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MICROBIOLOGICAL AND PHYSICOCHEMICAL ANALYSIS OF VARIOUS SACHET WATER CONSUMED IN COMMUNITIES IN OWERRI WEST, IMO STATE, NIGERIA

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ABSTRACT

This research work was conducted to determine the microbiological and physicochemical state, and quality and safety of selected sachet water brands consumed in Nekede and Ihiagwa communities in Owerri West LGA, Imo State, Nigeria. Ten (10) popular sachet water samples were randomly collected from both communities (Nekede and Ihiagwa) in Owerri West and the physicochemical and microbiological properties were analyzed. Twelve bacteria were isolated, of which, three of the isolates were Gram negative bacteria (*Chromobacterium* sp., *Flavobacterium*sp. and *Pseudomonas* sp.), four were non – spore forming Gram positive bacteria (*Micrococcus* sp., *Staphylococcus* sp., *Corynebacterium*sp., and *Aerococcus* sp.) and five species of spore forming Gram positive bacteria (*Bacillus sps.*). The physicochemical analysis of the samples indicated that only sachet water samples 5, 9, 10 were below the WHO permissible limit for pH level (6.5 – 8.5). The temperature range of the samples were 30.0^0C – 32.1^0C, indicating levels above the permissible limit of WHO (27^0C – 29^0C). These results obtained for pH and temperature may be attributed to the presence of acidic metabolites and changes in environmental condition. The level of calcium 26.24 – 35.20mg/l and 29.24 – 38.20mg/l, chlorine 68.00 – 82.00mg/l and 74.10 – 94.24mg/l, magnesium 9.45 – 22.10mg/l and 12.50 – 24.10mg/l and hardness 65 – 84mg/l and 70 – 88mg/l for the sachet water samples were within the permissible limit of WHO. The results for Most Probable Number (MPN), *Salmonella – Shigella* and Vibrio counts indicated that all the samples analyzed recorded zero count for Coliform and Vibrio species suggesting that the samples are not contaminated with fecal material. The result also indicated a higher total culturable heterothrophic bacteria count ranging between (1.2×10^2 - 2.9×10^2cfu/ml for sachet water samples. Hence, public education should be initiated and intensified on the need to purify water to make it fit for drinking and other domestic purposes.

KEYWORDS: Culturable, Isolates, Microbiological, Physicochemical, Sachet water.

INTRODUCTION

Water is a transparent fluid that forms the world's streams, lakes, oceans and rain, and it is the major constituent of the fluids of organisms. It covers about 70% of earth's surface and makes up about 70% of the human body mass and is essential for life (Shakhashiri, 2011). Access to safe drinking water is a vital agent for human living (Khatoon and Pirzada, 2010). Unavailability of good quality drinking water is wide spread and this has serious health implication (Onweluzo and Akuagbazie, 2010**).** However, it is estimated that about 1.2 billion individuals worldwide do not have access to potable water (Third World Water Forum on Water, 2003). In many developing countries (including Nigeria), availability of water has become a critical and urgent problem and it is a matter of great concern to families and communities that depend on non-public water supply system (Okonko, Ogunjobi, Adejoye, Ogunnusi and Olasogba, 2008).

The inadequacy of pipe borne water supply in Nigeria is a growing problem; as a resort to buying water from vendors, and sachet or bottled water became a major source of drinking water. Sachet or packaged drinking water is any water that is in a sealed plastic or polythene bag and is distributed or offered for sale and is intended for human consumption **(**Tagoe *et al*., 2011). The sale and consumption of packaged drinking water continues to grow rapidly in most of the developing countries of the world (Mgbakor *et al*., 2011). Sachet drinking water was introduced into the Nigerian markets as a less expensive means of accessing drinking water than bottled water (Ogundipe, 2008). Small nylon sachets which are electrically heated and sealed at both ends are used to package water; 0.5 liters of water and these were introduced into the market. There are many different brands of sachet drinking water that are beautifully packaged, properly labeled and advertised (Ekwunife, *et al*., 2010). The continuous proliferation of this sachet

drinking water and their indiscriminate consumption are of concern to public health. An understanding of their microbiological quality and safety are therefore pertinent (Muazu *et al*., 2012). Microbiological quality of drinking water is defined by the range of microbial variables or microbial parameters present in water, which limit the use of water, while the physicochemical quality of drinking water involves the analysis of the physical and chemical parameters of the drinking water.

