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Storage and its Effect on Chemical Quality Indicators in Sachet Water Brands Sold in Owerri Municipal, Imo State, Nigeria

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ABSTRACT

This study investigated the effect of storage on certain sachet water quality indicators over a twelve-week period. Three brands of sachet water were collected within 24 h of production and analyzed for pH, nitrate, phosphate, and dissolved oxygen. These were then placed in normal storage. According to our results, pH values increased significantly in all brands after week 8. Moreover, nitrate and dissolved oxygen values decreased throughout the investigation period, while phosphate values increased in all brands tested. All tested brands showed various degree of variation over the period of study. Still, all brands analyzed were within permissible limit by World Health Organization (WHO) stipulations. However, continuous storage can significantly alter the chemical quality indicators to a level that exceeds the limit set by WHO, hence, becoming harmful to human health. Therefore, it is recommended that sachet water should not be stored for more than 12 weeks from the date of production.

***Keywords*:** Nitrate, Phosphate, Dissolved oxygen, pH, Sachet water, Water quality

1. INTRODUCTION

Water is a vital substance for the survival of all lives (Thliza et al., 2015; Mberekpe and Eze, 2014). Therefore, access to safe drinking water is critical to human health and development (Pruss et al., 2002). Efforts to ensure access to safe drinking water have historically focused on communal drinking water sources and piped supplies (Michael et al., 2015). However, access to these piped supplies is limited in most cities in Nigeria (Omalu *et al*., 2010; Sunday *et al*., 2011). Improving access to safe or potable drinking water can result in tangible benefit to health (WHO, 2006). This in turn has caused increase in production, sales and consumption of packaged water in most countries of the world, especially in developing countries (Oyedeji *et al.*, 2010; Mgbakor *et al.*, 2011; and Gangil *et al.*, 2013), thereby causing packaged water (*i.e*. sachet or bottled water) becoming a major source of drinking water.

Sachet water can be referred to as ready to drink packed and machine-sealed water (Adiotomre and Agbale, 2015**)**. They are commonly referred to as "pure water" by many of the locals in Nigeria. Sachet water is also sold in hand filled, hand-tied plastic bags. This is locally referred to as "ice-water". The water is the most widely consumed liquid for both the rich and poor in Nigeria because it is relatively cheap, readily available and an easy alternative to the bottled brand. Sachet water production in Nigeria is regulated by the National Agency for Foods and Drugs Administration and Control (NAFDAC). The agency ensures that productions and product meet required standards for clean and safe drinking water. However, sachet water is not completely sterile and may not be entirely free of all infectious microorganisms (Sunday *et al*., 2011). The contamination of sachet water could be due to the source of water. Most of the water used for production is obtained from ground water. The ground water could be polluted through percolation of harmful physical, biological and chemical constituents (e.g. fine suspended matter, faecal coliform, and fluoride) through soils (Enyoh *et al*., 2017). Another source of contamination of sachet water is poor treatment, packaging materials, dispensing in packaging material and closure (Omalu *et al*., 2010). In Nigeria, sachet water is often stored at temperature that is unfavourable for the water quality. Prolonged storage can grow total aerobic heterotrophic bacteria to levels that may be harmful to humans (Warburton *et al*., 1992). Many common and widespread health risks have been found to be associated with drinking water in developing countries, a large percentage of which are of biological origin.

Several studies have been carried out on water quality of varying degrees and coverage. These studies have considered chemical quality of the water, microbiological quality, physical quality and some on the radiological contaminations of the water (Obiri-Danso *et al.*, 2003; Orisakwe *et al*., 2006; Kwakye-Nuako *et al*., 2007; Ajayi *et al*., 2008; Dada, 2009; Oluwafemi and Oluwole 2012; and Ackah *et al*., 2012). Sunday *et al*., (2011), investigated the effect of storage on the physicochemical status and bacteriological quality of sachet water produced in Port Harcourt, Nigeria, for a period of four months and results of the experiment indicate that 60% of the brands analyzed met the WHO guideline limit for drinking when stored at ambient temperature within four-week period. However, storage beyond this period led to diminished aesthetic quality of sachet water and increased proliferation of bacteria to a level deleterious to human health. Also in the study, chemical parameters of the water were altered significantly over the study period. Abudu *et al*., (2013) carried out a study on the changes in the physicochemical properties of stored water on weekly and monthly basis for a period of three months. Their results indicated that there was no significant difference ($p > 0.05$) in the physicochemical parameters for the sachet water under the different storage conditions over the period. Handling and level of hygiene in production areas are possible reasons for these observations.

