Physico-Chemical and Bacteriological Analysis of Sachets and Bottled Water Samples in Katsina Metropolis, Nigeria

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ABSTRACT

Sachet and bottled water has been introduced and widely accepted to provide safe and affordable drinking water in many rural and urban settlements of Nigeria. In spite of the varying levels of contamination widely reported, sachet and bottled water are still well accepted. This study therefore collected Seventeen (17) brands of sachet water labelled A-Q and three (3) brands of bottled water labelled X-Z commonly found in the market for human consumption in Katsina Metropolis, Nigeria, during dry season of the year 2017. The samples were examined for physical, chemical and bacteriological qualities to compare their compliance with World Health Organisation (WHO). Physicochemical parameters were determined using standard methods. Presence of Calcium (Ca), Sodium (Na), Potassium (K), Barium (Ba) and Fluoride (F) elements were also determined using standard analytical techniques. Bacteriological quality of the sample, Namely Fecal coliforms, Pseudomonas aeruginosa, Salmonella sp and Escherichia coli were examined using Multiple Tube Techniques (MPN). The results showed variations in the concentrations of the physical parameters in the water samples. The pH values ranged from 6.68±0.23 to 8.94±0.33; Electrical Conductivity ranged from 188 ±0.22 to 356±0.25µS/cm; and turbidity ranged from 0.70±0.64 to 3.33±0.23. All the concentrations were below or within the World Health Organization (WHO) permissible limits. The results of physical analysis also show that all the samples analysed were colourless and odourless. The results of the chemical analysis yielded the following mean values: Ca (5.4mg/l), Na (0.03 mg/l), K (0.02mg/l), Ba (7.3mg/l) and F (1.7 mg/l). The Bacteriological results also showed that 45% of the brands had Fecal coliforms, 35% had Pseudomonas aeruginosa, 15% had Salmonella sp. while 5% of the sample brand had E. coli. Average values of Calcium, Sodium and Potassium in the samples analysed are within the acceptable limits set by WHO for safe drinking water. However, the mean values of Ba analysed are above the maximum permissible levels set by the WHO for safe drinking water. The results therefore support the conclusions that all the samples examined were not risk free, they are either untreated or are produced under unhygienic conditions as some of the bacteriological and chemical components of the water samples are above the WHO permissible limit for drinking water. Hence there is need for strict attention and routine monitoring by regulatory agencies with the view of raising standards of quality of sachet water produced and sold in Katsina Metropolis.

Keywords: Analysis, Bacteriological, Bottled Water, Katsina Metropolis, Physicochemical, Routine Monitoring, Sachet water

1 INTRODUCTION

Water is a polar inorganic compound composed of the chemical elements hydrogen and oxygen and existing in gaseous, liquid and solid states. It is one of the most plentiful and essential of compounds needed by all forms of life, man, animals and plants. It is by far the most studied chemical compound and is described as the "Universal Solvent" it is also the third most abundant molecule in the universe. It is present in almost all part of the earth, about three quarter (¾) of the entire earth surface is make up of water [5]. Water is an essential part of human nutrition. It is required for the maintenance of personal hygiene, food production and prevention of diseases [1].Since creation water has been essential to man, animal and without water life on earth would not exist. From the very beginning of human civilization people have settled Close to water sources, along river, beside lake or near natural spring. Good quality water is odourless, colourless, tasteless, and free from faecal pollution [5].

Package water also known as sachet water is any water that is in sealed plastic and is distributed or offered for sale, for human consumption [9]. Yusuf et al, [16] explained sachet water as any commercially treated water, manufactured, packaged and distributed for sale in sealed food grade containers and is intended for human consumption. Water quality is generally defined as the physical, chemical and bacteriological characteristics of water in relation to the requirements to human need [8], [4].

The production of sachet water in Nigeria started in the late 90s and today, the advancement in scientific technology has made sachet water production one of the fastest growing industries in the country. The production requires two important raw materials, a water source which is usually borehole or tap water and the packaging materials [15].

In many developing countries, availability of potable water has become a critical and urgent problem and it is a matter of great concern to families and communities depending on Non-public water supply system. Increase in human population has exerted an enormous pressure on the provision of safe drinking water in developing countries [7]. Most people living in the major cities of Nigeria do not have access to pipe borne water, probably due to its unavailability and/or inadequacy where obtainable [13]. This has led to increased water related diseases that has continued to be one of the major health problems globally.

Sachet water consumers are frequently unaware of the potential health risks associated with consuming water borne contaminants. These contaminants, when consumed have often led to diseases like diarrhea, cholera, dysentery, typhoid fever, legionnaire's disease and parasitic diseases [13]. Sachet water like any other food product must be processed and packaged under aseptic conditions; free from every possible source of contamination. Although these sachet water products are popularly termed "Pure Water", they are usually not free of physical, chemical and microbial contaminants [11].

The scale of packaged water consumption is substantial: in 2011, documented global bottled water sales exceeded 225 billion liters [2].Packaged drinking water is widely consumed in low- and middle-income and many urban users rely on packaged sachet water as their primary source of water for consumption. However, few rigorous studies have investigated packaged water quality in Katsina, Nigeria. This study therefore examined physical, chemical and bacteriological qualities of package water commonly sold in Katsina state in comparison to World Health Organisation (WHO) standards.

