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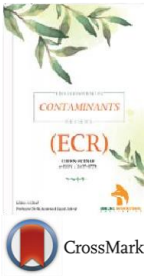

RESEARCH ARTICLE

DRINKING WATER PREFERENCE AND MICROBIOLOGICAL CONTENTS OF SELECTED, LOCALLY CONSUMED SACHET WATER AT SINKOR, LIBERIA

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ABSTRACT

This research assesses the microbiological quality and reasons for brand preference among consumers of sachet water samples in Sinkor area, Monrovia, Liberia. The study looked at the bacterial profile of sachet water in Sinkor, Monrovia, and considers factors that determined individuals' preference of each water brand. A survey consisting of questionnaires was administered to 102 respondents in order to determine the several parameters, while the bacteriological quality assessments of sachet water samples were determined by the Most Probable Number (MPN), and pH value was determined by the pH meter. Five mostly patronized water brands were involved. Results showed that the order of factors considered before choosing a brand is in the following order: good taste> clean appearance>good packaging> odorlessness while they detested water brands based on same factors in the following order: bad odor> bad taste>possession of color or particles > rough packaging>lacks expiry date on the container. In addition to these, microbiological profile revealed that all of the sachet water samples analyzed fulfill WHO requirements. Monitoring bodies in charge of drinking water in the study area must be encouraged to maintain standards.

KEYWORDS

Water quality, contaminant, pH, preference, drinkability, Liberia.

1. INTRODUCTION

Sachet water is water that has been mechanically packed and sealed. As opposed to other nearby African countries like Ghana, Nigeria, Togo, etc. where it is known as "pure water," many Liberians refer to this water as "plastic water" in their daily conversations. Sachet water is also sold in plastic bags that have been manually filled and tied. The local phrase for this is "ice water" (Kusa and Joshua, 2023). The majority of the water in the sachets comes from a borehole. Aeration, double or single filtration using porcelain molecular candle filters or membrane filters, and disinfection are the most common treatments used by small-scale producers of sachet water. Usually, the source of the water has an impact on the level of treatment. Water used for human consumption must meet a number of requirements, including being free of all pathogenic bacteria and containing little in the way of compounds that are immediately dangerous or have significant long-term effects on health. Ideally, drinking water should be clear, odorless, and free of any additives that can add flavor or color (Adiotomre and Agbale, 2015).

Drilling shallow wells and boreholes through the current water table to create well points allows for the extraction of drinking water from the earth. In some parts of Africa, water that percolates through the soil picks up detrimental physical, biological, and chemical elements that render it unfit for human consumption, such as fluoride, fine suspended debris, and fecal coliform. Due to potential effects on public health, the quality of drinking water has garnered a lot of attention worldwide (Abdulai, 2015). Drinking water supplied in sachets is widely available in Liberia and frequently used as a main supply of water at canteens and other food stands. Since the majority of people consume it, it is necessary to evaluate the quality of sachet and borehole water in order to protect users' health. Drinking water in underdeveloped nations has been linked to several, widespread health hazards, a substantial portion of which are biological in nature. According to reports, among the 20 main risk factors for health burden in developing nations, unclean water, inadequate sanitation, and poor hygiene are in third (Mebrahtom et al., 2022).

The guidelines for quality drinking water is intended for use by countries as a basis for the development of national standards which if properly implemented, will ensure the safety of drinking water (Dinka, 2018). Access to clean drinking water is a significant global issue, with biological pollution causing 400 deaths per hour (Ndayambaje, 2023). Safe water and minimal sanitary facilities can reduce diarrhea, sleeping sickness, and guinea worm infections. Recording the physiochemical and bacteriological characteristics of sachet water brands is crucial. Liberia's government struggles to provide enough pipe-borne water for its residents, leading to the development of sachet or plastic water manufacturing factories. These water systems are free of pathogenic bacteria, contain low levels of chemicals, are clear, smell-free, and free of undesirable colors or tastes (Apeh, 2018). In Liberia, sachet water is often available in food canteens and from street sellers, but its characteristics must be determined to protect consumers' well-being. Information on the healthiness of water, or level of pollution of sachet water in Liberia is not available in literature. Therefore, work aims to collect necessary information on water health and pollution in the study area. This study aims to determine the bacteriological profile of sachet water samples in Sinkor, Monrovia, investigate people's perceptions of drinking water brands, and compare total bacterial counts with standard permissible units.

