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Full Length Research Paper

Health and environmental components of sachet water consumption and trade in Aba and Port Harcourt, Nigeria

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80 sachet water products from 10 different brands were sampled in four study locations in Aba and Port Harcourt (PH) cities respectively. Sampling was carried out by stratified simple random techniques. The products were bacteriologically assessed weekly for 12 months between January and December, 2008. Samples were exposed to sunlight (SL) and room temperature (RT) and analysis done using membrane filter (MF) procedures for coliform bacteria enumeration. Public survey to determine the possible effect of sachet water consumption on socio-economic, health and environmental life of residents was also conducted. Results revealed absence of coliform organisms within the first and second week respectively for SL and RT samples. When compared with World Health Organization (WHO) guidelines for potability, all the RT samples analyzed in Aba were within the recommended (0 to 4 cfu/ 100 ml) excellent quality grading in the 4th week while 25% of similar parameter treatment marginally exceeded the limit in PH within the same period. The coliform bacteria level for SL exposed samples in Aba for 3rd week analysis showed an appreciable increase (16.7%) over the value (8.3%) recorded in Port Harcourt (PH) within the same period. In the 4th week, over 91.7% of the SL exposed samples were observed to have exceeded the WHO limit for excellent potable water quality in the two cities. There is growing knowledge by city dwellers that sachet water consumption and trade is responsible for a number of health related disorders ranging from waterborne infections (such as diarrhoea and gastroenteritis) to huge environmental nuisance created by the non biodegradable nature of littered sachet water nylons. The study therefore recommends adequate chemical treatment of source water, shelf-life specification on the sachet water and establishment of recycling plants to manage the growing volume of used sachet water nylons and other plastic materials littering our streets and market places.

Key words: Sachet water nylon, coliform, health, environmental.

INTRODUCTION

The term potable water refers to water that is safe for drinking. Potable water therefore is one that is free of disease producing organisms and chemical substances deleterious to human health (Frederick, 1990). Potable water is an integral component and indispensable requirement in life. It therefore cannot be substituted for any other fluid. It can be sourced from surface water such as rivers, streams and ground water sources like spring, well water and borehole water.

In recent times, packaging of potable water in form of bottled water or sachet water has gradually gained wider acceptability in our major cities. Demographic and

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socioeconomic variables are largely responsible for the choice and preference for this product. Sachet water is a mineral water of about 0.5 L meant for human consumption. It is usually packaged and sold to members of the public in sealed nylons. This occurs mostly in motor parks, markets, public functions and street corner shops. The growing popularity of this potable water unit in our cities singles it out as one of the fastest growing small scale businesses in Nigeria today.

Sachet water notably, offers the most accessible and quickest means of assuaging the feeling of thirst. The relatively cheap and inexpensive nature of the sachet water compared to bottled water makes it a cherished and preferred commodity in the hands of many. Water no doubt, is absolutely necessary for most life driven processes, it can also be a carrier and vehicle for transmission of many diseases such as dysentery, hepatitis, typhoid fever and shigellosis (Oguntoyinbo et al., 1978; Gangarose et al., 1980; Faechem et al, 1983; Jiburum and Uba, 2004; Kwakye et al., 2007). Isirimah (2003) reported that waterborne diseases accounts for 80% of illnesses in developing world, killing a child every 8 s. It is also believed that hospital beds are occupied by people suffering from water borne diseases due to polluted drinking water sources In the present study, the isolation of some species of *Escherichia, Klebsiella, Shigella* and *Streptococci* after a period of storage is an indication that the sachet water products are unwholesome. The continued reliance of this product as a veritable potable water source (often referred to as 'pure water') may be responsible for the increasing level of water borne infections attested to by respondents during a survey in the two cities studied. Regrettably, the attitude exhibited by most consumers of sachet water in terms of littering and proper disposal of used nylons is most worrisome. This has not only created an image and scenic beauty problem but has entrenched a culture of complacency in the quest for preservation and enhancement of the quality of our environment. The study was therefore initiated to evaluate the quality of the sachet water products after temporary storage, assess health indices of consuming sachet water products and the impact of such trade on environment of the affected cities.

