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QUALITY EVALUATION OF BOTTLED WATER PACKAGED WITHIN NIGER STATE, NIGERIA

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ABSTRACT

Ten different brands of bottled water were procured from different regions of Niger State, Nigeria for this study. The labeling information, temperature, pH, turbidity, electrical conductivity, total hardness, chloride, alkalinity, lead, copper, manganese and iron contents of the water samples were determined using standard methods. The investigation revealed that the temperature, pH, electrical conductivity, total hardness, chloride and alkalinity of the samples ranged between 26.5±0.50–28.0±0.00 ^{o}C, 6.20±0.09–7.33±0.30, 13.5±1.50– 317.5±1.50 µScm^{-1}, 13-125 mg/L, 2.89 - 31.36 mg/L and 5-60 mg/L, respectively. Lead and copper were not detected in all the samples except SB10 with 0.01 mg/L of copper. Similarly, manganese was detected in six samples at concentrations between (0.02-0.08 mg/L) while iron ranged between 0.01-0.16 mg/L). The physical, chemical and heavy metals composition of the water samples complied with World Health Organization (WHO) and Standard Organization of Nigeria (SON) permissible limits for drinking water except the pH of one sample (SB8) that was below the permissible limit. However, 60% of the brands had no manufacturing and expiry dates on their label as required by the Nigeria's National Agency for Food and Drug Administration and Control (NAFDAC). Therefore, periodic evaluation and monitoring by concerned agencies should be intensified to ensure that bottled water producers in the state strictly adhere to the standard operating procedures.

Keywords: Bottled water, heavy metals, physical examination, physicochemical, recommended standards.

INTRODUCTION

Water is an integral part of human life and an indispensable natural resource for the well-being and socio-economic development of every nation [1-3]. It is very abundant in nature as it occupies about 70% of the earth crust. Yet, about 70% of Nigerian populace and 1.2 billion people globally lack access to portable water [4]. Many health challenges in developing countries are associated with inaccessibility to safe water. About 80% of all the diseases and over 30% of death in the developing countries are attributed to drinking water [4-6]. Also, five million children die annually from diseases attributed to consumption of contaminated water [7-8]. Larger percentages of the diseases are infectious. The presence of toxic inorganic chemicals in drinking water may cause cancer, respiratory and nervous system disorder, damages to immune system and organs, abnormal physical and mental development in babies and young children, internal hemorrhage and birth defects [9].

Niger State, like several other states in Nigeria, is faced with problem of shortage of adequate potable water. The supply of public pipe borne water is grossly inadequate due to increased population and human activities. Consequently, many households sought for alternative sources (boreholes, hand-dug wells, ponds, water vendors and packaged water) to meet their domestic water needs [10-13].

The quality of water obtained from these sources in Niger State has been evaluated by different researchers [2-3, 12-14]. Studies on water quality in Suleja, Niger State revealed that the analyzed water samples; hand-dug wells, boreholes and surface water in the area were poor for domestic purposes [2]. Yisa *et al.* [12] worked on underground water quality assessment in Doko Community, Niger State, Nigeria, and reported that the chemical oxygen demand (COD) and nitrate (NO_3^-) values of the water samples exceeded the permissible limit of WHO, while chloride and iron contents were below the WHO limits. A study on selected sachet water produced in some part of Minna, Niger State, Nigeria revealed that the pH, iron, copper and nitrate values of some of the samples analyzed did not conform to WHO/EPA standards [14]. Gimba [3] also assessed the quality of drinking water in Bosso Town, Niger State. The result of the analysis on forty water samples obtained from pond, wells, borehole, tap and sachet water in the study area; revealed that 11.1% and 33.3% of well water samples had nitrite (NO^-_2) and nitrate (NO_3^-) contents higher than the recommended values, while residual chlorine for tap and

sachet water was below 0.5 mg/L WHO recommendation. The study also showed that the only samples from borehole failed to meet the guideline value for both iron and fluoride. In view of this, people tend to go for bottled water which they considered to be safe for drinking because of its pleasant taste, absence of odour and the belief that it is free from microbial contamination and harmful chemicals.

A number of studies have been carried out on the quality of bottled water in different parts of Nigeria and other parts of the world. The quality evaluation of bottled water in Isuochi town of Abia State, revealed that most of the samples analyzed had copper, iron, zinc, calcium and magnesium above WHO and SON recommended limits [15]. Assessment of bottled water in Gboko Metropolis in Benue State revealed that 25% of the bottle water samples analyzed had iron content above WHO recommended limits [1]. In a study carried out in Imo State, the analyzed bottled water brands were within SON recommended limits for the investigated parameters [16]. Similarly, bottled water produced and/or sold in Ibadan metropolis, Oyo State were of good quality [17]. The report on bottled drinking water in Zimbabwe showed that the investigated bottled water brands failed to comply with WHO guidelines for drinking water [18].

In spite of the prevalence of bottled water within Niger State, limited report has been documented on the quality of bottled water in the state in recent time. Thus, this study aimed to evaluate the labeling information, physicochemical parameters and heavy metals composition of some bottled water packaged within Niger State, Nigeria with a view to ascertain their level of compliance with international and national recommended standards for drinking water.