2 MATERIALS AND METHOD

2.1 Study Area

Katsina metropolis was chosen as the study area because the city is the most populated in Katsina state (Fig. 1) with a population of 318,459 at the 2006 census. There are numerous sachets and quite a number of bottled drinking water sold and/or produced in Katsina metropolis, with consumption of sachet water higher than bottled drinking water owing to cost difference. Katsina Urban Area lies between N120 411 4511 to N130 401 5011 and E0070 311 1011 to E0070 411 4511 in Katsina State.

Katsina city has an area of 142km^2, it lies within the Tropical Continental Climate environment (Humid Tropical), characterized by a relatively long period of dry season that last between 6 to 8 months i.e October to April and a shorter period of wet season lasting from May to September with a cool harmattan season in between the two major seasons. Katsina Urban Area falls within the Sudan Savanna belt and experiences a continental wet and dry climate, which is controlled by the Inter-Tropical Convergence Zone.

The Area is located at the centre of Hausa plains, at the extreme northern part of Nigeria majorly of Hausa and Fulani population with different industrial, commercial trading and manufacturing business activities and densely populated as the City Capital. The study area is bounded with Kaita in the North, Jibia in the west, Batagarawa in the south and Rimi in the east. Katsina Urban Area is part of the headquarters of Katsina Local Government Area and it is also the capital of Katsina State.

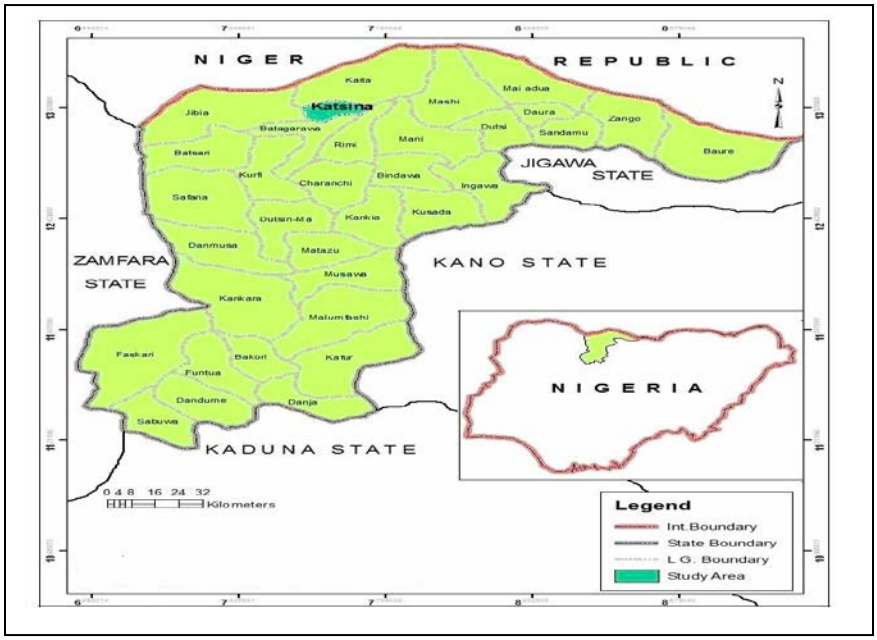


Fig. 1: Map of Katsina State Showing Katsina Metropolis

2.2 Study Design and Population

The study design used, was descriptive and experimental, it involved Fifty (50) respondents including staff in sachet and bottled water companies of the study area.

2.3 Sampling Technique

To ensure adequate representative sampling, a preliminary survey was conducted before selection of the water to be analyzed. Enquiries identify popular brand names mostly patronized in the study area. A total of twenty (20) samples consisting of seventeen (17) brands of sachet water and three (3) brands of bottled water were identified. Samples were taken from four divisions across the metropolis. The divisions namely: Katsina South, Katsina West, Katsina East and Katsina North. Samples from each factory were collected just immediately after production, labeled, and put in sterile polypropylene sample containers with leak proof lids. The samples were clearly marked for easy identification, and transported to National Water Research Institute in Kaduna State for analysis. Samples were stored under the same condition and the analysis was conducted for four weeks (i.e. between September, 2017 to October, 2017).The samples were listed in table 1.

Table 1: Seventeen (17) Brands of Sachet Water and Three (3) Brands of Bottled Water Analyzed

BRANDS OF SACHET WATER	BRANDS OF BOTTLED WATER
Brand A	Brand X
Brand B	Brand Y
Brand C	Brand Z
Brand D	
Brand E	
Brand F	
Brand G	
Brand H	
Brand I	
Brand J	
Brand K	
Brand L	
Brand M	
Brand N	
Brand O	
Brand P	
Brand Q	

2.4 Instrument of Data Collection

The instrument used to collect data was self-structured questionnaire and experimentation. The questionnaire was divided into three sections: section A: Socio-demographic data, section B: Analysis of

bacteriological and chemical component sold in Katsina metropolis C: Knowledge about water and water borne diseases.

