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A critical assessment of quality status of selected sachet water in Calabar Municipality, Nigeria

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Abstract

Nigeria is endowed with abundant surface and sub-surface water resources, yet most urban areas are still faced with the challenges of providing potable and adequate water supply for its residents. The use of water is restricted by it quality which makes it unhealthy for a particular use. This paper assessed the water quality status of five sachet water in Calabar Municipality with the aim of comparing their physico-chemical parameters with those permissible by World Health Organization (WHO). Purposive sampling technique was employed to select five widely consumed sachet water with National Agency for Food and Drug Administration and Control (NAFDAC) registration numbers in five retail shops across the Metropolis. The result revealed that the physico-chemical parameters found in the selected sachet water samples did not vary ($p>0.05$), as their proportions were within the same range and ideal for consumption. Also, the analysis revealed that Blue Rose sachet water was adjudged the most suitable for consumption as the proportions of its parameters were within WHO permissible limits; this was followed by Marian sachet water, while Laura and Dukon sachet water samples were fairly potable for consumption, because the proportions of iron (Fe) and manganese (Mn) far exceeded WHO maximum desirable limits for drinking water. Based on the findings, it was suggested among others that NAFDAC should critically monitor and carry out routine assessment of the site, water sources, equipment and chemical used by water factories. In addition, to maintain their suitability for consumption, regular monitoring of the sachet factories should be ensured by the concerned authorities.

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Introduction

Water is one of the most important resources of the earth. It has a critical function in all spheres of life. Adequate water is needed for drinking, personal hygiene and other domestic purposes. The demand for water for these purposes has consequently led to a close relationship between water availability and economic development of a nation (Oyegun, 2001; Eze and Abua, 2002). Despite Nigeria's endowment with abundant surface and sub-surface water resources, most urban areas are still faced with the challenges of providing adequate water supplies for its residents (Ayoade 1988; Ayoade and Oyebande, 1978). However, to successfully manage her water resource, the Nigerian government in the past decades set up Federal and State institutions as well as River Basin Development Authorities to solve her water problems. Despite these efforts, potable water supply continues to remain a major problem in Nigeria.

The use of water is restrained by its quality which makes it unhealthy for a particular use. Water quality assessment is therefore an important aspect of water resource evaluation; as physical, biological and anthropogenic factors are important in water quality assessment (Eze and Abua, 2003). Hence, water quality depends on the physical, chemical and biological composition of water and an understanding of the physio-chemical and biological composition of water will enhance the detection of future deviation in water quality. However, the most important characteristics that determine water quality are physical characteristics which include colour, clarity, tastes, odour and amount of suspended solid content; chemical characteristics include amount of dissolved solids, hardness, amount of nitrogenous matter, and biological characteristics like bacteriological content of dissolved oxygen (Eze and Abua, 2003; Adelekan and Alawode, 2011).

Water pollution is however, one of the fastest growing environmental problems in our modern society. Pollution effectively limits the quality of water available for most uses, as it is harmful to both man and aquatic life on which man depends on for survival. Water pollution is due almost entirely to improper and inefficient disposal of industrial effluents and household wastes (Asuquo, 1989; Afangideh et al. 2011). Polluted water nevertheless serves as sanctuaries for fatal diseases such as typhoid, cholera, hepatitis, filariasis and schistosomiasis among others which may be caused by different disease organisms such as parasites, bacteria, viruses and other pathogens. Drinking water becomes poisonous if it contains mineral elements in quantities excessive to normal metabolism (Fada, 2007). In Nigeria, despite the myriads of problems associated with the supply of potable water, access to improved urban water supply is 58% (WHO, 2005). Arising from the above, it is estimated that only about 50% of the urban population currently has access to reliable water supply of acceptable quality due to poor maintenance and unreliability of supplies (Fade, 2007). Many diseases endemic in the country are due to the supplies of unsatisfactory drinking water, poor sanitary conditions and inadequate health education programmes. Thus, better access to potable water can relieve about the same total burden of disease (measured in daily adjusted life years) as do improvements in public health care.