Although, potable and affordable, the problems of its purity and other health concerns have begun to manifest. Sachet water has been reported to contain bacteria such as *Bacillus sp*., *Pseudomonas sp*., *Klebsiella sp*., *Streptococcus sp*., and oocysts of *Cryptosporidia sp.* Apart from environmental contaminants, improper storage and handling by vendors also poses a serious threat to the health of the ignorant consumers (Omalu *et al*., 2010). Although these products are popularly termed "Pure Water", they are usually not free of microorganisms (Omemu, Edema and Bankole, 2005; Oladipo, Onyenike and Adebiyi, 2009 & Ibemesim, 2014). Occasionally, contamination of sachet water may occur either during the processing, transportation or improper handling by hawkers.

Several studies on the quality of sachet water have reported violation of international quality standards (Anunobi, Onajole and Ogunnowo, 2006, Dada, 2009); and several studies have documented the detection of coliform and heterotrophic bacteria in sachet drinking water which far exceeded the national and international standards set for potable water for human consumption (Adekunle *et al*., 2004, Ajayi *et al*., 2008 & Ezeugwunne, 2019). Coliform are commonly used bacterial indicator of sanitary quality of foods and water.

Approximately, 88% of deaths due to diarrhoeal illnesses worldwide are attributable to unsafe water consumption, inadequate sanitation and poor hygiene (World Health Organization [WHO], 2015). It is the second leading cause of death among children under five, as it kills more children than AIDS, malaria and measles combined (WHO, 2015). Therefore, this research work seeks to examine the microbiological safety and the physicochemical quality of sachet consumed in Ihiagwa and Nekede communities; to determine the safety value of the water they consume.

MATERIALS AND METHODS

Study Design

The study design of this research is an experimental (interventional) design involving the selection and sampling of various sachet water and borehole water consumed in Nekede and Ihiagwa communities in Owerri West L.G.A, in Imo State, Nigeria. This quantitative research design study was used to establish the physicochemical and microbiological quality of sachets and borehole water consumed in both communities. Through results obtained from laboratory analysis of the water samples, the safety value will be ascertained.

Study Area

This research was carried out in Nekede (with the geographical coordinates of $5^{o}25'$ 14" N and 7^{o} 4' 36" Eis made up five villages, namely, Umuoma, Umuofocha, Umuerim, Umuokomoche, and Umukoto) and Ihiagwa (with geographical coordinates of 5^{o} 24' 2" N and 7^{o} 12' 4" E is a located in the local government area of Owerri West in Imo State, Nigeria. It is located 12km south of the capital of Owerri. The township is composed of eight villages, namely, Umuelem, Umuchima, Mboke, Nnkaramochie, Iriamogu, Aku / Umuokwo, Ibuzo and Umuezeawula) communities both located in Owerri West local government area of Imo state, South Eastern part of Nigeria. These communities are located near the city of Owerri and are Igbo speaking communities. The choice of these locations was due to the fact that most of the population is mainly students from the two prestigious federal higher institutions, civil servants, a huge number of lodges, visitors from all works of life, traders, of whom lives and works in the localities under study. As such, there was need to ascertain the safety of the water they consume.

Sampling and Sampling Technique

Random sampling method was used to select the various sachets water consumed by the population. The sachets were also sampled and selected based on the popularity and continued patronage of the population to the brands been sold in the community. Based on this, a list was made of all the sachets water consumed, with each brand's name written on a paper and then folded.

Instruments for Data Collection

This involves the materials, media and diluents used in the collection and preparation of the sachet water samples.

Materials: Sterile Sample Bottle, Cigarette gas Lighter, Methylated Spirit for sterilization (70% ethanol content), Navigational aids (e.g. GPS coordinate device), Sterile hand gloves, Cooler containing ice packs, pH meter, Thermometer, Sterile cotton wool, Paper work and record keeping notebook and Camera.

Media: Nutrient agar (NA), Nutrient broth (NB), *Salmonella-Shigella*agar (SSA), Thiosulphate Citrate Bile Salt (TCBS) agar, Lactose broth, Eosin Methylene Blue Agar, Simon Citrate agar and Mueller-Hinton agar. were used. All media were prepared and sterilized according to manufacturer's instruction.

Diluents: Physiological saline was prepared by dissolving 0.85g analytical grade of sodium chloride (NaCl) in 100ml of distilled water. Nine milliliters were dispensed into test tubes, sterilized by autoclaving at 121^{0}C for 15minutes at 15psi and allowed to cool.