2.5 Physico-chemical Analysis

The appearance of the water samples was observed virtually and the samples were inhaled to note odour. A conductivity meter was used to measure the conductivity of the water samples. KCl standard solution with the conductivity of 100 umhocm-1 was first prepared by diluting 5.1g of KCl in 1litre of distilled water and conductivity cell was then carefully suspended in the KCl standard solution and the conductivity reading adjusted to100 umhocm-1. The cell was then rinsed with distilled water and the measurements were carried out in the same way on the water samples. The turbidity of the water sample was determined using a turbidity meter. The pH determinations were done using Jenway model pH meter. The instrument was calibrated with standard buffers of pH 4.0, 7.0 and 9.0. Potassium, Sodium, Flouride, Calcium hardness and Calcium ion were determined using the Instrumental, Titrimetric, Wet Chemistry and Gravitational methods.

2.6 Bacteriological Quality Analysis

2.6.1 Microbiological method:

All the media were prepared according to manufacturer's specifications. The Microbiological procedure used was multiple tube fermentation technique as describe by Mackie and McCartney [3]. Primary isolation was first done using MacConkey broth, using a sterile 10 mL syringe and needle 10 mL was withdrawn from the sample sachet water and dispensed ascetically into 5 bottles each containing 10 mL of the media broth and then 50 mL of the sample was dispensed into 1 bottle containing 50 mL of the media broth. Each bottle contained an inverted Durham tube accordingly. The bottles were closed tightly and then shaken to distribute the sample uniformly throughout the medium and to make sure the inverted durham tube is full of broth and there's no air bubble trapped inside it. The bottles where then incubated at 37ºC for 24 h. The procedure was carried out in a clean-lighted flow hood and was repeated for the remaining 10 brands of samples. The chamber was always disinfected with 70% alcohol before and after the analysis. After 24 h the tubes from the presumptive fermentation test showing gas and acid formation by a change in colour from purple to amber yellow and entrapment of gas in the Durham tube were recorded and the corresponding Most Probably Number (MPN) index was determined from the probability table.

2.6.2 Biochemical test:

Kligler Iron Agar (KIA) Test: Using a sterile wire loop, a colony from the purified subcultures was isolated and stabbed straight down into the slanted agar medium. The wire loop was removed, flame sterilized and the inoculums was streaked on the surface of the slant. The test tube was covered tightly with a screw cap and labeled accordingly before it was placed into the incubator where it was left for 24 h at 37ºC. It was then removed and observed for fermentation, shown by a change in colour from bright red to amber yellow.

Urease Test: Using a sterile wire loop, a colony from the purified subculture was isolated, stabbed and streaked on the surface of the media. The bijou bottle was then covered tightly with a screw cap and labeled accordingly before it was placed into the incubator for 24 h at 37ºC. It was then removed and observed for growth

Citrate Test: The procedure was the same as that of urea agar.

Indole Test: Using a sterile wire loop, a colony from the purified subcultures was isolated and inoculated into the bijou bottles containing 3 mL of the sterile peptone water. The mouth of the bijou bottles was then flamed sterilized and covered tightly with a screw cap and labeled accordingly, it was incubated for 24 h at 37ºC. The bijou bottles where then removed and 0.5 mL of Kovac's reagent was added. The bijou bottles were then shaken gently and left standing for 10 min. Examination for positive result was done by the formation of red colour in form of a ring on the surface layer of the culture media.

Oxidase Test: The oxidase test is used in the identification of pseudomonas species, as it produces the enzyme cytochrome oxidase. A piece of filter paper was placed in a clean Petri dish and 2 or 3 drops of the oxidase reagent was added to it. Using a sterile wire loop, a colony from the purified subculture nutrient agar was removed and a smear was made on the filter paper. The filter paper was left for 10 seconds after which it was observed for the development of a blue purple colour as a positive oxidase test.

2.7 Quality Assurance

In order to ensure that the results of analysis obtained were accurate, quality assurance measures were observed as follows: All the instruments used in this research were calibrated with standards of known concentrations, according to the manufacturer's instruction. Samples were analysed based on Standard Methods for Examination of Water and Wastewater. The average value of three triplicate samples was taken for each determination of water quality parameter. The concentrations of some ions measured in the analyzed samples by colorimetric and photometric methods were determined from standard calibration curves after their respective transmittance were determined. Suitable blanks were also prepared and analysed accordingly. Defined methods for storage of water samples were also complied with, for example, the use of ice cubes for sample preservation and minimization of time between sample collection, storage and analysis. All the glass wares were thoroughly cleansed with appropriate detergent and rinsed with distilled water, otherwise autoclaved as in bacteriological quality analysis. Pair of scissors, automatic pipette, single strength MacConkey broth, tryptone water and distilled water were all autoclaved at 121ºC for 15 minutes. The tips of each sample of sachet and bottled water were disinfected with 70% ethanol before opening and inoculation. Where bacteriological analysis was to delay, the samples were refrigerated at 40C but analysed within 24 hours after collection.