MATERIALS AND METHODS

Study area

The study was conducted in Aba and Port Harcourt cities southern Nigeria. Aba is located between latitude 6°20" to 6°58"N and longitude 7°15" to 7°49"E, while Port Harcourt lies between 4°50" to 6°15"N and 6°05" to 7°10"E. Aba is a major city in Abia State, eastern Nigeria. It has one of the biggest international markets in West Africa. The entrepreneurial spirit in the lives of residents compels many to competitive productive ventures. Exchange of goods and services within and outside the city places it at the centre of commercial activity east of the Niger. The city is also confronted with developmental challenges in areas of infrastructural provision, pipe-borne water and environmental sanitation. The sight of used sachet water nylons littering the streets is an indirect measure of the level of patronage and consumption of the product in the city. Port Harcourt city on the other hand, is only about 70 km away from Aba. The city plays host to most multilateral organizations including operators of oil and gas sectors. The influence of oil and gas industries in the city has led to unprecedented surge in population density with enormous pressure on public utility and housing. The response from pressure due to increased demographic and socio-economic changes on residents has created condition favorable for the production and hawking of sachet water products in every for seeable corner of the city. Incidentally, the proliferation of private and commercial water boreholes in Port Harcourt is gradually replacing the usual public pipe-borne water reticulation scheme peculiar to cities in the past. Over 90% of the packaged sachet water sold today is sourced from boreholes which are most often constructed without proper feasibility study and land use criteria.

Sample collection

10 different sachet water brands were randomly collected from Aba Central Motor Park and Ariaria Market in Aba while samples from Port Harcourt were sourced from Borokiri Market and mile 1 market/flyover park. Four (4) samples of each brand made up of 2 duplicate sets of each brand were collected at each of the study areas in Aba and Port Harcourt respectively.

Bacteriological analysis

Enumeration of total coliform bacteria was done by membrane filter (ME) procedure using McConkey broth. About 100 ml amount of each of the sample was filtered using a 47 mm filter paper of 0.45 µm pore size. After filtration, the filter paper was transferred onto absorbent pad saturated with McConkey broth in a petri dish. The plates were incubated at 37°C for 24 h and presumptive total coliform bacterial colonies enumerated with the help of magnifying glass in line with Public Health Laboratory Services (PHLS) (1980) and APHA (1995) guidelines. Presumptive colonies from the filter paper were sub cultured onto 2 tubes of lactose peptone water with phenol red and Durham's tubes at 44 and 37°C respectively. After 6 h, growth from tube at 37°C was sub cultured onto a plate of nutrient agar medium and incubated at 37°C to facilitate emergence of pure culture for isolation and identification. Bacteria isolates were identified after studying their gram staining reaction and morphological characterization. Other tests conducted were oxidase, indole, methyl red, voges proskaeuer and citrate. Tubes of lactose peptone water were also observed for acid and gas production and color change noted. Tubes with no gas production were re-incubated for additional 24 h at 37°C and coliform count recorded. The method of identification of isolates followed that described in Buchannan et al., 1974; Fawole and Oso (1988).

RESULTS

A summary of the monthly total coliform bacteria (TCB) count is presented in Figures 1 and 2 for sachet water samples from Aba and Port Harcourt (PH) cities. These samples were stored at room temperature (RT). Details

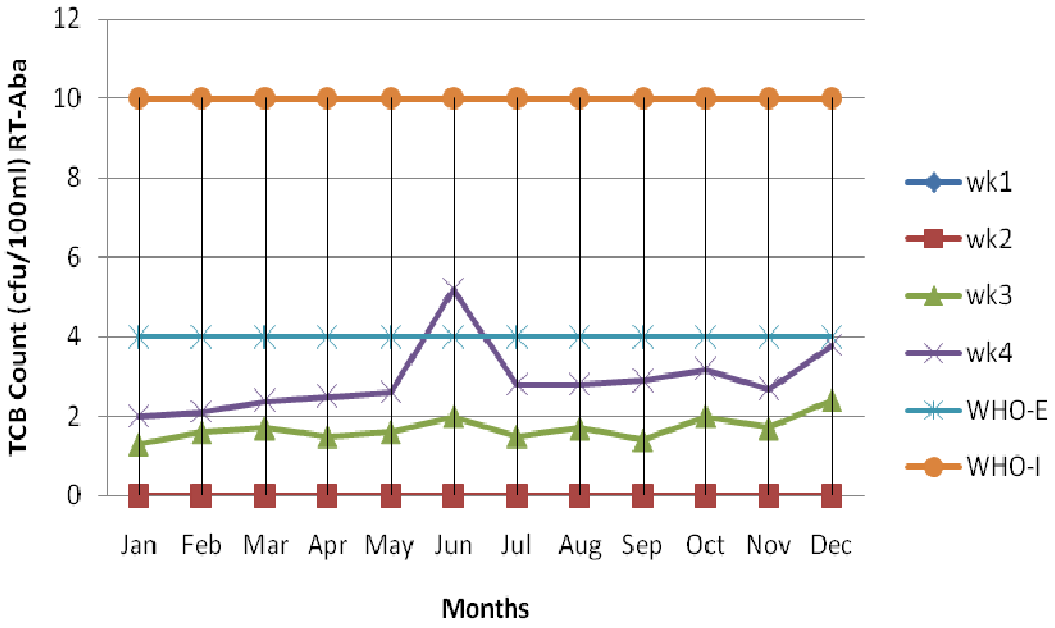

Figure 1. Mean TCB count for RT samples from Aba compared with standard.