Preparation of Samples
One milliliter each of the water samples were withdrawn from each sample container (SW1 to SW10) and transferred into 9ml sterile physiological saline in test tubes and serially diluted by ten-fold serial dilution.

Analysis of Physical Parameter
The physicochemical parameters were determined according to procedures outlined in the standard methods for the examination of water and wastewater (APHA, 1998). The temperature and pH of the water samples were measured at the site of sample collection using a calibrated thermometer and pH meter respectively. Calcium and Magnesium were measured by EDTA (ethylenediaminetetraacetic acid) titration. Chloride by gravimetric analysis and Hardness by standard methods (total hardness (mg/l as $CaCO_3$) = Calcium hardness (mg/l as $CaCO_3$) + Magnesium hardness (mg/l as $CaCO_3$). = 2.50 × Calcium conc. (mg/l as Ca^{2+}) + 4.12 × Magnesium conc. (mg/l as Mg^{2+}). See plate 1 below.

Culturing of Samples on Various Media
cultures of the samples were made on various media, including Nutrient Agar, *Salmonella Shigella* Agar, Thiosulphate Citrate Bile Salt Agar and Most Probable Number Multiple Tube technique.

Isolation and Identification of Isolates
After incubation, Nutrient Agar culture plates with colonies between 30 -300 were counted and the mean value expressed as colony-forming unit per ml (cfu/ml). Bacterial colonies were isolated based on their colonial morphology (color, shape, size, elevation) on nutrient agar media. Bacteria colonies were sub-cultured in 10ml nutrient broth, incubated at 37^0C for 24hrs. A loopful of the culture was inoculated from each tube into nutrient agar plates and incubated for 24hrs at 37^0C. Discrete bacteria colonies were stained for Gram and spore reaction.

Validity of Instruments
The instruments used during the research which included the use of graduated laboratory wares such as measuring scales to weigh media and all other measuring instruments, were viewed and corrections made by the Head of Department of Microbiology Laboratory, where the laboratory work was carried out. This was done on face validity, to ensure that the instrument was devoid of parallax errors. Corrections and inputs were also made.

Method of Data Collection
Packaged water samples (i.e. sachet water), two (2) sachets collected from each brands, were purchased from selected shops from the two communities (Nekede and Ihiagwa) in conditions in which the consumers purchase and use them and were labeled (SW1 to SW5) represents samples collected from Nekede community, while the water samples (SW6 to SW10) represents samples collected from Ihiagwa. After collecting the water samples, they were placed in different coolers containing ice packs for preservation and for onward transport to the Laboratory of the Department of Microbiology, Rivers State University of Science and Technology, Rivers State, for microbiological analysis of the water samples. This was done within 3 hours after the water samples were collected. However, 100m/l from each of the water samples were transferred into a clean beaker and analyzed for pH and temperature using pH meter and thermometer respectively at the site of sample collection.

RESULTS
Physicochemical Parameters of Sachet Water Samples
The data on the physicochemical parameters in the table 2 below shows that the pH of sachet water samples 1 to 4 (SW1 to SW4) with pH values (7.90, 7.80, 7.62 and 7.14 respectively), collected from Nekede community were within the WHO permissible limit of 6.5 – 8.5 (WHO, 2006; 2009) (table 1), while the sachet water sample (SW5) with pH value of 6.31 was below the WHO permissible limit of 6.5 - 8.5. The temperature of all the sachet water samples analyzed for Nekede community were above the WHO guideline of 27^oC - 29^oC (Ambient). The level of chlorine concentrations indicated that SW3 had the highest concentration level of about 80.84mg/L while SW4 had the lowest concentration level of about 68.24mg/L.

The results in the table above, also shows that the value of total hardness, calcium and magnesium were within the WHO permissible limit (150mg/L for total hardness, 75mg/L for calcium and 30mg/L for magnesium respectively).

On the other hand, the data in table 2 below shows that the pH of sachet water samples 1 to 3 (SW6 to SW8) with pH values (7.02, 6.84 and 7.50 respectively), collected from Ihiagwa community were within the WHO permissible limit of 6.5 – 8.5 while the sachet water samples (SW9 and SW10) with pH value of 6.02 and 5.95 were below the WHO permissible limit of 6.5 - 8.5 (WHO, 2006; 2009).

