The Effect of Sunlight in Storage on Sachet Water Quality in Kaduna Metropolitan Area, Kaduna State- Nigeria

Awopetu M. S., Sahabo M. M*, Abubakar M. S., Abenu A., Badamasi I. B. and Terlumun S.

Department of Civil and Environmental Engineering, Faculty of Ground and Communication Engineering, Air Force Institute of Technology, Kaduna

ABSTRACT

This study investigated the effect of sunlight radiation on the microbiological and physicochemical quality of sachet water in Kaduna metropolitan area. Sachet water samples were collected from different locations and exposed to sunlight for varying durations (1, 14, 28, and 42 days). Lead, E. coli levels, and various physicochemical parameters like temperature, conductivity, and turbidity were analysed. The results revealed a significant increase in lead content with sunlight exposure, exceeding the WHO drinking water quality standard in several cases. Sunlight had a negligible impact on E. coli levels. Physicochemical parameters deteriorated with exposure, indicating a quality decline. The findings highlight the potential health risks associated with consuming sunlight-exposed sachet water, particularly for vulnerable populations. Public awareness campaigns, stricter regulations for production and storage, and investment in alternative water sources are crucial to address this issue and ensure safe and healthy drinking water for the residents in the study area.

KEYWORDS: *Sachet water, Sunlight radiation, Drinking water, Physicochemical, Microbiological*

Corresponding author: Sahabo M. M., Email: musty4uf@gmail.com

1 INTRODUCTION

The provision of potable water is *sine qua* non to human health and well-being (Shamimuzzaman et al., 2019). Water forms the basis of blood, digestive juices, urine and perspiration. The body can't store water for too long and therefore we need a constant fresh supply of drinking water every day to make up for the losses from the lungs, skin, urine and faeces (Bona et. al. 2018). The responsibility of providing water of adequate quantity and acceptable quality which should be that of the government has been shifted to the citizens of Nigeria. Sachet water, also known as "pure water", has become a very popular, acceptable and well-liked commodity in some regions (Mosi et. al., 2019). It is a type of packaged drinking water commonly sold in small sachets or sealed plastic bags. Its appeal is due to its affordability, convenience and availability in almost all communities in Nigeria (Ojekunle et al, 2015). The so-called "pure water" is usually treated and purified to meet specific drinking water standards before being packaged in affordable and convenient but non-biodegradable single-use sachets (Bona et. al., 2018). It is seen in almost all communities in Nigeria, particularly in places with low access to safe and clean drinking water. The choice to packaging in sachets is motivated by numerous influences such as its cost-effectiveness and solution for providing clean drinking water (Lukubye and Andama, 2017). The low cost of production as well as packaging makes it more affordable for consumers, particularly in low-income areas. The convenience and lightweight nature of sachets make them easy to carry, facilitating access to safe drinking water on the go. This portability is especially valuable in regions where carrying larger water containers may be unworkable as claimed by Palamuleni and Akoth, (2015). The individual sachet packaging helps preserve the portability of the water and reduces the risk of contamination that could occur when water is stored in larger containers or communal sources (Islam et al., 2021). While sachet water is a popular choice for clean drinking water, it is not entirely immune to the effects of natural factors, including sunlight (Ikpeazu & Amos, 2017). It is pertinent to mention that the quality of some sachet water in terms of portability may not be completely guaranteed due to the shoddy means of its production and storage (Maddah and Alzhrani, 2017). Sachet water is usually stored at room temperature, refrigerator and in open places where sunlight has direct contact with it for several days (Ikpeazu & Amos, 2017; Akharame et al., 2018; Okoro et al., 2023). Adesakin et al. (2022) examined the impact of extended storage conditions on the physicochemical and microbiological quality of specific sachet water brands sold in the Samaru community, as well as the potential health consequences for consumers. Numerous research has been carried out on the storage of sachet water. Based on protocols and standard methods of APHA (2005), three brands of sachet water were submitted to various storage settings and analysed for microbiological and physicochemical characteristics at intervals of three weeks for three months. Adesakin et al. (2022) investigated the possible health effects for customers as well as the effects of

