organisms and for water to be portable for human consumption, it is expected to meet the required standards specified by the water quality regulatory agencies [4]. It has been noted that such regulatory bodies include the World Health Organization (WHO) and the Standard Organizations of Nigeria (SON) Regulations for Drinking Water. Some common diseases have been traced to the consumption of water that is contaminated by microbial organisms and these diseases include cholera, typhoid fever and dysentery. The consumption of water contaminated by chemical substances like heavy metals could also lead to cancer and depressed immune system [5][6].

Abuja is the Federal Capital Territory (FCT) of Nigeria and one of the commonest sources of water for consumption in the city is the sachet water otherwise, known as "pure water". Sachet water has been indispensable in virtually all households due to its affordability and importance. However, the purity of these sachet waters has been doubtful due to their proliferation and alleged sharp practices of the producers. Such water has been reported to contain bacteria such as Bacillus sp., Pseudomonas sp, Klrbsiella sp., Streptococcus sp., and oocysts of cryptosporidia sp. which are disease causing organisms [6][7]. It is in this light that the assessment of the physicochemical properties of sachet water from some communities in Abuja metropolis was necessitated.

Materials and Methods

Sample Collection

Sachet water samples were purchased from eight (8) communities in Abuja, Nigeria. Three samples of each brand

were collected to make a composite sample of the brand. A total of ten (10) composite samples were obtained, coded and labeled representing the different brands of sachet water sold in the city. A description of the sachet water samples is given in Table 1.

Table 1: Locations of Sample Collection

Serial	Code	Product Address	Communities	Coordinates
1.	S1	No1 Opposite AA RANO Filling Station Nyanya, FCT	Nyanya	9.0561°N 7.5789°E
2.	S2	Ground Floor, HS 1.4, Block NL 3, Knowledge Court Estate, Galadimawa Abuja	Galadimawa	8.9905°N 7.4300°E
3.	S3	Lungi Shopping Complex Maitama Abuja	Maitama	9.0882°N 7.4934°E
4.	S4	D`rive 5, House 24, Prince and Princess Estate, Abuja	Lokogoma	8.9786°N 7.4582°E
5.	S5	No33, Flat A, Phase 2, Kubwa, FCT, Abuja	Kubwa	9.1538°N 7.3220°E
6.	S6	Plot 1599 Oka Akoko Street, By Zenith Bank Entrance, Off Lagos Street, Garki 2 Abuja	Garki	8.9995°N 7.4956°E
7.	S7	No 74 AN Amosu Avenue, NAF Valley ~Estate Asokoro Abuja	Asokoro	9.0479°N 7.5155°E
8.	S8	No 39 Kenneth Ojo NGO Estate (Sahara 4) Lokogoma Abuja	Lokogoma	8.9786°N 7.4582°E
9.	S9	No 8Owo Close Area 10 Garki Abuja	Garki	8.9995°N 7.4956°E
10.	S10	No 12 Idu, Abuja	Idu	9.0325°N 7.3895°E

Water Quality Analysis

The reagents used for analysis of the sachet water samples were of analytical grade and the analytical instruments were pre-calibrated before measurements. The pH was determined using the pH meter model HI2209. The temperature on the other hand, was determined by using a simple mercury-in-glass thermometer calibrated in degrees Centigrade as described by [5]. The turbidity in Nephelometric Turbidity Unit (NTU) was determined using the Turbidimeter model HI88703. Furthermore, the EC and the dissolved oxygen (DO) of the samples were determined by using Orion Versaster Pro-advanced electro chemistry meter while NO_3^-, NO_2, SO_4^{2+} and Cl^-) were determined using multiparameter photometer model HI83399. The TSS were determined using TSS meter sensor while the Calcium, Magnesium, Zinc and Lead were determined using the Atomic Absorption Spectrometer model ICE 3000 series. All analysis were conducted at the Sheda Advanced Science and Technology Complex (SHETSCO) Abuja, apart from the determination of temperature and pH which were done in situ at the point of purchase.

