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PHYSIOCHEMICAL AND BACTERIOLOGICAL ANALYSIS OF SELECTED SACHET WATER IN JERE AND MAIDUGURI, BORNO STATE NIGERIA

Mohammed Modu Aji[1]*, Shettima Abba Kyari[2] and Mustapha Hussaini[3]
[1, 3]Department of Chemical Engineering University of Maiduguri, Borno State Nigeria
[2]Department of Chemistry Federal College of Education Technical (FCE) Potiskum, Yobe State Nigeria
*Corresponding author: ajimohammed@ymail.com

Abstract

The study involved the determination of some physiochemical and bacteriological properties in sachet-water samples taken within selected geopolitical wards in Jere and Maiduguri Metropolis. The purpose was to ascertain the quality of sachet water sold for consumption within the area. Ten samples were drawn, five from each study area. The samples were analysed for temperature, colour, turbidity, pH, conductivity, iron, total alkalinity and total dissolved solid. Bacteriological analysis was also carried out using multiple tube (most probable number) technique for enumeration of both total coliform count and differential *Escherichia coli* count. Other physical examination like volume, National Agency for Food and Drugs Administration and Control (NAFDAC) registration number, batch number, production date and expiry date were also examined. The results obtained were compared with World Health Organization (WHO), NAFDAC and Nigeria Standard of Drinking Water Quality (NSDWQ). Variations were observed among the entire samples in comparison with the standard. Some of the parameters conform to the standard like the Tempreture, pH, colour, odour, iron content and NAFDAC registration number while others like TDS, total alkalinity and volumetric quantity fell below the standard. The bacteriological analysis also showed that 80% of the samples studied revealed the presence of *coliforms*. Hence, there is need for regulatory agencies like NAFDAC and Standard Organisation of Nigeria (SON) to intensify effort in the routine monitoring of quality of sachet water marketed for consumption.

Keywords: NAFDAC, WHO, NSDWQ, Standard, Sachet Water.

Introduction

The quality of drinking water is a powerful environmental determinant of health (WHO, 2010). Water plays an indispensable role in sustenance of life and it is a key pillar of health determinant, since 80% of diseases in developing countries are due to lack of good quality water (Cheesbrough, 2006). Drinking water quality management has been a key pillar of primary prevention of disease for over one and half centuries and it continues to be the foundation for the prevention and control of water borne diseases (WHO, 2010). Contaminated water is a global public health threat placing people at risk of a host of diarrhea and other illness as well as chemical intoxication (Okonko *et al.*, 2009).

Many years of neglect by the government and inadequate investment has left the public drinking water supply in Nigeria in an unreliable state. The society has therefore taken several adaptive measures of alleviating this stress. One of these is dependent on sachet water, popularly referred to as 'pure water' (Dada, 2009). The quality of sachet water has been questioned based on research findings (FAO, 1997; Adekunle *et al*. 2004 and Dada, 2009), and NAFDAC has been monitoring the production and quality of sachet water. However, most manufacturing factories abandon NAFDAC's guidelines on quality soon after they get registered. (Waziri & Bomai, 2012). Increase in human population pose a great pressure on provision of safe drinking water especially in developing countries (Okonko *et al*., 2009).

The study of environmentally polluted water in particular has been of considerable importance not only to analytical chemist, but also to engineers, hydrologists and pathologists. Since most of these contaminants pose great threat to man's life due to lack of proper water quality monitoring and evaluation, analysis of natural water for physical and chemical properties therefore becomes important for public health studies (Kot *et al.,* 2000; Soylak *et al*., 2002). Portable water supply is the responsibility of government; unfortunately this is not always met especially in developing countries like Nigeria where this is characterized by low productivity and inefficient service delivery compounded by limited technology, insufficient technical inputs and poor maintenance culture (Amoo and Amuho, 2005).

Studies done by previous authors' show that the physicochemical analysis of sachet water commonly known as "pure water" carried out in some part of the country is heavily contaminated. Waziri and Bomai (2012) reported that there are considerable variations among the examined samples with respect to their chemical constituents which occasionally fell above the Nigerian Drinking Water Standards as stipulated by the National Agency for Food and Drugs Administration and Control (NAFDAC). Jere and Maiduguri Metropolis are urbanized area in the north-eastern part of Nigeria where several brands of bottled and sachet water are sold to the public. The continuous proliferation of these packaged water products and their indiscriminate consumption are of concern to public health. Thus, this may justify the purpose of this research.