2.8 Data Analysis and Presentation

The data was collected, checked manually for completeness, errors, and inputted for analysis with a computer software programme called Statistical Package for Social Sciences 20.0 (SPSS), which is subsequently analyzed using statistical tables and bar graph. With these tables and graph, it will be very easy to see the opinion of respondents at a glance and conclusions easily drawn

3 RESULTS AND DISCUSSION

3.1 Results

Table 2: Age Distribution of the Respondents.

AGE RANGE	FREQUENCY	PERCENTAGE (%)
16-20	7	14%
21-25	15	30%
26-30	18	36%
31-40	10	20%
TOTAL	**50**	**100%**

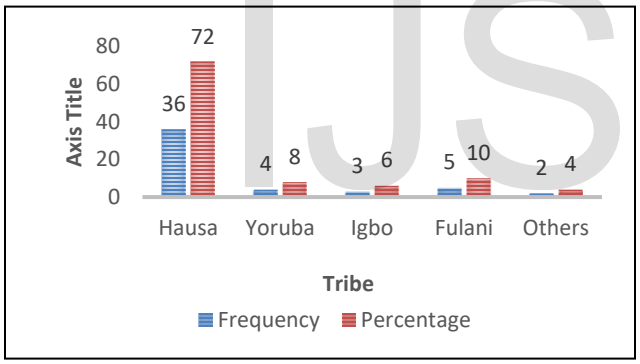


Fig. 2: Bar Chart showing the Tribe of the Respondents.

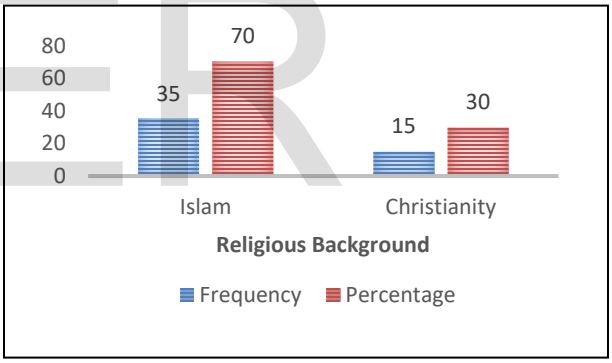
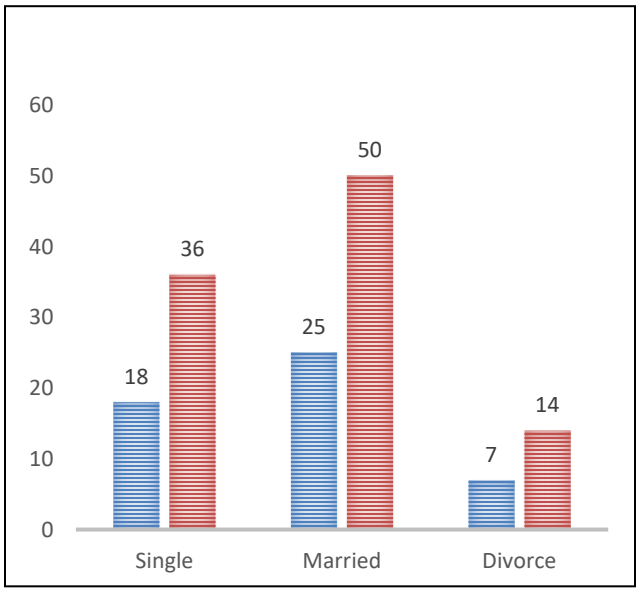


Fig. 3: Bar Chart Showing Religion of Respondents.



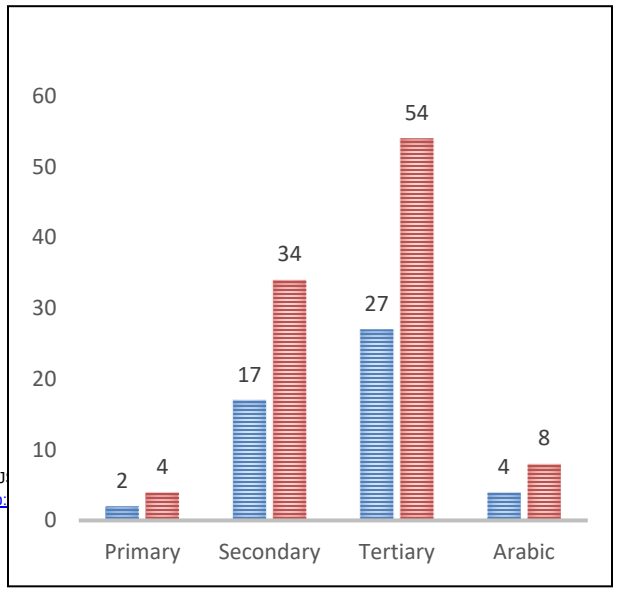


Fig. 4: Bar Chart Showing Marital Status of Respondents.

Fig. 5: Bar Chart Showing Professional Qualification of Respondents.