Results and Discussion

The physical examination of the samples was conducted as shown in Table 2 below. The physical examination model was used to evaluate the compliance of the sachet water companies to the laid down rules of the regulating bodies like the WHO and SON in Nigeria. It is in line with the physical examination model cited by [9], where the positive (+) and negative (-) signs were used to denote the presence or absence of the parameters under assessment. In other words, the sachet water samples are supposed to have all the parameters listed above but unfortunately, do not have NAFDAC Batch Number, Date of Manufacture and Expiry Date. The absence of these vital information prevents the

consumers from making a preliminary assessment of the quality of sachet water available for their consumption.

Table 2: Model of Physical Examination

Serial	Producer's Code	NAFDAC Registration Number	Batch Number	Manufacture Date	Expiry Date
1.	S1	+	-	-	-
2.	S2	+	-	-	-
3.	S3	+	-	-	-
4.	S4	+	-	-	-
5.	S5	+	-	-	-
6.	S6	+	-	-	-
7.	S7	+	-	-	-
8.	S8	+	-	-	-
9.	S9	+	-	-	-
10.	S10	+	-	-	-

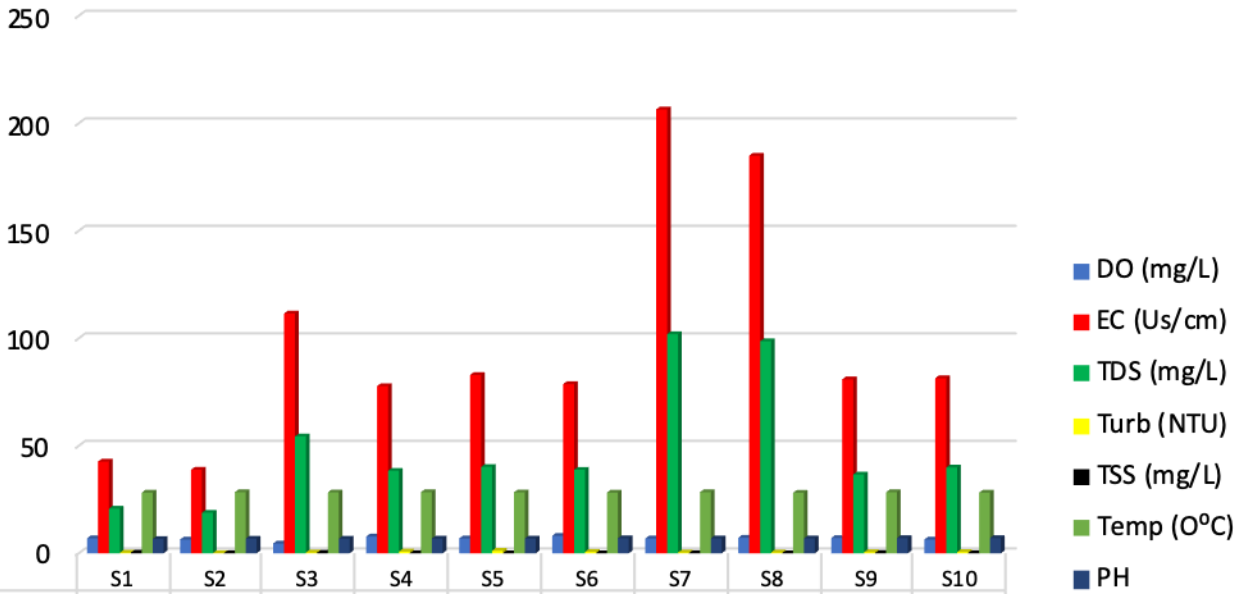
+ present, - absent

The results of the physicochemical analysis of selected sachet water samples sold in some communities in Abuja are contained in Figure 1. The temperature of the sachet water samples ranged from 28.1 to 28.4 ◦C which were within the ambient temperature recommended by [10]. The values for DO of the sachet water samples ranged from 6.4 to 7.8 mg/L which fell within the permissible limit of >4mg/L recommended by [10] for safe drinking water. These values were in agreement with results in other reports [11][12] with limits within the acceptable range of <4mg/L. Dissolved oxygen is an important parameter for testing ground water quality because it regulates the valence state of trace metals and it constrains the bacterial metabolism of dissolved organic species [8][13]. Furthermore, its value is a direct indicator of an aquatic resource's ability to support aquatic life [8][14][15]. The DO levels of the sachet water samples were within the safe limit recommended by the [10]. Similarly, the values of EC ranged from 42.64 µS/cm to 206.00 µS/cm in the sachet water samples. This is in line with the acceptable limits of 0 - 2000 µS/cm recommended by [10] guidelines for drinking water quality. The EC is one of the most useful and frequently tested parameters when determining water quality because it indicates the level of pollution that has entered the water source. It is a measure of the total ionic content in water, a reflector of how well water can conduct electricity and maybe an indicator of the level of dissolved salts in water [11].