The importance of potable water in the daily lives of urban residents in Nigeria has been noted by Onokerhoraye (1984), as quoted by Ikelegbe and Okoruwa (2007). Consequently, the nation since the colonial era has focused on the improvement of drinking water and plans for public supplies have been based on respected increase in the total population and the financial allocation of this sector has also increased over the years. However, the development of the nation's water resource has been haphazard, uncoordinated and based on any national and nationally formulated policy (Fade, 2007). This has perhaps brought private bodies into the race of enhancing urban water availability and demand. The role of water vendors (private bodies) becomes paramount in trying to meet contingency and transaction of any demand for water (Afangideh et al. 2011). As such, people are however skeptical about the quality of water supplied by these bodies because, there are many brands of sachet water, some registered by National Drug (NAFDAC) and many still operating without its approval.

The boreholes of some of these corporate bodies are more often than not unhygienic or located in poorly hygienic areas. In some cases, the containers used are often times not properly cleaned, inside of which contain a lot of algal growth. The need therefore for assessing the quality of sachet water retailed in Calabar Municipality becomes not only imperative but urgent due to the high and growing rate of hospitality industries, tourist sites as well as the exodus of people from rural, sub-urban and nearby states into the municipality for job opportunities, leisure and other necessities of life. This study is therefore aimed at assessing and comparing the physico-chemical properties present in five selected and widely consumed sachet waters with WHO permissible level of water quality in order to assess if the quality of water sampled is ideal for human consumption.

Materials and methods

Study area

This study was carried out in Calabar Municipality between the 3rd and 6th of May, 2007. It has an area of 142 km² and a population of 179,392 at the 2006 census. Calabar Municipality lies between latitude 04° 15' and longitude 8° 25' E. It is bounded in the North by Odukpani Local Government Area, in the North-East by the great Kwa River. Its Southern shores are bounded by the Calabar River and Calabar South Local Government Area. Calabar Municipal Government Area plays a dual role. Apart from being the Capital city of Cross river State, it also plays its role as headquarters of the Southern Senatorial District. Two ethnic groups form the indigenous population. These are the Quas and the Efiks. However, because of its cosmopolitan status, there abound people from all parts of the state and Nigeria in the city. The average annual rainfall is about 3070mm with concentration between March and November. The dry season lasts from November to March. Calabar town is situated in the interfluves separating the great Kwa River and Calabar River, which encompasses from southwest to west. The peninsular of Calabar is moderately undulating with its land descending rather abruptly to the Calabar River at the western boundary of the town, while it slopes gently towards the coastal range from about 40km to the Atlantic shore at height of 60-70 meters above sea level. Geologically, Calabar belongs to the tertiary era; sedimentary deposits which are dominated by coarse sand type have a high infiltration rate. In terms of vegetation, Calabar Municipality is located at the mangrove swamp region which is fast becoming more of forest savannah. Calabar municipally despite being surrounded by large expanse of water bodies is still faced with the problem of potable and good quality water of its urban residents. However, with the high rate of urbanization, majority of its residents are faced with problems water supply of acceptable quality due to unreliability of suppliers. With the high rate of hospitality industries and the attendant demand for water, people are however skeptical about the quality of sachet water provided by private bodies to meet the increasing demand of water in the Municipality.

Sampling procedure and data analysis

In older to thoroughly examine the physico-chemical properties contained in five selected sachet waters, the following materials and methods were carried out. The sampling design employed was the purposive sampling technique. This made it possible for five widely consumed sachet water samples in the municipality with National Agency for Food and Drug Administration and Control (NAFDAC) registration numbers to be sampled. The five selected sachet water samples included Laura, Blue Rose, Marian, Biokab and Dukon. These categories of packaged waters were selected as a result of their acclaimed quality by residents in the metropolis. Samples of the aforementioned sachet waters were obtained from five retail shops across the Municipality and immediately taken to the laboratory for analysis of physical and chemical parameters using standard methods (APHA, 1998). Results obtained from the laboratory analysis were represented using tables and averages, while analysis of variance (ANOVA) and Pearson's correlation were applied to determine significant variation in water quality among the selected sachet water samples as well as association between the variables using SPSS 17.0 for Windows.