The temperature of all the sachet water samples analyzed for Ihiagwa community were above the WHO guideline of 27^oC - 29^oC (Ambient). The level of chlorine concentrations indicated that SW7 had the highest concentration level of about 82.00mg/L while SW10 had the lowest concentration level of about 68.00mg/L. The results in the table also show that the value of total hardness, calcium and magnesium were within the WHO permissible limit (150mg/L for total hardness, 75mg/L for calcium and 30mg/L for magnesium respectively). Graph of the physicochemical parameters of the sachet water samples in shown in figure 1 below.

Population Density of Bacteria from Sachet Water Samples
The bacterial population density obtained from sachet water samples is shown in table 4 below. The highest

total culturable heterotrophic bacterial counts was obtained for SW10 with 2.9×10^2cfu/ml while the lowest count of 5.0×10^1cfu/ml was obtained for SW1. The table also shows a zero count for Faecal and Total Coliform bacteria group, *Salmonella – Shigella* and Vibrio species respectively.

Morphological and Biochemical Characterization of Bacterial Isolates

The results of the table 5 below shows the result of the morphological characteristics of the isolates from both the sachet and borehole water samples collected from Nekede and Ihiagwa communities. The features of each isolates include the colony size, the color of the isolate, the surface, the elevation, the edge, the opacity and the texture.

The results of the table 6 below show the various criteria used in the identification of bacterial isolates. Three (3) of the isolates were cocci in shape while nine (9) were rods. Nine (9) of the isolates were Gram positive and three (3) were Gram negative. All the isolates tested negative to coagulase test except one. For motility, citrate utilization and methyl red test, seven (7) each of the isolates were positive while five (5) tested negative respectively. Six (6) of the isolates were positive to catalase test while the other six (6) tested negative. For the production of oxidase enzyme, eight (8) of the isolates were negative while four (4) were positive. Voges Proskauer test was positive to ten (10) isolates and two (2) were negative. Eleven (11) isolates were negative to indole test while one (1) was positive.

For sugar fermentation, eight (8) of the isolates were positive to acid production, only one (1) produced gas while four (4) were negative, all for glucose. For lactose, five (5) of the isolates were positive to acid but negative to gas production while seven (7) were negative to acid and gas production. Ten (10) isolates were negative to acid and gas production for maltose while two (2) produced acid without gas.

Table 1: The Permissible/ Allowable Limits for Microbiological and Physicochemical Parameters in Drinking Water.

Parameters	Unit	Maximum Permitted Levels	Health Impact
Physicochemical			
Colour	TCU	15	None
Odour	-	Unobjectionable	None
Taste	-	Unobjectionable	None
Temperature	^{0}Celcius	Ambient	None
Turbidity	NTU	5	None
pH	-	6.5 – 8.5	None
Arsenic	mg/L	0.01	Cancer
Hardness($CaCO_3$)	mg/L	150	None
Magnesium(Mg^{+2})	mg/L	30	-
Microbiological			Indication of faecal contamination
Total coliform Count	cfu/100mL	0	Urinary tract infections, bacteraemia, diarrhoea, etc.
Thermo-tolerant coliform or *Escherichia coli*	cfu/100mL	0 0	Indication of recent faecal contamination
Faecal streptococcus	cfu/100mL		Index of intermittent faecal
Clostridium perfringens spore	cfu/100mL	0	contamination.

Key: TCU – True Colour Unit; NTU – Nephelometric Turbidity Units; cfu – Colony Forming Unit; mL – Millilitres **(WHO, 2009; NIS, 2007).**

Table 2: Physicochemical Parameters of Sachet Water Samples from Nekede Community

SAMPLE CODE	PARAMETERS ANALYZED					
	pH	Temperature (^{O}C)	Calcium (mg/l)	Chlorine (mg/l)	Magnesium (mg/l)	Hardness (mg/l)
SW1	7.90	30.0	27.10	70.91	13.69	80
SW2	7.80	31.4	28.20	78.56	20.15	65
SW3	7.62	32.5	27.22	80.84	9.45	72
SW4	7.14	32.1	29.40	68.24	12.60	68
SW5	6.31	31.1	32.0	72.34	14.50	84
WHO	**6.5-8.5**	**Ambient**	**75**	**250**	**30**	**150**

Key: SW- Sachet Water; **WHO** – World Health Organization; **mg/l** – microgram per liter; **^{o}C** – Degree centigree, **Ambient:** 27^{o}C - 29^{o}C.

