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Tests of Quality of Some Products of Sachet Water in Ogoja, Cross River State, Nigeria

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ABSTRACT

This study was designed to determine the quality of some sachet water products in Ogoja Local Government Area using the World Health Organization (WHO) acceptable standards for drinking water. Ten different (newly produced) products of sachet water were randomly selected from the Local Government on each sampling occasion. The water samples were then subjected to physical, chemical and microbial analysis. The physical-chemical components examined included pH, temperature, conductivity, turbidity, manganese, total hardness, nitrate, nitrite, magnesium, calcium, lead, zinc, copper, total suspended solid, aluminum, iron, fluoride, color, chloride, salinity and total dissolved solids. The microbial examination was for total and faecal coliform counts using multiple tube fermentation. Results revealed that all the different sachet water products sampled deviated from the WHO standards. The concentration of the micro and macro elements were significantly different ($P<0.05$) from the WHO recommended benchmark. The total and faecal coliform counts were significantly higher than the required standard. The findings of this study deduce that sachet water samples examined, do not meet microbiological standards for drinking water quality. This therefore suggests that sachet water products sold and consumed in Ogoja are not safe for drinking as they contain pathogenic organisms that can cause diseases to consumers. National surveillance agencies such as National Agency for Food and Drugs Administration and Control (NAFDAC) and Standard Organization of Nigeria (SON) need to monitor and enforce compliance with the constituted standards for drinking water.

Keywords: *Sachet Water, Ogoja, Tests, Cross River State, Quality, Nigeria*

1. INTRODUCTION

Water is an essential part of human nutrition, both directly as drinking water or indirectly as constituent of food. In addition to various other applications in daily life, water is not only essential for life; it also remains a most important medium of illness and infant mortality in many developing countries and even in technologically more advanced countries (Ford, 1999). It is also a key parameter influencing survival and growth of microorganisms in foods and other microbial environments.

In order of importance, air, water and food are the three main necessities of life. A person can survive for about a month without food, about a week without water and less than five minutes without air (Sooryamoorthy and Anthony, 2003). The provision of an adequate supply of safe drinking water was one of the eight components of primary health care in 1978 (Edema et al., 2011). Increase in human population has exerted an enormous pressure on the provision of safe drinking water especially in developing countries (Edema et al., 2011).

Having safe drinking water and basic sanitation is a human need and right for every man, woman and child. People need clean water and sanitation to maintain their health and dignity. Having better water and sanitation is essential in breaking the cycle of poverty since it improves people' health, strength to work and ability to go to school. Yet 884 million people around the world live without improved drinking water and 2.5 million people still lack access to improved sanitation, including 1.2 billion who do not have a simple latrine at all (WHO/UNICEF, 2008). Many of these people are among those hardest to reach; families living in remote rural areas and urban slums, families displaced by war and famine and families living in the poverty-disease trap, for whom improved sanitation and drinking water could offer a way out.

The World Health Organization (WHO) estimates that 88% diarrheal disease is caused by unsafe drinking water, inadequate sanitation and poor hygiene. As a result, more than 4,500 children die every day from diarrhea and other diseases. For every child that dies countless others, including older children and adults, suffer from poor health and missed opportunities for work and education. The global water crisis claims more lives through disease than any war claims through guns (UNDP, 2006). In cities and towns today in Nigeria, water attracts rates and fees (Edema et al., 2011). With insufficient government supply of water, private sector participation has evolved and the idea of packaged drinking water popularly referred to as "pure water" is now a common phenomenon in the country. Drinking water is now commercially packed in easy-to-open 50-60ml polyethylene sacs are referred to as "sachet or pure water". This packaged water is cheap and convenient and have increasingly become popular (Edema et al., 2011). Due to the popularity of the packaged drinking water, is the abuse of its production leading to a situation whereby the pure water is everything but pure. Drinking water regulations require that potable water for human consumption be free from human disease causing bacteria and specific indicator bacteria that are indicative of the presence of these pathogens. Some of these bacteria that have greater probability of causing disease in humans are classified as pathogens (Edema et al., 2011). Example of bacteria pathogens and their related diseases are Salmonellatyphi (typhoid fever), Shigelladysenteriae

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(dysentery) and Legionella pneumophilia (Legionnaires disease).