prolonged storage conditions on the microbiological and physicochemical quality of several sachet water brands offered in the Samaru community. The storage of sachet water has been the subject of numerous studies (Ladokun and Oni, 2015; Ikpeazu & Amos, 2017; Mosi et. al., 2019; Okoro et al., 2023). The susceptible nature of sachet water to certain environmental influences, including sunlight makes it essential to store sachet water properly, away from direct sunlight and in a cool environment, to preserve its quality and safety. Sunlight exposure can have numerous impacts on sachet water according to Pangborn and Bertolero, (1972). When sachet water is exposed to sunlight, its temperature can rise considerably, specifically in hot and sunny climates (Bona et. al., 2018). Continuous exposure to sunlight can vitiate the plastic packaging of sachet water over time (Yasin et. al., 2015). This mortification may compromise the integrity of the packaging, making it more susceptible to leaks or contamination (Tyson and Harrison, 1990). Some vitamins, particularly those sensitive to light, may degrade when exposed to sunlight. This could result in a reduction of vitamin content in sachet water over time (WHO, 2017). Because vendors on the road sides and small shops don't have enough space to store the sachet water, they leave it outside under the sun. It is of utmost importance to assess the water quality after being exposed to sunlight since it has become the major source of drinking water in the local community. The study therefore aimed at ascertaining the effect of sunlight on sachet

water quality, to further buttress the consequences of improper storage.

2 RESEARCH METHODOLOGY

2.1 Study area
The Kaduna metropolitan area is a local government area in Kaduna State, and was the previous political hub of Northern Nigeria which serves as the research subject region. As of 2023, the population of Kaduna stands at approximately 1,221,000 according to Macrotrends. It is located on coordinates $7.750°$ E longitude and $10.333°$ N latitude and has a total area of 431 km^2 (166 sq mi). The study area is characterized by a tropical climate with a dry season from November to April and a wet season from May to October. The existing water sources in the study area include well water, borehole and rain water.

2.2 The Materials/Sampling
Fifteen (15) well-known sachet water brands from the Kaduna metropolis were chosen at random. The brands were coded as AA, BB, CC, DD, EE, FF, GG, HH, II, JJ, KK, LL, MM, NN, and OO in order to prevent any conflicts of interest. One bag of each brand, each holding a total of twenty water sachets; samples were bought straight from the manufacturers and packaged without being exposed to sunlight beforehand. After that, the samples were brought to the Nigeria Institute of Water Resources' laboratory for examination. Every sample was shipped at room temperature. The manufacturers use polythene packaging for the water bags and the source of water used by the manufacturers is borehole water. Water

106

treatment includes the use of chlorine and boiling the water. The expiry date of sachet water is usually indicated as two months after production.

2.3 Procedure

The fifteen brands of sachet water were subjected to different storage conditions and examined for microbiological and physicochemical properties every three weeks for three months, using the procedures and standard methods of APHA (2005). For microbiological and physicochemical quality investigations, subsamples were taken from the stock samples both right away and after two months. Instrumental methods were used to determine the physical characteristics. Standard titrimetric and spectrophotometric techniques were used to measure the cationic and anionic constituents, while an atomic absorber was used to determine the trace and heavy water contents.

2.3.1 Exposure of sachet water to sunlight

To design the experiment, 15 brand sachet water samples were randomly assigned to two groups: the control group and the test group. The test was conducted in different numbers of days to ascertain the quality of the water at different stages after production. After 14, 28, and 42 days, the test group of the same brands was exposed to direct sunshine, simulating an unusual setting for regular commercial stores in Kaduna, while the control group, which was not exposed to sunlight, was kept indoors and away from sunlight. The trials were set up with an average daily temperature of 35 degrees Celsius between October 1st and November 12th, 2023.

The sachet water samples were examined for heavy metals and physicochemical characteristics at the conclusion of each exposure window.

