Advances In Multidisciplinary & Scientific Research
A Multidisciplinary & Interdisciplinary Journal
Volume 9, No 3, September 2023 Series

Assessment of Indicator Microorganisms and Physicochemical Parameters of some Sachet Water (Pure water) Sold in Selected Locations of Bauchi Metropolis, Nigeria.

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ABSTRACT

Sachet water has gradually become the most widely consumed portable water for everyone in Nigeria. This study aimed to asses' indicator microorganisms and physicochemical parameters some sachet water sold in selected location in Bauchi metropolis, Nigeria. A total of five (5) brands of sachet pure water sample were considered in this study, two sachets from each brands of pure. The parameters were analyzed include:Physical parameters tested such as; color, pH, temperature and turbidity in all (100%) the sachet water samples conformed to the recommended limits. Chemical analysis carried out such as; conductivity, total dissolved solids (TDS), chloride content, fluoride content, Iron content, nitrate and nitrite content, total hardness all conformed to the requirements of the WHO,NIS and NAFDAC standards. All water samples were subjected to standard bacteriological tests such as Heterotrophic plate count and coliform count and multiple tubes (MPN). The mean pH ranged from 7.32 to 7.48 for the water samples while temperature ranged from 26.24 to 28.00 ^{0}C, the turbidity of the water samples ranges from 0.48 to 0.60 (NTU) and chemical properties were within the permissible limit, as compared to National Agency for Food and Drug, Administration Control and Standard Organization of Nigeria standards. The mean heterotrophic plate count ranged from 1.4 x 10^{1} to 2.6 x 10^{2}cfu/ml. The MPN/100ml of the samples ranged from < 3 to > 1200 coliform/ml. All sachet brands of pure water samples did not meet up with the standard stipulated by the WHO, NIS and NAFDAC standards for drinking water quality. The pathogenic, organic and indicator organisms present in all the water samples studied, as well as their physicochemical implications, render them unfit for human consumption, though they can be used for other purposes. Effort needs to be intensified in the monitoring the activities of the rapidly expanding pure water Company with a view to raising standard and ensuring safety of the populace.

Key: Indicator, microorganisms, physicochemical, sachet, pure water,

Aims Research Journal Reference Format:
Lawal, R.A. (2023): Assessment of Indicator Microorganisms and Physicochemical Parameters of some Sachet Water (Pure water) Sold in Selected Locations of Bauchi Metropolis, Nigeria.Advances in Multidisciplinary and Scientific Research Journal Vol. 9. No. 3. Pp 35-48. .www.isteams.net/aimsjournal.

INTRODUCTION

Water is essential to life, where it is very important for the composition and renewal of cells (Abera*et al.,* 2011*)*. The occurrence of packaging water into sachets popularly referred to as "pure water" is one of the most lucrative business ventures in some West African countries including Nigeria.

This business has gained much popularity and acceptance among the Nigerians populace particularly because in the past, drinking water was sold in cups and plastic bags hand-tied at one end; a practice which was faced with a lot of sanitary issues. Currently, the exact numbers of sachet water companies is unknown, as new ones spring up almost daily. There are more unregistered producers than registered ones, with the current estimate of registered producers reaching thousands. “Pure water” contains 50cl of water in a clear plastic bag that is electrically heated and sealed at opposite ends. Water used for “pure water” is mostly obtained from ground water, springs and potable pipe-borne water. Prior to packaging, the water goes through a number of treatment processes, mainly filtration, in an attempt to make it cleaner and safer for consumption. Most households and families depended greatly on public water from Gubi water board for drinking and household activities including cooking1. However, with the frequent shortages associated with the supply of potable water across the country, and the questionable quality of the water supplied, many households and families in Nigeria have resorted to using “pure water” mostly for drinking and cooking purposes.