It is a fact that good water quality produces healthier humans than one with poor quality (Anjum *et al.*, 2013). Therefore, the study was undertaken to determine some physicochemical and bacteriological parameters of some selected sachet water vended for drinking in Jere and Maiduguri Metropolis, so as to ascertain the quality of sachet-water considered for human consumption and determine its suitability for drinking compared with the standard guidelines set by WHO and NAFDAC to avoid endangering the populace.

Materials and methods

Study Area

The study was conducted in Jere and Maiduguri metropolitan areas of Borno state, located in northeastern Nigeria. It covers more than 3000 km of different land units. Maiduguri and Jere environs are known for dryness, with semi-arid climate, savannah or tropical grasslands vegetation, light annual rainfall of about 300 to 500 mm and the average daily temperature ranging from 22 to 35°C, with mean of the daily maximum temperature exceeding 40°C between March and June before the onset of the rains in July to September (Hauwa *et al.*, 2013). It has mainly sandy and loamy soils (Arku *et al.*, 2011). It is divided into twenty-one different geographical zones (Rudiger, 2002).

Collection of water sample

In this study, ten producers of packaged water vended for consumption were randomly selected in Jere and Maiduguri Metropolis. The samples were collected in August, 2014 from five different geopolitical wards within Jere, which are: *Jiddari(A), Unimaid(B), Mairi(C), Mashamari(D) and Ngomari(E)* and that of Maiduguri Metropolis which includes: *Bulumkuttu(A), Gwange(B), Mashidimami(C), Moduganari(D) and Pompomari(E)* respectively. All samples were bought from the vendors in the stated areas and taken to the laboratory for analysis.

Physicochemical analysis

The water samples were analysed for temperature, colour, turbidity, pH, total dissolve solid, conductivity, iron content and total alkalinity using standard methods; Temperature, pH, turbidity and conductivity were measured by thermometer, digital pH meter (precise pH meter Model PHS-3C), UV-VIS Spectrophotometer and a conductivity meter as described by Uwah *et al* (2014). Total alkalinity, total dissolved solid (TDS) were analysed as described by FAO (1997). Other physical examination like: volume, NAFDAC (National Agency for Food and Drugs Administration and Control) registration number, batch number, production date and expiry date were also examined physically by visual sense organ.

Bacteriological analysis

Bacteriological characteristics of the water samples were determined using multiple tube fermentation method (most probable number) for enumeration of both total coliform

count and differential *Escherichia coli* count. Lauryl Tryptose Broth (LTB) along with fermentation tubes (Durham tubes) was used. A serial dilution of the water sample to be tested was made and inoculated into LTB growth media. Samples were then incubated at 35°C for 48 h for the presumptive test for total coliform count. After the positive tubes were transferred to brilliant green lactose bile broth (confirmation test) and incubated for 48 h at 35°C, the growth or gas production confirmed the presence of coliform (Nollet Leo, 2007).

Results and discussion

The results of the physicochemical and bacteriological properties of the sachet water vended for drinking in Jere and Maiduguri are presented in the tables below. The geopolitical areas selected within each study area were alphabetically coded A – E representing the five areas selected.

Table I. Physicochemical Properties of some selected sachet water in Jere.

S/N	Parameters	A	B	C	D	E	WHO		NAFDAC	NSDWQ
							HDL	MPL		
1	Temp (^oC)	27.20	26.81	28.35	29.9	27.50	-	40	-	Ambient
2	Colour	All the samples are colourless					6	-	15	15
3	Odour	All the samples are odourless								
4	pH	6.20	7.20	6.85	7.11	7.25	7-8.5	6.5-9.2	6.5-8.5	6.5-8.5
5	Volume (C l)	45	40	48	45	50				
6	Total Dissolve Solid (mg l^{-1})	79	81	65	84	82	500	1500	500	500
7	Conductivity (µs cm^{-1})	166	178	130	71	121	NS	NS	NS	1000
8	Turbidity (NTU)	0.30	0.24	0.28	0.26	0.33	5	25	-	5
9	Total Alkalinity (mg l^{-1})	14	15	17	19	18	80	120	100	-
10	Iron (mg l^{-1})	0.10	-	0.12	-	-	-	-	-	0.3
11	NAFDAC Reg.	All registered							Recommended	

Note: World Health Organization (WHO), National Agency for Food and Drugs Administration and Control (NAFDAC), Nigeria Standard of Drinking Water Quality (NSDWQ), No Standard (NS), Highest Desirable Limit (HDL), Maximum Permissible Limit (MPL).

Table II. Physicochemical Properties of some selected sachet water in Maiduguri.