Table 3: Physicochemical Parameters of Sachet Water Samples from Ihiagwa Community

SAMPLE CODE	PARAMETERS ANALYZED					
	pH	Temperature (^{O}C)	Calcium (mg/l)	Chlorine (mg/l)	Magnesium (mg/l)	Hardness (mg/l)
SW6	7.02	32.1	35.20	76.20	18.00	78
SW7	6.84	30.2	26.24	82.00	16.40	70
SW8	7.50	30.6	30.10	74.40	22.10	76
SW9	6.02	31.1	28.30	80.24	20.00	82
SW10	5.95	32.1	27.20	68.00	15.60	74
WHO	**6.5-8.5**	**Ambient**	**75**	**250**	**30**	**150**

Key: SW- Sachet Water; **WHO** – World Health Organization; **mg/l** – microgram per liter; **^{o}C** – Degree centigree, **Ambient**: 27^{o}C - 29^{o}C.

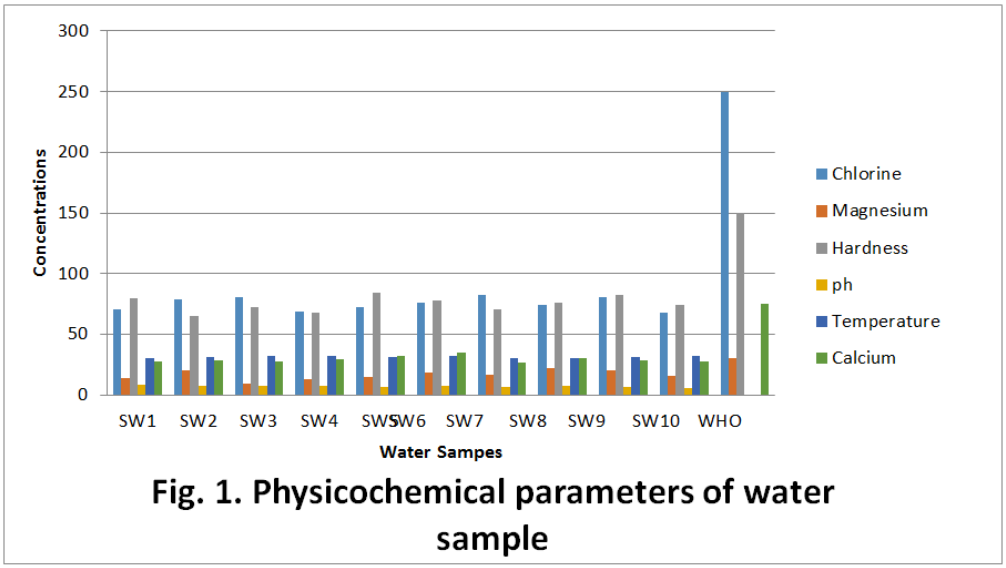

Fig. 1. Physicochemical parameters of water sample

PLATE 1: Serial dilution and Inoculation of a portion into the prepared media (Using the Spread Plate Method)

Table 4: Microbiological results of Sachet Water Samples for Nekede and Ihiagwa communities.

SAMPLE CODE	MEAN TCHBC (CFU/ML)	MEAN FCC (CFU/ML)	MEAN TCC (CFU/ML)	MEAN SSC (CFU/ML)	MEAN VC (CFU/ML)
SW1	5.0×10^1	0	0	0	0
SW2	1.20×10^2	0	0	0	0
SW3	2.60×10^2	0	0	0 0	
SW4	1.20×10^2	0	0	0	0
SW5	2.60×10^2	0	0	0	0
SW6	1.70×10^2	0	0	0	0
SW7	2.60×10^2	0	0	0	0
SW8	2.20×10^2	0	0	0	0
SW9	7.0×10^1	0	0	0	0
SW10	2.90×10^2	0	0	0	0
WHO	**1.0×10^2**	**0**	**0**	**0**	**0**

Key: SW- Sachet Water; **TCHBC** – Total Culturable Heterotrophic Bacteria Count;
FCC – Faecal Coliform Count; **TCC** – Total Coliform Count; **SSC** – *Salmonella- shigella*Count;
VC – Vibrio Count; CFU/ML – Colony forming unit per mililitres

Table 8: Results of the Morphological Characteristics of the Isolates.

