Effect of Solar Radiation on Packaged Sachet Water in Minna, Niger State

Musa, I. H[1]., Saidu, M[2]., and Musa, J. J[1].

1Agriculture and Bioresources Engineering, Federal University of Technology, P M B 65, Minna, Niger State

[2]Civil Engineering Department, Federal University of Technology, P M B 65, Minna, Niger State

johnmusa@futminna.edu.ng

Abstract

In recent times, concerns have been raised over the quality of drinking water stored under solar radiation. Package water production has tremendously increased due to increase in population. This has lead to over production of the packaged water which has resulted in prolong storage duration. The purpose of this study was to determine at what duration of exposure to solar radiation does these packaged sachet water starts to deteriorate considering the various physiochemical parameters. Different brands of most commonly consumed packaged water were collected from the open market upon its supply by the various distributors. Samples obtained were analysed in the laboratory (using standard method) at interval of one week for five. The materials used for packaging were also analysed. A significant variation was recorded for the mean values of Temperature, pH, Conductivity, Chloride, Total hardness, Nitrate, Magnesium and Calcium ranging between 30.29 to 32.86 mg/L; 6.670 to 7.993 mg/L; 132.14 to 373.14 mg/L; 8.299 to 16.380 mg/L; 35.71 to 49.00 mg/L; 0.116 to 0.198 mg/L; 8.19 to 10.55 mg/L; 14.91 to 19.59 mg/L respectively due to exposure to solar radiation. Similarly, the effect of solar radiation on the sachet packaging materials showed a significant increase in the mean values of only two out of the three measured parameters, Manganese and Chromium ranging between 0.092 to 0.151 mg/L; 0.086 to 0.151 mg/L respectively while Zinc was found to be relatively negligible. Although, significant variation in parameters began occurrence at week 1 for both sachet water and its package material but; however, all the parameters measured were within the recommended standard for WHO and NSDWQ. Hence implementation of checks and balances on the producers of the packaged waters and the facilities available in the open market for storing these packaged water should be the solution to safe guard public health.

***Keywords**: Quality, radiation, sachet, solar, water*

Introduction

In recent times, many concerns have been raised over the quality of package drinking water (Fewtrell *et al.,* 1997; Rosenberg, 2003; Khaniki *et al.,* 2010). In Nigeria, package sachet water is commercially available in 50–60 ml polyethylene packs known as sachet/pure water (Umeh *et al.,* 2005; Okonko *et al.,* 2008). Package sachet drinking water in Nigeria is presently a lucrative business, with many people involved in the production and marketing of the product (Ekwunife *et al.,* 2010). Many people in rural and urban communities rely more on package sachet water as their major source for their drinking. The integrity of these packaged sachet waters is doubtful, in fact, unconfirmed report abounds that most of the vendors do not treat their sachet waters before selling to the public. This became a major concern for public health workers and any right-thinking individual when one consider the fact that public including nursing mothers patronize these vendors to procure water for their small children (Oladipo *et al.,* 2009; Guler *et al.,* 2009; and Lucy, 2010). The demand for safe drinking water in Nigeria cannot be overemphasized, considering the inability of the governments to provide adequate pipe borne water to the populace. Well-packaged water in food grade polyethylene sachets designed for food processing stands is a ready alternative for the growing population of over 150,000,000 people. However, safe drinking water is very scarce. The aim of this study is to determine at what stage of the exposure duration the package sachet

water start deteriorating and by extension determine the physical and chemical qualities of stored packaged sachet waters under solar radiation.

Research Methodology

Sample Collection Method

A total of Seven (7) different brands of packaged sachet water samples mostly consumed by the populace were collected from the open market at same time between 0800 hours and 1000 hours upon its supply by the various distributors and analysed at one week interval for five (5) weeks with day one week zero serving as the control.

Sample Analysis

The first test was carried out upon arrival at the water resources laboratory for control and subsequently others were also analysed at intervals of one week for 4 weeks. The packaged material analyses were performed alongside the packaged sachet waters to trace the presence of certain parameters such as Manganese, Zinc, Copper, Iron, Lead and Chromium. All samples carried self-adhesive labels as these were affixed on the sample packages to prevent lost or misplacing, causing sample mix-up. The information carried on the sample label includes; location, time and date.

Statistical Analysis

All parameters measured during the period of experiment were subjected to analysis of variance for a randomized complete block design (RCBD) experiment and correlation analysis. This was implemented using statistical analysis system (SAS) model. The data obtained from the experiment were analysed with analysis of variance (ANOVA) table and student newman keuls test (SNK), and also correlation matrix.