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2. Materials and Methods

2.1 The Study Area

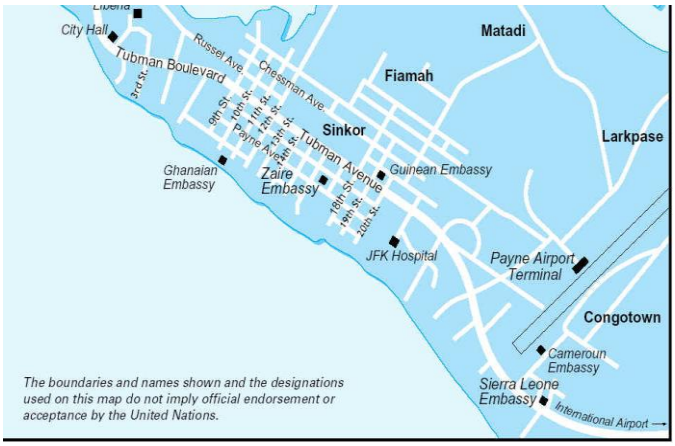

Figure 1: A map containing the study area (Source: Ellis, 2010)

Sinkor (Figure 1) is situated in Monrovia, Montserrado county of the Republic of Liberia, at 6 18' 0" North and 10 46' 0" West. Monrovia (6°18′48″N 10°48′5″W) is the cultural, political and financial center of the country and a main hub of commerce and transportation. The city has a population of about 1 million people in the Greater Monrovia District (nationsonline.org, 2023).

2.2 Data Collection and Analysis Methods

(1) Based on the aim of this work, data was collected in two main forms as follows:

2.2.1 Survey

There were 102 questionnaires administered randomly to 102 respondents in order to assess their perceptions of the selected brands of water they prefer with regard to taste, odor, appearance, and packaging. The 102 respondents were able to answer these questions, and the results were recorded in this study.

2.2.2 Microbiological and pH Analysis

Seven different sachet water brands were collected from sale areas, and they were labeled samples A–G. Three of each brand of sachet water were sampled randomly for bacteriological analysis. This collection was repeated in three replicates. A total of eighteen various samples of different brands were purchased at different locations and each was labelled with special codes for identification, placed in clean polythene bags, and taken to the laboratory for microbial analysis. Within 24 hours of the sample collection, a test for microbes was performed on the samples. Salmonella, E. coli, total viable count, total coliform, and fecal coliform were all determined using the Most Probable Number (MPN) methods (Cao et al., 2023). A piece of each water brand was cut with a knife and put into a beaker along with sample names and locations. In order to add three drops of water from the beaker to each of the petri dishes containing plat count agar, maximum recovery diluent, brilliant green, laury tryptose broth, hektoen enteric agar, dichloran medium, and base rose Bengal, the puppet's tail was attached to the puppet. Each petri dish bears the name of the water brand and the store where it was purchased. The water drops in the petri plates were distributed using the spreader. The petri plates were heated in the incubator to 440 °C for 18 to 24 hours, and the color change was noted (Cao et al., 2023).

2.2.3 pH

The pH meter was calibrated using pH buffers of 4.0, 7.0, and 10.0 to make sure the mV versus pH plot maintained the tertian relation. A beaker was filled with a 100ml aliquot of each sample, and the pH was then measured using a pH meter. This was completed at the time of the laboratory analysis (Lanjwani et al., 2023).