Isolate Code	Colony Size	Colour	Surface	Elevation	Edge	Opacity	Texture
ISO 1	Large	Whitish	Rough	Flat	Rough	Opaque	Dry
ISO 2	Large	Whitish	Smooth	Flat	Undulated	Opaque	Dry
ISO 3	Moderate	Colorless	Rough	Slightly-raised	Pin center	Opaque	Dry
ISO 4	Small	Whitish	Smooth	Flat	Smooth	Translucent	Moist
ISO 5	Small	Whitish	Shiny	Flat	Entire	Translucent	Moist
ISO 6	Small	Dark	Shiny	Flat	Entire	Opaque	Moist
ISO 7	Moderate	Whitish	Rough	Flat	Rough	Translucent	Dry
ISO 8	Small	Light-yellow	Shiny	Slightly-raised	Entire	Translucent	Moist
ISO 9	Small	Purple	Shiny	Flat	Entire	Opaque	Moist
ISO 10	Small	Colorless	Shiny	Flat	Entire	Translucent	Moist
ISO 11	Moderate	Greenish-orange	Shiny	Raised	Entire	Opaque	Moist
ISO 12	Large	Whitish	Smooth	Flat	Rough	Opaque	Dry

Key: ISO – Isolate.

Table 9: Biochemical Characterization of Bacterial Isolates.

Isolate Code	Cell shape	Gram React.	Spore React.	Mot	Coa	Cat	Cit	Oxi	Ind	MR	VP	Glu	Lac	Mal	Probable Isolates
ISO 1	Rods in chains	+	+	+	-	-	-	-	-	+	+	A/G	-	-	*Bacillus sp.*
ISO 2	Rods	+	+	+	-	-	-	-	-	+	+	A	-	-	*Bacillus sp.*
ISO 3	Cocci	+	-	-	-	+	+	+	-	-	+	-	A	-	*Micrococcus sp*
ISO 4	Cocci in clusters	+	-	-	+	+	+	-	-	-	+	A	A	A	*Staphylococcus sp.*
ISO 5	Cocci	+	-	-	-	-	+	-	-	-	+	A	-	A	*Aerococcus sp.*
ISO 6	Rods in chains	+	+	+	-	-	-	-	-	-	+	A	-	-	*Bacillus sp.*
ISO 7	Rods in chains	+	+	+	-	-	-	-	-	-	+	-	A	-	*Bacillus sp.*
ISO 8	Short rods	+	-	-	-	+	+	-	-	+	+	A	A	-	*Corynebacterium sp.*
ISO 9	Short rods	-	-	+	-	+	+	+	-	+	-	-	A	-	*Chromobacterium sp.*
ISO 10	Short rods	-	-	-	-	-	-	+	+	+	+	A	-	-	*Flavobacterium sp.*
ISO 11	Rods	-	-	+	-	+	+	+	-	+	-	-	-	-	*Pseudomonas sp.*
ISO 12	Slender rods	+	+	+	-	+	+	-	-	+	+	A	-	-	*Bacillus sp.*

KEY: Mot – Motility; Coa – Coagulase; Cat – Catalase; Cit – Citrate; Oxi – Oxidase; Glu – Glucose; Lac – Lactose; Mal – Maltose; + - Positive; (-) – Negative, A – Acid; G - Gas; M-R - Methyl- Red; V-P - Voges-Proskauer.

DISCUSSION

The pH values of the water samples (SW1 to 4, 6, 7 and 8) were observed to be within the WHO permissible limit (6.5 – 8.5) (WHO, 2006; 2009), except in sachet water (SW5, 9 and 10) that had a slightly lower pH than the WHO permissible limit. This level of pH concentration

indicates that the water sample sources are acidic, soft and corrosive. Although, there is no health concerns as regards to the pH level in drinking water, however, this low pH level may react with the nylon used in packaging the water, which can cause health problems.

The temperature of all the water samples analyzed was above WHO guideline of 27^{o}C -29^{o}C (Ambient). The increased temperature of the water samples could be attributed to changes in climatic condition during storage. hence, it is mostly sold cold. The level of chlorine in Borehole samples were higher than the Sachet water sample though at a level within WHO permissible limit of 250mg/l. The presence of chlorides in natural and sachet (treated) water could be attributed to pollutions from sewage, minerals, and the water treatment process (Agunwamba, 2000). According to Erah *et al*., (2002) geochemical conditions could make chlorides to be present in water at varying conditions.