Although there is dearth of documented data on incidences of rates of water borne diseases directly associated with consumption of impure water, it has been widely observed that with its advent, the cases of Salmonellosisand typhoid fever has significantly increased in recent years (NAFDAC, 2003). Between January and August, 2010, over 200 hospitalizations were reported in the news in parts of Nigeria arising from cholera outbreaks. Water pollution has continued to create negative impacts on health and economic development in Nigeria (Adelegan, 2004).

The National Agency for Food and Drug Administration and Control (NAFDAC) is mandated to enforce compliance with internationally defined drinking water guidelines, but regulation of the packaged water industry aimed at good quality assurance has remained a challenge to the Agency (CAMON, 2007). To control this menace of contaminated water in sachets, NAFDAC declared a possible 'gradual' nationwide ban on sachet water to allow manufacturers of sachet water to start winding down or change to bottle packaging (CAMON, 2007). Successful implementation of this ban has remained far from reality as the sachet water market is witnessing tremendous growth, especially among the poor and middle social classes (Edema et al., 2011).

This study aimed at investigating the quality (physical-chemical examination and microbial assessment) of sachet water in Ogoja. The results obtained were compared with WHO acceptable standards for drinking water.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Ogoja is a Local Government Area in Cross River State, Nigeria. It is located at the Northern part of Cross River State. It's headquarter is in the town of Ogoja, in the north-east of the area near the A4 highway latitude $6^o37'52N$ and longitude $8^o49'24'E$. it has an area of $972km^2$ and a population ranging from 5,000 to 10,000 at the 2006 Census. The town was one of the providences during pre-colonial independence. It comprises of many tribes, which includes: Ishibori (this village has different clans like Uhmuria, Ikaptang, Ikajor, Ishinyema, Ikariku, Imerakorm) and Igoli as the central town. Mbube being one of the major tribes consists of different villages which include: Odajie, Adagum, Ekumtak, Idum, Ojirim, Egbe, Nkim, Ogberia 1 and 2, Oboso, Benkpe,Edibe, Bansan, Aragban, Keruen, etc. Their major source of livelihood is agriculture, basically farming of cassava, yams, palm oil, palm wine, etc. (Akwaete, 2010).

2.2 Sampling of Sachet Water

Sampling and analysis of the sachet water products was done between May and July, 2013. Ten brands of sachet water were randomly selected from the different brands available in Ogoja Local Government Area. Samples of each brand were purchased and taken to the laboratory in a cooler containing ice block. Analysis was carried out within 24 hours after sampling. Samples of the ten products of sachet water were analyzed 3 times for each of the parameters and the mean values recorded.

2.3 Physical and Chemical Examination of Water Samples

The water samples were examined for turbidity, odor, taste, color, pH, temperature, total dissolved solid, total suspended solid, lead, zinc, iron, magnesium, ammonium, nitrate, nitrite and slimness. Odour, taste and sliminess were evaluated using sense of smell, taste and touch respectively. The pH was determined by a combined glass electrode and pH meter (Mettler-Toledo, Essex Mz509 Type 340).The pH meter was calibrated by inserting its probe in a standard pH solution at 7.0 then rinsed with distilled water and inserted in samples. The pH meter was started by pressing the 'read' button. At the final digital reading, there was a beep. The pH level was read off above the temperature level displayed on the screen. The procedure was repeated for other samples.

Turbidity was determined with the help of turbidity meter. The sample bottles were filled and inserted into the holder. The machine was then started and the reading taken. Lavibond comparator was used to determine color. A 50ml cylinder was filled with the sample and placed on the left hand side of the comparator. The disc NS was then inserted and on rotation, the nearest color match was recorded. Conductivity was determined with conductivity meter. The conductivity probe was rinsed and immersed into the sample and the reading noted. The conductivity value was multiplied by 1.3 to get the Total Dissolved Solid (TDS). I.e. TDS = conductivity x 1.3. For Total Suspended Solids (TSS) measurement, a filter paper was weighed using an electronic digital balance and the initial reading noted. 100ml of the sample was then filtered through and the filter oven dried at 50^oC for 1 hour. The filter paper was then re-weighed and the final weight was noted. The difference between the initial and final weights of the filter paper gave the value of TSS.