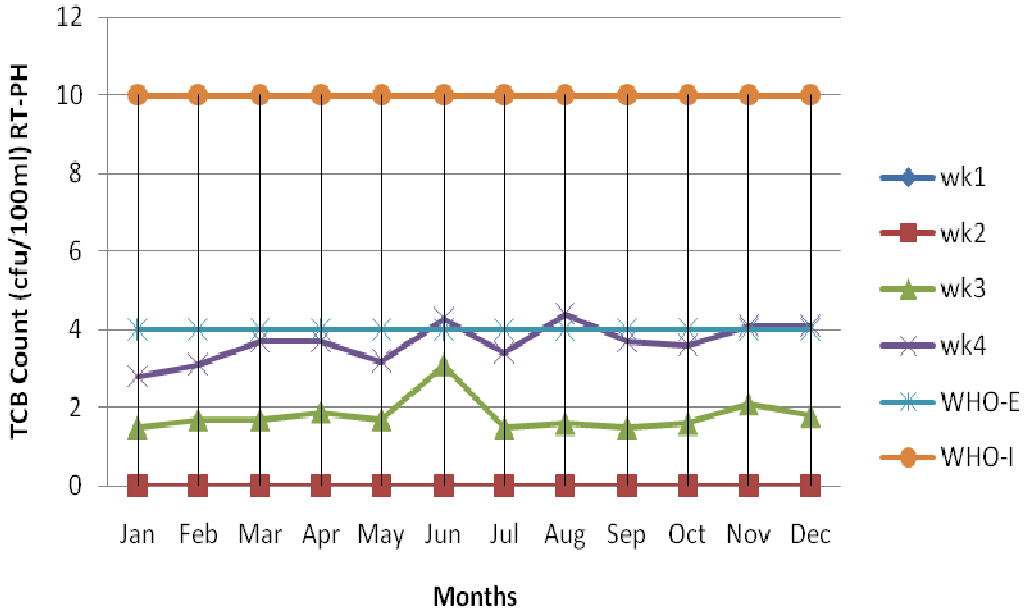

Figure 2. Mean TCB count for RT samples from PH compared with standard.

from the 4-week analysis of samples indicate a comparatively similar range of 0 to 5 cfu/100 ml for Aba and PH cities respectively. The maximum weekly mean TCB (4.3 ± cfu/100 ml) of samples from PH in the month of June was comparably higher than the mean TCB peak (3.8 ± 0.63 cfu/100 ml of sample from Aba in the month of December (Figure 2). The TCB count recorded in Aba for RT samples is fairly within the World Health Organization (WHO), excellent (WHO-E) (0 cfu/100 ml) and satisfactory (0 to 4 cfu/100 ml) grading for quality. However, the coliform counts observed in the months of June, November and December for RT samples in PH were higher than the WHO excellent / satisfactory limit (0 to 4 cfu/100 ml) but within the intermediate (WHO-I) (4 to 10 cfu/100 ml) water quality grading for potable uses.