There is paucity of data as well as published work on the effect of storage on sachet water quality. This study will be build on the existing works by assessing the storage effect on sachet water quality produced and sold in Owerri municipal. It will determine the level of selected chemical quality indicators that are dependent on microbial density in water over a three-month period.

2. MATERIAL AND METHODS

2. 1. Study Area

Owerri, the capital of Imo State of Nigeria, lies between 4°55'N and 5°35'N, and between 6°35'E and 7°30'E parallels. Three popular water-packaging companies whose sachet water brands are sold in Owerri Municipal, Imo state, were selected for this study. These companies include: Apex sachet water from Auspex, Umuguma, Owerri (Sample A), Alvana sachet from Alvana, Alvan Ikoku Federal College of Education, Owerri (Sample B), and Domino water from Domino, Ikenegbu layout, Owerri (Sample C).

2. 2. Sample collection and preparation

The samples were collected (three packs per brand) within 24 hours of production, transported to the laboratory and tested immediately for pH, phosphates, nitrates, and dissolved oxygen. For each brand, 50 mL of water was collected separately from three randomly selected sachets from each of the three packs and mixed thoroughly in a beaker. The water samples were tested for the stated parameters. This procedure was repeated weekly over a 12-week period.

2. 3. Instrumentation

The pH of the samples was determined using a pH meter (Checker Plus pH meter by Hanna Instruments). Nitrate, phosphate, and dissolved oxygen in sachet water samples were determined by photometry (Hannah Multiparameter Bench Photometer HI 83200).

2. 4. Data Analysis

Mean values of data for the twelve weeks were obtained for the four parameters tested. The minimum, maximum, ranges, standard deviations, and coefficient of variation were determined for each brand. A time-series plot was used to show the variations over the study period.

3. RESULTS AND DISCUSSION

The pH values of the sachet water samples are presented in **Figure 1**. The pH values varied from 7.26-8.06 with the mean of 7.67 in sample A. Sample B recorded pH values ranging from 7.37-7.88 with the mean 7.60, while Sample C ranged from 6.85-7.69 with the mean of 7.41 throughout the investigation period. These values were well within the NAFDAC (6.3-8.5) and WHO limits (6.5-8.5).

WHO limits are aimed at reducing corrosion in metal pipes (WHO, 2011), and thus may not be relevant to sachet water (Fisher *et al*., 2015). However, bacterial population growth in water is significantly related to pH. Prescott *et al*. (1999) stated that microorganisms frequently change the pH of their own habitat by producing acidic or basic metabolic wastes. Observed increases in pH in this study could be attributed to the production of basic metabolic wastes by increasing bacterial population. Drinking water with high pH could lead to the condition known as alkalosis. Alkalosis can cause arrhythmia or irregular heartbeats, imbalanced electrolyte levels, and coma.