Globally, 1.1 billion people do not have access to adequate and potable water supply and over 460 million people are currently suffering acute water shortage and 2.4 billion lacking adequate sanitary facilities. According to WHO guidelines, water for drinking must not present any significant risk to the health of the consumer over a lifetime of consumption. Neither should the consumption of such water present different sensitivities that may arise between life stages. Invariably, safe drinking water should be colorless and tasteless, free from harmful chemicals as well as other suspended materials and most importantly should be devoid of disease-causing organisms. Among many other concerns, the possibility of drinking water being the source of disease causing organisms and related illnesses has been a huge hurdle to overcome, especially in parts of developing countries where availability, accessibility and affordability of potable and safe drinking water continues to be a challenge.

Consequently, given the renewed global commitments towards the MillenniumDevelopment Goals (MDG) marked for 2015, the importance and contribution of locally sourced low-cost alternative drinking water schemes to sustainable access in rural and peri-urban settings of developing nations cannot be over-emphasized (UNDESA, 2004).One such local intervention in Nigeria, where public drinking water supply is unreliable (Egwari and Aboaba, 2002), is drinking water sold in polythene sachets. In Lagos State, with up to 70% of the population deriving daily water provision from sources other than the state municipals (Coker, 2004), many people depend on water vendors to whom they pay heavily for provision of water to meet daily domestic needs. The production, marketing and consumption of sachet water have increased tremendously.

There are now several brands of these type of packaged water marketed in Nigeria and other developing nations (Ogan, 1992; Kassenga, 2007).Water in sachets is readily available and the price is affordable, but there are concerns about its purity. The integrity of the hygienic environment and the conditions where the majority of the water in sachets are produced has also been questioned (C.A.M.O.N, 2007). Although nationally documented evidence is rare, there are claims of past outbreaks of water-borne illnesses that resulted from consumption of polluted water in sachets (C.A.M.O.N, 2007).The National Agency for Food and Drug Administration 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(C.A.M.O.N, 2007).

To control the menace of polluted water in sachets, NAFDAC declared a possible 'gradual' nationwide ban on sachet waters to allow the manufacturers of sachet water to start winding-down or change to bottle packaging (C.A.M.O.N, 2004).

Although the introduction of sachet water was intended to provide affordable and readily available safe drinking water for Nigerians, investigations on its quality and wholesomeness for consumption have revealed considerable gaps especially with regards to microbial quality.The most common group of indicator organisms used in water monitoring water quality are *Coliforns, E coli, Salmonella, Shigella* etc. These organisms are representative of bacteria normally present in the intestinal tract of mammals including human, so they provide an adequate index of faecal contamination of drinking water (Fewtrell and Bartram, 2001). The coliform group comprises strains of the four genera of the intestinal group: *Escherichia coli, Enterobacter, Klebsiella and Citrobacter.* The number of *Escherichia* and *Enterobacter* remainshas much higher in the intestine compared to the remaining two (Stevens *et al*., 2003).

Bacterial contamination of drinking water is a major public health problem worldwide, because water is an important vehicle of some gastrointestinal diseases such as diarrhea, vomiting etc. In terms of public health significance, *E. coil* has frequently been reported to be causative agent of traveler's diarrhea, urinary tract infection, haemorrhagiccolitis and haemolyticuraemi ancesyndrome *Klebsiella pneumoniae* is associated with pneumonia and upper respiratory tract infection. However, *Enterobacter* and *Citrobacter* species have also been previously reported as causes of cystitis, enteritis, pneumonia, diarrhea and food poisoning (Kistemann*et al*.,2002). However, the presence of coliform in drinking water could also indicate a breakdown of the treatment process. The bacteria qualities of groundwater, pipe borne water and other natural water supplies in Nigeria have been reported to be unsatisfactory, with coliform counts far exceeding the level recommended by WHO (Edema *et a*l., 2001).The public health significance of water quality in Nigeria thus, cannot be over emphasized. Many infectious diseases are transmitted by water through the faecal-oral route. Diseases contacted through drinking water kill about 5million children annually and make 1/6th of the world population sick (WHO,2004).