The values of TDS obtained from the analysis of sachet water samples ranged from 18.85 mg/L to 101.90 mg/L which are below the <1000 mg/L as recommended by [10]. Total Dissolved Solids is a measure of all dissolved solutes in water which includes organic and inorganic matter. High TDS levels can indicate the presence of contaminants, such as heavy metals, which can have adverse effects on human health and can affect the taste and odour of the water [14][8] There was a very wide variation between the least value and the maximum value obtained from the samples. This could be due to the difference in the nature of the geology of the groundwater source and the available soluble minerals in the water source. This agrees with the result of [16] who stated that TDS gives the general nature of groundwater quality and the extent of contamination. They added that the concentrations of TDS in water vary considerably in different geological zones owing to differences in the solubility of minerals.

The values of Turbidity obtained from the results of the water sample ranged from 0.30 NTU to 1.16 NTU which are within the safe limit of <5.0 NTU recommended by the [10][17]. Turbidity is the clarity or haziness of water, which depends on the presence of suspended insoluble particles and determines how much the passage of light is restricted by the suspended solid matter. Turbid water may be a breeding medium for pathogens which may lead to outbreaks of waterborne diseases [18]. The causes of turbidity vary depending on the water source and treatment systems. The result of the sachet water analysis was in agreement with the outcome of a similar studies [19]. Similarly, the values of TSS obtained from the samples ranged from 0.01 to 0.32 mg/L which are less than 10.0 mg/L as recommended by [10]. The TSS is a measure of insoluble particles in a water source. It is the turbidity that results from silt and organic matter [21].

The pH values of the sachet water ranged from 6.65 to 7.07 which were within the limits of 6.5 -8.5 recommended by both the [10][17][25] for drinking water quality. The values agree with the results of a similar study [21]. Figure 1 is a bar chart showing the values of physicochemical parameters of the sachet water samples.



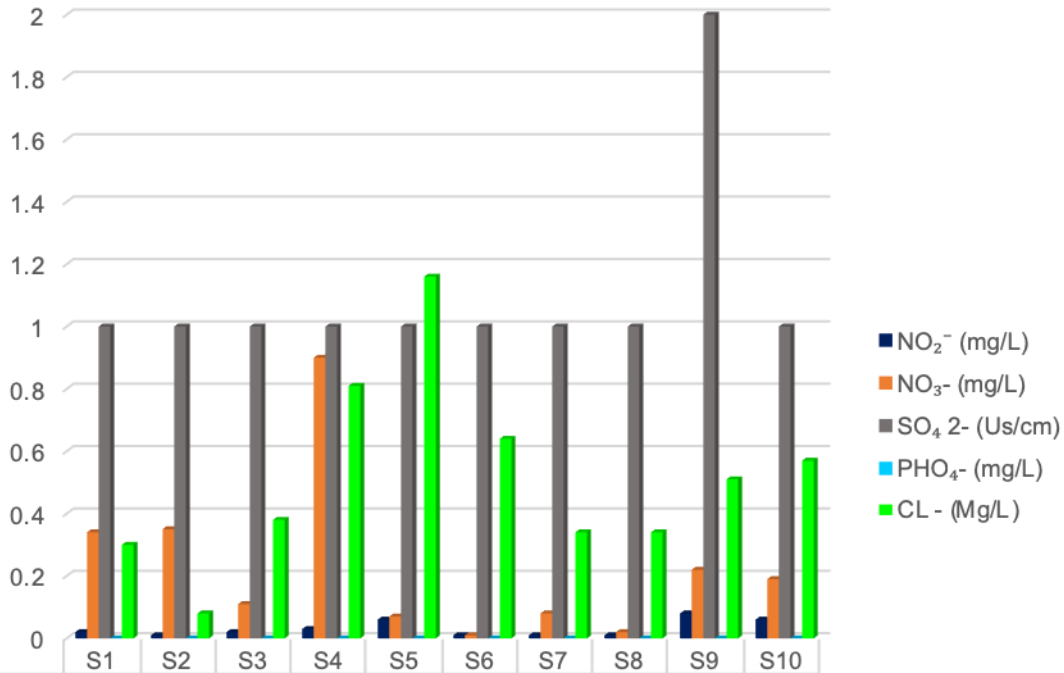
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
DO (mg/L)	7	6.4	4.5	7.8	6.9	8.1	6.9	7.2	7.1	6.4
EC (Us/cm)	42.64	38.85	111.5	77.74	82.93	78.66	206.4	184.9	80.88	81.41
TDS (mg/L)	20.78	18.85	54.37	38.36	40.15	38.8	101.9	98.6	36.62	39.86
Turb (NTU)	0.3	0.08	0.38	0.81	1.16	0.64	0.34	0.34	0.51	0.57
TSS (mg/L)	0.32	0.05	0.22	0.05	0.03	0.01	0.08	0.01	0.11	0.09
Temp (O°C)	28.2	28.4	28.3	28.4	28.3	28.2	28.4	28.1	28.4	28.2
PH	6.65	6.8	6.77	6.85	6.86	6.96	6.9	6.9	7.07	7.06