3. Results and Discussion

Table 1: Socio-Demographic Data of Respondents

Characteristics	Categories	Frequency	Percentages
Age	15-25	45	44%
	26-35	36	35%
	36-45	16	16%
	Above 45	5	4.9%
Sex	Male	65	64%
	Female	37	36%
Educational Level	No Education	1	0.9%
	Primary	18	17.6%
	Junior High	39	38.2%
	Senior High	13	12.7%
	Vocational	30	29.4%
	Tertiary	1	0.9%
Occupational Status	Government Job	19	18.6%
	Private Job	15	14.7%
	Self-employed	6	5.9%
	Farmer	4	3.9%
	Trader	17	16.7%
	Unemployed	41	40.2%

Based on the evaluation of a select group of local sachet water consumers, Table 1's socio-demographic data revealed that 36% of respondents were female and 64% were male. Table 1 showed that 1 respondent for primary school had 0.98 percent, 18 for junior high had 17.65 percent, 39 for senior high had 38.24 percent, 13 for senior high had 12.75 percent, 30 for senior high had 29.41 percent, and 1 had 0.98 percent. These figures show the total number of respondents and the proportion of respondents based on educational attainment.

Following the findings on the perception of the locally consumed sachet water in Sinkor, it was observed (Table 1) that the percentage age group of respondents was 44% for individuals between the ages of 15 and 25, 35% for individuals between the ages of 26 and 35, 16% for individuals between the ages of 36 and 45, and 5% for people over the age of 45.

Significant findings on respondents' impressions of a sample of locally used sachet water in Sinkor are presented in Table 1 and show the quantity and distribution of respondents' jobs as follows: For government positions, there were 19 responders for an 18.6% response rate. There were 15, making up 14.7 percent. There were 6, with an independent contractor percentage of 5.9. There were 4 for farming occupations. There were 17, with a 16.7 percent. There were 41 jobs with an unemployment rate of 40.2.

Table 2: Respondents' Preferences of A Particular Brand of Sachet Water

	SAMPLE A	SUPERIOR F	SAMPLE C	SAMPLE B	SAMPLE F	SAMPLE G	SAMPLE D	TOTAL
GOOD TASTE	11	5	4	3	1	4	3	31
ODORLESS	2	7	1	3	2	0	2	17
CLEAN AND HYGIENIC	7	5	5	2	4	3	2	28
WELL PACKAGED	3	6	4	6	3	3	1	26
TOTAL RESPONDENTS	23	23	14	14	10	10	8	102

3.1 Brands of Water Preferred by Respondents

Table 2: It was revealed from 102 respondents about the kind of water they thought they preferred, and found that 23 of them preferred Sample A, 10 preferred Sample E, 14 preferred Sample C, and 14 preferred Sample B. Sample D is preferred by 8 respondents, Sample G by 10 respondents, and Sample F by 23 respondents. The table 2 results showed that the order of factors considered before choosing a brand is in the following order: good taste> clean appearance>good packaging> odorlessness.

3.1.1 Discussion

In poor nations, including Liberian towns, access to water remains a challenge. Consumers prioritize safe, quality, and visually appealing sachet water for cooking, drinking, and other activities. A good brand and quality water boosts customer confidence. Table 2 shows 31 out of 102 respondents believe water has good taste, supporting study in Ghana, which found 75% believe water has taste (Addo et al., 2020). This study found that 28 respondents thought that water looks clean and hygienic and 17 respondents said that water is odorless (Table 2), which is consistent with cross-sectional study done in Nigeria that believed that water should be colorless and orderless (Oludairo et al., 2020). Good quality water shouldn't have any color, so this study's findings indicate that 28 respondents thought that water looks clean and hygienic. Consumer choice for sachet water was found to be significantly influenced by color and odor as indicators. Additionally, customers were seven times more likely to favor a specific brand if they stated that the color and smell of the water influenced their choice when purchasing sachet water. This indicates that users of sachet water were aware of the dangers of consuming colored or odorized water because it was unfit for human consumption. Drinking water color and smell could be caused by metal concentrations, microorganisms, or chemicals.