2.3.2 Physical analysis of water samples

Evaluations were conducted on physical parameters, including pH, temperature, total dissolved solids (TDS) and turbidity. A digital thermometer (EXTECH: 39240 model) was dipped for one minute into the water samples at each of the exposure window to measure the temperature (°C). The thermometer's reading was then recorded. Using a hand-held, pocket-sized electronic pH metre (pH-1 model, Germany), the pH of the water samples was determined by submerging the meter's probe end in the water for two minutes. The turbidity (NTU) was measured with a turbidity metre (LOVIBOND: T 3210 Mod). First, a 5 ml water sample was placed into the turbidity vial, which was then placed within the cell compartment and closed. Finally, the reading was obtained by pressing the read button. The total dissolved solids (TDS) were measured with a TDS metre (MYRON L COMPANY DS METRE model). The values of the TDS, in mg/L were obtained by placing a water sample in a cell cup and pressing the button to reveal the reading.

2.3.3 Chemical and microbial analysis of water samples

The coliform count utilising the Agar plate count method served as the basis for the microbial examination of the sample. The samples were cultured in eosin methylene blue agar for 24 hours at temperatures between 22 and 37 °C. After thoroughly shaking 5 ml of the

water sample and 5 drops of fluoride reagent-1 (F-1), the fluoride content was measured. The fluoride value was noted after comparing formed colours to the fluoride colour chart. Atomic absorption spectrophotometry according to the APHA 3500-pB method was used.

3 RESULTS & DISCUSSION

The effect of sunshine radiation on various parameters of sachet water that have been stored for 1, 14, 28, and 42 days were examined. The parameters that were measured were pH, turbidity, temperature, lead and fluoride contents, total dissolved solids (TDS), and the presence of *E. coli*. Both control and test samples were analysed, with the test samples exposed to sunlight while the control samples were stored indoors away from sunlight.

3.1 pH

For the control group, all brands showed p^H levels within the acceptable range of 6.5-8.5 across the exposure periods, indicating stability in acidity and alkalinity. While the test group: Brands AA, BB, DD, EE, FF, GG, II, KK, LL, MM, and OO generally maintained pH levels within the acceptable range, slight fluctuations were observed in Brands CC, HH, and NN, and these exhibited pH levels slightly below the acceptable range during some exposure periods, suggesting a potential decrease in alkalinity. According to World Health Organisation guidelines, water should have a pH of at least 6.5 or more than 8.5 to be considered potable. Table 1 shows a clear

variation in the pH level on the 14, 28, and 42 days of exposure. For the test groups, all the brands exhibited a general decrease in pH for all the periods of sunlight exposure, and this agrees with the findings of studies carried out by Ikpeazu and Amos (2017), and Akharame et al., (2018), This likely reflects natural chemical processes within the sachet water, potentially influenced by storage temperature and microbial activity. The decrease was more pronounced in brands with initial pH values closer to the upper limit of the WHO guideline (6.5 - 8.5). It was found that pH varies with control but stays within the WHO standard when compared to the WHO standard limit and control.

3.2 Turbidity

Both control and test group turbidity levels remained below the maximum permissible limit of 5 NTU for all brands and exposure periods, indicating clarity in the water samples (Table 2). While all the brands showed an increase in turbidity over time, an indication of the particulate matter generation in the water due to sunlight-induced photo degradation of plastic polymers or other organic compounds, the values were below 5 NTU. The extent of turbidity increase varied across brands, possibly influenced by the type of plastic used and the initial water quality. Table 2 presents the variations in the turbidity level on the 14, 28 and 42 days of exposure. Similar outcomes were observed in the study conducted by Fajoyomi et al. (2022) with turbidity values falling within the WHO standard. However, in comparison with Okoro et al.'s (2023) study, "Effect of Sunlight, Temperature and Time on

the Physicochemical Properties of Sachet Water in Yola Metropolis, Adamawa State, Nigeria" reported turbidity values of water samples had increased from 11.40 - 48.0 NTU exceeding the WHO standard. The divergence in results could be a result of a lot of factors including the difference in sunlight intensities, the difference in water source, purification process, differences in polymer packaging material, and elusive method errors.