For metals analysis, Spectrophotometry was employed. Five milliliter (5ml) of water sample was added in a reaction cell, 5 drops of the metal reagent was then added and mixed. The concentration of the following metals (lead, zinc, iron, magnesium, ammonium, nitrate and nitrate) was determined in the spectrophotometers.

2.4 Microbiological Assessment (Bacteriological Analysis)

The multiple tube fermentation test for enumeration of total coliform bacteria and Escherichia coli as recommended by APHA (2005) was employed to determine the bacteriological quality of drinking water sold in sachets. Results obtained for the multiple tube fermentation tests was used to calculate coliform density

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and results computed. For confirmation of Escherichia coli, both from positive presumptive tube was streaked into plates of MacConkey and MFC agar base, and incubated at 35ºC for 24 hours. This temperature is recommended by manufacturers of the Endo and MFC agar for optimum growth of faecal coliforms and mesophilic bacteria.

2.5 Statistical Analysis

Results are presented in tables. Analysis of variance (ANOVA) was used to justify the significant difference of the microbial and physic-chemical parameters in the ten different products of sachet water.

3.1 Physical Examination

Physical assessment of the various water samples shows that all the different sachet water products had National Agency for Food and Drug Administration and Control (NAFDAC) number. S_1, S_2, S_4, S_7 and S_8 had expiring date while others did not have. Only S_1 and S_7 had the manufacturing date in-scribed on the sachets. The nutritional value and analysis was only found in S_2. The net volume of each of the water was:S_1 (50cl), S_2 (50cl), S_3 (60cl), S_4 (60cl), S_5 (50cl), S_6 (50cl), S_7 (60cl), S_8 (50cl), S_9 (60cl) and S_{10} (60cl). The physical assessment is presented in table 1

3. RESULTS

Table 1: Physical examination of some products of sachet water available in Ogoja, Cross River State, Nigeria

Sachet water products	NAFDAC No:	Expiring date	Manufacturing date	Nutritional value	Net volume
S_1	+	+	+	-	50cl
S_2	+	+	-	+	50cl
S_3	+	-	-	-	60cl
S_4	+	+	-	-	60cl
S_5	+	-	-	-	50cl
S_6	+	-	-	-	50cl
S_7	+	+	+	-	60cl
S_8	+	+	-	-	60cl
S_9	+	-	-	-	60cl
S_{10}	+	-	-	-	60cl

+ = Present, - = absent, S= Sachet water sample

3.2 Physical Parameters

Results of the physical parameters are presented in table 2. The results show a significant difference ($P<0.05$) between the sachet water products and the WHO acceptable standard in various parameters examined. Temperature in all the sachet water products varied from the approved standard of 25ºC. The highest value of 26.96 temperature was recorded in S_9 followed by $S_1$and S_{10}which was 26.72 and 28.58 respectively, while the lowest temperature of 24.88ºC was in S_5. The conductivity, turbidity and total hardness of the different sachet water products were below the WHO benchmark of 1000ws/on, 20 and 100mg/l respectively. Total Suspended Solids were not detectable in S^1, S_2, S_3, S_4, S_5 and S_7. TSS inS_8, S_9 and S_{10}were 0.0034, 0.0052 and 0.08 respectively and were below the 0.01 benchmark while S_6 (0.014) was higher than the WHO standard. The color was <5 in all the sachet water products. The salinity in the different water products were also lower than the WHO standard, with S_3 and S_4 having the highest mean value of 0.041 respectively, while the lowest was observed in S_8 (0.035). The total dissolved solids in the different sachet water products fell below and above the standard being 50.28mg/l. The highest was observed in S_6 and S_2 (84.94 and 71.01mg/l) respectively while the lowest was in S_5 and S_7 (21.53 and 22.6mg/l) respectively.