More so, it is known that packaged water in food grade polyethylene sachets designed food processing, serves as a ready alternative for a growing population (Rompre *et al*., 2002). The drinking qualities of sachet water are largely dependent on the concentration of biological, chemical and physical contaminants as much as environmental and human activities in such respects (Emmanuel *et al*., 2015). Increase in population is however causing an increase in incidences of pollution of drinking water sources, which most often are from surface water that are likely to be polluted with domestic, industrial as well as agricultural waste (Dada, 2009). Provision of safe drinking water is of major public health significance. The ever increasing demand for readily available water has led to the general perception that packaged water is safe, consumption (Adekunle *et al*., 2004), sachet water being considered to be safe. According to the NAFDAC, majority of sachet water are produced under questionable hygienic environmental conditions, without approval and does not meet standards (Zakaria, 2012). Regardless of all these problems associated with sachet water within Bauchi metropolis, it is still considered wholesome for drinking purposes as compared to river, well water and borehole,

if the industrial standards are followed. The problems of the purity and health of sachet water concerns sometimes manifest after it has been stored for a lengthy period (Oladipo *et al.*, 2009). Some sachet water producers do not see the essence of proper storage and continually expose bagged sachet water to sunlight. There is also inadequate screening and monitoring of distributors, retailers, vendors, that sometimes compromise on quality of standards complying products through improper handling, packaging, storage and distribution of sachet water within Bauchi metropolis. Therefore, consumer confidence in the industry, which used to be very high, is gradually being eroded by these quality mishaps (Adam, 2014). Perhaps most disturbing of all is the health risks associated with these quality problems. However, this study set out to ascertain the indicator organisms of the water in sachets and to identify some physicochemical parameters that determine the fate of sachet water sold in Bauchi metropolis.

The study will also help in sensitizing manufactures, vendors and the general public on the need to observed storage and the hazards associated with drinking such contaminated water.The findings of this research would assist government policy on regulation of quality management in sachet water industry. It would enable monitoring agencies and other stakeholders realize the need for proper storage as a strategy to improve performance of the water producers in order to achieve the objective of ensuring safe and acceptable drinking water for the populace.

2. MATERIALS AND METHODS

2.1 Sample collection

To ensure adequately representative sampling, a preliminary survey was conducted before selection of the water to be analyzed.Geographical zoning was done using the five markets spread within the study location. Inquiries were also made at randomly chosen locations, houses, retail and wholesale outlets to identify popular brand names commonly patronized in the market zones of the study area. Following this procedure, five brands of sachet water were identified. Duplicate of five (5) of samples from each identified brand accounted for the 10 sachet pure water samples analyzed. Samples were purchased just after production directly from the factory and from the outdoor vendors (hawkers). These were labeled appropriately and transferred within 4 h to theMicrobiology Laboratory and stored at 4^{o}C prior to analysis.

2.2 Physical analysis

2.2.1 Test for color

The colour of the samples was determined using colour test kit (Lovibon comparator, 2000 visual). One tube of the Lovibond comparator matched tube was filled with the water sample to be examined and the other tube was filled with distilled water used as standard control. Both tubes were placed in the comparator, adjusted by rotating the disc until the nearest colour match was observed. The results was then expressed in whole number and recorded as Hazen unit (Dinrifo et al., 2010).

2.2.2 Determination of Temperature

The temperature of all the water samples was determined using a simple mercury-in-glass thermometer calibrated in degrees centigrade as described by (Edema *et al*., 2001 and Dinrifo*et al.*, 2010).

2.2.3 Determination of Turbidity

Turbidity of all the water samples was determined using turbidometer (HANA instrument HI93703) expressed in whole number as Nephelometric turbidity unit (NTU) as described by other workers (Essien and Olisah, 2010; Dinrifo*et al*., 2010; Olaoluwa*et al*., 2010).

2.2.4 Determination of pH

The pH of the water samples was determined using a pH meter (Toledo, MP220). Each water sample was measured into 100 cm3 beaker and the pH determined by inserting the pH meter probe after standardization into the beaker and taking the reading.Standardization of the meter was ensured after each reading (AOAC, 2006).This involved visual examination of features external to the water itself such as the label, presence of certification number and other product information. Specific odour and appearance (colour, turbidity and presence of floating particles or extraneous materials) were also noted.