EXPERIMENTAL

Study Area

Niger state is in North-central Nigeria. The study areas are located in Niger State. The State lies on the Guinea savanna zone at latitude 9^0 37 N and longitude 6^0 33 E (Fig.1). It covers an area of 76,363 square kilometers with a population of 3,950,249. Its capital is in Minna with an estimated population of 304,113 according to 2006 population census [19].

Sampling

Bottled water samples packaged within Niger state, Nigeria, were collected from different regions in the state for the purpose of this research. A total of ten brands which include Sabo

Best, Habees, Maizube, BHG, Goje, FUTMIN, Supreme, Golden Age, Mutunci, and Dan Yabo bottled water were identified and purchased from vendors in Kontagora, Bosso and Chanchaga (Fig. 2) LGAs in the state as packaged by the manufacturers.

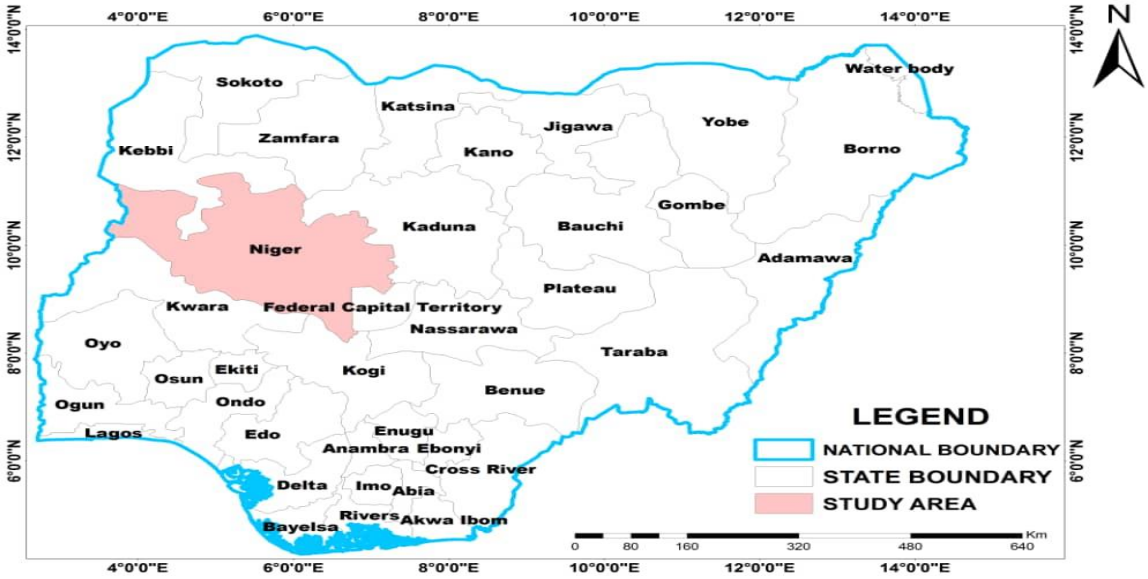

Figure 1: Niger State in Nigeria Context

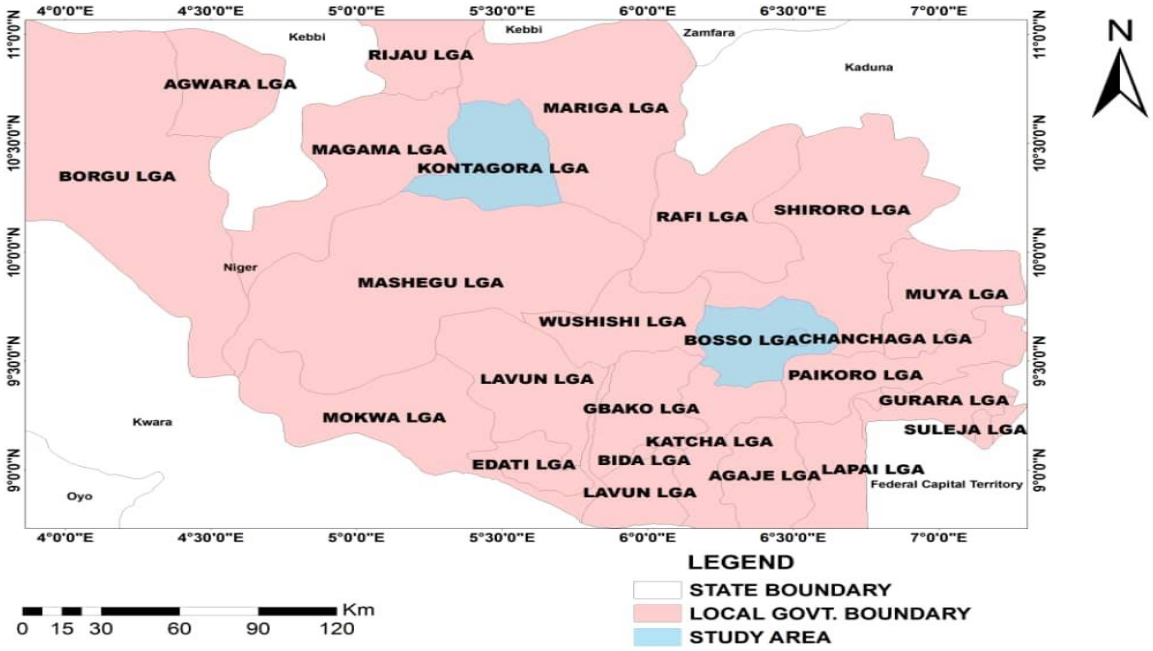

Figure 2: The Study Areas in Niger State Context

Physical Examination of Labeling

The labeling information was physically examined on each sample [4, 20].