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Table 2: WHO Standards and physical parameters of some products of sachet water available in Ogoja, Cross River State, Nigeria

Parameters	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**	**S_7**	**S_8**	**S_9**	**S_{10}**	**WHO standards**
Temperature (O^oC)	26.72 ± 7.43^{bcd}	25.92 ± 2.46^{abcd}	25.12 ± 4.61^{a}	25.66 ± 3.42^{abc}	24.88 ± 2.51^{a}	25.52 ± 6.31^{ab}	25.64 ± 3.99^{ab}	25.38 ± 4.41^{a}	26.96 ± 5.32^{d}	26.58 ± 4.02^{bcd}	25.00
Conductivity (Ws/cm)	69.76 ± 4.88^{a}	109.24 ± 13.02^{a}	43.70 ± 8.21^{a}	56.90 ± 4.83^{a}	33.12 ± 4.92^{a}	130.68 ± 9.42^{a}	$34.795.34^{a}$	55.60 ± 3.88^{a}	60.74 ± 6.42^{a}	65.65 ± 7.38^{a}	1000
Turbidity	0.35 ± 0.02^{a}	0.51 ± 0.08^{a}	0.37 ± 0.01^{a}	0.43 ± 0.01^{a}	0.70 ± 0.02^{a}	0.38 ± 0.01^{a}	0.37 ± 0.01^{a}	0.28 ± 0.01^{a}	0.84 ± 0.03^{a}	0.70 ± 0.02^{a}	20
TH (Mg/l)	21.30 ± 2.43^{ab}	111.00 ± 4.83^{bc}	24.82 ± 6.48^{c}	21.46 ± 4.99^{ab}	22.06 ± 4.10^{bc}	17.10 ± 3.33^{ab}	25.76 ± 4.33^{cd}	19.96 ± 6.10^{ab}	29.48 ± 1.88^{d}	23.08 ± 4.11^{bc}	100
TSS (Mg/l)	ND ^{a}	ND ^{a}	ND ^{a}	ND ^{a}	ND ^{a}	0.014 ± 0.001^{a}	ND ^{a}	0.0034 ± 0.0001^{a}	0.0052 ± 0.001^{a}	0.008 ± 0.009^{a}	0.01
Colour	$<5^{a}$	$<5^{a}$	$<5^{a}$	$<5^{a}$	$<5^{a}$	$<5^{a}$	$<5^{a}$	$<5^{a}$	$<5^{a}$	$<5^{a}$	2.0
Salinity (Mg/l)	0.038 ± 0.001^{a}	0.039 ± 0.02^{a}	0.041 ± 0.002^{a}	0.041 ± 0.002^{a}	0.038 ± 0.001^{a}	0.039 ± 0.001^{a}	0.039 ± 0.002^{a}	0.035 ± 0.001^{a}	0.037 ± 0.001^{a}	0.040 ± 0.003^{a}	280
TDS (Mg/l)	$45.35 \pm 4.08_{a}$	71.01 ± 5.38^{a}	28.40 ± 3.73^{a}	$36.99 \pm 2.48_{a}$	21.53 ± 4.08^{a}	84.94 ± 6.91^{a}	22.61 ± 4.92^{a}	$37.21 \pm 5.18_{a}$	39.48 ± 3.09^{a}	42.32 ± 1.98^{a}	50.28

TH = Total Hardness, TSS = Total Suspended Solids, TDS = Total Dissolved Solids.
Values are presented as mean$\pm$ standard error. All means followed by the same case letter shows no significant difference.

3.3 Chemical Parameters

The highest pH of 7.25 was recorded in S_1, followed by S_2 (6.70) while the lowest was recorded in s_8(4.43). S_1, S_2 and S_3 fell within the WHO approved range. Manganese concentration in all the water samples was higher than the approved level of 0.05mg/l. The highest was observed in S_5 (2.54) while the lowest was recorded in S_1 (1.16).

Results also indicate that the level of NO_3 in the sachet water products was lower than the WHO standard which is 10mg/l. NO_2 also varied in the different sachet water product with some falling above the stipulated standard. Only S_{10} had the required NO_2 concentration of 0.07mg/l (table 3). Magnesium, Iron, Lead and Aluminum concentrations in the water samples were all higher than the WHO benchmarks. The range observed was 7.34-2.06mg/l for Magnesium, 0.36-0.23mg/l for Iron, 0.046-0.022 for Lead and 0.21-0.04 for Aluminum.