The value of total hardness, calcium and magnesium of the Sachet and Borehole water samples were within WHO permissible limit (150mg/l for total hardness, 75mg/l for calcium and 30mg/l for magnesium respectively) although there were variations among samples. Total hardness is a function of the geology of the area with which the water is associated. It may affect the taste of water as well as influence its lathering ability when used for washing. Calcium, which is essential for nervous system and for the formation of bones, is commonly present in all water bodies where it usually comes from the leaching of rocks (Agunwamba, 2000). However, magnesium is usually less abundant in water than calcium, perhaps due to the fact that magnesium is found in the earth's crust in much lower amounts as compared to calcium. High concentration of magnesium in drinking water gives unpleasant taste to the water (WHO, 2006).

The microbial analysis of the water samples revealed the presence of heterotrophic bacteria and free of *Vibrio, Salmonella – Shigella* and Coliform bacteria group in all the water samples analyzed. The concentration of *Vibrio, Salmonella – Shigella* and Coliform bacteria group obtained from the water samples (zero count) were within WHO standard of 10MPN/100ml. This indicates that all the samples are free from indicator organism and Vibrio species. Contrast to this research findings, Agbabiaka *et al.*, (2011) opined that the MPN coliform index per 100ml of water samples collected from selected boreholes in Ilorin metropolis ranged from 0 to 16MPN/100ml. Erah, *et al.*, (2002) in a related study isolated some members of coliform in stored borehole water samples. Orji, *et al*. (2006) also obtained high faecal coliform from wells and boreholes water in some peri-Urban communities in Kumasi, Ghana.

The presence of counts exceeding the WHO limits of 1.0 x 10^{2}cfu/ml for TCHB indicates that the water samples contain high concentration of bacteria that could make the water unsafe for human consumption. The results show that the values of TCHB count ranged from 5.0 x 10^{1}cfu/ml to 2.9 x 10^{2}cfu/ml for the sachet water samples. However, these results for bacteria count reveals that only sachet water samples 1 and 9 (5.0×10^{1} and 7.0×10^{1}), Borehole water samples 6 and 10 (6.0×10^{1} and 9.0×10^{1}) were within WHO permissible limit for drinking water while the count for other samples were above the WHO limit. This result corroborates the finding of Uzoigwe and Agwa, (2012) in their research findings, that there are high counts of total heterotrophic bacteria in most borehole water samples in Port Harcourt, Nigeria. Erah, *et al*. (2002) in a separate research obtained a range of THB counts that are unacceptable by WHO from boreholes in Benin City, Nigeria.

The bacteriological identification of the isolates obtained from the water samples indicated that the organisms were *Bacillus sps., Micrococcus sp., Aerococcus sp., Corynebacterium sp., Chromobacterium sp., Flavobacterium sp., Pseudomonas sp. andStaphylococcus sp.* These organisms are important human pathogens associated with a variety of infectious diseases such as gastroenteritis, skin infection (dermatitis), urinary tract infections and respiratory diseases etc (Orji, *et al.* 2006; Nwidu, *et al.*, 2008). Their presence raises serious public health concern because they are known causative agents of different water-borne diseases and indicates that these water sources are not potable for consumption. Their entry into water sources could be attributed to seepages from nearby septic tanks, as opined by Nwidu, *et al.*, (2008).

CONCLUSION AND RECOMMENDATION

This study has shown that most of the sachet water analyzed from the two communities are potential health risks for consumers. Among the strategies to adopt in combating water pollution problem is the promotion of household water storage, and the need to improve on personal behavior and hygiene practices to reduce microbial load in water supply. Sachet water producing companies should observe and maintain in detail the standard procedure in treatment of water to ensure that the water is portable for consumers. It is evident that water-borne diseases are due to improper disposal of refuse, contamination of water by sewage, unhygienic production conditions and/or environment and improper treatment of water.

The issues arising from this study afford the opportunity for further research to determine the water quality of other sachet water brands produced and consumed within and outside the study area. There should be regular and routine monitoring of borehole water sources, from which the packaged (sachet) water are produced by the relevant authorities such as the National Agency for Food and Drugs Administration and Control (NAFDAC) and Standard Organization of Nigerian (SON) in order to ensure that quality and standard are maintained.

Public education should be initiated and intensified on the need to purify water to make it fit for drinking and other domestic purposes. Packaged water industries and residential owners should be encouraged on the need for regular and effective treatment of their boreholes which would enhance the quality of the distribution systems before supply to final consumers.

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