Determination of Physicochemical Parameters

A simple mercury-in-glass thermometer (Model HACH/210) was used to determine the temperature of all the water samples shortly after they were obtained. The pH of each water sample was determined using a pH meter (Model PHS-25). The electrical conductivity and turbidity were measured using electrical conductivity meter (Model DD-307) and turbidity meter (Model WT 3020), respectively. Chloride, total alkalinity and total hardness were determined according to the method prescribed by APHA [21].

Heavy Metals Analysis

The heavy metals (Cu, Mn, Pb,and Fe) of the water samples were determined with atomic absorption spectrophotometer (Model AA500) following the procedure described by Chinedu *et al*. [22].

RESULTS AND DISCUSSION

Physical Examination of Bottled Water

The result of the labeling information obtained from physical examination of bottled water samples as required by the National Agency for Food and Drug Administration and Control (NAFDAC) is presented in Table 1.

Table 1: Physical Examination of Bottle Water

S/N	Product/ Parameter	Product Name	Manufacturer Address	Manufacturing Date	Batch Number	Expiry Date	NAFDAC Number
1	SB1	+	+	-	+	-	+
2	SB2	+	+	-	+	-	+
3	SB3	+	+	-	+	-	+
4	SB4	+	+	-	+	-	+
5	SB5	+	+	+	+	+	+
6	SB6	+	+	+	+	+	+

7	SB7	+	+	-	+	-	+
8	SB8	+	+	+	+	+	+
9	SB9	+	+	-	+	-	+
10	SB10	+	+	+	+	+	+
Ref	WHO guidelines	+	+	+	+	+	+
Ref	SON guidelines	+	+	+	+	+	+

+ = Indicated, - = Not Indicated, [7, 23]

NAFDAC stipulates that all information on the labeling of food and drugs must be informative and accurate [4, 24-25]. From the results, all the examined samples showed 100% compliance concerning product name, manufacturer address, batch number and registration number as they are clearly displayed on the labeling. However, only 40% indicated manufacturing and expiry date on their labeling. The NAFDAC number on the labeling is an indication that the factories are duly registered and certified to operate by NAFDAC while batch number is highly useful to track and withdraw any product from the market in case of discovery of defects in the product. The manufacturing and expiry dates are crucial as they indicate the period within which the consumer can consume the water while the manufacturer's address gives information of where the factory is located. Therefore, lack of compliance to the stipulated standards by some packaged water manufacturer as observed in this present study could impact negatively on the health of consumers.

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Physicochemical Parameters of Bottled Water

The results of physicochemical parameters of the investigated samples are presented in Figure 3-7.