S/N	Parameters	A	B	C	D	E	WHO		NAFDAC	NSDWQ
							HDL	MPL		
1	Temp (^oC)	28.20	27.85	31.0	27.0	27.50	-	40	-	Ambient
2	Colour	All the samples are colourless					6	-	15	15
3	Odour	All the samples are odourless								
4	pH	6.50	7.20	7.10	6.90	7.25	7-8.5	6.5-9.2	6.5-8.5	6.5-8.5
5	Volume (C l)	50	43	50	45	48				
6	Total Dissolve Solid (mg l^{-1})	81.50	84.80	80.67	78.50	85.70	500	1500	500	500
7	Conductivity (µs cm^{-1})	189	191	176	178	122	NS	NS	NS	1000
8	Turbidity (NTU)	0.60	0.53	0.23	0.55	0.48	5	25	-	5
9	Total Alkalinity (mg l^{-1})	15	17	20	28	34	80	120	100	-
10	Iron (mg l^{-1})	-	0.01	-	-	0.10	-	-	-	0.3
11	NAFDAC Reg.	All registered							Recommended	

Note: World Health Organization (WHO), National Agency for Food and Drugs Administration and Control (NAFDAC), Nigeria Standard of Drinking Water Quality (NSDWQ), No Standard (NS), Highest Desirable Limit (HDL), Maximum Permissible Limit (MPL).

Table III Bacteriological analysis of some selected sachet water in Jere

S/N	Samples	coliform count	*Escherichia coli* count (CFU $1ml^{-1}$)
1	A	3	Nil
2	B	0	Nil
3	C	6	Nil
4	D	**10**	Nil
5	E	**11**	Nil
6	NSDWQ standard	<10 per 100 ml	0
7	WHO standard	0 per 100 ml	0 per 100 ml

Table IV Bacteriological analysis of some selected sachet water in Maiduguri

S/N	Samples	Total coliform count	*Escherichia coli* count (CFU $1ml^{-1}$)
1	A	4	Nil
2	B	**14**	Nil
3	C	0	Nil
4	D	2	Nil
5	E	1	Nil
6	NSDWQ standard	<10 per 100 ml	0
7	WHO standard	0 per 100 ml	0 per 100 ml

Discussion

There are variations in temperature in all the samples analysed. The temperature ranged from 26.81- 31.0^{o}C. Though there is no recommended value for temperature (Howard, 2009), but variations in temperature were observed in all the samples, which may be attributed to the sampling location as suggested by (waziri and Bomai, 2012). The water samples were colourless, odourless and tasteless. This is in accordance with the results of Taiwo *et al.* (2012), Nwosu and Ogueke (2004), and Daniel *et al.* (2007); they observed that poor odour and taste may result from contamination with dusty particles and dissolved solids.

All the samples gave pH values within the recommended limit of 6.5-8.5 for drinking water (NAFDAC 2001, WHO 2006), indicating that all the samples are safe for human consumption, except for sample A in Jere area which fall below the recommended limit and hence it's in agreement with Hauwa *et al.* (2013). Low water pH can cause gastro-intestinal irritation in sensitive individuals (A.U, 2014) .The volumetric analysis shows that most of the sachet water samples are less in volume than what is labeled on their respective packages. All the sachet water were registered with appropriate regulatory agency (NAFDAC) but none of the sachet water producers indicated manufacturing date, expiring date and batch number on the sachet, therefore not complying with the labeling compliance as stipulated by the WHO (1997).

The Total Dissolved Solids (TDS) value recorded which range from (65.00 - 85.70 mg l^{-1}) is lower when compared to the approved standards of water quality of the World Health Organization (WHO), which is also in accordance to that of A.U, (2014). Low loaded TDS imparts flat, insipid taste to drinking water Marier *et al.* (1979). The conductivity and total alkalinity also ranged from (71 - 189 µs cm^{-1}) and (14 - 34mg l^{-1}) respectively, which were also found to be below the maximum permissible limits of 1000µs cm^{-1} and (80 –

120mg l^{-1}) set by the Standard Organization of Nigeria (SON) and WHO respectively. Turbidity ranged between 0.23±0.01 and 0.60±0.01 NTU, while the iron content is traceable in about 40% of the sample and not above the permissible limit recommended by NSDWQ (2007).