On the other hand, other chemical parameters such as Calcium, Zinc, Total Suspended Solids, Copper and Floride were significantly lower than the required WHO standards as presented in table 2. The concentration of Total Dissolved Solids varied among the different sachet water samples. The TDS concentration of S_6 (84.94) and S_2 (71.01) were significantly higher than the 50mg/l approved by WHO while others fell below 50mg/l with the lowest observed in S_7 (22.61mg/l). The highest Calcium was observed in S_9 which was 26.80mg/l, while the lowest was recorded in S_6 and S_7 having 16.00 and 16.60mg/l. Zinc highest value of 1.70mg/l was recorded in S_8, followed by S_{10} (0.610mg/l) while S_1 had the lowest value (0.086mg/l). The concentration of copper, fluorine and chlorine were between the range of 0.025-0.32mg/l, 0.28-0.55mg/l and 4.28-6.92mg/l, respectively.

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Table 3: WHO standards and chemical parameters of some products of sachet water available in Ogoja, Cross River State, Nigeria

Parameters	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	WHO standard
pH	7.25 ± 1.87^{d}	6.70 ± 0.21^{cd}	6.99 ± 1.32^{ed}	6.31 ± 1.06^{bcd}	5.18 ± 0.61^{a}	5.48 ± 0.82^{ab}	6.21 ± 1.01^{bc}	4.43 ± 0.43^{a}	6.03 ± 0.51^{abc}	5.46 ± 0.98^{ab}	6.5-8.5
NO_3 (Mg/l)	3.64 ± 0.83^{d}	2.68 ± 1.04^{bc}	2.78 ± 0.38^{bc}	2.40 ± 0.08^{b}	3.48 ± 0.82^{b}	3.12 ± 0.83^{cd}	3.14 ± 0.39^{cd}	2.66 ± 0.16^{bc}	1.62 ± 0.58^{a}	1.48 ± 0.09^{a}	10
NO_2 (Mg/l)	0.062 ± 0.003^{a}	0.064 ± 0.005^{a}	0.066 ± 0.001^{a}	0.072 ± 0.002^{a}	0.068 ± 0.002^{a}	0.074 ± 0.003^{a}	0.060 ± 0.004^{a}	0.056 ± 0.001^{a}	0.062 ± 0.003^{a}	0.070 ± 0.008^{a}	0.07
Mg (Mg/l)	4.72 ± 1.04^{a}	7.34 ± 0.88^{a}	6.28 ± 0.99^{a}	6.00 ± 1.04^{a}	5.28 ± 0.08^{a}	6.70 ± 0.88^{a}	5.90 ± 0.99^{a}	6.54 ± 0.98^{a}	2.06 ± 0.09^{s}	3.64 ± 0.85^{a}	0.20
Ca (Mg/l)	17.40 ± 3.53^{a}	17.00 ± 4.31^{a}	17.60 ± 2.43^{a}	16.20 ± 1.88^{a}	18.20 ± 2.09^{a}	16.00 ± 2.48^{a}	16.60 ± 4.81^{a}	17.00 ± 3.04^{a}	26.80 ± 5.09^{b}	18.60 ± 3.98^{a}	50
Fe (Mg/l)	0.35 ± 0.06^{a}	0.26 ± 0.01^{a}	0.33 ± 0.10^{a}	0.29 ± 0.14^{a}	0.32 ± 0.13^{a}	0.29 ± 0.08^{a}	0.23 ± 0.09^{a}	0.28 ± 0.04^{a}	0.31 ± 0.07^{a}	0.36 ± 0.13^{a}	0.03
Zn (Mg/l)	$0.086\pm0.004^{a`}$	0.180 ± 0.004^{a}	0.180 ± 0.002^{a}	0.188 ± 0.04^{a}	0.186 ± 0.002^{a}	0.226 ± 0.009^{a}	0.326 ± 0.001^{a}	1.70 ± 0.080^{a}	0.376 ± 0.001^{a}	0.610 ± 0.0003^{a}	5.0
Cu (Mg/l)	0.14 ± 0.08^{a}	0.12 ± 0.07^{a}	0.12 ± 0.06^{a}	0.15 ± 0.03^{a}	0.025 ± 0.04^{a}	0.13 ± 0.04^{a}	0.13 ± 0.02^{a}	0.32 ± 0.06^{a}	0.31 ± 0.04^{a}	0.20 ± 0.01^{a}	1.0
Pb (Mg/l)	0.046 ± 0.004^{a}	0.022 ± 0.002^{a}	0.050 ± 0.001^{a}	0.0034 ± 0.001^{a}	0.034 ± 0.001^{a}	0.0024 ± 0.002^{a}	0.038 ± 0.001^{a}	0.046 ± 0.0001^{a}	0.034 ± 0.010^{a}	0.036 ± 0.001^{a}	0.01
Al (Mg/l)	0.10 ± 0.08^{a}	0.07 ± 0.06^{a}	0.11 ± 0.02^{a}	0.05 ± 0.002^{a}	0.06 ± 0.001^{a}	0.21 ± 0.09^{a}	0.08 ± 0.002^{a}	0.05 ± 0.001^{a}	0.04 ± 0.001^{a}	0.06 ± 0.002^{a}	0.01
Fl (Mg/l)	0.32 ± 0.04^{a}	0.38 ± 0.06^{ab}	$0.48\pm0.10_{abc}$	0.51 ± 0.09^{bc}	0.51 ± 0.09^{bc}	0.55 ± 0.02^{c}	0.51 ± 0.03^{bc}	0.54 ± 0.02^{c}	0.33 ± 0.01^{a}	0.28 ± 0.01^{a}	1.0
Cl (Mg/l)	4.28 ± 0.48^{a}	5.08 ± 1.02^{ab}	5.88 ± 0.89^{b}	5.74 ± 0.99^{b}	4.34 ± 0.74^{a}	5.56 ± 0.68^{b}	$4.74.0.98^{a}$	5.80 ± 0.89^{b}	6.92 ± 0.69^{c}	5.14 ± 0.95^{ab}	8.0