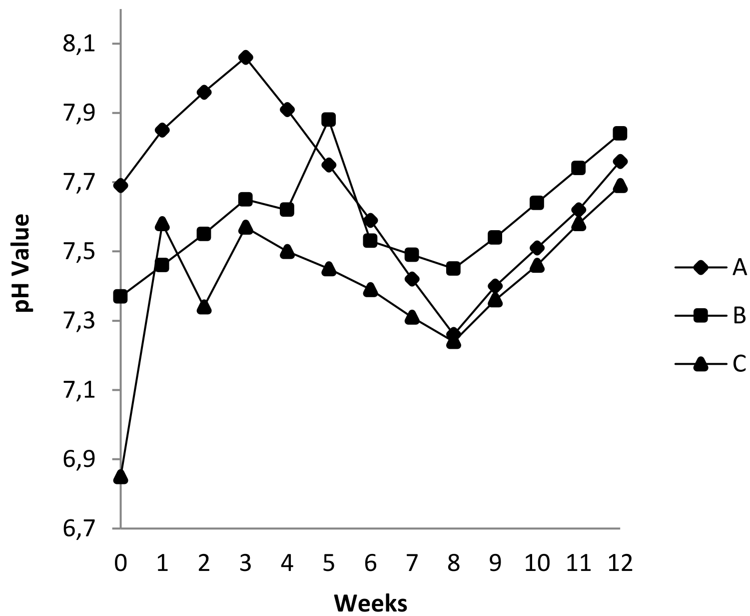

Figure 1. Changes in pH over 12-week period

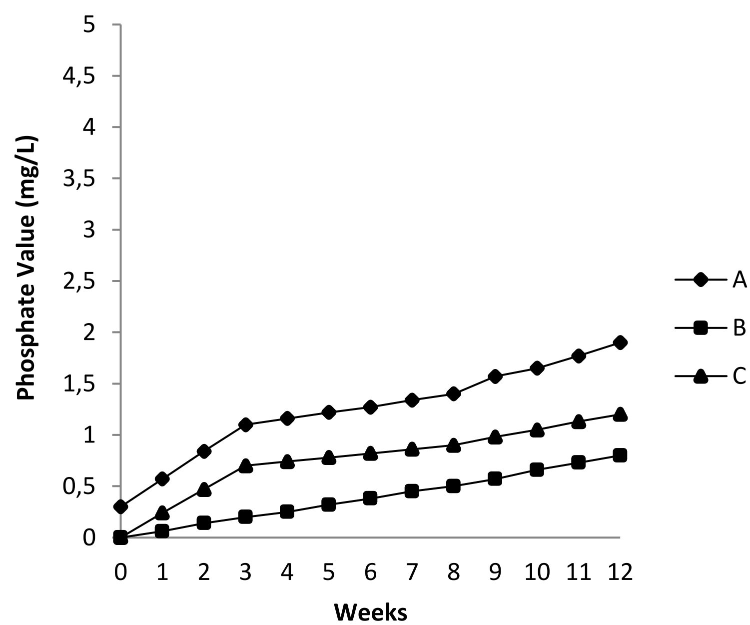

Figure 2. Changes in Phosphate concentration over 12-week period

Changes in phosphate levels in the studied samples are presented in **Figure 2**. The values of phosphate ranged from 0.3-1.9 mg/L, 0-0.8 mg/L and 0-1.2 mg/L in samples A, B, and C, respectively. The mean values were in the order A (1.24) > B (0.39) > C (0.76). These values were below the permissible limit of 5 mg/L set by WHO. Phosphate values increased throughout the investigation period. These suggest that further storage will cause further increase in the phosphate levels. Sunday *et al.*, (2011) also obtained increasing phosphate level in sachet water studied over 16 weeks in Port Harcourt Metropolis. This could be attributed to microbial death and accumulation of metabolic waste (Prescott *et al.*, 1999). Phosphates are not toxic to humans or animals unless they are present in very high levels. Digestive problems could also occur from extremely high levels of phosphate.

Nitrates in human systems can interfere with the ability of the red blood cells to transport oxygen and may cause difficulty in breathing. Nitrate values obtained for the sachet (**Figure 3**) ranged from 16.1-25.9 mg/L, 0.6-8.8 mg/L and 4.4-8.1 mg/L in samples A, B, and C, respectively, averaging A (20.91 mg/L) > C (6.67 mg/L) > B (2.57 mg/L). The values were below the permissible limit set of 40 mg/L by WHO. Over the study period, a general decrease in the nitrate levels was observed. Microorganisms utilize nitrate for growth and reproduction (Prescott *et al.*, 1999), and their presence in the studied samples could be the cause for continual decrease in the nitrate levels over the study period.