2.3 Chemical analysis

2.3.1 Determination of Conductivity

Conductivity of all samples was determined using a digital conductivity meter model 4520 JENWAY, serial No 01263. The meter was switched on and allowed to warm up for about 15 minutes. It was than standardized with 0.01M KCl solution where a conductivity value of 1413 microsiemen per centimetre was obtained, the electrode was thoroughly rinsed with distilled water and then introduced directly into the samples. The value for each sample was taken (Bennet and David, 1974).

2.3.2 Test for Total Hardness

Total hardness of each water sample was determined using a potable UV-visible spectrophotometer (HACH D 89) in which 10 cm3 of each water sample was pipetted into an sample cell and total hardness reagent H-1K added and allowed to stand for 3 minutes for reaction to take place, after which the total hardness was read (AOAC. 2006).

2.3.3 Test for Nitrate and Nitrite

This was done using a potable UV-visible spectrophotometer (HACH D 89). Two cuvettes were filled with 10 cm3 of the water sample and the content of nitraver 5 nitrate reagent powder pillow was added in one cell, stoppered and shaken vigorously for1minute, after which it was allowed to stand for five minutes. An amber color developed if nitrate was present and for nitrite, nitraver 3 reagent powder was added and allowed to stand for 5minutes, pink color development is an indication of positive nitrite.Absorbance expressed in mg/l was then measured (AOAC, 2006).

2.3.4 Determination of Total Dissolved Solids

Total dissolved solids (TDS) for each water sample was determined mathematically as a product of conductivity multiplied by a constant value, 0.6 (APHA, 1985).
TDS = conductivity x 0.6

2.3.5 Determination of Chlorine

Residual and total chlorine was measured by a calibrated HACH DR-900 colorimeter and instrument test kits are based on the DR900 Multi-Parameter Handheld Colorimeter.

The range of the meter was 0 - 4 mg/L, equivalent to 0 - 4 ppm. The standard operating procedure was based on the APHA Method 4500-CL: Standard Methods for the Examination of Water and Wastewater.

2.3.6 Test for Fluoride

Ten (10) millilitres of each water sample was introduced into dry square sample cell and 2cm3 of SPADNS reagent was added and swirl to mix. After a minute reaction time the absorbance of the samples was read from the spectrophotometer (AOAC, 2006).

2.3.7 Determination of Heavy Metal (Fe)

Iron (Fe) was determined for each water sample using AAS (Buck Scientific, VPG 210) procedure as reported by Oyelola *et al*., 2008 and Olaoluwa *et al*., 2010.Each sample was digested using 100cm^3 and a hallow cathode lamp of the desired metal was installed into the instrument and the wavelength characteristics of that metal was then set. The procedure used flame Atomic absorption spectrophotometry using acetylene/air. Concentrations of the analytes in mg/ml in the digested samples were obtained by extrapolation from the calibration curve prepared by American Public Health Association (APHA, 1985).

2.4 Microbial Assessment of brands of pure water sachet.

2.4.1 Heterotrophic plate count *Coliform* count

0.1ml of each sachet of pure water sample was aseptically inoculated into Nutrient Agar for heterotrophic plate count and MacConkey agar for coliform count according to Ibe and Okplenye (2005). All plates were inoculated in triplicates and incubated aerobically at 37^{o}C for 24-48hrs.

2.4.2 Total coliform count

This was determined by using the three test tube of the multiple tube test method (Ibe and Okpelenye, 2005). Presumptive test was performed by using Lactose broth. The first set of three tubes had sterile 10ml double strength lactose broth and the second and third sets had 9ml single strength broth. All the tubes contained Durham tubes before sterilization. The three sets of tubes were inoculated with 10ml, 1ml and 0.1ml of the water sample. Tubes were incubated at 37^{o}C for 24-48hr and examined for visible turbidity and carbon (IV) oxide gas production. Confirmed test was carried out by sub culturing a loopful of culture from positive tubes on MacConkey Agar.