Values are presented as mean$\pm$ standard error. All means followed by the same case letter shows no significant difference.

3.4 Microbial Parameters

Results gotten from the microbial analysis of the various water samples studied are presented in table 4. A significant difference ($P<0.05$) was observed between the sachet water samples and the WHO acceptable standards. Results indicate a significant increase in both faecal and total coliform counts. The highest faecal coliform count was recorded in S_7 (100mg/l) followed by S_3 (94.6mg/l) and S_6 (71.20mg/l), while the lowest was recorded in S_1 (35.2mg/l) compared to 0% stipulated by WHO. The highest feacal coliform count of 100mg/l was also recorded in s_7. S_3 and S_5 sachet water had faecal coliform counts of 85.2mg/l and 62.4mg/l respectively, while S_1 also recorded the lowest. The FCC also differed from the WHO standard.

Table 4: Total and faecal coliform count values of some products of sachet water available in Ogoja, Cross River State, Nigeria

Parameters	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	WHO Standard
TCC	35.2 ± 4.38^{a}	52.2 ± 6.04^{b}	94.6 ± 0.89^{e}	53.4 ± 8.10^{b}	70.8 ± 5.90^{cd}	71.2 ± 7.19^{d}	100.0 ± 0.30^{e}	55.4 ± 3.49^{bc}	65.0 ± 3.97	69.4 ± 4.13^{cd}	0.00
FCC	21.6 ± 4.01^{a}	24.8 ± 0.98^{a}	85.2 ± 2.99^{cd}	22.2 ± 0.51^{a}	62.4 ± 2.97^{bc}	30.2 ± 2.06^{a}	100.0 ± 1.12^{d}	25.6 ± 2.59^{a}	34.8 ± 6.09^{a}	42.4 ± 3.57^{ab}	0.00

TCC = Total Coliform Count, FCC = Faecal Coliform Count.