Results and Discussion

Response of physical properties of packaged sachet water to solar radiation

The highest values of temperature recorded at 2 and 4 weeks of exposure of package sachet water to solar radiation in this study could be attributed to the climatic condition of the study area. This is similar to the findings of Westerhoff *et al.,* 2011 who found out that exposure to elevated temperature significantly increases the concentration of antimony in PET material (polyethylene terephthalate), though, temperature has no negative impact on the consumer. pH value is a very significant indicator which determines the suitability of the water for various purposes (Yogendra and puttaiah, 2008). It is described as the measure of the acidity or basic nature of water. However, based on the analysis carried out; the packaged sachet water recorded highest value at 0 week, indicating that exposure of package water to solar radiation could further lead to acidification of the water. This finding is similar to Sulaiman *et al.,* 2011 that reported a slight acidic trend and concluded that pH of water generally is influenced by geology of the catchment area and buffering capacity of water and exposure to elevated temperature leads to acidification. Electrical Conductivity is the measure of ability of water to conduct electricity. Based on the analysis, conductivity of the sachet packaged water recorded highest value at zero (0) week after which there was a decline. This also could be attributed to the geology of the catchment area too.

Table 1. Variation in chemical composition of Sachet Water Packaged materials

Exposure period (week)	Mn(mg/L)	Zn(mg/L)	Cr(mg/L)
0	0.092^{b}	0.110^{a}	0.086^{c}
1	0.112^{b}	0.112^{a}	0.100^{b}
2	0.124^{a}	0.118^{a}	0.106^{b}
3	0.129^{a}	0.129^{a}	0.118^{b}
4	0.151^{a}	0.145^{a}	0.151^{a}
SE±	0.009	0.008	0.008

Means with the same letter in a column are not significantly different at 5% level of probability using Student Newman Keuls Test

Response of Chemical properties of packaged Sachet water to Solar Radiation

Total hardness which has to do with the presence of calcium and magnesium content in the packaged waters recorded highest value at zero (0) week for including its calcium and magnesium content in sachet water alone prior to exposure to solar radiation, this indicates that there is no adequate treatment carried out by the producers of this sachet water. However, many people venture into the business without adequate capital to set up a standard treatment plant. The concentration of Chloride content was observed to be highest at week 4 in sachet water which could be attributed to the chlorination reaction during exposure to solar radiation while Nitrate on the other hand was observed to record a highest value in week 3-4 again in sachet water which can be interpreted on the basis of the organic compounds in water (original organic compound in water and photo degradation by-product leached from the sachet materials) converted to inorganic species (NO_3^-) by solar radiation (Sulaiman Gafar, 2010).

Response of Chemical properties of the Sachet Packaging materials to Solar Radiation

Significant difference was recorded in the means of Manganese and Chromium except for Zinc upon exposure to solar radiation.Positive and negative significant correlation was recorded for the various parameters measured, but however, the strongest relationship was recorded between Total hardness and Magnesium.

Conclusions and Recommendations

The study has established that a significant increase due to exposure to solar radiation was recorded for the values of the various parameters measured, and similarly a significant increase was also recorded in the values of certain parameters such as Manganese and Chromium for the sachet packaged material. It should be further noted that packaged waters should not be stored under elevated temperature or expose to solar radiation because it leads to increase and decrease in the values of various parameters due to acceleration of organic and inorganic compounds leaching from packaged materials to the water content. It is recommended therefore that follow-up studies aimed primarily at the end product, leaving out the processes that determine the final fate of the packaged water as well as the people in whose hand lie the will and power to effect the desired change. Such a holistic approach may equally lead to a holistic solution to the problem. The present regulation bodies in charge of water resources management which comprise the mother ministry of water resources should put more checks and balances on the producers of the packaged waters and the facilities available in the open market for storing this packaged waters is expected to safe guard public health as well as also organising seminars and conferences for these producers of packaged waters to keep them abreast with modern ways of water quality appraisal.

References

Ekwunife C. A., Okafor S. O., Ukaga C. N., Ozumba N. A., and Eneanya C. I. (2010). Parasites Ekwunife C. A., Okafor S. O., Ukaga C. N., Ozumba N. A., and Eneanya C. I. (2010). Parasites Associated with Sachet Drinking Water (Pure Water) in Awka, South-Eastern, Nigeria. Sierra Leone Journal of Biomedical Research, 2010; 2(1): 23-27.

Fewtrell L., Kay D., Wyer M., Godfree A., & Neill G. O. (1997). Microbial Quality of Bottled Water. Journal of Water Science and Technology, 34: 47-53.

Khaniki G. R. J., Zarei A., Kamkar A.,Fazlzadehdavil M., and Ghaderpoori M, (2010). Bacteriological evaluation of bottled water from domestic brands in Tehran markets in Iran. World Applied Science Journal. 8(3): 274-278.

Okonko I. O., Donbraye E., and Babatunde, (2009). Microbial Quality Seafood Processors and Water Used in Two Different Sea Processing Plant in Nigeria. EJEAFChe, 2009; 8(8): 621-629.

Rosenberg F. A. (2003). The Microbiology of Bottled Water. Clinical Microbiology Newsletter, 2003; 25: 41-44.

Sulaiman G. M., Lawen S. E., and Shelear H. H. (2011). Effect of storage temperature and sunlight exposure on the physiochemical properties of bottled water in Kurdistan region-Iraq. Journal of Applied Science and Environment. Vol. 15 (1) 147-154.