Table 1. The pH analysis result of various brands at different exposure windows

Parameter	Brand	Exposure							WHO
		0 days	14 days		28 days		42 days		
		Control	Control	Test	Control	Test	Control	Test	
p^H	AA	6.81	6.7	6.4	6.5	6.2	6.6	6	6.6-8.5
	BB	7.12	7	6.75	6.9	6.5	6.8	6.2	
	CC	6.95	6.8	6.6	6.7	6.4	6.5	5.9	
	DD	7.44	7.3	7	7.2	6.8	7	6.6	
	EE	7.23	7.2	7	7.1	6.9	6.9	6.7	
	FF	7.89	7.7	7.4	7.6	7	7.3	6.7	
	GG	7.13	7.2	6.9	7	6.7	7.1	6.5	
	HH	6.92	6.8	6.7	6.7	6.5	6.6	5.8	
	II	7.09	7.1	6.8	6.9	6.8	6.8	6.6	
	JJ	7.55	7.4	7.2	7.3	7	7	6.8	
	KK	6.85	7	6.6	6.7	6.5	6.6	6.1	
	LL	7.38	7.24	7.1	7.1	6.8	6.9	6.6	
	MM	7.11	7.4	7.2	7.01	6.9	6.8	6.6	
	NN	7.09	7	6.9	6.2	6.8	7.2	6.5	
	OO	7.78	7.5	7	7.6	6.9	7.2	6.7	

Table 2. The turbidity analysis results of various brands at different exposure windows

Parameter	Brand	Exposure							WHO
		0 days	14 days		28 days		42 days		
		Control	Control	Test	Control	Test	Control	Test	
Turbidity (NTU)	AA	0.49	0.41	1.09	0.64	1.43	0.95	1.65	5 (MAX)
	BB	0.47	0.51	0.89	0.7	1.7	1.2	1.4	
	CC	0.84	0.34	0.9	0.87	1.3	1.01	1.81	
	DD	0.27	0.45	1.1	0.6	1.5	0.82	1.83	
	EE	0.67	0.78	1	0.88	1.35	1.41	1.6	
	FF	1.24	0.45	0.7	0.76	1.3	1.12	2.3	
	GG	0.26	0.45	1.22	0.63	1	0.98	1.57	
	HH	0.99	1	1.31	1.27	1.45	1.87	1.9	
	II	0.22	0.31	1.32	0.53	1.61	0.83	1.67	
	JJ	0.13	0.42	1.42	0.73	1.62	1.02	1.69	
	KK	0.77	0.94	1.33	1.24	1.41	1.61	1.72	
	LL	0.54	0.65	1.1	0.98	1.33	1.2	1.97	
	MM	0.74	0.77	1.34	1.34	1.53	1.58	1.75	
	NN	0.64	0.86	1.4	1.35	1.36	1.85	1.91	
	OO	0.36	0.54	1.7	1.5	1.42	1.87	1.9	

3.3 Temperature

Temperature values remained below the permissible limit of 30 °C for all brands and exposure periods, indicating consistency in temperature; with the test group, the Brands BB, CC, EE, FF, GG, II, JJ, KK, LL, MM, NN, and OO presented temperature fluctuations within acceptable limits. Thus, suggesting minimal impact of sunlight exposure on water temperature (Table 3). The consistently exhibited higher temperatures in sunlight-exposed samples compared to controls throughout the study period is a result of the direct effect of solar radiation absorption by water and packaging. In contrast to the research conducted by Okoro et al. (2023), all sachet water brands that were exposed to sunshine had lower temperature levels.