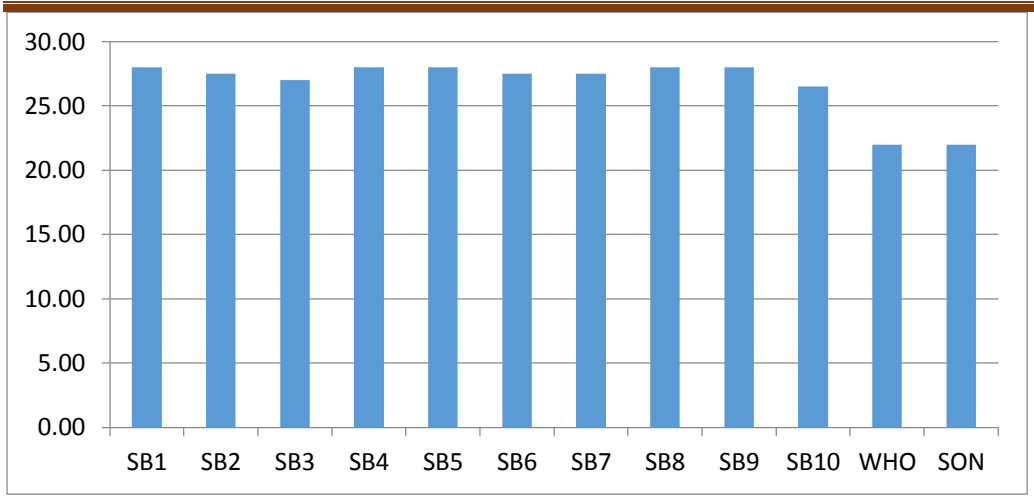

Figure 3: Temperature of Bottled Water

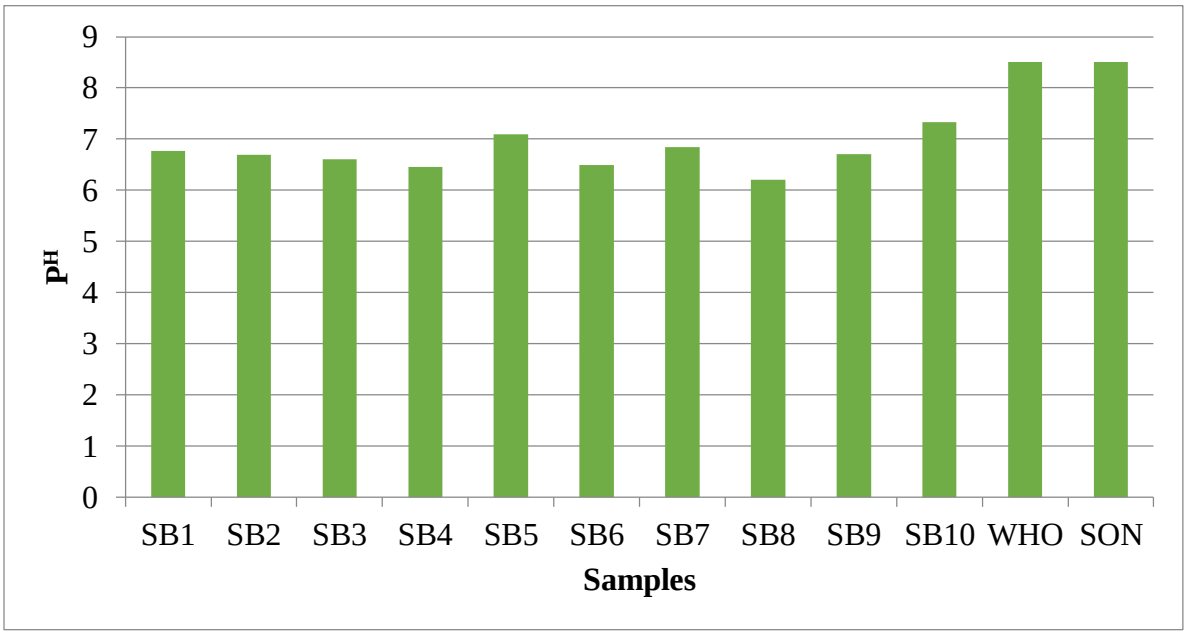

Figure 4: pH of Bottled Water

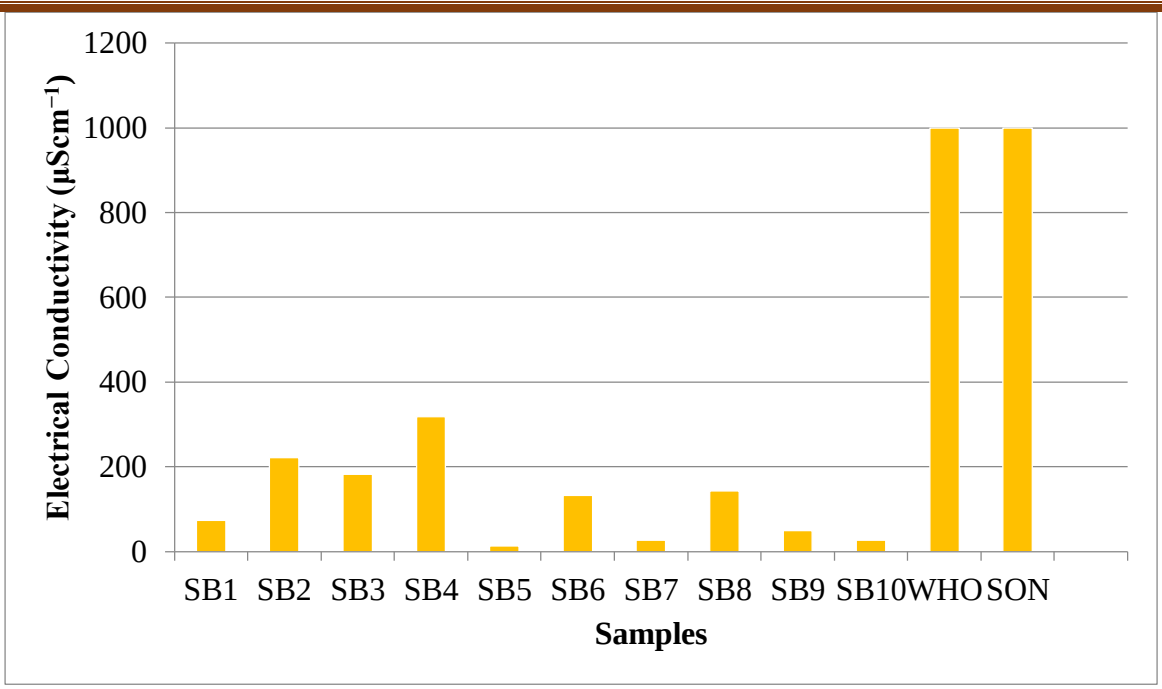

Figure 5: Electrical Conductivity of Bottled Water

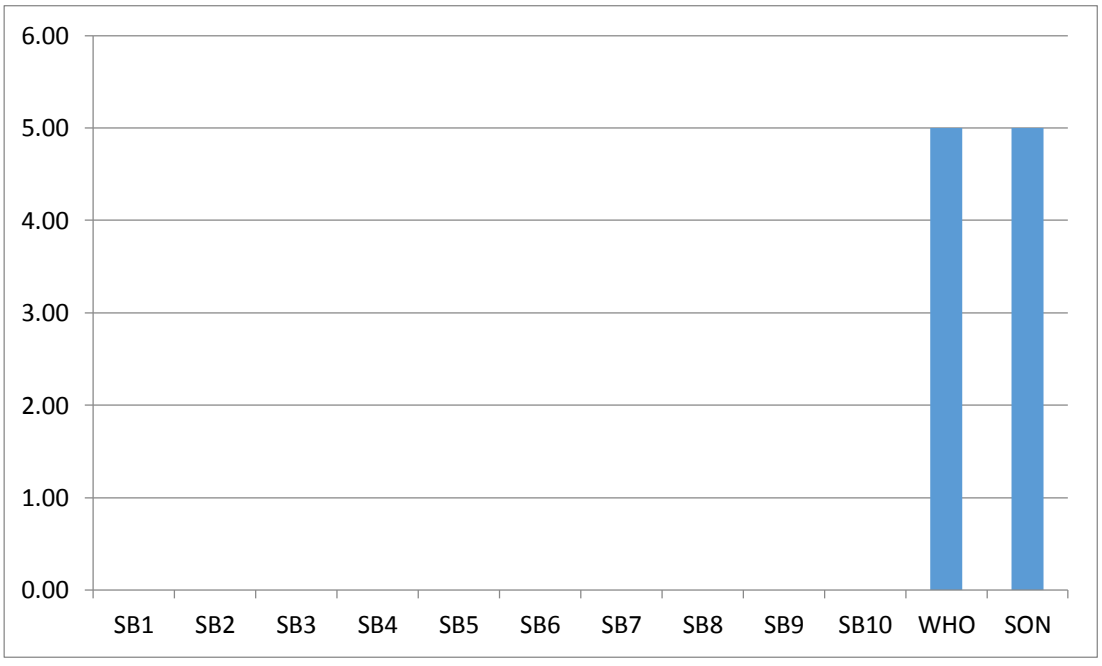

Figure 6: Turbidity of Bottled Water

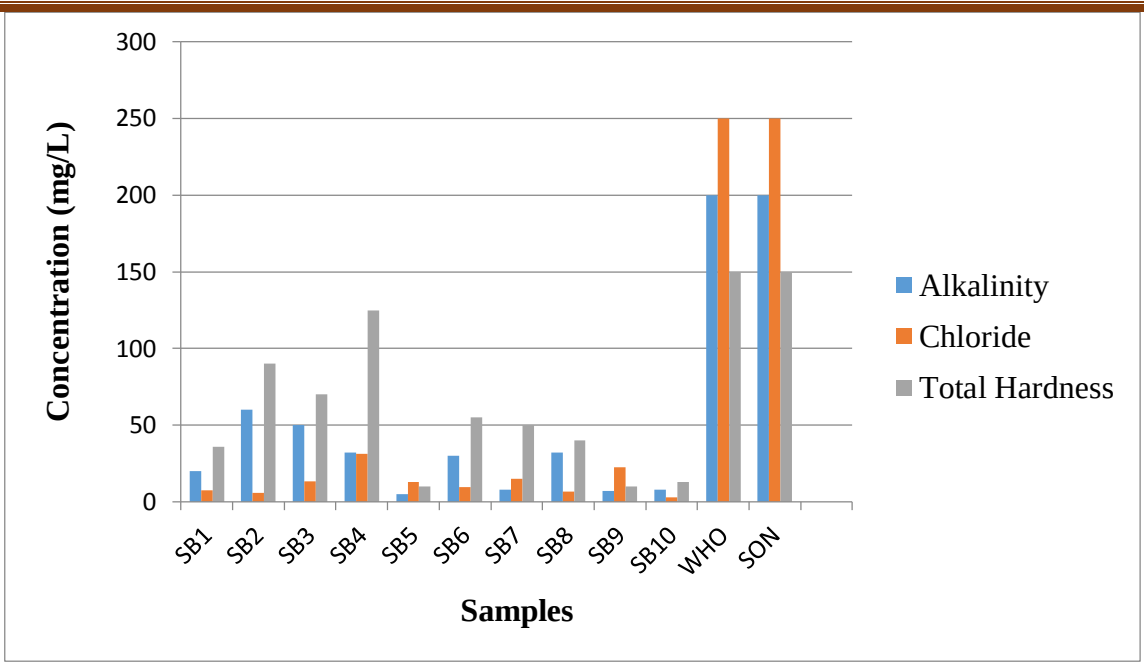

Figure 7: Chemical Parameters of Bottled Water

Temperature is the measure of the average thermal energy of a substance. The temperature of the bottled water samples ranged from 26.5±0.50 to 28.0±0.00 ^{o}C (Fig. 3). These values are within the ambient temperature recommended by the Standard Organization of Nigeria (SON). The values were similar to the temperature range of 26.1-27.0 reported by Ibrahim *et al.* [4]. Temperature influences the chemical and biochemical qualities of water [26-27].

The pH values of the bottled water samples were between 6.20±0.09-7.33±0.30 (Fig. 4). All the samples had pH values in agreement with the recommended standards except sample SB8 (6.20±0.09) that was slightly below WHO and SON set limits of 6.50-8.50. The pH of this sample needs to be adjusted as they are likely to dissolve heavy metals or cause acidosis.

The electrical conductivity of the water samples analyzed was found to range from 13.5±1.50–317.5±1.50 µScm^{-1} (Fig. 5), which is far below the maximum 1000 µScm^{-1} recommended by WHO and SON for drinking water. The low value is due to the presence of a minute amount of dissolved salt. Duru and Ike [16] reported similar results of 10–270 µScm^{-1} from their findings on the quality assessment of popular bottled water brands sold in Owerri Municipal, Imo State, Nigeria.