The TCB of samples from Aba and Port Harcourt

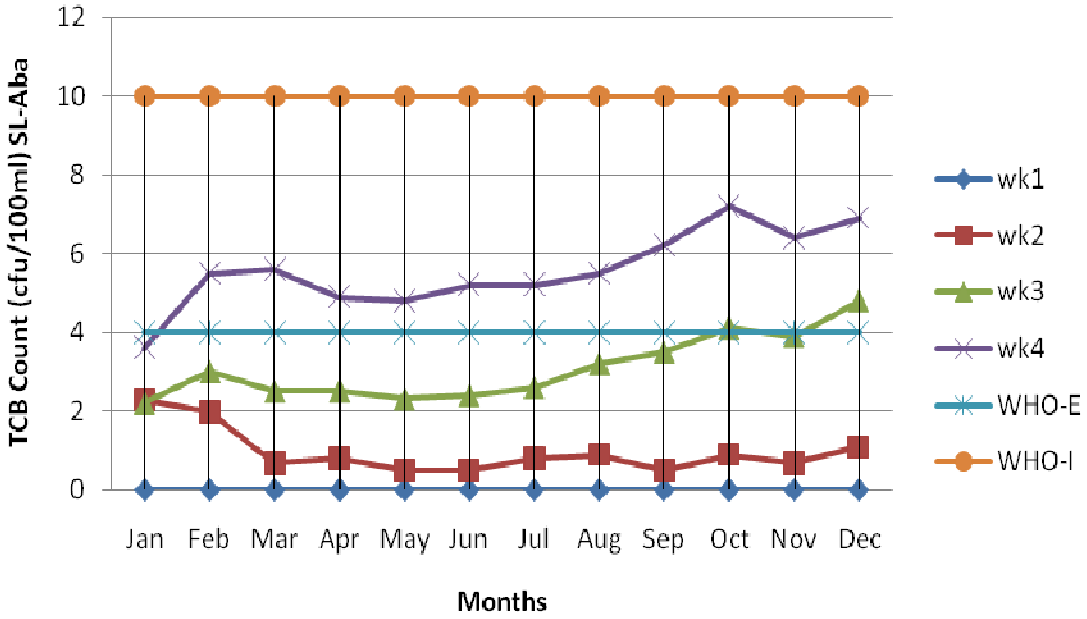

Figure 3. Mean TCB count for SL samples from Aba compared with standard.

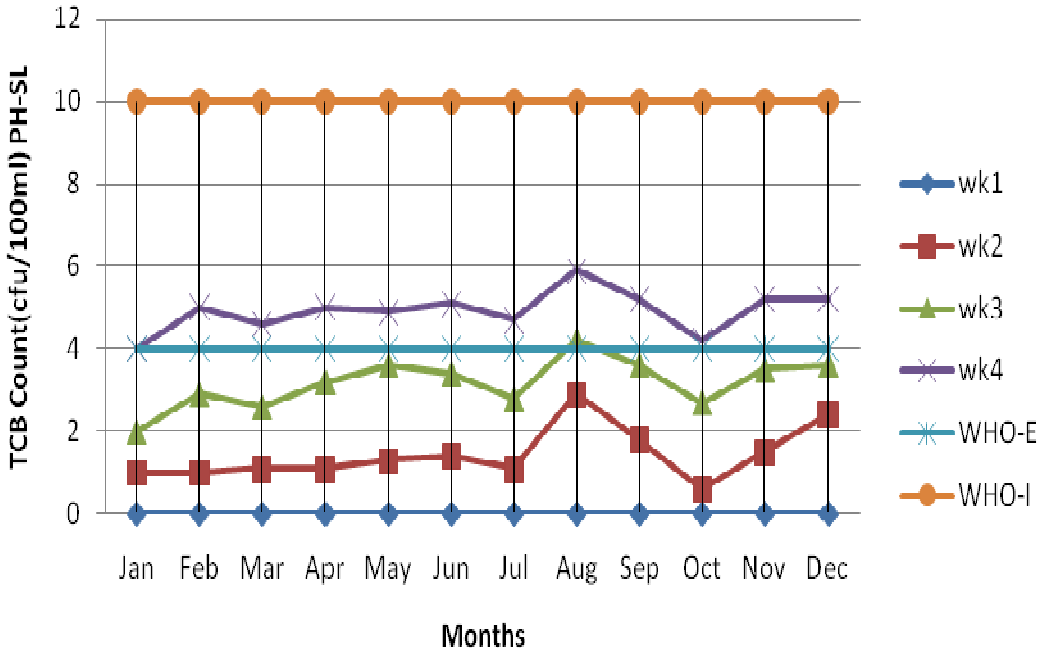

Figure 4. Mean TCB count for SL samples from Port Harcourt compared with standard.

exposed to sunlight (SL) showed higher coliform densities compared to RT samples (Figures 3 and 4) though the TCB range of 0 to 7 cfu/100 ml was recorded for samples from Port Harcourt, a slightly higher range of 0 to 9 cfu/100 ml was observed in samples from Aba. Consequently, the mean weekly TCB count ranged from 2.2 ± 0.78 to 4.8 ± 0.91 cfu/100 ml in week 3 and 3.6 ± 1.17 to 7.2 ± 1.13 cfu/100 ml in week 4 in Aba. The values in Port Harcourt are 2.0 ± 0.66 to 4.2 ± 0.63 in the 3rd week and 4.0 ± 0.81 to 5.9 ± 0.56 cfu/100 ml in the 4th week of analysis. In Port Harcourt, the relatively higher coliform count (4.2 ± 0.63 cfu/100 ml) in August in the 3rd week and counts from The TCB of samples from Aba and Port Harcourt February to December in the 4th week are