Going by the zero tolerance levels stipulated by regulatory agency for coliforms in drinking water, most of the packaged water studied did not meet the existing standards as shown in Table III and IV respectively. Based on WHO guidelines for water classification (2004), sachets water sample B, in Jere and the samples C, D and E in Maiduguri having less than three coliforms count per 100 ml belong to the satisfactory category while sachets water samples A and C in Jere and sample A in Maiduguri with less than 9 coliforms count per 100 ml of sample, belong to the intermediate category. Samples D and E in Jere and the sample B in Maiduguri have ten and above coliforms. Ten (10) coliforms count per 100 ml of sample is classified unsatisfactory and unfit for use WHO (1997, 2004). Previous studies in other parts of the country reported similar bacterial load indicative of poor water quality (Olayemi, 1999; Itah and Akpan, 2005). Relatively high aerobic colony counts are indicative of poor, unhygienic handling and processing. Bacteria growth in water may be unnoticed even in transparent packaged water and the presence of some of these microorganisms may pose a potential risk to consumer (Geldriech, 1996).

However, the bacteriological analysis in this study showed that 100% of the samples used for the analysis did not contain E. coli. Its presence in any drinking water poses a serious threat to health of individuals, since it is an intestinal parasite that may indicate faecal contamination (Rose et al., 1993)

Conclusion

It could be concluded that most of the sachet water studied are unfit for drinking purpose owing to the fact that 80% of the samples studied revealed the presence of *coliforms*. Therefore, they do not meet the bacteriological requirement of drinking water. Though some physiochemical parameters investigated were within the tolerable limit of Nigeria Standard of Drinking Water Quality (NSDWQ), NAFDAC and World Health Organization. But still some parameters also fail to conform to the standard. Hence, there is need for regulatory agencies like NAFDAC and SON to intensify effort in the routine monitoring of quality of sachet water marketed for consumption. They should also ensure that all sachet water contains both manufacturing and expiry dates as well as batch number for easy recall.

References

Adenkunle, L.V, Sridhar, M.K.C, Ajayi, A.A., Oluwade, P.A., Olawuyi, J.F., 2004. Assessment of the Health and Socio-Economic Implication of Sachet Water in Ibadan, Nigeria. Afri. J. Biomed. Res. 7(1):5-8.

Anjum Praveen, Rajesh Kumar, Pratima and Rajat Kumar, 2013. Physio- Chemical Properties of the Water of River Ganga at Kanpur International Journal of Computational Engineering Research||Vol, 03||Issue, 4||

Akoto, O. and Adiyiah, J., 2007. Chemical Analysis of Drinking Water from Some Communities in the Brong Ahafo Region. Int. J. Environ. Sci. Tech., 4(2): 211-214.

Amoo, I.A. and Amuho, U.E., 2005. Comparison of Water Quality in Concrete Ringed Water Wells and Unrigged Wells, M.Sc Thesis, Chemistry Department, Federal University Of Technology, Akure, Ondo State, Nigeria, Pp: 13.

Arku A.Y, Musa S.M, Mofoke A.L.E, Dibal J.M., 2011. Re-Examining Raw Effluents from Nigerian Bottling Company Maiduguri for Crop Irrigation. J. Appl. Phytotechnol. Environ. Sanit. 1 (1):43-49.

Cheesbrough, M., 2006. District Laboratory Practice in Tropical Countries. Part 2. Cambridge University Press. Pp. 143-157.

Dada A. C., 2009. Sachet Water Phenomenon in Nigeria: Assessment of the Potential Health Impacts. Jan African Journal of Microbiology Research 3: 15-21, Number 1.

Daniel E.U, Alamede I.C, Ibrahim B.A., 2007. Bacteriological Examination of Some Packaged Water Produced in Minna Metropolis. In Proceedings of the 31st Annual Conference /General Meeting of the Nigerian Institute of Food Science and Technology (Ed)Elemo, G.N 8-9.

FAO, 1997. Chemical Analysis Manual for Food and Water 5th Edition. FAO Rome P: 20-26.

Geldriech, E.E., 1996. Sanitary Significance of Feacal Coliforms in the Environment Publication No. WP-20-3. Federal Water Pollution Control Administration, Cincinnati, Ohio, Pp: 122.

Hauwa S. B., Mustafa A. I., Abubakar S. and Ibrahim A. A., 2013. Physiochemical Changes and Bacteriological Contamination of Drinking Water from Wash Boreholes in Jere, Borno State Nigeria. Journal of Microbiology and Biotechnology Research Scholars Library Vol. 3 (3). P: 126-131.

Howard, P., 2009. Water Science for Schools: Water Properties, Water Measurements. Available: http://www.ga.water.usgs.gov/edu/mwater.html.