The total hardness of the packaged water ranged from 13-125 mg/L, as shown in Fig. 7. This indicates that all the water samples analyzed were within the recommended standards. This is due to the absence of bicarbonates and sulphates of alkali metals in the water samples, except SB4 (125 mg/L), which is hard. The values observed in this study were higher than 4.01-26.05 mg/L and 0.8-3.0 mg/L reported for Quality of Bottled Water in Isuochi Town of Abia State and Nsukka Town respectively [5, 15].

The chloride of the packaged water analyzed ranged between 2.89 - 31.36 mg/L as shown in a Fig. 7. This indicated that chloride ion was present in all the water samples investigated, but at a low concentration below 250 mg/L maximum permissible concentration set by WHO and SON for drinking water. Higher concentrations of chloride ions in water add to its taste, increase concentrations of other metals and cause hypertension [14, 28-29]. The values in this study were higher than 0.00 to 0.13 mg/L reported for Bottled Water Brands Sold in Owerri Municipal, Imo State, Nigeria [16], 1.87 –5.83 mg/L for water marketed in Bauchi Metropolis Nigeria [4] and 1.04 –7.89 mg/L for bottled Sold in Nsukka Town, Nigeria [5].

Alkalinity is the ability of water to neutralize the acidic effect of water which can be a result of the presence of carbonate and bicarbonate in water. The alkalinity of bottled water in this study ranged between 5-60 mg/L (Fig. 7). These values fall within the WHO specifications (200 mg/L) allowed for drinking water. An increase in the total alkalinity of water is due to an increase in bicarbonates in such water [30], and high alkalinity in water gives unpalatable taste [31]. The result obtained in this study is higher compared to the alkalinity between 2.00-14.00 mg/L for bottled water in Isuochi town, Abia State, Nigeria [15].

Heavy Metals Composition of Bottled Water

The result of the heavy metal analysis in this study is presented Fig. 8.

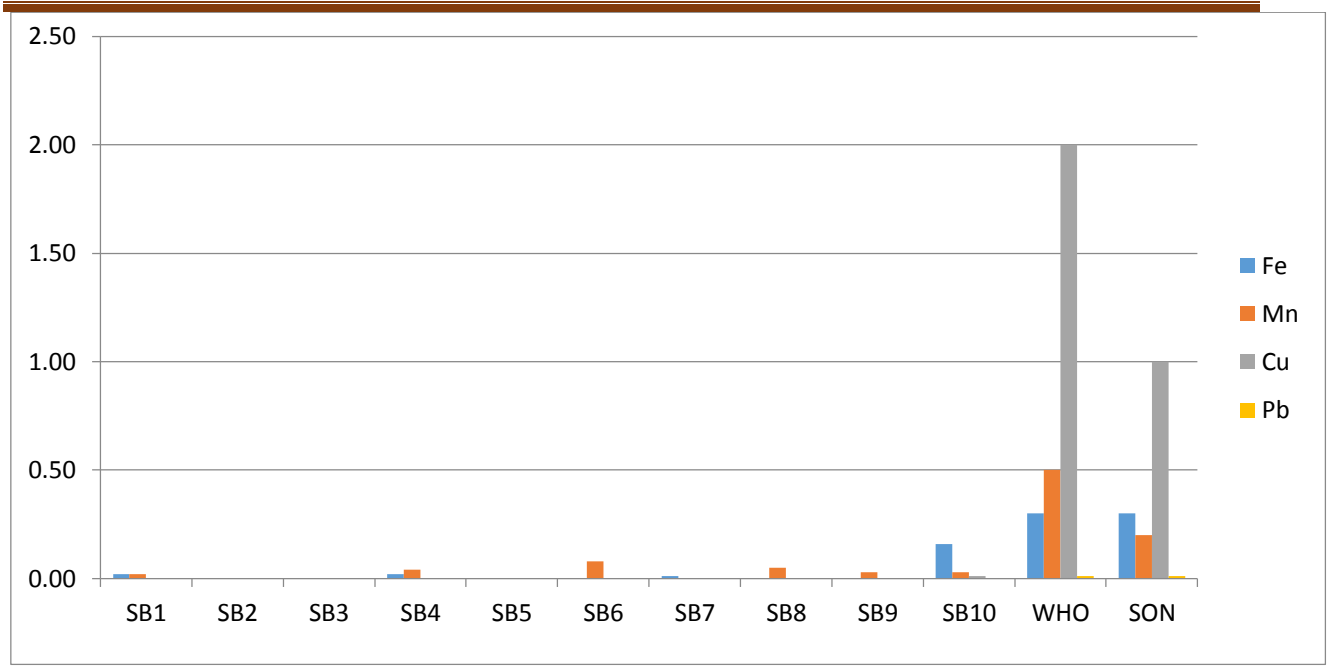

Figure 8: Distribution of Heavy Metals in Bottled Water

The result of the heavy metal analysis in this study presented Fig. 8, revealed that copper present in only one sample (SB10) at a concentration of 0.01mg/L while lead was not detected in any of the samples. Manganese was not detected in four samples while the remaining six brands SB1, SB4, SB6, SB8, SB9, SB10 revealed the presence of manganese at a concentration ranging between 0.02-0.08 mg/L. Iron was absent in most brands except SB1, SB4, SB7, and SB10 that contained appreciable quantity at a concentration between 0.01-0.16 mg/L.