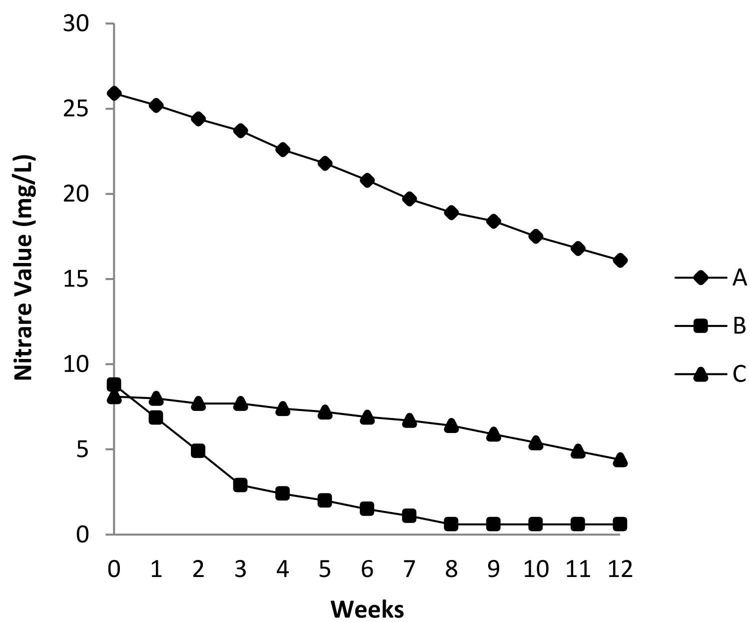

Figure 3. Changes in Nitrate concentration over 12-week period

Dissolved oxygen is an important factor in the chemistry and microbiology of water. The dissolved oxygen values obtained for the sachet water samples over the study period are presented in **Figure 4**. The dissolved oxygen values ranged from 6.6-7.0 mg/L, 7.0-7.2 mg/L and 7.0-7.6mg/L in samples A, B and C respectively. The mean values were in the order: C (7.25) > B (7.09) > A (6.82). There was a general decrease in dissolved oxygen in sachet water samples over the study period.

This is similar to the result obtained by Sunday *et al.* (2011), who stated the decrease is an indication of possible bacterial respiration of organic materials by the bacterial flora of the sachet water samples tested. In addition, there is a tendency for the level of dissolved oxygen to fall with time, indicating possible microbial respiration of organic materials amongst other reasons (WHO 1996). However, the dissolved oxygen over the period of study was within the permissible limit of 5-8 mg/L set by WHO.

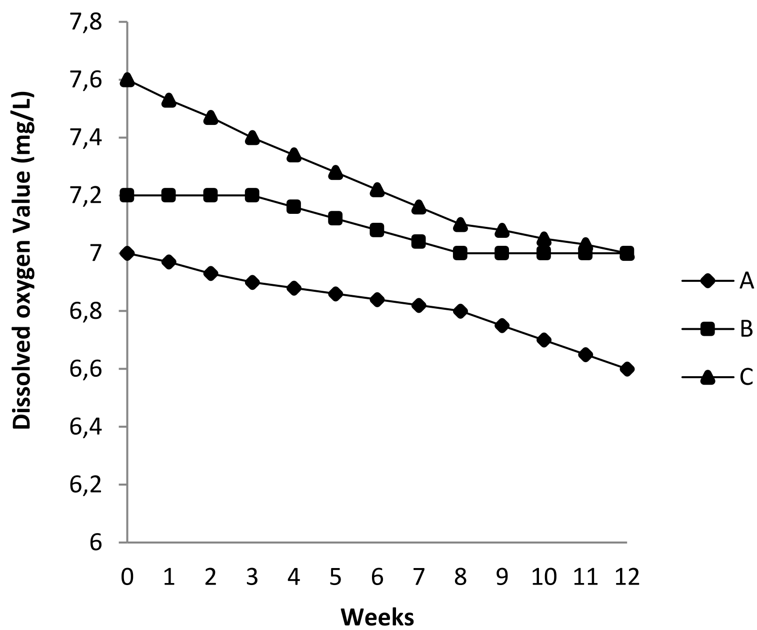

Figure 4. Changes in Dissolved oxygen concentration over 12-week period

Statistical analysis of quality indicators in the sachet water samples are presented in **Table 1**.