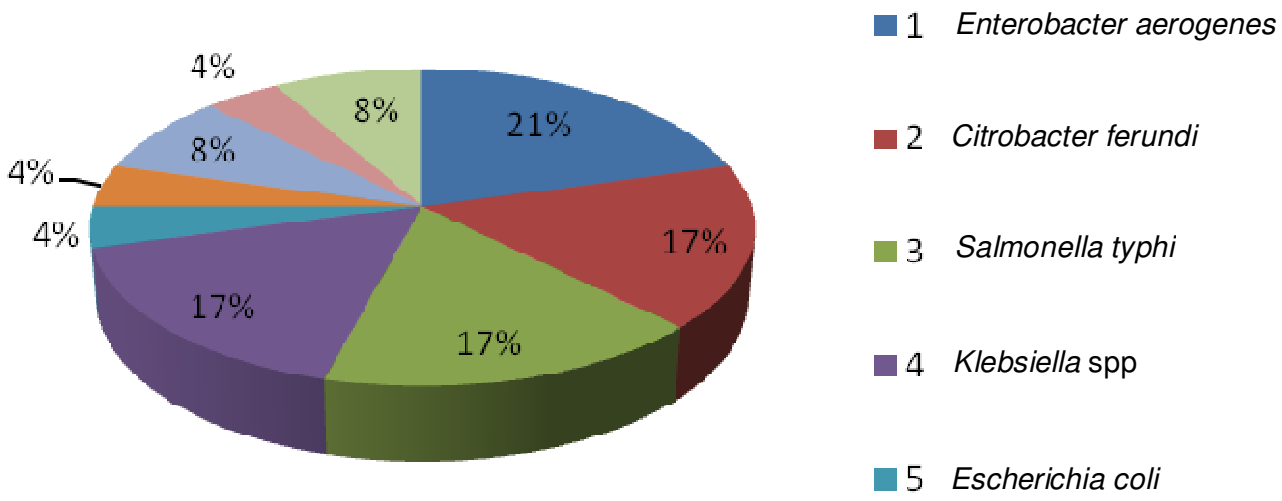

Figure 5. Distribution of bacteria isolates from samples in Aba.

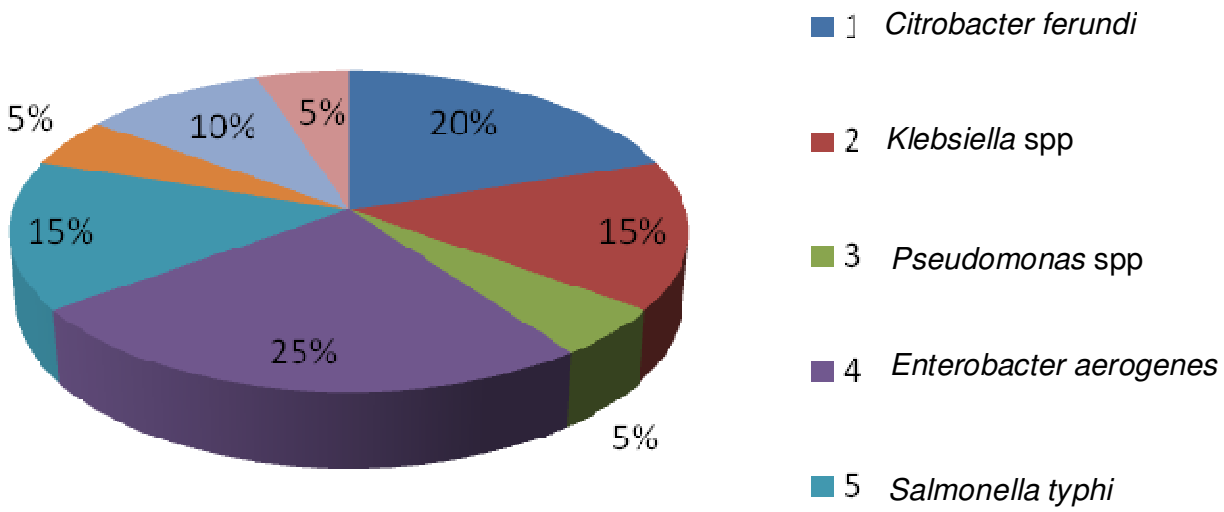

Figure 6. Distribution of bacteria isolates from samples in Port Harcourt.

higher than WHO excellent and satisfactory (0 to 4 cfu/100 ml) standards for potable uses.

Figures 5 and 6 show the distribution of bacteria isolates from samples in Aba and Port Harcourt. Besides, the presence of a few Gram positive bacteria like *Staphylococcus epidermidis,* and *Staphylococcus saprophyticus,* about 62.5% others are mostly gram negative bacteria. The isolates from samples in Aba include, *Enterobacter, Salmonella, Klebsiella, Shigella, Escherichia and Citrobacter* species. The organisms implicated in samples from Port Harcourt comprise species of *Klebsiella, Enterobacter, Pseudomonas, Escherichia, Streptococcus and Micrococcus.*

The data presented in Tables 1 and 2 seek to ascertain the level of familiarity with sachet water in the cities. From the tables, a high level of awareness by the respondents with the product in the cities was evident. Incidentally the percentage reporting knowledge of respondents who know sachet water as water in sealed nylon was about 61% in PH while a higher percentage (45.2%) of respondents in Aba have come to associate it with its popular name “pure water”. Other respondents equally thirst and is also hawked everywhere as pure water.