Thereafter, the complete test was done by streaking a loopful of isolate from the MacConkey agar plates on Eosin Methylene Blue Agar, plates were then incubated at 37^{o}C for 24-48hr. After the incubation period, colonies that showed characteristics of coliforns were subcultured and subjected to gram staining and biochemical tests using standard microbiological methods

2.5 Statistical Analysis

The results were statistically analyzed using Analysis of variance (ANOVA) operated through SPSS software developed by Microsoft Inc. to determined the variance of the physicochemical parameters and microbial properties of sachet pure water.

3. RESULT AND DISCUSSION

Table 1: Physical parameters of different brands of sachet pure water sold in Bauchi metropolis.

Parameters	Color	Temperature (^{O}C)	Turbidity (NTU)	pH
AA1	clear/crystal	26.30 ^{a}	0.48 ^{d}	7.40^{j}
AA2	,,	26.24^{b}	0.50^{j}	7.32^{a}
BB1	,,	27.00 ^{c}	0.50^{i}	7.48^{c}
BB2	,,	27.20 ^{e}	0.54 ^{f}	7.50^{d}
CC1	,,	26.80^{a}	0.52 ^{e}	7.56^{b}
CC2	,,	27.10 ^{j}	0.54 ^{h}	7.55^{c}
DD1	,,	27.60 ^{c}	0.58^{a}	7.60^{j}
DD2	,,	28.00 ^{a}	0.60^{c}	7.62^{i}
EE1	,,	26.88^{i}	0.52 ^{c}	7.48^{a}
EE2	,,	27.14^{g}	0.56^{i}	7.84^{b}
NAFDAC/SON (2015)	clear/crystal	35-40	5.00	6.5-8.5
WHO (2011)	clear/crystal	35-40	4.80-5.00	6.5-8.5

Means on the same column with different superscripts are significantly different ($p<0.05$).

Color

The results obtained for the physical properties of different brands of sachet pure water are presented in the Table 1.Physical parameters tested in all the sachet water samples include; color, odor and taste. These are important quality parameters affecting acceptability of water for consumption (Yakasai et al., 2010). All the sachet water samples analyzed are clear, colorless, tasteless and odorless. This can be attributed to the use of sand and activated carbon filtration processes used during production in all the sachet water companies. However, all the results were within the permissible limit by NAFDAC, SON and WHO.

pH

The data obtained from as presented in Table 1 shows that the pH mean concentration ranged from 7.32-7.84, it was observed to be within permissible limit recommended by NAFDAC , SON and WHO Standards. The variation in the pH mean values for the five brands of sachet pure water shows no significant difference ($p < 0.05$) among the brands. Oladipo*etal*., (2009) reported similar research with the pH value ranged from 4.43-7.71 which was slightly lower than the value obtained in this research which may be due to differences in the source of water. However, water with high pH has been reported to reduce blood viscosity, this may help reduce cardiovascular strain due to dehydration.

Temperature

The temperature is one of the major parameters used to assess quality of portable water and all other parameters are depend on it such as solubility, viscosity, amplifications of taste, color, sedimentation etc of water have to be considered (Olajire and Imeppeoria,2001).Table 1 indicates that the mean value of temperature for the five brands ranged from 26.24-28.00 and this was discovered to be within the permissible limit recommended by NAFDAC /SON and WHO. Therefore, the results indicate that there is no significant difference at ($P>0.5$) among the five brands of sachet pure water.

Also in the study reported by Ojekunle*et al*., (2015) reported similar result, but the temperature was higher than the value obtained in this research which may be due to climatic changes.