Table 3. The temperature analysis result of various brands at different exposure windows

Parameter	Brand	Exposure							WHO
		0 days	14 days		28 days		42 days		
		Control	Control	Test	Control	Test	Control	Test	
Temperature (^{0}C)	**AA**	23	23.3	24.3	23.8	25	22	24	30
	BB	24.7	24.2	27.2	23.2	25.6	23	27	
	CC	26	24.4	26.4	25	27	26.7	28.4	
	DD	21	21.4	24.7	22	24.9	23	25.5	
	EE	27	22	25.8	23	26	23.4	26.9	
	FF	27.3	26.3	28	26	28.6	27	28.9	
	GG	26.4	25	28.1	26	27	26.4	28	
	HH	23	24.4	25	23.7	25.5	25	27	
	II	28	26	29	26.5	28.6	26	28.8	
	JJ	20	23	23	21	24	22.5	25	
	KK	22	24	24	23	23.7	24.7	25	
	LL	28.1	28	29	27	28.4	26	28.8	
	MM	24	24.7	26	23	25.4	24.8	26.5	
	NN	23.2	23	25	23.5	25.3	24	26	
	OO	23.4	22	26	23	24	24.9	26.7	

3.4 Total Dissolved Solids (TDS)

From Table 4, the results show variations in the TDS level on the 14, 28 and 42 days between the sun-exposed samples and the control group; however, all the samples remained significantly below the maximum permissible limit of 1200 mg/L for all brands. While the Test Group brands of BB, DD, GG, HH, JJ, LL, MM, and OO exhibited the highest TDS levels during some exposure periods, suggesting an increase in dissolved solids, while brands AA, CC, EE, FF, II, KK, and NN also showed fluctuations in TDS levels, indicating variability in dissolved mineral content. Most brands displayed a gradual increase in TDS over time, with slightly higher values observed in sunlight-exposed samples. Evaporation or chemicals seeping from the plastic packing may be responsible for the result of increase observed in the dissolved materials. The exposed sachet water values in this investigation were greater than those found by Adedire et al. (2018) and Ikpeazu and Amos (2017).

Table 4. TDS analysis result of various brands at different exposure windows

| Parameter | Brand | 0 days | 14 days | | 28 days | | 42 days | | WHO |
		Control	Control	Test	Control	Test	Control	Test	
TDS (mg/L)	**AA**	55.9	60.4	61.3	63.4	66.4	64	68.7	1200
	BB	78.9	79.9	83	82	85.9	85.3	88.3	
	CC	40.1	46.1	48.7	53.8	55.2	54.1	63	
	DD	65.6	55	68.2	70.9	74	72.6	78.0	
	EE	39.2	43.7	44.5	44.9	49.2	45.4	57.3	
	FF	50	50.9	54.4	53.4	60.3	57.4	60.8	
	GG	78	71.9	80.2	79.4	82.3	81.9	85.8	
	HH	65	67.1	69	71.4	75.3	73.6	75.6	
	II	34	38	36.6	39.8	40.5	40.9	44.1	
	JJ	100	65	67.4	66.9	73	69.2	75.1	
	KK	45	46.1	48.3	47.4	50	49.9	59.9	
	LL	63	63.7	66.7	65	68.4	67.9	70.3	
	MM	80	73.2	75.7	74.2	77.8	78.6	82	
	NN	55	60.2	59.9	62.9	66.7	65	69.7	
	OO	74	77	77.9	78	82.3	79	82.9	

Fluoride

The WHO standard for fluoride concentration in drinking water falls between 0.5 to 1.5 milligrams per litre (mg/L). Table 5 shows the variations in the fluoride level at the 14, 28 and 42 days of exposure, both control and test samples showed a slight decrease in fluoride content over time. This decline is likely due to natural processes like hydrolysis and adsorption. However, the decrease was more pronounced in the test samples exposed to sunlight, suggesting that sunlight might accelerate fluoride loss. It is noteworthy that the initial fluoride levels were already within the WHO recommended range (0.5 - 1.5 mg/L). Water contains a naturally occurring element called fluoride, which is crucial for building stronger teeth and bones. It lessens the development of bacteria in the mouth and prevents cavities. Fluoride, however, can result in dental fluorosis at high doses, which causes brown or white streaks or patches above the teeth.