Table 1. Statistical Analysis of the Quality Indicators in Sachet Water Samples

Parameter	**Quality Indicators**											
	pH			**Phosphate**			**Nitrate**			**Dissolved Oxygen**		
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Minimum Value	7.26	7.37	6.85	0.30	0.00	0.00	16.10	0.60	4.40	6.60	7.00	7.00
Maximum Value	8.06	7.84	7.69	1.90	0.80	1.20	25.90	8.80	8.10	7.00	7.20	7.60

Coefficient of Variance (%)	Standard Deviation	Mean	Range
3.12	0.24	7.67	7.26-8.06
1.97	0.15	7.60	7.37-7.88
2.83	0.21	7.41	6.85-7.69
37	0.46	1.24	0.3-1.9
66.7	0.26	0.39	0-0.8
46.05	0.35	0.76	0-1.2
15.78	3.30	20.91	16.1-25.9
103.89	2.67	2.57	0.6-8.8
17.99	1.20	6.67	4.4-8.1
1.76	0.12	6.82	6.6-7
1.26	0.09	7.09	7-7.2
2.76	0.20	7.25	7-7.6

A = Apex B = Alvana C = Dominion

The descriptive statistics was done to describe meaning and provide a summary of data without listing every value of the data set. The minimum and maximum value is the smallest and largest value, respectively, in the data set. The standard deviation is a quantity expressing how much the members of a group differ from the mean value for the group. The Coefficient of Variance (CV) measures dispersion of a probability distribution or frequency distribution. In other word, it is useful in comparing the degree of variation from data series to another. They were categorized as little variation (CV% < 20), moderate variation (CV% = 20-50) and high variation (CV% > 50), (Verla *et al*., 2015). From Table 1, samples A, B, and C showed little variation over the period of study for pH and dissolved oxygen, indicating low dispersion of data from week 0 to week 12. Samples A (37%) and C (46.1%) showed moderate variation for the phosphate while B (66.7%) showed high variability. Samples A and C showed little variation in nitrate levels over the study period, while sample B had a high level of variation, indicating rapid microbial activity in the product.

4. CONCLUSIONS

The present study has revealed that storage of sachet water at room temperature over long periods can lead to significant alteration in chemical quality indicators to a level that exceeds limit set by World Health Organization thereby becoming harmful to human health. It is recommended that sachet water should not be stored for more than 12 weeks from the date of production. Standardized method of storage of sachet water should be developed to improve its shelve-life. Periodic sanitary inspection of sachet water factories by the regulatory bodies is very necessary to ensure conformity. Also, NAFDAC should enforce the inclusion of expiry date of sachet water products which is often not stated on the packaging materials.

References

[1] Abudu B.D., Samuel J.C., and Mark O.A., Effect of storage on the quality of sachet-vended water in the Tamale metropolis, Ghana. *Journal of Environmental Protection* 4 (2013) 629-637

[2] Ackah M., Anim A., Gyamfi E., Acquah J., Nyarko E., Kpattah L., Assessment of the quality of sachet water consumed in urban townships of Ghana using physicochemical indicators: A preliminary study. *Advances in Applied Science Research* 3(4) (2012) 2120-2127

[3] Ajayi A., Sridhar M., Adekunle L., Oluwande P., Quality of packaged waters sold in Ibadan, Nigeria. *African Journal of Biomedical Research* 11(3) (2008) 251-258.

[4] Ajayi O., Adesida G., Radioactivity in some sachet drinking water samples produced in Nigeria. *Iranian Journal of Radiation Research* 7(3) (2009) 151-158

[5] APHA, Standard methods for the examination of water and wastewater. 20th Edition, American Public Health Association, American Water Works Association, Water Environment Federation. United Book Press, Inc., USA 1998.