Fig.1: Physicochemical Properties of Sachet Water Samples sold in Abuja Metropolis

The levels of NO_2^- and NO_3^- in the sachet water ranged from 0.01 to 0.08 mg/L and 0.01 to 0.90 mg/L respectively which are below the maximum limits of 1.0 mg/L for NO_2^- and 10.0 mg/L for NO_3^- recommended by the [10]. The source of NO_2^- and NO_3^- in portable groundwater could be from point sources such as sewage disposal or non-point sources such as fertilized croplands. These anions could get into the groundwater through leaching. The health hazard of drinking water contaminated by NO_3^- occurs when NO_3^- is converted to NO_2^- in the digestive system of infants below 6 months old. The nitrite oxidizes the iron in the hemoglobin of the red blood cell to form methemoglobin, which lacks the oxygen carrying ability of hemoglobin. This creates a condition called methemoglobinemia, often called "blue baby syndrome" in babies [21][22]. However, the low values obtained in this study indicate that the sachet water are safe for consumption with respect to NO_2^- and NO_3^-.

The value of SO_4^{2-} in the sachet water ranged from 1.0 to 2.0 mg/L which are below the maximum limit of 100.0 mg/L and 250 mg/L for SO_4^{2-} recommended by the [17] [20] respectively. Elevated SO_4^{2-} levels may have a laxative effect that can lead to the body lacking in fluids [23][26][27]. This is mostly the case for infants and not adults. It also gives the water a bitter taste [27]. The values of SO_4^{2-} in the sachet water samples are in agreement with another report by [27].

Chloride is useful in maintaining acid-base balance in the body and it is a significant anion found in water. However, when it becomes excess in drinking water, it might cause dropsy. The values of Cl^- obtained from the sachet water samples ranged from 0.08 to 1.16 mg/L which are far below the maximum limit 5.0 mg/L and recommended by the [10] for drinking water but consistent with the findings of [26] [27]. Therefore, the Cl^- level of the sachet waters is quite good. A bar chart of the distribution of the anions across the various samples is shown in Figure 2.



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
NO_2^- (mg/L)	0.02	0.01	0.02	0.03	0.06	0.01	0.01	0.01	0.08	0.06
NO_3- (mg/L)	0.34	0.35	0.11	0.9	0.07	0.01	0.08	0.02	0.22	0.19
SO_4 2- (Us/cm)	1	1	1	1	1	1	1	1	2	1
PHO_4- (mg/L)	0	0	0	0	0	0	0	0	0	0
CL - (Mg/L)	0.3	0.08	0.38	0.81	1.16	0.64	0.34	0.34	0.51	0.57