Results and discussion

The result in Table 1 gives information on the quality status of sachet water in comparison with WHO permissible limits for drinking water. Dissolved oxygen (DO) is a measure of the degree of pollution by organic matter, the destruction of organic substances as well as the self purification capacity of the water body. DO in liquid provides a source of oxygen needed for the oxidation of organic matter when the concentration is high and lack of it causes the water body to become dead or devoid of aquatic life (Chukwu, 2008; Ewa et al. 2011). The result shows that the proportion of dissolved oxygen (DO) of the sachet water samples ranged from 4.00 to 4.20mg/l with a mean value of 4.12mg/l. This value falls with WHO permissible range of 5.7mg/l. The mean value of DO indicates that the sachet waters are non-turbid and unpolluted. The concentration of iron (Fe) in the sachet water samples ranged from 0.20 to 0.40mg/l with a mean value of 0.28mg/l. The mean Fe content in the sampled sachet water samples falls within WHO maximum permissible limit of 0.3mg/l. The low concentration of Fe is an indication that the sachet waters have no potentials for health hazard. The value of manganese (Mn) ranged from 0.30 to 0.80mg/l with a mean value of 0.61mg/l; the mean content of Mn (0.61mg/l) is above WHO maximum desirable limit of 0.5mg/l. This implies that water from the sachet water samples have bad taste and could promote the growth of algae in reservoirs or collection tanks (Nwankwoala et al. 2011). Nevertheless, nitrate (NO_3) ranged from 5.50 to 5.60mg/l with a mean value of 5.56mg/l. The relatively low value of NH_3 in the sachet water is attributed to the location of boreholes far away from soak away pits and dumpsites; as the boreholes do not receive domestic and municipal wastes that could contain these elements (Adamu and Adekiya, 2010; Afangideh et al. 2011).

Table 1. Summary of water quality parameters of sachet water samples.

Parameters	Range		Mean values	WHO limits
	Min	Max		
DO (mg/l)	4.00	4.20	4.12±0.04	5.7
Fe (mg/l)	0.20	0.40	0.28±0.04	0 - 0.3
Mn (mg/l)	0.30	0.80	0.61±0.09	0.1-0.5
NO_3 (mg/l)	5.50	5.60	5.56±0.02	45-50
Carbonate	12.00	24.00	14.40±2.40	12
Chloride (mg/l)	40.00	54.00	47.20±2.65	200-500
pH	6.10	6.40	6.30±0.05	6.5-8.5
Turbidity (FTU)	0.00	0.00	0.00±0.00	5-10

[a] Values are means ± standard errors

High concentrations of nitrate and/or nitrite can produce "brown blood disease" in fish. Nitrite enters the bloodstream through the gills and turns the blood a chocolate-brown color. As in humans, nitrite reacts with hemoglobin to form methemoglobin. Brown blood cannot carry sufficient amounts of oxygen, and affected fish can suffocate despite adequate oxygen concentration in the water. The value of NO_3 in the sachet waters is within WHO minimum desirable limits of 45mg/l. Furthermore, carbonate level in the sachet water samples ranged from 12.00 to 24.00mg/l with a mean value of 14.40mg/l. The carbonate values far exceed WHO maximum desirable limits of 14mg/l. Chloride's value in the sachet water was low and ranged from 40.00 to 54.00mg/l with a mean value of 47.20mg/l, which is far below WHO minimum allowable concentration of 200mg/l. This low value implies that water from these sachet water samples is harmless, as such safe for drinking (Afangideh et al. 2011). The pH value of a water source is a measure of its acidity or alkalinity. pH is a measurement of the activity of the hydrogen atom, because the hydrogen activity is a good representation of the acidity or alkalinity of the water. The pH values of the sachet water samples were slightly acidic and tending towards neutral with a pH range of 6.10 to 6.40 and a mean value of 6.30. The slightly acidic nature of sachet water samples is attributed to the absence of chemical pollution from industrial operations and individuals as well as the location of sachet water factories away from the discharges of wastewater. The pH values are below the minimum desirable limits of 6.5 set by WHO. The value of turbidity were zero; meaning that the water is harmless and potable for human consumption. It further indicates the absence of organic and inorganic solids in the water (Afangideh et al. 2011).