Itah, A.Y. and Akpan, C.E., 2005. Portability of Drinking Water in an Oil Impacted Community in Southern Nigeria. J. Appl. Sci. Environ. Mgt., 9(1): 135-141.

Kot, B., R. Baranowski, Rybak, A., 2000. Analysis of Mine Waters Using X-Ray Fluorescence Spectrometry.Polish J. Environ. Stud., 9: 429.

Marier, J.R., Neri, L.C., Anderson, T.W., 1979. Water Hardness, Human Health and The Importance of Magnesium. National Research Council of Canada, Ottawa.

NAFDAC (National Agency for Food and Drugs Administration and Control), 2001. NAFDAC Consumer Bulletin Oct-Dec 2001 1-9.

NSDWQ, 2007. Nigeria Standard for Drinking Water Quality, Nigeria Industrial Standard, Approve by Standard Organization of Nigeria Governing Council. ICS 13. 060. 20: 15-19.

Nollet Leo M.L., 2007. Hand Book of Water Analysis. CRC Press Taylor and Francis Group.

Nwosu J.N, Ogueke, C.C., 2004. Evaluation of Sachet Water Samples in Owerri Metropolis. Nig. Food J. Vol. (22), 0189-7241.

Okonko IO, Ogunjobi AA, Kolawale OO, Babatunde S, Oluwole I, Ogunnusi TA, Adejoyi OD, Fajobi, E.A., 2009. Comparative Studies and Microbial Risk Assessment of A Water Samples Used For Processing Frozen Sea Foods in Ijora- Olopa, Lagos State, Nigeria. Ejeafche. 8(6): 408-415.

Olayemi, A.B., 1999. Microbial Portability of Bottled and Packaged Drinking Waters Hawked In Ilorin Metropolis. Int. J. Environ. Health Res., 9(3): 245-248.

Rose J., Hass C., Gerbac, A., 1993. Water Borne Pathogens .Assessing Health Risk. Health and Environment Digest, 1-3.

Rudiger, K.V., 2002. To The Memory of Dr. Ursula (Uschi) Greinert-Byer. Published Drukerei Franz Hansen, Bergisan Gladbach. 70-90.

Soylak, M., F. Armagan Aydin, S. Saracoglu, L. Elci, Dogan, M., 2002. Chemical Analysis of Drinking Water Samples from Yozgat, Turkey. Polish J. Environ. Stud., 11(2): 151-156.

Taiwo A.A, Idowu Oluwadare, Lanre-Iyanda Y.A, Jolaoso A.A, Jiboku O.O, Ijaola T.O and Taiwo, A.G., 2012. Physico-Chemical and Bacterialogical Analyses of Sachet Water Samples in Abeokuta Metropolis. Global Advanced Research Journal of Agricultural Science Vol. 1(1) Pp. 001-006, March, 2012 Available Online http://garj.org/garjas/index.htm.

Uduma, A.U., 2014. Physicochemical Analysis of the Quality of Sachet Water Consumed in Kano Metropolis. American Journal of Environment, Energy and Power Research Vol. 2, No. 1, January 2014, PP: 01-10, ISSN: 2329 - 860X (Online) Available Online At http://www.ajeepr.com/ 1

Uwah, E. I., Busari, W. R. and Sayi, A., 2014. Physicochemical and Bacteriological Analyses of Sachets Water Samples in Kano Metropolis, Nigeria IOSR Journal of Applied Chemistry (IOSR-JAC) e-ISSN: 2278-5736. Volume 6, Issue 6 (Jan. 2014), PP 52-56.

Waziri, M. and Bomai, A. M., 2012. The Physiochemical Quality of Sachet Water in Damaturu, Yobe State Nigeria. International Journal of Basic and Applied Chemical Science. Vol 2 (3) July – September Pp. 21-24. ISSN: 2277-2073.

World Health Organization W.H.O, 1997. Guidelines for Drinking Water Quality. Expert Committee on International Standard for Drinking Water, Geneva 27, Switzerland.

W.H.O., 2004. Guidlines 11 for Drinking Water Quality Volume 1 EFP/82.39.W.H.O, 1211 Geneva 27, Switzerland.

WHO (World Health Organization), 2006. *WHO Guidelines for Drinking Water Quality*. First Addendum to Third Edition Volume 1.

World Health Organization (W.H.O), 2010. Guidelines for Drinking-Water Quality. Recommendation, Geneva, P: 1-6. Retrieved From http://www.who.int/water_sanitation_health/whs_wwd2010_guidelines_2010_6_en.