Table 3: Consumers' Reasons of Disliking A Particular Brand of Sachet Water

	SAMPLE A	SAMPLE E	SAMPLE C	SAMPLE B	SAMPLE F	SAMPLE D	SAMPLE G	TOTAL
NUMBER OF RESPONDENT	16	11	17	11	26	13	8	102
IT HAS BAD TASTE	6	1	6	0	5	1	3	22
IT HAS BAD ODOR	4	5	6	6	9	7	2	39
IT'S DIRTY	3	3	1	2	6	2	3	20
NOT NEATLY PACKAGED	3	2	2	2	5	3	0	14
NO EXPIRY DATE WRITTEN ON IT	0	0	2	1	1	0	0	4
TOTAL NUMBER OF RESPONDENTS	16	11	17	11	26	13	8	102

3.2 Reasons Why Citizens Dislike Certain Brands of Sachet Water

Table 3: After a thorough investigation into the subpar quality of particular sachet water brands, it was found that 16 respondents largely disapproved of Sample A, 11, mostly disapproved of Sample E, 17, mostly disapproved of Sample C, 11, mostly disapproved of Sample B, 26, mostly disapproved of Sample F, 13, mostly disapproved of Sample D, and 8, mostly disapproved of Sample G. Water brands were preferred based on factors in the following order: bad odor> bad taste>possession of color or particles > rough packaging>lacks expiry date on the container.

3.2.1 Discussion

Access to water still remains a challenge in most developing countries including some communities in Liberia. Some communities in Liberia rely on other sources of water for their domestic activity like washing and bathing but resort to sachet water for cooking and drinking purposes. This study looked at what informed consumers on the brand of sachet water they purchased and used and its quality. The availability of drinking water that is not only safe in terms of its quality but also acceptable in its color, taste and odor is of utmost priority to the consumer. Water that is meant for drinking purposes that has good aesthetic value will appeal to the confidence of the consumer. According to Table 3, the respondents' preferences indicated that 22 out of 102 respondents affirmed that water has bad taste, this study supports the studies of in Ghana which indicated that 75% of the respondents believe that water has taste (Addo et al., 2020). The presence of taste in drinking water could be attributable to metal concentrations, organisms, and chemicals.

Water of good quality should not have color, therefore, this study revealed 20 respondents that observed that water looks dirty and 39 respondent said that water has bad odor (Table 3), goes contrary to cross-sectional study done in Nigeria that opined that water should be colorless and odorless (Oludairo et al., 2020). It was found that color and odor as an indicator were significant in informing consumers in making their preference of sachet water. In addition, consumers who said the color and odor of water informed their decision when buying sachet water were seven times more likely to have a preference for a particular brand. This means that consumers of sachet water were aware of the implications of drinking water that had color and odor as the color and odor rendered the water impure for human consumption. The presence of color and odor in drinking water could be attributable to metal concentrations, organisms, and chemicals.

Table 4: pH of Samples

Sample	pH
A	7.90
B	7.60
C	8.00
D	7.80
E	7.85
F	8.00

3.3 Ph Profile of The Sample

According to Table 4, sample A had a pH of 7.90, sample B's pH dropped to 7.60, which is basic, sample C's pH increased further to 8.00, sample D's

pH dropped to 7.80, which is borderline basic, sample E's pH increased to 7.85, which is also borderline basic, and sample F's pH increased to be 8.00

3.3.1 Discussion

pH values below 6.5 make water too acidic for human consumption; water with such low values could cause serious health complications due to acidosis, and water with a higher pH above 8.5 could also lead to serious homeostatic imbalance due to alkalosis (Cobbina et al., 2023). Based on this, the Liberia Water and Sewer Corporation (LWSC), Environmental Protection Agency (EPA), Ministry of Commerce, and World Health Organization (WHO) set a pH standard of 6.5–8.5 for drinking water. According to table 4 pH values from all retail points were all within this set standard. However, comparing individual water samples from retain points, all the samples of sachet water had a pH within the recommended standard (6.5 and 8.5, respectively). This gives a compliance percentage of 100%. This compliance percentage is above the percentage recorded by Owusu from a study conducted on water samples from the Techniman Municipality, Kumasi, Ghana (Owusu, 2016). In that study, they reported a compliance of 87.5% for pH. Therefore, this study supports Owusu, who indicated that sachet water sold in the study area was unlikely to cause any health problems relating to pH, such as acidosis and alkalosis (Owusu, 2016).