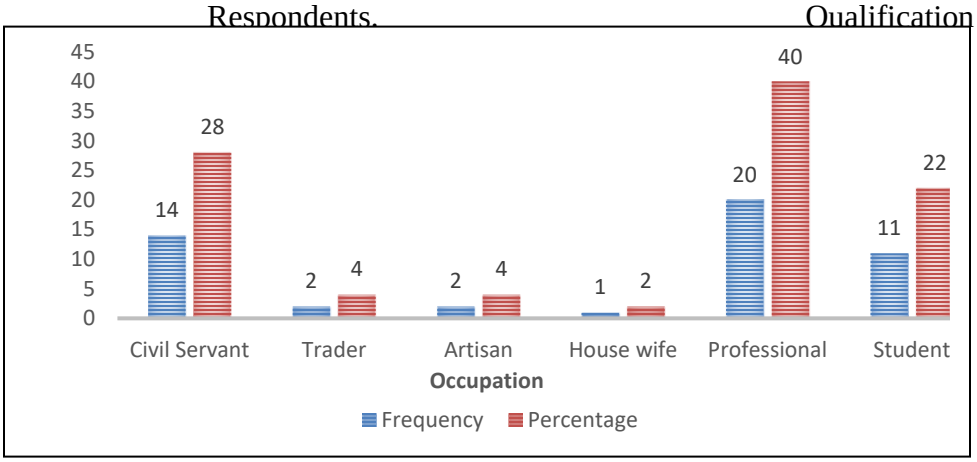


Fig. 6: Bar Chart Showing Occupation of Respondents.

Table 3: Frequency Distribution and Percentage of Respondents of those that are Knowledgeable of the Bacteria present in Water.

Responses	**Frequency**	**Percentage**
Vibro cholerea	9	18%
Salmonella typhi	7	14%
Shigella	6	12%
E-Coli	17	34%
All of the above	11	22%
Total	**50**	**100**

Table 4: Frequency Distribution and Percentage of Respondents on those that are Knowledgeable of the Chemical Components Present in Water.

Responses	**Frequency**	**Percentage**
PH	8	16%
Anions &Cations (dissolved solid)	4	8%
Dissolved gases	7	14%

Total dissolved solid (TDS)	5	10%
Hardness (Ca^{2+}, Mg^{2+})	15	30%
All of the above	11	22%
Total	**50**	**100**

Table 5: Frequency Distribution and Percentage of Respondents on those that are Knowledgeable of the sources of Contamination of Water.

Responses	**Frequency**	**Percentage**
Rain water	4	8%
Shallow well water	6	12%
Rusty/unwanted tanks	23	46%
Seepage of sewage and rainfall runoffs into well water and exposed boreholes	17	34%
Total	**50**	**100**

Table 6: Frequency Distribution and Percentage of Respondents that Responded on Whether the Quality of Sachet and Bottled Water sold in Katsina Metropolis is in Conformity with National and International Standards

Responses	**Frequency**	**Percentage**
Yes	39	78%
No	11	22%
Total	**50**	**100**

Table 7: Frequency Distribution and Percentage of Respondents that are Aware of the Effectiveness as Regard Treatment Procedures for Sachet and Bottled Water Sold in Katsina Metropolis.

Responses	**Frequency**	**Percentage**
Excellent	9	18%
Very Good	11	22%
Good	14	28%
Fair	13	26%
Bad	3	6%
Total	**50**	**100**

Table 8: Frequency Distribution and Percentage of Respondents on what they Understand by the term Water.

Responses	**Frequency**	**Percentage**
Water is transparent and nearly colorless chemical substances	4	8%
Water is the main constituent of earth's streams, lakes, oceans and the fluids of most living organism	17	34%

Water is liquid state of a substance that prevails at standards ambient temperature and pressure, it also occurs in solid state (ice) gaseous state (steam or vapor).	24	48%
Any liquid substance consumed by human	5	10%
Total	**50**	**100**

Table 9: Frequency Distribution and Percentage of Respondents who were Questioned on Whether they Heard About Water Borne Disease or not?

Responses	**Frequency**	**Percentage**
Yes	100	100%
No	0	0%
Total	**50**	**100**

Table10: Frequency Distribution and Percentage of Respondents who are Knowledgeable about Water Borne Diseases.

Responses	**Frequency**	**Percentage (%)**
Cholera	27	54%
Typhoid	15	30%
Gastroenteritis	6	12%
Amoebiasis	2	4%
Total	**50**	**100**

Table 11: Frequency Distribution and Percentage of Respondents who are Aware of the Factors that Cause Water Borne Disease?

Responses	**Frequency**	**Percentage (%)**
Pollution/contamination of surface/ground water	17	34%
Drinking of untreated water	14	28%
Poor personal hygiene	10	20%
Poor sanitary condition of the environment	9	18%
Total	**50**	**100**

Table 12: Frequency Distribution and Percentage of Respondents on how the Spread/Outbreak of Water Borne Disease can be Prevented?

Responses	**Frequency**	**Percentage (%)**
Regular hand washing before and after using the toilet	8	16%
Storage of water in a clean container	9	18%
Consumption of treated/uncontaminated water	20	40%
Through awareness creation/sensitization campaign	13	26%
Total	**50**	**100**

Table 13: Frequency Distribution and Percentage of Respondents as Regard the Levels of Sanitary Conditions of the Producers and Consumers of Sachet and Bottled water.