The assessment of public awareness level on sachet water products and incidents of contamination are presented in Tables 3 and 4. Details from the tables show a fairly average level of awareness across the cities. In Aba, the percentage reporting knowledge for product contamination occurring as impurities and undesirable odour respectively attracted 26.5% of the respondents comment. Similar level of awareness was also observed in PH with percentage reporting knowledge of

Table 1. Percentage distribution of respondents' knowledge and awareness about sachet water in Aba.

S/N	Awareness and knowledge of sachet water product	Sex		Total	% Distribution
		M	F		
	% Reporting knowledge of respondents who knows sachet water as:				
i	Product hawked everywhere	12	8	20	12.0
ii	Water in sealed nylons	17	20	37	22.3
iii	Water that can quench thirst	13	15	28	16.9
iv	Pure- water	40	35	75	45.2
vi	No idea	4	2	6	3.6
	Total	86	80	166	100

Table 2. Percentage distribution of respondents' knowledge and awareness about sachet water in PH.

S/N	Awareness and knowledge of sachet water product	Sex		Total	% Distribution
		M	F		
	% Reporting knowledge of respondents who know sachet water as:				
I	Product hawked everywhere	8	11	19	11.6
Ii	Water in sealed nylons	60	40	100	61.0
Iii	Water that can quench thirst	11	9	20	12.2
Iv	Pure- water	9	11	20	12.2
V	No idea	2	3	5	3.0
Vi	Total	90	74	164	100

Table 3. Percentage distribution of respondents' knowledge about sachet water products and incidents of contamination in Aba.

S/N	Awareness and Knowledge of sachet water product contamination	Sex		Total	% Distribution
	% Reporting knowledge of respondents who agrees and describes the nature of sachet water contamination in form of:	M	F		
I	Impurities in sachet water nylons	23	21	44	26.5
Ii	Unpalatable taste	20	18	38	22.9
Iii	Undesirable odour	23	21	44	26.5
Iv	Cloudy and opaque in appearance	20	20	40	24.1
	Total	86	80	166	100

respondents who associate contamination with such descriptions as unpalatable taste and undesirable odour recording 26.1 and 25.5% respectively.

The public perception rating of sachet water consumption and association with environmental degradation is presented in Tables 5 and 6. The data revealed that over 57.2% of the respondents perceive sachet water consumption and trade as being responsible for the unsightly littering of streets with used sachet water nylons (Plate 1) while 41.1% of respondents in Port Harcourt were in agreement with this factor.

The prevailing health indicators associated with sachet water consumption among different occupational groups in Aba and PH are presented in Tables 7 to 11. Data show that traders (21.4%) street hawkers (21.4%) and civil servants (17.6%) in Aba with the highest percentage occupational distributions have had one or combination of the indicated health disorders in the last 6 months. Though relatively higher number of respondents in PH identified civil servants (29.7%), traders (19.8%) and street hawkers (16.8%) as target groups, in Aba (Table 7), typhoid fever, gastroenteritis, diarrhea and worm infestation are still the common health complications prevalent in the city.

DISCUSSION

The result of pre-storage total coliform count (TCB) for room temperature (RT) samples revealed absence of

Table 4. Percentage distribution of respondents' knowledge about sachet water products and incidents of contamination in PH.

S/N	Awareness and knowledge of sachet water product contamination	Sex		Total	% Distribution
	% Reporting knowledge of respondents who agrees and describes the nature of sachet water contamination in form of:	M	F		
i	Impurities in sachet water nylons	21	18	39	24.2
ii	Unpalatable taste	22	20	42	26.1
iii	Undesirable odour	20	21	41	25.5
iv	Cloudy and opaque in appearance	20	19	39	24.2
	Total	83	78	161	100

Table 5. Knowledge about sachet water consumption pattern and link to environmental degradation in Aba.

S/N	Awareness and knowledge of sachet water product consumption and environmental degradation	Sex		Total	% Distribution
	% Reporting knowledge of respondents who perceive sachet water consumption and trade as being responsible for:	M	F		
i	Unsightly littering of streets	50	45	95	57.2
ii	Blockage of drainage channels	13	18	31	18.7
iii	Constituting waste management problems	18	10	28	16.9
iv	Water traps for breeding of mosquitoes	5	7	12	7.2
	Total	86	80	166	100

Table 6. Knowledge about sachet water consumption pattern and link to environmental degradation in PH.