Normality, observed in pH, could be attributed to the absence of the production of basic metabolic waste products by an increasing bacterial population. In their review, stated that microorganisms frequently change the pH of their own habitat by producing acidic or basic metabolic waste products (Li et al., 2017). Six out of seven samples were sent to a lab for microbiological analysis based on the survey results and the microbiological studies that were done on the samples. Since one sample (sachet water from Sample G) had the fewest respondents base on the respondents' dislike out of the seven, that one out of the seven was not sent to the laboratory for testing. The study called for the submission of six different brands of sachet water for testing. The results of the microbiological and socio-demographic investigations were provided in the appropriate sections with graphical and table examples and compared to the WHO drinking water standard.

Table 5: Coliform Count Profile

Samples	Salmonella	Total Viable Count	Fecal Coliform	*E. Coli*
A	Nil	Nil	Nil	Nil
B	Nil	Nil	Nil	Nil
C	Nil	Nil	Nil	Nil
D	Nil	Nil	Nil	Nil
E	Nil	Nil	Nil	Nil
F	Nill	Nil	Nil	Nil

3.4 Coliform Count Analysis

MPN Petri dishes did not show a color change from purple to yellow or gas after 24 hours, which indicated the absence of fecal coliforms, *E. coli,* total viable count, and *Salmonella.* From table 5: It demonstrates that none of the six sachet water samples had a coliform count that was negative. This means that the water sample contains neither E. coli bacteria nor total coliform.

3.4.1 Discussion

The microbiological analysis of a few sachet water samples collected at random from Sinkor's various selling zones is recorded in this study (Table 5). It is necessary to note that at the point of laboratory assessment, this study did not record any microbial contamination of the sachet water samples. Therefore, all six sachet water samples tested did not contain total coliforms. This can be attributed to a sufficient amount of filtering, addition of chlorine, or faulty UV system testing, which may also contribute to the lack of bacterial pathogens in the sachet. A group researchers all reported contamination of sachet water sold in both Ghana and Nigeria with total coliforms in ranges different from the results reported by this study (Mosi et al., 2018; Tenebe et al., 2013; Owusu, 2016).

Total coliforms are widely used as indicators of the general sanitary quality of untreated drinking water, while fecal coliforms give a much closer indication of fecal pollution (Niyoyitungiye et al., 2001). This lack of contamination of the sachet water samples without bacterial pathogens could be attributed to good hygiene practices at the factories and the ability of the filtration system to effectively remove all bacterial pathogens from the treated water. In Nigeria, reported that bacteria isolated from sachet water were even, in some cases, resistant to eight common antibiotics (Bello et al., 2017). This gives an indication of the public health issues that could be attributed to bacterial contamination of sachet water.

A study conducted in Lagos, Nigeria, revealed that the bacteriological characteristics of sachet water deteriorated considerably as products moved farther down the distribution chain. Less than 7% of sachet water contamination took place after production, while between 40 and 45% of the products were observed between the distribution sheds and the street hawkers (Venkatesan et al., 2014).

Table 6: WHO Drinking Water Quality Standards / Guidelines for Selected Parameters

Parameters	**Unit**	**Desirable**	**Maximum**
pH		6.5-8.5	No relation
Total Coliform Count Mg/L		Nil/100ml of sample	

4. Conclusion

Consumers choose sachet water based on factors like taste, odor, color, cleanliness, packaging design, and expiration date. Microbiological content met the WHO drinking water criteria (Table 6), indicating safe samples. The pH range of six samples was within WHO norms. A further study to identify heavy metal contaminants in sachet water brands in the study area is advised. Ensuring government oversight and adherence to regulations is important also in the study area. Environmental Protection Agency and Ministry of Commence should keep conducting routine inspections.

References

Abdulai, K., 2015. Investigation of water quality used by communities in the Savelugu-Nanton District of the Northern Region, Ghana (Doctoral dissertation).

Addo, P.C., Jiaming, F., Kulbo, N.B., and Liangqiang, L., 2020. COVID-19: fear appeal favoring purchase behavior towards personal protective equipment. The Service Industries Journal, 40 (7-8), Pp. 471-490.

Adiotomre, K.O., and Agbale, N.R., 2015. Comparative Analysis of Sachet Water Samples Sold in Benin City, Edo State, Nigeria. International Journal of Innovative Environmental Studies Research, 3 (3), Pp. 22-35.