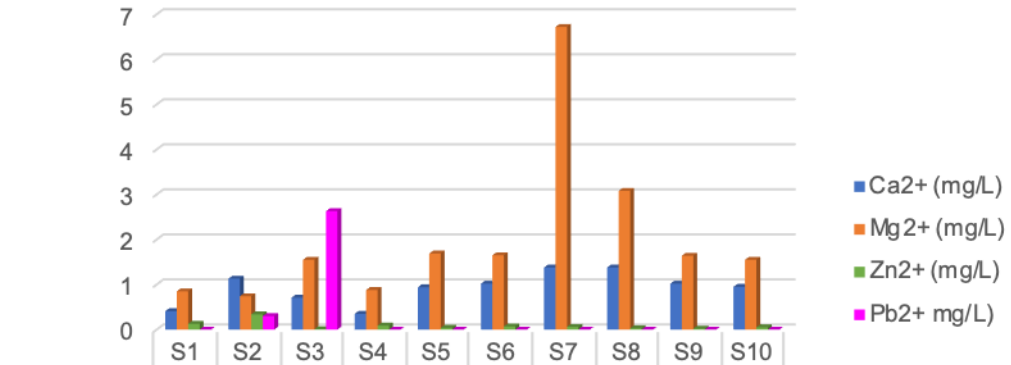
Fig. 2: Distribution of Anions across the Sachet Water Samples sold in Abuja Metropolis

The levels of Ca^{2+} in the sachet water ranged from 0.41 to 1.38 mg/L which were far less than the maximum limit of 200 mg/L recommended by [10]. Calcium ion is an important determinant of water hardness and it also functions as a pH stabilizer, because of the its buffering qualities. Calcium ion also gives water a better taste. The very low values of Ca^{2+} in the water samples indicated the softness of the water samples with respect to the ion. These values agreed with the low values obtained for Ca^{2+} by [28][29][30] from borehole in Kumasi, Ghana. Calcium is an essential mineral in drinking water, which helps in the formation of healthy bones and teeth.

The values for Mg^{2+} obtained from the sachet water analysis ranged from 0.74 to 6.72 mg/L which were within the limits of 150 mg/L recommended by the [17][25]. The low values of Mg^{2+} obtained from the samples agreed with the values obtained by [6][29][30] from underground water in East Java in Indonesia and by [6] from borehole samples in Kumasi Ghana.

The values of Zn^{2+} in the sachet water ranged from 0.02 to 0.34 mg/L which were within the maximum limit of 2.0 mg/L recommended by the [17]. Zinc is an essential mineral needed by human for building up immunity, however, when taken orally in large amount, it can lead to stomach cramps, nausea and vomiting [26][27].

The level of Pb^{2+} the sachet water ranged from 0.00 to 2.63 mg/L. The level of lead in two (2) of the water samples (S2 and S3) were above the [10] maximum limit of 0.01 mg/L. Lead is a toxic heavy metal that is persistent in the environment and can accumulate in the body over time. The possible sources of lead in the sachet water samples are; corrosion of plumbing works, pollution of the water source, water factory equipment and industrial activities in the area of production of the sachet water. The S2 and S3 with high level of lead should be withdrawn from circulation and further investigation on the presence and source of lead in the water be carried out. There should also be further treatment during the production process to avoid lead poisoning of the unsuspected public. A bar chart showing the distribution of cations in the samples is shown in Figure 3.



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Ca2+ (mg/L)	0.41	1.13	0.71	0.35	0.94	1.02	1.38	1.38	1.02	0.95
Mg2+ (mg/L)	0.85	0.74	1.55	0.88	1.69	1.65	6.72	3.08	1.64	1.55
Zn2+ (mg/L)	0.13	0.34	0.01	0.09	0.04	0.07	0.06	0.03	0.02	0.05
Pb2+ mg/L)	0	0.3	2.63	0	0	0	0	0	0	0

Fig. 3: Distribution of Cations across the Sachet Water Samples sold in Abuja Metropolis

Conclusion

The research assessed the physicochemical and elemental properties of 10 brands of sachet water sold in eight (8) communities of the Federal Capital Territory, Abuja, Nigeria. The results revealed that all the parameters, apart from lead, analysed for were within the regulatory limits set for drinking water quality. The levels of lead in two of the ten samples (S2 and S3) were 0.3 mg/L and 2.63 mg/L respectively instead of the <0.01 mg/L recommended. Therefore, the eight brands of water with properties within the recommended limits are good for consumption while the two with elevated levels of lead be withdrawn from circulation and further investigation on the presence and source of lead in them be carried out. There should also be further treatment during the production process to avoid lead poisoning of the unsuspected public.

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