Responses	**Frequency**	**Percentage**
Excellent	12	24%
Very Good	11	22%
Good	15	30%
Fair	9	18%
Bad	3	6%
Total	**50**	**100**

Table 14: Concentrations of Some Physical Parameters in the water samples

Sachet and Bottled Water Samples	**pH**	**Turbidity (NTU)**	**Electrical Conductivity (µS/cm)**	**Appearance**	**Odour**
Brand A	6.77±0.21	1.04±0.06	275±0.20	Colourless	Odourless
Brand B	6.84±0.32	3.24±0.22	188±0.35	Colourless	Odourless
Brand C	7.30±0.22	2.01±0.21	256±0.01	Colourless	Odourless
Brand D	7.17±0.16	0.70±0.64	314 ±0.02	Colourless	Odourless
Brand E	7.13±0.12	2.04±0.57	274±0.24	Colourless	Odourless
Brand F	6.77±0.43	2.73±0.12	192±0.22	Colourless	Odourless
Brand G	8.94±0.33	2.01±0.11	301±0.04	Colourless	Odourless
Brand H	8.56±0.60	2.30±0.84	243 ±0.02	Colourless	Odourless
Brand I	6.74±0.38	1.74±0.09	273±0.10	Colourless	Odourless
Brand J	6.76±0.73	2.26±0.42	228±0.35	Colourless	Odourless
Brand K	6.70±0.39	2.02±0.11	197±0.21	Colourless	Odourless
Brand L	7.44±0.20	0.80±0.54	304 ±0.02	Colourless	Odourless
Brand M	7.52±0.27	1.54±0.96	356±0.25	Colourless	Odourless
Brand N	7.68±0.23	0.97±0.66	312±0.32	Colourless	Odourless
Brand O	8.52±0.63	3.33±0.23	190±0.08	Colourless	Odourless
Brand P	8.74±0.80	0.74±0.02	211 ±0.07	Colourless	Odourless
Brand Q	7.12±0.22	3.04±0.76	265±0.30	Colourless	Odourless
Brand X	6.68±0.23	2.84±0.42	278±0.15	Colourless	Odourless
Brand Y	6.72±0.33	3.01±0.31	195±0.21	Colourless	Odourless
Brand Z	7.14±0.30	0.75±0.57	302 ±0.32	Colourless	Odourless
WHO Standard	6.5-9.5	5.00	900	Colourless	Odourless

Table 15: Result for Chemical Parameters of Sachet and Bottled Water

Sachet and Bottled Water Samples	Ca	Na	K	Ba	F
Brand A	1.6	0.02	0.03	8	0.52
Brand B	4.03	0.05	0.02	5	0.27
Brand C	9.68	0.02	0.03	4	1.12
Brand D	8.06	0.05	0.03	5	1.15
Brand E	3.23	0.04	0.01	25	1.13
Brand F	19.76	0.02	0.01	4	1.57
Brand G	3.63	0.05	0.01	11	14.95
Brand H	3.02	0.04	0.01	17	0.91
Brand I	8.47	0.05	0.01	12	-0.97
Brand J	7.26	0.04	0.01	4	0.38
Brand K	1.6	0.04	0.01	4	0.86
Brand L	5.04	0.02	0.02	3	1.16
Brand M	2.82	0.04	0.05	3	0.39
Brand N	4.03	0.04	0.02	3	0.6
Brand O	3.43	0.02	0.02	12	2.17
Brand P	2.82	0.02	0.01	5	1.15
Brand Q	9.48	0.05	0.01	4	1.12
Brand X	3.02	0.02	0.01	5	2.18
Brand Y	3.63	0.02	0.02	8	0.57
Brand Z	2.82	0.02	0.02	4	2.57
Mean	5.4	0.03	0.02	7.3	1.7
Min.	1.6	0.02	0.01	3	-0.97
Max.	19.76	0.05	0.05	25	14.95
Stan Dev.	4.2	0.01	0.01	5.7	3.2
Above limit level (WHO standard) in percentage	0%	0%	0%	100%	25%

Table 16: Coliform Count Using the Most Probable Number (MPN) Based on The Presumptive Positive Bottles

	No of bottles giving true positive reaction		
Brands of sachet and bottled water	**In 1 bottle of 50ml broth/50ml of water**	**In 5 bottles of 10ml broth/10ml of water**	**Most Probable Number (MPN) of coliforms in 100mls of water**
Brand A	1	0	2
Brand B	0	1	1

Brand C	0	2	2
Brand D	1	0	2
Brand E	1	4	16
Brand F	0	4	5
Brand G	0	3	4
Brand H	0	2	2
Brand I	0	2	2
Brand J	1	4	16
Brand K	1	0	2
Brand L	1	2	6
Brand M	0	2	2
Brand N	1	0	2
Brand O	0	1	1
Brand P	0	2	2
Brand Q	0	1	1
Brand X	0	2	2
Brand Y	0	1	1
Brand Z	0	1	1