Table 5. The fluoride content analysis result of various brands at different exposure windows

| Parameter | | 0 days | 14 days | | 28 days | | 42 days | | WHO |
		Control	Control	Test	Control	Test	Control	Test	
Fluoride(mg/L)	**AA**	1.5	1.5	1	1.5	1	1	1	1.5
	BB	1.5	1.5	1.5	1.5	1	1.5	1	
	CC	1	1	1	1	1	0	0	
	DD	1	1	1.5	1	1	1	1	
	EE	1.5	1.5	1.5	1.5	1	1	1	
	FF	1	1	1	1	1	0	0	
	GG	1	1	1	1	1	1	0	
	HH	1	1	1	1	1	1	0	

II	1.5	1.5	1.5	1	1	1	1
JJ	1	1.5	1	1	1	1	0
KK	1.5	1.5	1	1	1	1	1
LL	1.5	1.5	1	1	1	1	1
MM	1.5	1.5	1.5	1	1	1	0
NN	1.5	1	1	1	1	1	0
OO	1	1.5	1	1	1	1	0

Lead

Across all brands, exposure to sunlight resulted in a notable increase in lead concentration. Table 6 shows the levels of lead in sachet water for both the control and test groups. The average lead content for control groups (1 day) was 0.004 mg/L, while the sun-exposed groups (42 days) showed an average of 0.06 mg/L, representing a 1500% increase. Some brands displayed higher susceptibility to lead leaching under sunlight exposure. Brand AA exhibited a rise from 0.006 mg/L to 0.06 mg/L (1000% increase). Conversely, brands like BB and CC showed comparatively smaller increases. Lead content generally increases with the duration of sunlight exposure. The average lead levels at 14, 28, and 42 days were 0.01 mg/L, 0.03 mg/L, and 0.06 mg/L, respectively. The findings align with Fajoyomi et al., (2022) demonstrating the negative impact of sunlight on lead leaching from plastic packaging. Sunlight-induced temperature fluctuations and degradation of the plastic can accelerate the migration of lead stabilizers into the water. Lead, a hazardous heavy metal, can have serious health effects; especially in young children. It can also cause kidney damage, cancer, and cardiovascular conditions like high blood pressure, heart disease, and stroke.

Table 6. The lead content analysis result of various brands at different exposure windows

Parameter	Brand	0 days	14 days		28 days		42 days		WHO
		Control	Control	Test	Control	Test	Control	Test	
Lead (mg/L)	**AA**	0.006	0.007	0.01	0.02	0.04	0.01	0.06	0.01
	BB	0	0.002	0.007	0.004	0.01	0.006	0.04	
	CC	0	0.001	0.005	0.003	0.007	0.007	0.01	
	DD	0.004	0.006	0.02	0.008	0.03	0.009	0.01	
	EE	0	0.004	0.009	0.004	0.04	0.01	0.02	
	FF	0.003	0.002	0.007	0.002	0.009	0.007	0.02	
	GG	0	0.003	0.006	0.005	0.02	0.1	0.07	
	HH	0.009	0.009	0.06	0.01	0.04	0.03	0.05	
	II	0	0	0.03	0.01	0.07	0.06	0.11	
	JJ	0.001	0.004	0.04	0.02	0.07	0.04	0.09	
	KK	0.03	0.05	0.11	0.06	0.17	0.09	0.2	
	LL	0	0.008	0.03	0.01	0.04	0.03	0.07	
	MM	0.01	0.006	0.05	0.01	0.07	0.45	0.09	
	NN	0.007	0.01	0.009	0.04	0.03	0.03	0.06	
	OO	0.003	0.005	0.01	0.009	0.01	0.03	0.08	

Escherichia coli

One type of bacteria that is frequently discovered in both animal and human intestine is *Escherichia coli*, or *E-coli*. It indicates contamination with faecal matter when found in water. While some are harmless, however, if ingested some can cause diarrhea, vomiting, and urinary tract infection. No case of *E. coli* contamination was detected in any brand or sample throughout the study (Table 7). This indicated good initial water quality and effective sachet water treatment practices. All sachet water brand samples used as both control and test groups showed zero *E. coli* presence in all 100ml samples, indicating adherence to safety standards for microbial contamination and dissimilar findings were made by Ikpeazu and Amos (2017).