Copper is a trace element that occurs naturally in water at a very little quantity in drinking water [32]. The maximum concentration of copper set by SON for drinking water is 1.00 mg/L. From the analysis, none of the samples was observed to contain the trace element above the stipulated concentration. When copper in drinking water exceeds the stipulated concentration, it can cause gastrointestinal disorder [33].

The non-detection of lead in the samples can be due to the non-contact of the water source with indiscriminate dispose of refuse. WHO [7] and SON [23] recommend maximum of 0.01 mg/L of lead to be present in drinking water. High levels of lead in drinking water have a lot of health impacts which include cancer, interference with Vitamin D metabolism, effect on mental development in infants; and toxicity to the central and peripheral nervous systems [33].

CONCLUSION

This study evaluated the labeling information, physicochemical and heavy metals composition of selected bottled water brands packaged within Niger State, Nigeria. The results obtained were compared with the standards recommended by WHO [7] and SON [23]. The results showed that the water samples complied with WHO and SON in terms of physical, chemical and heavy metal characteristics except the pH of one sample that was below the permissible limit. In addition, 60% of the brands had no manufacturing and expiry dates on their label as recommended by NAFDAC. Therefore, concerned agencies should carry serious surveillance and monitoring to ensure that bottled water producers in the state strictly adhere to the standard operating produces. In view of the growing demand for packaged drinking water in the state, it is recommended that further studies be conducted intermittently to analyze wide range of water quality indices. Also, it is recommended that the producers strictly adhere to the rules and regulations guiding bottled water production and packaging.

REFERENCES

[1] Akpen, G. D., Kpoghol, I. S., & Oparaku, L. A. (2018). Quality Assessment of Sachet and Bottled Water Sold in Gboko, Benue State, Nigeria. *Nigerian Journal of Technology*, 37(1), 241-248.

[2] Amadi, A. N., Obaje, N. G., Goki, N. G., Abubakar K. U., Shaibu, I. &Nwakife, C. N. (2016). Studies on Water Quality in Suleja, Niger State for Domestic and Irrigational Purposes. *Journal of Natural and Applied Sciences*, 5(1), 16-29.

[3] Gimba, P. B. (2011). Assessment of Quality of Drinking Water in Bosso Town, Niger State. M.Sc Dissartation, ABU,Zaria. 2000pp.

[4] Ibrahim, D. M., Musa, U., &Akindele, A. A. (2015). Quality Assessment of Sachet and Bottled Water Marketed in Bauchi Metropolis Nigeria. *Journal of Environmental Management and Safety*, 37, 11-23.

[5] Oweluzo, J. C. &Akuagbazie, C. A. (2010). Assessment of Quality of Bottled and Sachet Water Sold in Nsukka Town. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension*, 9(2), 104 – 110.

[6] Olaoye, O. A. & Onilude, A. A. (2009) Assessment of microbiological quality of sachet-

packaged drinking water in Western Nigeria and its public health significance. *Public Health*, 123 729–734. doi:10.1016/j.puhe.2009.09.

[7] WHO (2011). Guidelines for Drinking Water Quality, 4th ed., Geneva, Switzerland.

[8] Shittu, O. B., Olaitan, J. O., & Amusa, T. S. (2008). Physico-Chemical and Bacteriological Analysis of Water Used for Drinking and Swimming Purpose. *Afr. J. Biochem. Res*, 11, 285-290.

[9] Isa, M. A., Allamin, I. A., Ismail, H. Y., & Shettima, A. (2013). Physicochemical and Bacteriological Analysis of Drinking Water from Wash Boreholes in Maiduguri Metropolis, Borno State, Nigeria. *African Journal of Food Science*, 7(1), 9-13 DOI: 10.5897/AJFS12.073.

[10] Emigilati, A. H., Mohammed, I. I., Kuta, G. I, Usman, B. Y., & Hassan, A. B. (2014). An assessment of Alternative Water Source for Domestic Use in Minna Metropolis, Niger State. *Nigeria. Journal of Environment and Earth Science*, 4(18), 10-15.

[11] Adeleye, B. A., Medayese, S. A., & Okelola, O. L. (2014). Problems of Water Supply and Sanitation in Kpakungu Area of Minna Nigeria. *Journal of Culture, Politics and Innovation*, 9(2), 1-29.

[12] Yisa, J., Gana, P. J., Jimoh, T. O., & Yisa, D. (2012). Underground Water Quality Assessment in Doko Community, Niger State Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences*, 3(2), 363-366.

[13] Adegbehin, A. B., Yusuf, Anumonye, E. N., &Shehu, A. U. (2016). Problems of Domestic Water Supply in Dutsen Kura Gwari, Chanchaga Local Government Area of Niger State. *Nigeria Journal of Geography, Environment and Earth Science International, 7*(4), 1-9.

[14] Ndamitso, M, M., Idrisi, S., Likita, M. B., Tijani, Y. O, Ajai A. I., &Bala, A. A. (2013). Physico-chemical and Escherichia coli Assessment of Selected Sachet Water Produced in Some Areas of Minna, Niger State, Nigeria. *International Journal of Water Resources and Enviromental Engineering*, 5(3), 134-140.