[6] Dada A., Sachet water phenomenon in Nigeria: Assessment of the potential health impacts. *African Journal of Microbiology Research* 3(1) (2009) 15-21

[7] Enyoh, C.E., Ihionu E.A., Verla A.W. and Ebosie P.N., Physicochemical parameter of palm oil and soil from Ihube community, Okigwe, Imo State Nigeria. *International Letters of Natural Sciences* 62 (2017) 35-43

[8] Gangil R., Tripachi R., Patyal A., Dutta P., and Mathur K.N., Bacteriological evaluation of packaged bottled water sold at Jaipur city and its public health significance. *Veterinary World* 6 (2013) 27-30

[9] Kwakye-Nuako G., Borketey P., Mensah-Attipoe I., Asmah R., Ayeh-Kumi P., Sachet drinking water in Accra: the potential threats of transmission of enteric pathogenic protozoan organisms. *Ghana Medical Journal* 41(2) (2007) 62-67

[10] Mgbakor C., Ojiegbe G.C., Okonko I.O., Odu N.N., Alli J.A., Nwaze J.C., and Onoh C.C., Bacteriological evaluation of some sachet water on sales in Owerri metropolis, Imo State, Nigeria. *Malaysian Journal of Microbiology* 7 (2011) 217-225

[11] Fisher M.B., Williams A.R., Jalloh M.F., Saquee G., Bain R.E.S., and Bartram J.K., Microbiological and chemical quality of packaged sachet water and household stored drinking water in Freetown, Sierra Leone. *PLoS One* 10(7) **(**2015) 1-17

[12] Obiri-Danso K., Okore-Hanson A., Jones K., The microbiological quality of drinking water sold on the streets in Kumasi, Ghana. *Letters in Applied Microbiology* 37(4) (2003) 334-339

[13] Oluwafemi F., Oluwole M.E., Microbiological examination of sachet water due to a cholera outbreak in Ibadan, Nigeria. *Open Journal of Medical Microbiology* 2 (2012) 115

[14] Orisakwe O.E., Igwilo I.O., Afonne O.J., Maduabuchi J., Obi E. and Nduka J.C., Heavy metal hazards of sachet water in Nigeria. *Archives of Environmental & Occupational Health* 61(5) (2006) 209-123

[15] Oyedeji O., Olutiola P.O. and Moninuola M.A., Microbiological quality of packaged drinking water brands marketed in Ibadan metropolis and Ile-Ife city in South Western Nigeria. *African Journal of Microbiology Research* 4 (2010) 96-102

[16] Prescott L.M., Harley J.P. and Klein D.A., The influence of environmental factors on growth. Microbiology. 4th Edition. McGraw-Hill Companies, Inc., USA (1999) 123-132

[17] Mberekpe P. and Eze N., Effect of preservation on the quality of sachet water consumed by households in Nsukka zone. *Civil and Environmental Research* 6(7) (2014) 25-30

[18] Prüss A., Kay D., Fewtrell L., Bartram J., Estimating the burden of disease from water, sanitation, and hygiene at a global level. *Environmental Health* Perspectives 110(5) (2002) 537-42

[19] Thliza L.A., Khan A.U., Dangora D.B. and Yahaya A., Study of some bacterial load of some brands of sachet water sold in Ahmadu Bello University (Main Campus), Zaria, Nigeria. *International Journal of current Science* 14 (2015) 91-97

[20] Verla E.N., Verla A.W., Ugwulor L., Seasonal variation of heavy metals in playgrounds of public schools within Owerri metropolis, Imo State, Nigeria. *International Letters of Chemistry, Physics and Astronomy* 50 (2015) 61-70

[21] Warburton D.W., Dodds K.L., Burke R., Johnston M.A. and Laffey P.J., A review of the microbiological quality of bottled water sold in Canada between 1981 and 1989. *Can. J. Microbiol.* 38 (1992) 12-19

[22] WHO, Guidelines for Drinking-water quality, 4th Ed. Geneva, Switzerland (2011).

[23] World Health Organization, Guidelines for Drinking Water Quality– incorporating first Addendum to 3rd Edition 1: Recommendation (2006)

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