Table 17: Biochemical Tests of Different Samples of Sachet and Bottled Water

Brands of sachet and bottled water	**Fermentation on Mac Conkey agar**	**Growth in EMB**	**Growth on nutrient agar**	**Growth on Deoxycholate Citrate Agar (DCA)**	**Indole test**	**Citrate test**	**Urea test**
Brand A	+ve	-ve	-ve	-ve	-ve	+ve	+ve
Brand B	+ve	-ve	-ve	-ve	-ve	-ve	-ve
Brand C	+ve	-ve	-ve	-ve	-ve	-ve	-ve
Brand D	-ve	-ve	+ve	-ve	+ve	+ve	-ve
Brand E	+ve	+ve	-ve	-ve	-ve	-ve	-ve
Brand F	+ve	-ve	+ve	-ve	-ve	+ve	+ve
Brand G	+ve	-ve	_ve	-ve	-ve	-ve	-ve
Brand H	-ve	-ve	+ve	-ve	+ve	+ve	-ve
Brand I	+ve	-ve	-ve	-ve	-ve	+ve	-ve
Brand J	+ve	+ve	-ve	-ve	+ve	-ve	-ve
Brand K	-ve	-ve	+ve	-ve	-ve	-ve	-ve
Brand L	-ve	-ve	-ve	+ve	-ve	-ve	-ve
Brand M	+ve	-ve	-ve	-ve	-ve	+ve	-ve
Brand N	+ve	-ve	-ve	-ve	-ve	-ve	-ve
Brand O	+ve	-ve	-ve	-ve	-ve	-ve	-ve
Brand P	-ve	-ve	-ve	+ve	-ve	-ve	-ve
Brand Q	-ve	-ve	+ve	-ve	-ve	-ve	-ve
Brand X	+ve	-ve	-ve	-ve	-ve	-ve	-ve
Brand Y	+ve	-ve	-ve	-ve	-ve	-ve	-ve
Brand Z	-ve	-ve	-ve	+ve	-ve	-ve	-ve

+ve: Positive growth; -ve: Negative growth

Table 18: Result of Biochemical Test and the Identification of Isolate Present in Sachet and Bottled Water

Brands of sachet and bottled water	**Oxidase test**	**Growth in Kligler Iron Agar (KIA) after 24hours**	**Growth in KIA after 48 hours**	**Serotyping for salmonella**	**Gram staining**	**Isolate present**
Brand A	-ve	-ve	+ve	-ve	-ve	*Coliform spp*
Brand B	-ve	-ve	-ve	-ve	-ve	*Coliform spp*
Brand C	+ve	+ve	-ve	+ve	-ve	*Coliform spp*
Brand D	+ve	-ve	+ve	-ve	-ve	*Pseudomonas spp*
Brand E	-ve	-ve	-ve	-ve	-ve	*Pseudomonas spp*
Brand F	-ve	-ve	-ve	-ve	-ve	*Coliform spp*
Brand G	-ve	-ve	-ve	-ve	-ve	*Coliform spp*
Brand H	+ve	+ve	-ve	-ve	-ve	*Pseudomonas spp*
Brand I	-ve	-ve	-ve	-ve	-ve	*Coliform spp*
Brand J	-ve	-ve	-ve	-ve	-ve	*E. coli*
Brand K	+ve	-ve	-ve	-ve	-ve	*Pseudomonas spp*
Brand L	+ve	+ve	-ve	+ve	-ve	*Salmonella spp*
Brand M	-ve	+ve	-ve	-ve	-ve	*Coliform spp*
Brand N	-ve	-ve	-ve	-ve	-ve	*Pseudomonas spp*
Brand O	+ve	-ve	-ve	-ve	-ve	*Pseudomonas spp*
Brand P	-ve	+ve	-ve	+ve	-ve	*Salmonella spp.*
Brand Q	-ve	-ve	-ve	-ve	-ve	*Coliform spp*
Brand X	-ve	+ve	-ve	+ve	-ve	*Salmonellaspp*
Brand Y	+ve	-ve	-ve	-ve	-ve	*Pseudomonas spp*

+ve: Positive result; -ve: Negative result;

Table 19: WHO permissible limit for coliform bacteria in drinking water

Class	**Grade**	**Presumption count (per 100ml)**	**No of samples (n)**	**Percentage (%)**
1	Excellent	0	0	0
2	Satisfactory	1-3	15	75
3	Suspicious	4-9	3	15
4	Unsatisfactory	10 and above	2	10
Total			20	100%

3.2 Discussion

The results present respondents from 16-40 years of age (Table 2). This shows that different age groups participated in the study. The highest percentage of respondents was Hausa (Fig. 2) with frequency 36 (72%). This may be due to the predominant tribe in the study area. Fig. 3 shows that 35 (70%) of the respondents were Muslims. This may be due to the predominant religion in area of the research. Fig.4 shows that most of the respondents are married with frequency of 25 (50%). The professional qualification of the respondents shows 27 (54%) which indicates that most of the respondents are within tertiary educational level. Fig. 6 indicates that the frequency 20 (40%) of the respondents falls within professional occupation level.