Turbidity

It is measure of relative clarity of water and ability of light to penetrate the body of water. The turbidity mean value for the five brands sachet pure water were discovered to be within the permissible limit by NAFDAC /SON and WHO standards and also the results shows no significance difference at (P>0.05) for the brands.Turbidity occurs as a result of the pressure of suspended material which could be industrial waters, agricultural wastes, microbial growth, erosion products, and presence of human organs which will result to some disease. Joshua *et al.*, (2014) posited that turbidity does not have a health based guideline but it is recommended that it should be ideally below 1.0 NTU for effective disinfection.

Table 2: Chemical properties of different brands of pure sachet pure water in Bauchi metropolis.

Brands	Conductivity (µs/cm)	TDS (mg/l)	TH (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	fluoride (mg/l)	Nitrite (mg/l)	Iron (mg/l)
AA1	146.00	128.02	68.00	1.40	2.40	-	0.08	0.24
AA2	152 .00	131.00	72.01	1.38	2.80	-	0.07	0.28
BB1	208.00	161.10	80.04	24.00	4.11	-	0.16	0.18
BB2	220.02	166.06	84.06	22.02	4.20	-	0.18	0.20
CC1	110.00	140.08	74.02	18.04	2.00	-	0.05	0.19
CC2	98.01	144.22	76.08	20.08	1.98	-	0.04	0.17
DD1	312 .10	160.10	66.05	2.16	6.60	-	0.16	0.30
DD2	318.04	168.24	62.00	2.20	7.00	-	0.15	0.30
EE1	96.02	88.06	86.12	0.80	10.04	-	0.12	0.22
EE2	108.06	90.44	82.16	1.00	9.80	-	1.00	0.20
NAFDAC/SON (2015)	1000	<500	100	>100	<50	1.5	0.2	0.3
WHO (2011)	<1000	500	150	250	50	1.5	0.2	0.3

Key:
TDS: Total dissolve solid, TH: total hardness

Electrical Conductivity

It is the mobility of anion and cation in water, which is highly determined by ionic species at a particular temperature. It also, a measure of salinity that greatly affects the taste of water and it shows the presence of dissolved ions.The data captured in Table 2 indicates the mean value of electrical conductivities (EC) were within the permissible limit recommended by NAFDAC/ SON (2015) and WHO (2011) standards. However the results also indicates that the mean value of EC shows significance difference at (P>0.05) among the brands. Uduma, (2014) obtained conductivity value ranged from 375-680 mg/l which was higher than the ranged obtained in this research; differences may be due to water source or during production. Meanwhile, the high electrical conductivity (EC) is caused by higher ionizable salt in water (Jain and Agarwal, 2012).

Total Dissolve Solids

This is an important parameter of water quality, which measure the total amount of mobile charged ions dissolved in a volume of water. The results presented in table 2; indicates that the water samples analyzed from the five factories were within the permissible limit recommended by NAFDAC /SON (2015) and WHOstandard.Tthere was no significance difference at (P>0.05) among the brands. The portability of water with TDS level of less than about 500 mg/l is generally considered to be good, whereas drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L. (Hussain et al., 2010) also observed that the presence of solids in sachet water may be as a result of poor filtration methods.

High value of TDS in water is generally not harmful to human beings, but in high concentration of these may affect persons who are suffering from kidney and heart diseases. Water containing high solid may cause laxative or constipation effects, (Haruna et al., 2002). Also, high level TDS values ix water nindicates the water is highly mineralized which may be due to the presence of rock materials in the area which are resistance to dissolve (Nirmala et al., 2012). This may also attribute to the surface run-off constituents like bicarbonates, chloride, nitrate, sodium, potassium, calcium and magnesium which may result to hardness of water which is unfit domestic and agricultural purpose (Olumuyiwa et al., 2012).

Total Hardness

Hard water prevents lather formation with soap (Kumar and Kumar, 2013). The principal elements that responsible for hardness in water are calcium, magnesium salt and bicarbonate formed by reactions in the soil and rock through which the water percolates. The results shows that the five brands as presented in Table 2 indicates that the mean value of total hardness were within the permissible limits recommended by NAFDAC /SON and WHO standard. The results also shows significance difference at (P>0.05) for the five brands of sachet pure water. Total hardness in natural water is mainly due to the presence of calcium and magnesium salts.