[15] Abasiekong, K. S., Dim, F. A., & Azubike-Izah, F. O. (2016). Quality Evaluation of Sachet and Bottled Water in Isuochi Town of Abia State - South East Nigeria. *Food Science and Quality Management*, 50, 65-72

[16] Duru, C. E., & Ike, E. M. (2017). Quality Assessment of Popular Bottled Water Brands Sold in Owerri Municipal, Imo State, Nigeria. *International Journal of Chemical, Material and*

Environmental Research, 4(2), 118-122.

[17] Airaodion, A. I., Ogbonnaya, E., Awosanya, O. O., Ogbuagu, E. O., Ogbuagu, O., & Okereke, D. (2019). Assessment of Sachet and Bottled Water Quality in Ibadan, Nigeria. *Global Journal of Nutrition & Food Science, 1(4), 1-12.*

[18] Gombiro, P. E., Mukaro, J., Mugadza, K., Ashley, G., Zaranyika, M. F., & Benhura, C. (2014). Drinking Water Quality Assessment in Zimbabwe: A Case Study of Bottled Drinking Water from Selected Retail Outlets in Harare. *Journal of Chemical, Biological and Physical Sciences*, 4(3), 2691-2700.

[19] www.nigerstate.gov.ng: Government of Niger State Official Website [Accessed on 26/03/2020].

[20] Oyeku, O., Omowumi, O., & Kupoluyi, C. (2001). Wholesomeness Studies of Water Produced and Sold in Plastic Sachets (Pure Water) in Lagos Metropolis. *Nigerian Food Journal*, 2(11): 63-69.

[21] APHA. (1998). Standard for the Examination of Water and Waste Water, 18th Edition. American Public Health Association (APHA).American Water Works Association (AWWA) and Water Pollution Control Federation (WPCF) Washington, D.C, 10-195.

[22] Chinedu, S. N., Nwinyi, O. C., Oluwadamisi, A. Y., & Eze, V. N. (2011). Assessment of Water Quality in Canaanland, Ota, Southwest Nigeria. *Agriculture and Biology Journal of North America*, 2(4), 577-583. doi:10.5251/abjna.2011.2.4.577.583.

[23] SON (2007). Nigerian Standard for Drinking Water Quality. ISC 13.060.20, Nigeria Industrial Standard, NIS-554-2015.Abuja, Nigeria. Pp.15–16.

[24] Dada, A.C (2009). Sachet Water phenomenon in Nigeria: Assessment of the potential health impacts. *African Journal of Microbiology Research*, Vol.3 (1), 015-021, Available online http://www.academicjournals.org/ajmr.

[25] Musa, U., Aliyu, M.A., Sadiq, M. M., Mohammed, I. A, Manase, A. & Mustapha, D.I. (2014). Quality Assessment of Sachet Water in Minna Metropolis of Niger State, Nigeria, *Proceedings of 44th Annual Conference, Exhibition of Nigerian Society of Chemical Engineers (NSChE),* Nov. 20-22nd, 2014, Owerri, Imo State.

[26] Manjare, S. A., Vhanalakar, S. A. & Muley, D. V. (2010). Analysis of water quality using physicochemical parameters of Tamdalge Tank in Kolhapur district, Maharashtra.

International Journal of Advanced Biotechnology and Research. 1(2): 115-119.

[27] Samuel, O., John, N., & Frederick, O. (2018). Physicochemical Studies of Public Hand- Pump Borehole Water in Onueke, Ezza Local Government Area of Ebonyi State, Nigeria. *American Journal of Quantum Chemistry and Molecular Spectroscopy,* 2(2), 31-38. doi: 10.11648/j.ajqcms.20180202.12.

[28] Barati, A. H; Maleki, A. & Alasvand, M. (2010). Multitrace Element Level in Drinking Water and the Prevalence of Multichronic Arsenical Poisoning in Residents in the West Area of Iran. *Science of the Total Environment*, 408(7), 1223-1233.

[29] WHO (2006). Guidelines for Drinking Water Quality 1st Addendum V.1.1 Recommendations. 3rd Edition Electronic version for the Web.http//www.who.int/water.

[30] Basavaraja, S; Hiremath, S. M, Murthy, K. N. S., Chandrashekarappa, K. N., Patel, A. N. & Puttiah, E. T. (2011). Analysis of Water Quality Using Physicochemical Parameters from Hosahalli Tank in Shimoga District,Karnataka, India. *Global Journal of Science Frontier Research*, 1(3), 31-34.

[31] Goel, P. K. (2006). Water Pollution: Causes, Effects and Control. (2nd Ed.). *Macmillan Publishers, London,* 154-232.

[32] Saleh, M. A., Ewane, E., Jones, J. & Wilson, B. (2001). Chemical Evaluation of Commercial Bottled Drinking Water from Egypt. *Journal of Food Composition and Analysis*, 14, 27-152. doi.10.006/jfca.2000.0858.

[33] SON (2015). Nigeria Standard for Drinking Water Quality. ISC 13.060.20, Nigeria Industrial Standard, NIS-554-2015. Abuja, Nigeria. pp. 17-18.