The highest frequency of the respondents knowledgeable of the presence of bacteria in drinking water is 17 (34%) while the highest frequency of 15 (30%) is shown in Table 4 for those that are knowledgeable of the chemical component present in water. Table 5 shows the highest frequency of those that are knowledgeable about rain water as one of the sources of contamination of drinking water is 23 (46%). Table 6 shows highest frequency of 39(78%) of those that responded on the conformity of sachet and bottled water sold in Katsina metropolis with National and International Standards i.e. (WHO). Table 7 shows that the highest frequency of 14 (28%) of the respondents are with the opinion that the effectiveness of the treatment procedure is good. Table 8 shows that 17 (34%) of the respondents stated that water is the main constituent of earth's streams, lakes, oceans and the fluids of most living organism. Table 9 indicates the frequency of 100 (100%) which shows that all the respondents are aware of water borne diseases. Table 10 shows that respondents who are knowledgeable about Cholera as one of the water borne diseases have the highest frequency of 27 (54%).Table 11 shows the highest frequency of respondents 17 (34%) select pollution/contamination of surface/ground water as the causes of water borne diseases. Water borne diseases can be prevented through consumption of treated/uncontaminated water (Table 12) which shows the frequency of 20 (40%) from the respondent. Table 13 with frequency of 15 (30%) shows the frequency of respondents on good sanitary condition of the producers and consumers of sachet and bottled water.

All the samples analysed are colourless and odourless. Their concentrations were below or within the World Health Organization (WHO) permissible limits (Table 14), indicating that the samples are safe for human consumption in term of physical parameters.

All sachet and bottled water analysed are within the 25mg/l permissible limit of Ca (Table 15) set by World Health Organization WHO. All the water samples analysed have Na concentrations below the 200mg/l recommended by the WHO in drinking water. All the sampled have K concentrations below the recommended level by the WHO in drinking water. The highest Ba concentration of 25mg/l was recorded in Brand E. WHO (2003) have suggested that the most desirable value level of Ba in drinking water is 0.07mg/l, this clearly indicated that the sachet and bottled drinking water samples analysed in Katsina Metropolis are unsafe in terms of Ba parameter (Table 15). Brand G has the highest Fluoride concentration of 14.95mg/l as shown in Table 15. About 25% of water samples have Flouride values within the permissible limit set by WHO. Thus, the high fluoride concentration has health implication,

The result of coliform count using the Most Probably Number (MPN) was shown in Table 16 which defined the degree of contamination and the microbiological quality of the selected sachet drinking water sample brands. Going by the zero tolerance levels stipulated by regulatory agency for coliforms in drinking water, a cumulative figure of 0% meets the standards of quality water and a cumulative figure of 100% (n = 20) of all the identified packaged water did not meet the existing standards as shown in table 16.

Previous studies in other parts of the country reported similar bacterial load indicative of poor water quality [12]. Relatively high aerobic colony counts are indicative of poor, unhygienic handling and processing, bacteria growth in water may be unnoticed even in transparent packaged water and the presence of some of these microorganisms may pose a potential risk to consumer [6]. Table 17 shows the results of various biochemical test carried out to determine the type of bacteria present, while.

The results indicate that nine (9) samples of the water brands where found to contain isolates of coliform species, which is about 45% of the total number of the sachet and bottled water brands used as shown in table 18. Therefore, the presence of *coliform* species as well as *E.coli* which is also a member of the *coliform* group found in one brand of the sampled water, making it 5% of the sample water brands. This suggests that these sample of water brands have been contaminated with feces either of human or animal origin [10].

The presence of *Pseudomonas* sp. wasdetected in seven brands (Table 18) of the sampled water (35% of the sample water brands) this suggests contamination of the water either through decay or improper sanitization or sterilization of the factory equipment or instrument used in the production processes. It can also result from the use of unsterile polythene which is used for the packaging of the water product.

The presence of *Salmonella* Sp. Detected in three brands (15%) of the sample (Table 18) suggest a serious pathogenic water borne threat, liable of causing serious disease to the consumer of those sample water brand. This could be as a result of serious microbial pollution of the factory equipment or from an infected worker, working under unhygienic practices.

High demand for packaged water for various occasions has led to springing up of small scale entrepreneur who engage in production of package waters without due regard to hygienic practices in the production process, and the implication of this is lack of guarantee that the products will meet set standard for drinking water quality.

4 CONCLUSIONS

The results obtained are supportive with the conclusions that, the pH, EC, Turbidity, Ca, Na and K average values of the sachet water samples analysed in Katsina Urban Area are within the acceptable limits set by WHO for safe drinking water; on the other hand, the mean values of Ba observed are above the maximum permissible levels. However, not all the average values of F in the water samples are within the acceptable limits set by the WHO in drinking water. Also, the microbiological quality of the samples revealed the presence of *coliforms*, *E. coli*, *Pseudomonas* sp. and *Salmonella sp*. Hence the sachet and bottled water brands in Katsina metropolis are prone to chemical and microbiological contamination. And thus, it can be concluded that all the satchet and bottled water are not risk free and may have adverse effect on human health of the study area.

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