Chloride

The occurrence of chloride ions in water is as a result of saline intrusion, sewage discharge, drainage of irrigation water and contamination from refuse (Olumuyiwa et al., 2012). The mean values of the chloride assessments were presented in Table 2, indicates that the values were within the permissible limits as recommended by NAFDAC /SON and WHO. The result also shows significance deference at (P>0.05). The differences among the brands may be due to differences in the source of water for production. The sample BB1 has the highest value of chloride (24.00mg/l) compare to all other samples.

Chloride level higher than the agreed standard imparts a salty taste and nay cause physiological damages (Nirmala et al., 2012). The acceptable levels for chloride level in drinking water is 250mg/l which if the level exceeds it becomes toxic to human health (Ayesha,2012) where people exposed to such levels of chloride are subjected to laxative effects (Murhekar, 2011). Chloride toxicity has not been observed in human except in the special case of impaired sodium chloride metabolism, e.g. in congestive heart failure. Healthy individuals can tolerate the intake of large quantities of chloride provided that there is a concomitant intake of fresh water (Bukar et al., 2015).

Nitrate

The result of the nitrate in brands of pure water ranged between 1.98 to 10.04mg/l respectively. The values recorded are within the acceptable limits of 50mg/l required by the NIS, 2007 and WHO, 2011 standard. However, statistical analysis showed no significant difference ($p>0.005$) between five brands of sachet pure water considered. Bukar*et al.,* (2015) reported similar research with nitrate concentration range from 1.42-4.97 mg/l but the value recorded was lower than the value obtained in this research, the differences may be due to location of water source.Nitrate accumulation in plants is a subject of concern for human and animal health, as edible part may contain very high concentrations of this ion that has been implicated in the occurrence of methaemoglobinemia and possibly in gastric cancer (Bukar*et al.,* 2015).

Iron

The data shown in Table 2 for water analysis indicates that the mean values of Iron were within the permissible limit as recommended by standards. The result also indicate that that there was no significance difference at ($P>0.05$). Iron plays an important role in respiration, photosynthesis and the production of healthy green leaves. In crops, and especially in those grown on calcareous soils, iron deficiency is a major nutritional disorder that causes decrease in vegetative growth and marked yield and quality losses.Other chemical parameters analyzed include nitrite and fluorides are all within the acceptable limits of the standards.

Table 3: Heterotrophic plate count and Coliform count of sachet water of different brands.

Brands of sachet water	Mean Plate Count (cfu/ml)	Mean Coliform Count (cfu/ml)
AA1	1.4×10^2	1.0×10^1
AA2	2.2×10^2	2.4×10^1
BB1	2.4×10^2	1.8×10^1
BB2	2.0×10^2	1.6×10^1
CC1	7.8×10^1	4.6×10^1
CC2	6.2×10^1	2.6×10^1
DD1	1.8×10^2	0.4×10^1
DD2	8.4×10^1	7.5×10^1
EE1	2.6×10^2	0.8×10^1
EE2	1.8×10^1	1.4×10^1
NAFDAC/SON (2015)	0/100ml	0/100ml
WHO (2011)	0/100ml	0/100ml

Microbiological examination of drinking water emphasizes the assessment of the hygiene quality of the water supply. Coliform bacteria should not be detectable in treated water supplies but found, suggests inadequate treatment, post treatment contamination and presence of excessive nutrients (Copes et al., 2009). There was significance difference at ($P>0.5$) for the five brands of sachet water considered in this finding. Heterotrophic count (HPC) measures a range of bacteria that are naturally present in the environment. Bukar et al., (2015) in their research in Zaria reported the presence of E.coli or Coliform counts up to 58 cfu/100ml which is much higher than the value obtained in this research.

The presence of Coliforms in portable water is used as indicator of water contamination. Although coliforms are generally not harmful, they indicate the presence of pathogenic bacteria, viruses and protozoa.. The total bacteria counts for all the brands of sachet pure water samples were generally high. Table 3 showed that the counts were above standard for drinking water with a range of 1.4 x 101 to 2.6 x 102 cfu/ml, which exceed the limit for drinking water.