S/N	Awareness and knowledge of sachet water product consumption and environmental degradation	Sex		Total	% Distribution
	% Reporting knowledge of respondents who perceive sachet water consumption and trade as being responsible for:	M	F		
i	Unsightly littering of streets	35	30	65	41.1
ii	Blockage of drainage channels	20	15	35	22.1
iii	Constituting waste management problems	13	18	31	19.6
iv	Water traps for breeding of mosquitoes	16	11	27	17.0
	Total	84	74	158	100

coliform bacteria during the first week of analysis. The highest mean TCB for RT samples from Port Harcourt (PH) recorded in June was 4.3 ± 0.67 cfu/100 ml while the peak sunlight (SL) sample value (7.2 ± 1.13 cfu/10 ml) recorded in Aba occurred in the month of October.

The higher counts observed in the months of June and October may be related to seasonal factor. Aroh (2006) while studying the effect of temporary storage on sachet water quality, identified contamination of ground water (borehole water) as one of the contributory factors for the TCB increase in the city. In most cities, borehole serves as primary source of water for operators of sachet water business. Aroh et al. (2006) in a related study on borehole water quality in Diobu area of Port Harcourt city attributed the increase in intestinal parasite in the area to gross contamination from seepage and occasional recharge from septic tanks during the wet season.

According to the authors, the indiscriminate sinking of borehole close to septic tanks (soak away pits) increases the likelihood of groundwater contamination during rainy season when water table is usually high and borehole recharge comes from diverse sources. This is further accentuated in localities where borehole was sunk at a dept not exceeding 10 m (Aroh et al., 2006).

There is no doubt however that the proximal location of borehole and soak away pits which are indistinguishably sited in Aba and Port Harcourt cities may have discernable effects on the ground water quality. These boreholes are widely sourced by most borehole operators who engage in adulteration of the products by merely filling the water nylons in the closet of their home without recourse for adequate treatment. Apparently, the high counts noted in SL samples after storage for a certain period may be attributed to poor or inadequate

Table 7. Prevailing health indicators associated with sachet water consumption among different occupational class in Aba.

Occupation	TF	GE	DR	CL	HP	WI	Total	%
Civil servant	8	7	6	0	3	6	30	17.6
Transport	2	1	1	1	0	0	4	7.6
Trader	6	4	4	0	2	4	20	21.4
Market women	6	3	3	0	2	2	16	16.8
Street hawker	5	4	1	0	1	2	17	21.4
Student	4	2	2	0	0	2	10	13
Unemployed	2	0	0	0	0	0	4	2.3
Total	33	22	22	0	8	16	101	100

TF-Typhoid fever, GE-Gastroenteritis, DR-Diarrhea, CL-Cholera, HP-Hepatitis, WI-Worm infestation.

Table 8. Prevailing health indicators associated with sachet water consumption among different occupational class in PH.

Occupation	TF	GE	DR	CL	HP	WI	Total	%
Civil servant	6	5	4	0	3	5	23	29.7
Transport	3	2	3	0	0	2	10	4.0
Trader	8	6	5	0	4	5	28	19.8
Market women	6	5	6	0	2	3	22	15.8
Street hawker	7	6	7	0	3	5	28	16.8
Student	5	4	3	0	2	3	17	9.9
Unemployed	2	1	0	0	0	0	3	4.0
Total	37	29	28	0	14	23	131	100

TF-Typhoid fever, GE-Gastroenteritis, DR-Diarrhea, CL-Cholera, HP-Hepatitis, WI-Worm infestation

Table 9. Distribution of respondents in the study locations in Aba (Occupation).

Occupational engagement (b)	Aba Central Motor Park		New Market (Ekeoha)		Ariaria Market	
	Sex		Sex		Sex	
	M	F	M	F	M	F
Civil servant	6	4	6	6	6	4
Transporter	5	2	3	-	4	-
Trader	10	2	9	3	10	4
Market woman	-	8	-	7	-	8
Street hawker	5	6	4	4	6	7
Student	5	6	4	3	3	4
Total	31	28	26	23	29	27

Table 10. Distribution of respondents in the study locations in PH (Occupation).

Occupational Engagement (b)	Borokiri Market		Mile 1Market/Flyover Motor Park		Mile 3 Market/ Motor Park	
	Sex		Sex		Sex	
	M	F	M	F	M	F
Civil servant	10	9	10	8	10	10
Transporter	3	-	3	-	2	-
Trader	6	2	5	2	5	3
Market woman	-	7	-	7	-	6
Street hawker	3	3	4	3	3	4

Table 11. Occupational status.