Apeh, C.C., 2018. Survey of sachet water waste disposal in Liberia. Journal of Health and Pollution, 8 (20).

Ayamba, A., 2016. Determination of the Physico-Chemical and Bacteriological quality of sachet water produced in Tumu, Ghana (Doctoral dissertation).

Bello, O.O., Mayowa, O.O., Temitope, K.B., and Olumayowa, T.A., 2017. Occurrence of antibiotic-resistant bacteria in sachet and bottled water brands in Ondo City, Nigeria.

Cao, C., Zhao, W., Lü, Z., Mo, Y., Hu, W., Sun, S., and Yang, B., 2023. Microbiological analysis and characterization of Salmonella and ciprofloxacin-resistant Escherichia coli isolates recovered from retail fresh vegetables in Shaanxi Province, China. International Journal of Food Microbiology, 387, Pp. 110053.

Cobbina, S.J., Michael, K., Salifu, L., and Duwiejua, A.B., 2013. Rainwater quality assessment in the Tamale municipality. International Journal of Scientific & Technology Research, 2 (5), Pp. 1-5.

Dinka, M.O., 2018. Safe drinking water: concepts, benefits, principles and

standards. Water challenges of an urbanizing world, Pp. 163.

Ellis, S., 2010. The mask of anarchy updated edition: The destruction of Liberia and the religious dimension of an African civil war. NYU Press.

Kusa, R., and Joshua, W.K., 2023. Evaluating the potability and human health risk of sachet water in Wukari, Nigeria. Archives of Environmental & Occupational Health, 78 (2), Pp. 71-79.

Lanjwani, M.F., Altunay, N., and Tuzen, M., 2023. Preparation of fatty acid-based ternary deep eutectic solvents: Application for determination of tetracycline residue in water, honey and milk samples by using vortex-assisted microextraction. Food chemistry, 400, Pp. 134085.

Li, X., Kappler, U., Jiang, G., and Bond, P.L., 2017. The ecology of acidophilic microorganisms in the corroding concrete sewer environment. Frontiers in microbiology, 8, Pp. 683.

Mebrahtom, S., Worku, A., and Gage, D.J., 2022. The risk of water, sanitation and hygiene on diarrhea-related infant mortality in eastern Ethiopia: a population-based nested case-control. BMC Public Health, 22 (1), Pp. 1-14.

Mosi, L., Adadey, S.M., Sowah, S.A., and Yeboah, C., 2018. Microbiological assessment of sachet water "pure water" from five regions in Ghana. AAS Open Research, 1.

Nations online. 2023. https://www.nationsonline.org/oneworld/map/google_map_Monrovia.htm

Ndayambaje, B., 2023. Linking Child Stunting, Water Quality, and Pathogen Sharing at the Human-Animal-Environment Interface in Rwanda: A One Health Study (Doctoral dissertation, The University of Nebraska-Lincoln).

Niyoyitungiye, L., Giri, A., and Ndayisenga, M., 2020. Assessment of coliforms bacteria contamination in Lake Tanganyika as bioindicators of recreational and drinking water quality.

Oludairo, O.O., Aiyedun, J.O., Olorunshola, I.D., Bale, J.O.O., and Akintola, O.O., 2020. Physical properties, correlation and regression analyses of potable water in Ilorin, Nigeria. Journal of Research in Forestry, Wildlife and Environment, 12 (2).

Owusu, A.D., 2016. Quality of sachet water sold in the Techiman Municipality (Doctoral dissertation).

Tenebe, I.T., Babatunde, E.O., Eddy-Ugorji, C.C., Etu, E.E.E., Ogarekpe, N.M., Ekeanyanwu, C.V., and Ezeudu, O.B., 2023. Bacterial Contamination Levels and Brand Perception of Sachet Water: A Case Study in Some Nigerian Urban Neighborhoods. Water, 15 (9), Pp. 1762.

Venkatesan, K.D., Balaji, M., and Victor, K., 2014. Microbiological analysis of packaged drinking water sold in Chennai. International Journal of Medical Science and Public Health, 3 (4), Pp. 472-476.