Table 7. The *E. coli* content analysis result of various brands at different exposure windows

Parameter	Brand	0 days	14 days		28 days		42 days		WHO
		Control	Control	Test	Control	Test	Control	Test	
E. coli (ML)	AA	0	0	0	0	0	0	0	Zero in 100ML
	BB	0	0	0	0	0	0	0	
	CC	0	0	0	0	0	0	0	
	DD	0	0	0	0	0	0	0	
	EE	0	0	0	0	0	0	0	
	FF	0	0	0	0	0	0	0	
	GG	0	0	0	0	0	0	0	
	HH	0	0	0	0	0	0	0	
	II	0	0	0	0	0	0	0	
	JJ	0	0	0	0	0	0	0	
	KK	0	0	0	0	0	0	0	
	LL	0	0	0	0	0	0	0	
	MM	0	0	0	0	0	0	0	
	NN	0	0	0	0	0	0	0	
	OO	0	0	0	0	0	0	0	

4 CONCLUSION & RECOMMENDATIONS

This study investigated the impact of sunlight radiation on the microbiological and physicochemical quality of sachet water in Kaduna metropolis, Nigeria. The results provide substantial evidence for the following conclusions: exposure to sunlight radiation significantly increases the lead content in sachet water. Lead levels across all brands showed a notable rise over 42 days of exposure, exceeding the WHO guideline value of 0.01 mg/L in several cases. This poses a potential health risk, particularly for vulnerable populations like children and pregnant women. Sunlight exposure has a negligible impact on E. coli levels, while some initial reduction might occur, bacterial counts can rebound or even increase over time due to factors like heat-induced stress response and nutrient availability. Physicochemical parameters like temperature, conductivity, and turbidity also increased in values with sunlight exposure. This indicates further deterioration of the water

quality and highlights the need for proper storage and handling practices. According to the revised NAFDAC regulation (2023) section 6 states that finished product in this case the sachet water should be stored on pallets or shelves and be covered appropriately. It is hereby recommended that packaging material coupled with water treatment technologies that minimize lead leaching and microbial contamination in sachet water should be encouraged.

ACKNOWLEDGMENT

CONFLICT OF INTEREST

The author declares no conflict of interests.

REFERENCES

Adedire OM, Atere A, Ogundipe WF, & Farinu AO, 2021' 'Effects of direct and indirect sunlight on polythene packs, sensory, microbial and chemical properties of sachet water', *Journal of Advances in Biology and Biotechnology*, Vol. 24 no 1 pp. 25-34.

Adesakin, TA, Oyewale, AT, Mohammed, N A, Bayero, U, & Adedeji, AA, 2022, 'Effects of prolonged storage condition on the physicochemical and microbiological quality of sachet water and its health implications: A Case Study of selected water brands sold within Samaru Community, Northwest Nigeria', *Microbiology Research Vol 13*, no 4, pp 706–720 https://doiorg/103390/microbiolres13040051

Akharame, MO, Ekhosuehi, A, Okolafor, FI, & Sadoh, KA, 2018, 'Effect of sunlight exposure on the quality parameters of bottled water', *J of Appl Sci and Environ Manage* Vol 22 no 5 pp 769-774

APHA 2017' 'Standard Methods for the Examination of Water and Wastewater', Edn 23, American Public Health Association (APHA), Washington DC, USA, 20

Bona, SK, Gogra, AB, & Koroma, BM, 2018, 'Quality Assessment of Five (5) Brands of Sachet Water Marketed in Bo City', *Natural Resources*, Vol 9, no 4, pp 110-128 https://doiorg/104236/nr201894008

Fajoyomi BU, John, GN, Woga EM, & Daodu BT, 2022, 'Sunlight effect on physio-chemical properties of potable water Marketed in Port Harcourt', *International Journal of Recent Research in Life Sciences* (IJRRLS), Vol 9 no 1 pp 10-15

Ikpeazu, CJ, & Amos OO, 2017, 'Effect of storage and exposure to sunlight on the quality of sachet water sold in Ibadan Metropolis', *Science Journal of Public Health,* Vol 5 no 4 Pp 321-328 https: doi: 1011648/jsjph2017050417