The quality status of water obtained from the five sachet water samples (table 2) varied spatially and significantly due to variation in the location of the boreholes as well as the type and human activities within and around their catchment. The quality status of Laura sachet water indicates that the content of DO was little below the minimum range acceptable by WHO and thus, suitable for drinking. The maximum recommended Fe (iron) concentration by WHO is 0.3mg/1, while that of Laura is 0.2mg/1 which is within the acceptable standard of WHO, hence, it is free from dental fluorosis. The concentration of manganese is 0.8mg/1 above WHO maximum permissible limit; hence, it is not suitable or potable for consumption. The concentration of chloride is 54.0mg/1 which is very much below WHO minimum permissible level of 200mg/1, while the level of pH (6.3) falls within WHO minimum permissible level of 6.5. In addition, the proportions of carbonate (24mg/l), chloride (54mg/l) and nitrate (5.6mg/l) are within WHO minimum desirable limits of 12mg/l, 200mg/l and 45mg/l respectively. Laura water is not turbid (0mg/l). The implication of the above analysis is that Laura sachet water going by the standard set aside by WHO, is fairly potable for drinking.

For Blue Rose sachet water, the concentration of DO is 4.2mg/1 which is also little below WHO maximum acceptable level of 5.7mg/1. Fe concentration is 0.3mg/1 and is within the WHO maximum permissible level; Mn concentration is 0.3mg/1 which is within the WHO maximum permissible limit of 0.5mg/l. In addition, nitrate level in Blue Rose is 5.5mg/1 which is far below WHO minimum permissible limit of 45mg/1. Also, the concentration of carbonate, chloride and pH are 12.0mg/1, 50.0mg/1 and 6.4mg/1 respectively; while carbonate and pH unit are within WHO permissible limits, chloride is far below WHO minimum permissible level of 200mg/1. Hence, it could be deduced that Blue Rose more suitable for consumption, far better than Laura water.

Table 2. Quality status of selected sachet waters.

Parameters	Selected sachet water				
	Laura	Blue Rose	Marian	Biokab	Dukon
DO (mg/l)	4.1	4.2	4.1	4.0	4.2
Fe (mg/l)	0.2	0.3	0.3	0.2	0.4
Mn (mg/l)	0.8	0.3	0.56	0.7	0.7
NO_3 (mg/l)	5.6	5.5	5.5	5.6	5.6
Carbonate	24.0	12.0	12.0	12.0	12.0
Chloride (mg/l)	54.0	50.0	50.0	42.0	40.0
pH	6.3	6.4	6.1	6.4	6.3
Turbidity (FTU)	0	0	0	0	0

Furthermore, the quality status of Marian sachet water indicates that the concentration of Fe (0.3mg/l) and carbonate (12mg/l) are within WHO maximum permissible limits of 0.3mg/1 and 12mg/l respectively.

DO and pH levels of 4.1mg/1 and 6.1mg/1 fall within WHO minimum permissible limits of 5.7mg/1 and 6.5mg/1 respectively, while the concentration of turbidity (0mg/l), nitrate (5.5mg/l), manganese (0.56mg/l) and chloride (50mg/l) are far below WHO minimum acceptable limits of 5mg/l, 45mg/l and 200mg/l, while the proportion of Mn (0.56mg/l) in Marian water is slightly above WHO minimum desirable limit of 0.5mg/l. This therefore implies that Marian table water like Blue Rose is portable for human consumption.

The quality status of Biokabs sachet water (Table 2) depicts that the concentration of Fe (0.2mg/l) and carbonate (12mg/l) are within WHO maximum recommended limits of 0.3mg/1 and 12.0 mg/1 respectively. The proportion of DO (4.0mg/l), chloride (42mg/l) and pH (6.4) are below WHO acceptable and recommended permissible level of 5.7mg/1, 200mg/1 and 6.5mg/1 respectively. While the concentration of Mn (0.7mg/l) exceeds WHO maximum recommended limit of 0.5mg/l. The concentrations of turbidity (0mg/l) and nitrate (5.6mg/l) are within WHO minimum permissible limits of 5mg/l and 45mg/1 respectively. Thus Marian water ideal and better for consumption compared to Laura sachet water.