This high indicator count microorganisms are indicative of the presence of high organic, pathogen and dissolve salts in the water (EPA, 2002). Therefore, the relative high indicator microorganism showed the presence of unhygienic handling, poor and processing.Presence of coliform indicates failure of treatment efficiency and integrity of the distribution system. All the water samples examined in this study indicated counts for coliform, hence, all the sachet brands of pure water investigated in this study fail to meet the standard set by (NAFDAC/SON, 2015, WHO, 2011 and NIS, 2007). The lowest coliform counts obtained in all brands of sachet pure water evaluated in this finding was 0.4 x 101cfu/ml while the highest coliform counts > 2.4 x 101cfu/ml. The high Colioform count obtained in the samples may be an indication that the water sources had faecal contamination (EPA, 2003). Some of the diseases that can be contacted through contaminated water includes: Diseases and illnesses that can be contracted in water with high fecal coliform counts include; typhoid fever, hepatitis, gastroenteritis, dysentery and ear infections.

Table 4: Most Probable Number (MPN) Index and the Probable Coliform Isolated

Sample code	Number of 10ml	Positive 1ml	Tube 0.1ml	MPN Index	Probable Organisms
AA1	2	1	0	68	*Escherichia coli*
AA2	1	2	2	25	*klebsiellaspp*
BB1	3	1	2	120	*Enterobacterspp*
BB2	2	0	0	50	*Pseudomonas spp*
CC1	2	0	1	9	*No bacteria growth*
CC2	1	1	2	4	*Escherichia coli*
DD1	2	0	1	1400	*Enterobacterspp*
DD2	3	2	3	240	*Escherichia coli*
EE1	3	1	1	8	*No bacteria growth*
EE2	0	2	0	9	*Escherichia coli*

The most probable number (MPN) index and the probable organisms are presented in table 4, showed that the brands sachet pure water samples had between than 3 *coliforms*/ml to more than 1200 *coliforms*/ml. Total of ninety (90) isolates were obtained with the highest incidence of occurrence obtained for *Escherichia coli*. *E.coil.* is significant in drinking water and is abundant in human and animal faeces. It is found in sewage, treated effluent and all natural water and soil subjected to faecal contamination, whether from human, wildlife or agriculture. *Enterbacter spp.* are examples of non faecal*coliform* and can be found in vegetation and soil which serve as sources by which pathogens enter the water (Schlegel, 2002). The British Standard Institute (BSI, 1993) specified that a count greater than 10^4 is considered unsatisfactory for *Enterobacter spp.*

4. CONCLUSION

Consumers usually perceive sachet pure water as a healthier and safer alternative to tap water; however package water has been implicated as a source of outbreaks of typhoid and cholera (Oseiet *al*., 2013). The assessment of sachet water quality produced in the five (5) different brands of sachet pure water, sold in Bauchi metropolis, via physicochemical analysis indicated that physical parameters such as appearance, colour, taste and pH conformed to the acceptable standards. Chemical properties such as conductivity, total hardness, nitrate and nitrite, total dissolved solids, fluoride, Chloride and Iron fall under the permissible limit and therefore having no effect on human health. The bacteriological qualities of the evaluated sachet pure water were shown to fall below acceptable standards.

The presence of indicator organisms in water for drinking is of public health significance considering the possibility of the presence of other bacteria, protozoa and enteric viruses that are implicated in gastrointestinal waterborne diseases and low infectious dose for these waterborne pathogens. Unlike municipal water which can be monitored and disinfected with residual chlorine still been effective, sachet pure water contained no residual chlorine, hence proper handling, transport and storage is essential to preserve its microbiological integrity (Ray, S.D 2005). Therefore, there is thus a great need to monitor the producers to ensure they comply with standard. The regulatory bodies and ministries should exercise more stringent surveillance programmers and awareness.

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