Umeh C. N., Okorie O. I., and Emesiani. G. A. (2005). Towards the provision of save drinking water: The bacteriological quality and safety of sachet water in Awka, Anambra State. In: the book of Abstract of the 29th Annual Conference and General Meeting on Microbes As Agent of Sustainable Development, organised by Nigerian Society for Microbiology (NSM), University of Agriculture, Abeokuta. p.22.

Westerhoff, P., Prapaipong, P., Shock, E., and Hillaireau, A., (2011). Antimony leaching from polyethylene terephthalate (PET) plastic used for bottled drinking water. Water Res., 2008, 42 (3), 551-556.

Yogendra, K and Puttaiah E. T. (2008), Determination of Water Quality Index and suitability of an urban waterbody in Shimoga Town, Karnataka. The Journal of Environmental hydrology. Vol 7, Pp 342-346.

Table 2. Variation of the effect of Solar Radiation on Physiochemical parameter of Sachet Water obtained from Minna metropolis

Exposure period (week)	Temp	Ph		Cond	Cl	Total H	Alkalinity	NO3	PO4	Na	K	Mg	Mn	Cu	Zn	Fe	Ca
0		30.29^{c}		7.99^{a}	373.14^{a}	8.29^{c}	49.00^{a}	14.14^{a}		0.11^{b}	0.15^{a}	7.71^{a}	4.45^{a}	10.55^{a}	0.029^{a}	0^{a}	0.014^{a}	0.15a	19.59^{a}
1		31.57^{b}		7.77^{a}	218.43^{b}	12.24^{b}	43.00^{b}	14.14^{a}		0.15^{b}	0.18^{a}	7.74^{a}	4.45^{a}	10.00^{a}	0.057^{a}	0.00^{a}	0.014^{a}	0.21a	17.28^{b}
2		32.86^{a}		7.76^{a}	167.71^{c}	12.65^{b}	40.57^{b}	12.71^{a}		0.13^{b}	0.15^{a}	7.75a	5.67^{a}	9.66^{b}	0.057^{a}	0.00^{a}	0.029^{a}	0.21a	16.34^{b}
3		31.86^{b}		7.21^{b}	152.14^{c}	11.74^{b}	38.57^{b}	13.14^{a}		0.19^{a}	0.17^{a}	7.71^{a}	4.56^{a}	9.26^{b}	0.057^{a}	0.043^{a}	0.049^{a}	0.25a	15.46^{b}
4		32.29^{a}		6.67^{c}	132.14^{c}	16.38^{a}	35.71c	12.43^{a}		0.19^{a}	0.19^{a}	7.75^{a}	4.61^{a}	8.19^{b}	0.071^{a}	0.049^{a}	0.049^{a}	0.25a	14.91^{b}
SE±		0.22	0.10	15.57	1.05	1.66		0.56		0.01	0.02	1.37	0.64	0.43	0.019	0.013	0.019	0.05	0.77
WHO LIMIT (2007)	Ambient	6.5-8.5	1000	250	100	100		0.2	0.3	200	200	50	0.2	-	3	0.3	50		
NSDWQ (2007)	Ambient	7.5-8.5	1000	250	100	100		0.2	0.5	200	200	30	0.1	-	3	0.3	75		

Means with the same letter in a column are not significantly different at 5% level of probability using Student Newman Keuls Test

Table 3. Correlation Matrix Between some Physiochemical properties of Sachet water as influenced by Solar Radiation.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	-0.427*	1.000										
3	-0.678**	0.603*	1.000									
4	0.544	-0.611**	-0.544*	1.000								
5	-0.538*	0.631**	0.595*	-0.495*	1.000							
6	-0.278*	0.279*	0.269*	-0.179*	0.602*	1.000						
7	0.255*	-0.639**	-0.543*	0.379*	-0.553*	-0.328*	1.000					
8	0.212*	-0.335*	-0.204*	0.308*	-0.346*	-0.233*	0.220*	1.000				
9	0.057*	-0.083*	0.056*	0.022*	-0.262*	-0.495*	-0.200*	0.379*	1.000			
10	0.295*	0.072*	0.022*	0.037*	-0.249*	-0.156*	-0.078*	0.281*	0.322*	1.000		
11	-0.305*	0.587*	0.369*	-0.441*	**0.912****	0.571*	-0.508*	-0.348*	-0.306*	-0.022*	1.000	
12	0.0245*	-0.198*	-0.216*	0.191*	-0.313*	-0.329*	0.404*	-0.097*	0.093*	0.167*	-0.343*	1.000

1—Temperature 4—Chloride 7—Nitrate (NO_3) 10—Potassium (K) * - Significant

2—ph 5—Total hardness 8—Phosphate (PO_4) 11—Magnesium (Mg) **- Highly significant

3—Conductivity 6—Alkalinity 9—Sodium (Na) 12—Manganese (Mn)