Occupational group	Sex		Total	% Distribution
	M	F		
Civil Servant	30	27	57	34.8
Transporter	8	-	8	4.9
Trader	20	7	27	16.5
Market Women	-	20	20	12.2
Street Hawker	10	10	20	12.2
Student	17	8	25	15.2
Unemployed	5	2	7	4.3
Total	90	74	164	100

purification and disinfection techniques identified, by Paul (1992), Aroh (2006) and Kwakye et al. (2007) in their separate studies. Bennie (2008) observed that mineral water as a product has a specific temperature condition under which it must be kept and failure to do so could cause serious health problems. The author further noted that the plastic material in which the sachet water is packaged contains certain micro-pores which render it susceptible to invasion by microorganism when exposed to sun. The moderately raised revels of coliforms recorded in SL exposed samples may be remotely linked to this factor.

In Port Harcourt, the coliform level (4.2 ± 0.63 cfu/100 ml) observed in August for SL samples in the 3rd week and counts recorded from February to December (equivalent to 90% of the sample brands investigated within the 12-month period) in the 4th week are higher than the European Community (1980), WHO (1971) satisfactory limit of 1 to 4 cfu/100 ml. This range is considered next to WHO grading for excellent potable water quality. This perhaps may reflect the general trend in sachet water quality across the cities given collaborative findings by investigators (Adenkule et al., 2004; Ifeanyi et al., 2006; Nwachukwu and Emeruem, 2007). The ultimate goal in qualitative assessment of water is to ensure that water is free from any form of contaminating agent and pathogenic microorganisms likely to affect human health. However, the isolation of coliforms and indicatior organisms such as *Salmonella typhi, Streptococcus faecalis, Escherichia* species and *Enterobacter aerogenes* in the current study are indications of contaminated drinking water and are in agreement with findings of Sahoata (2005) and Egwari et al. (2005).

However, beside inadequate chemical treatment, the practice of sourcing water from questionable sources including unsafe boreholes accounts significantly for the present level of coliforms in the brands.

The growing level of awareness in the knowledge of sachet water has led to its popularity in the cities (Adekunle et al., 2004). However, the awareness rating of members of the public on sachet water product and incidents of contamination is quite low. In the survey, less than 26% (Tables 3 and 4) affirmed that cases of contamination in form of impurities, undesirable odours and unpalatable taste in the products could suggest deterioration in quality and possible health problems. Besides, assuaging the feeling of thirst, the public still believes that sachet water consumption and trade is responsible for much of the health and environmental nuisance prevalent in the cities. There are strong indications that high level patronage of this commodity in our cities today is remotely linked with problems such as unsightly littering of streets, waste management problem, blockage of drainage channels and traps for breading of mosquitoes (Tables 5 and 6).

In Aba, for instance the public perception rating on sachet water consumption and effect on health was more than 43.7% while 42.6% was recorded in PH. On the health aspect, greater percentage of people was observed to have suffered from one health problem or the other due to contaminated sachet water. These health problems include gastroenteritis, diarrhea, and hepatitis. Laurie et al. (2004) noted that contaminated water causes an estimated 6 to 60 million cases of gastrointestinal illness annually. Majority of cases according to the author occur in rural areas. However, the situation is taking another dimension as more people in urban and semi urban centers are now beneficiary of this devastating health condition. This trend can be explained on the fact that sachet water can be consumed across these centers.

Remarkably, Adekunle et al. (2004) reported that an estimated 1.2 billion people around the world lack access to safe water and close to 2.5 billion people around the world are not provided with adequate sanitation.

In Nigeria, impact of this revelation is quite startling considering the population of Nigerians who are either not provided with pipe-borne water and sanitation facility or cannot afford the high cost of genuinely treated bottled water. Therefore, there is the need for concerted effort to provide potable water for city dwellers and re-orientate them on waste management culture and protection of the environment.

Conclusion

The study has shown that storage conditions of sachet water products present varying bacteriological qualities. Sachet water products when exposed to sunlight deteriorate faster than refrigerated ones due to solar radiation effect and inadequate chemical treatment. The comparably higher temperature differentials in Aba may have informed the slightly higher level of the bacteria recorded in the city when compared to Port Harcourt. The deterioration was observed to have commenced from the fourth (4th) week of storage.

The growing knowledge about sachet water, consumption and trade in the two cities, is an indication

of its acceptability, affordability and a means of trade. Unfortunately, the indiscriminate littering problem and non-biodegradable nature of the sachet water nylons after use are issues of great public health concern. This no doubt presents an emerging environmental challenge in our cities today. Concerted efforts are therefore needed by all relevant authorities and stakeholders to regulate and ensure proper application of technology to manage waste from sachet water trade.

Therefore, necessary environmental education should be intensified to inculcate the right attitude and consciousness towards environmental preservation. Similarly, regulatory agencies involved in food and beverages should be empowered in their regulatory and monitoring functions to check adulteration of these products and forestall frequent cases of waterborne diseases often linked to consumption of unwholesome sachet water products.

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