Islam, MA, Ghosh, S, Alam, AU, Islam, MT, & Kabir, MR, 2021, 'Assessment of Physico-Chemical and Microbiological Quality of

Drinking Water in Three Upazilas of Noakhali District in Bangladesh', *Open Access Library Journal*, Vol 9 No 6, pp 1-11, https://doiorg/104236/oalib1107941

Ladokun, OA & Oni, SO, 2015, 'Physico-Chemical and Microbiological Analysis of Potable Water in Jericho and Molete Areas of Ibadan Metropolis', *Advances in Biological Chemistry,* Vol 5, no 4, pp 197-202 http://dxdoiorg/104236/abc201554016

Lukubye, B, & Andama, M, 2017, 'Physico-Chemical Quality of Selected Drinking Water Sources in Mbarara Municipality, Uganda', *Journal of Water Resource and Protection*, Vol 9, pp 707-722 https://doiorg/104236/jwarp201797047

Maddah, HA, & Alzhrani, AS, 2017, 'Quality Monitoring of Various Local and Imported Brands of Bottled Drinking Water in Saudi Arabia', *World Journal of Engineering and Technology*, Vol 5, no 4, pp 551-563 https://doiorg/104236/wjet201754047

Mosi L, Adadey SM, Sowah SA, & Yeboah C, 2019, 'Microbiological assessment of sachet water "pure water" from five regions in Ghana', *AAS Open Research*, Vol 1 no 12, pp 1-19, https://doiorg/1012688/aasopenres128372

NAFDAC (2023), 'Guidelines for Inspection & Requirements for Packaged Water Facility in Nigeria (Fresh Applications)', Retrieved from https://nafdacgovng/wp-content/uploads/Files/Resources/Guidelines/FSAN_2023_To_2028/Guidelines-for-Inspection-and-Requirements-for-Packaged-Water-Facility-in-Nigeriapdf

Ojekunle, ZO, Ojekunle, VO, Eruola, AO, Oyebanji, FF, & Olatunde, KA, 2015, 'The effects of storage on sachet water quality in Ogun State, Nigeria', *Journal of Applied Science and Environmental Management*, Vol 19 no 2 pp 183 - 189

Okoro, LN, Vatsa, YH, & Uma, OI, 2023, 'Effect of sunlight, temperature and time on the physicochemical properties of sachet water in Yola Metropolis, Adamawa State, Nigeria', *J Appl Sci Environ Manage Vol* 27 no 6 pp 1237-1244

Palamuleni, L, & Akoth, M, 2015, 'Physico-Chemical and Microbial Analysis of Selected Borehole Water in Mahikeng, South Africa', *International Journal of Environmental Research and Public Health* Vol 12, no 8, pp 8619-8630 https://doiorg/103390/ijerph120808619

Pangborn, RM, & Bertolero, LI, 1972, 'Influence of Temperature on Taste Intensity and Degree of Liking of Drinking Water', *Journal of the American Water Works Association*, Vol 64, no 8, pp 511-515 https://doiorg/101002/j1551-88331972tb02739x

Shamimuzzaman, M, Nayeem, RH, Ara, N, Rahman, MM, & Jahid, M 2019, 'Physico-Chemical and Microbiological Quality Assessment of Supply Water around Dhaka City, Bangladesh', *Journal of Water Resource*

and Protection, Vol 11, no 3, pp 280-295 https://doiorg/104236/jwarp2019113016

Tyson, A, & Harrison, K, 1990, 'Water Quality for Private Water Systems', University of Georgia, Athens, Georgia Athens G A seminar paper Presentation University of Georgia

Yasin, M, Ketema, T, & Bacha, K, 2015, 'Physico-Chemical and Bacteriological Quality of Drinking Water of Different Sources, Jimma Zone, Southwest Ethiopia,' *BMC Research Notes*, Vol 8, pp 541 https://doiorg/101186/s13104-015-1376-5