Lastly, for Dukon sachet water, the levels of DO (4.2) and pH (6.3) are below WHO permissible limits of 5.7mg/l and 6.5, while the proportion of Fe (0.4) is far above the maximum permissible limit of 0.3mg/l. The concentration of nitrate (5.6mg/l), carbonate (12mg/l) and chloride (40mg/l) are also below WHO acceptable limit with values of 5.7 mg/1, 12mg/l and 200mg/1 respectively. On the other hand, the levels of pH (6.3) and turbidity (0mg/l) are within WHO minimum recommended and acceptable limits of 6.5 and 5mg/1, while Mn (0.7mg/l) exceeds the maximum desirable limit of 0.5mg/l. Thus, Dukon sachet water when compared with the four others is fairly suitable for human consumption. Comparatively, Blue Rose sachet water is adjudged the most suitable for consumption as the proportion of its parameters is within WHO permissible limits; this is followed by Marian sachet water and then Diokabs sachet water. The remaining two sachet waters, Laura and Dukon are fairly potable for consumption.

Table 3. Zero-order correlation matrix of the concentration of parameters.

Parameters	DO	Fe	Mn	NO_3	Carbonate	Chloride	pH
DO (mg/l)	1						
Fe (mg/l)	0.79*	1					
Mn (mg/l)	-0.48*	-0.29*	1				
NO_3 (mg/l)	-0.33*	-0.22*	0.86*	1			
Carbonate (mg/l	-0.13*	-0.54*	0.54*	0.41*	1		
Chloride (mg/l)	0.04*	-0.44*	-0.18*	-0.43*	0.64*	1	
pH	0.00*	-0.24*	-0.13*	0.37*	0.00*	-0.28*	1

*. Correlation is insignificant at the 0.05 level (2-tailed).

In addition, the Pearson's correlation matrix in table 3 indicates that the pH range (6.1 – 6.4) of the sachet water samples had substantial effects on the availability of parameters in the water. The pH ranged led to the decrease and insignificant association between the parameters. Indeed, the table generally shows insignificant as well as low (positive and negative) associations. However, only Fe and DO, NO3 and Mn as well as chloride and carbonate showed high and insignificant correlations ($p<0.05$). The moderate to high and positive correlations between these parameters (Fe and DO, NO3 and Mn, and chloride and carbonate) shows that the identified parameters must have probably originated from identical source. It is also an indication of common sources of pollution (Adelekan and Alawode, 2011).

Nevertheless, ANOVA was used to determine whether the quality status of water from the five selected sachet water samples vary significantly. The ANOVA result in table 4 shows that the concentration of parameters in the five selected sachet waters do not vary significantly ($F = 0.051$, $p>0.05$). This however, means that the five sachet water samples irrespective of the proportions of their individual parameters do not vary significantly; which perhaps implies that they are within the same range and ideal for consumption.

Table 4. ANOVA result of variation in water quality of the sachet waters.

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	59.552	4	14.888	0.051	0.995
Within Groups	8779.253	30	292.642		
Total	8838.805	34			

Conclusions

The study has shown that the physico-chemical parameters found in the selected sachet water samples do not vary, as their proportions are within the same range and ideal for consumption. Also, the analysis reveals that Blue Rose sachet water is adjudged the most suitable for consumption as the proportion of its parameters is within WHO permissible limits; this is followed by Marian sachet water, while Laura and Dukon sachet water samples are fairly potable for consumption, because the proportions of iron (Fe) and manganese (Mn) far exceeded WHO maximum desirable limits for drinking water. Since, water has critical functions in all man's spheres of life, there is therefore the need to reduce these marked differences in the physic-chemical parameters to meet WHO recommended standards, bearing in mind that poor quality water is a sanctuary for fatal diseases like typhoid and cholera. In order however, to avert the occurrence of these diseases, the following are suggested:

> NAFDAC should critically monitor and carry out routine assessment of the site, water sources, equipment and chemical used by water factories.

> There should be public awareness and enlightenment campaign on the implication of water-borne diseases on human health, and the need for water suppliers to meet WHO standards for potable water.

> However, to maintain their potable state/ suitability, regular monitoring of the sachet factories should be ensured by the authorities concerned.

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