Values are presented as means$\pm$ standard error. Values followed by the same case letters shows no significant difference at P=0.05

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4. DISCUSSION

The vital role water plays in the day to day life of humans and its function in the body system inform the attention it gets in terms of quality and safety. Results obtained from this study shows the water samples studied deviated from the WHO (2011) standard for most of the parameters examined. Physical and chemical analysis revealed that most of the water samples fell within the WHO standard for pH apart from S_5, S_6, S_8 and S_{10} that had pH of 5.18, 5.48, 4.43 and 5.46 respectively which values are lower than 6.8-8.5 set out by WHO. The temperature of the water samples was also significantly different from the WHO standard of 25^{o}C. The increase in the temperature might be due to the weather as at the time of analysis. The turbidity and conductivity of the water samples were lower than the WHO standard of 1000 for conductivity and 20 for turbidity. The water samples deviated in all other physical and chemical parameters examined. However, the only exception was S_{10} that had turbidity of 0.70 which is the same with the WHO standard of 0.70. The variations observed could be due to the fact that most sachets water manufacturers are only concerned about making profits and do not spend time and resources to ensure that the water contains the right proportion of major and trace elements required to make it healthy and safe for human consumption. This is similar to the findings of Omaluet al., (2011) who observed that 90% of packed "pure water" sold in the Nigeria are not fit for human consumption and are hazardous to health. Okorafor et al., observed high concentration of some parameters such as manganese, iron, lead and turbidity in streams and boreholes meant for drinking.

Result obtained from microbial analysis of the different water samples also indicated high total and feacal coliform counts. The highest for both total and faecal coliform counts was observed in S_7 being 100cfu/ml. This implies that the water is produced in an unhealthy environment. The poor hygiene of the manufacturers could create a conducive atmosphere for the microorganisms to thrive. This was also observed by Dada (2009) who discovered that the factors responsible for the contamination of sachet water ranges from sharp practices, poor hygiene of vendors, and non-adherence to WHO/NAFDAC regulations. Water that has been treated for the purpose of drinking should not be contaminated with coliform. Another reason for the presence of coliform in the entire water samples examined might be due to poor maintenance of filter systems, as observed by the International Standard Organization (2011). They reported that poorly maintained filter system are also possible source of contamination because bacteria grows on filters if there are not changed regularly, and thereafter enters water supply.

Moreover, other sources of contamination of water are the sachet used in packaging the water which if not properly sterilized and handled in a hygiene manner, may cause water contamination. The presence of feacel coliform in the water samples is indicative of contamination with animal and human wastes. They are primarily indicators of the presence of bacteria pathogens such as Salmonella spp, Shigella spp. Vibrio cholera, Camplylobacterjejuni, Campylobacter coli, Yersinia enterocolitica and pathogenic E. coli. These organisms can be transmitted via the faecal/oral route by contaminated or poorly treated water and may cause disease such as gastroenteritis, salmonellosis, dysentery, cholera and typhoid fever.

5. CONCLUSION

The primary objective of monitoring drinking water is to ensure that it is safe for consumption in order to protect the health of the community by preventing the spread of water borne disease. The quality of sachet water in Ogoja was assessed and compared with the standard set out by World Health Organization (WHO). Results obtained revealed that all the samples of water examined deviated from the WHO benchmark. The concentrations of micro and macro elements were significantly different in the water samples compared to WHO recommended standards. Also, the total and faecal coliform counts were significantly higher in the different sachet water than what is stipulated by WHO. These findings suggest that sachet water products sold and consumed in Ogoja are not safe for drinking and contains pathogenic organism that can cause diseases among consumers.

6. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. NAFDAC and other regulatory bodies should ensure that all sachet water producers are duly registered and comply with standards.
2. List of unregistered manufacturers should be published for proper enlightenment of the populace since most consumers don't check out for NAFDAC registration number before drinking these sachets water.
3. Monitors should be sent on regular basis or permanently distributed to the different water producers to enforce adherence to stipulated guidelines.
4. Consumers should be enlightened and encouraged to check out for relevant registration numbers before drinking sachet waters.

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