Science World Journal Vol 9 (No 1) 2014
www.scienceworldjournal.org
ISSN 1597-6343

Full Length Research Article

ASSESSMENT OF SOME PHYSICOCHEMICAL PARAMETERS LEVELS IN SACHET DRINKING WATER AND ITS EFFECTS ON HUMAN HEALTH IN KATSINA URBAN AREA, NIGERIA

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ABSTRACT

This study aims to establish the levels of some physicochemical properties in Sachet (Table) drinking water samples collected from 20 different sachet water samples brands and the effects of these on human healths in Katsina Urban Area, Katsina State, Nigeria. A total of 20 (20 each) sachet water samples were collected during dry and wet seasons of the year 2013. The gross appearance of Physicochemical parameters; pH, Electric Conductivity (EC), Turbidity, Hardness, Calcium (Ca), Sodium (Na), Potassium (K), Barium (Ba) and Fluoride (F) were analyzed using standard analytical techniques. The analysis yielded the following mean values with range: pH (6.4 – 6.8), Conductivity (145.2 – 161.1 ohm/cm), Turbidity (5 – 5 ntu), Hardness (132 – 171.7 mg/l), Ca (5.4 – 16.9 mg/l), Na (0.01 – 0.03 mg/l), K (0.02 – 0.08 mg/l), Ba (7.3 – 10.5 mg/l) and F (0.5 – 1.7 mg/l). These results support the conclusions that, the pH, EC, Turbidity, Hardness, Calcium, Sodium and Potassium average values of the sachet water samples analysed in dry and wet season of this study are within the acceptable limits set by WHO for safe drinking water. However the mean values of Ba analysed during dry and wet season of this study are above the maximum permissible levels set by the WHO for safe drinking water. Only dry season water samples average values of F is above the acceptable limits set by the WHO drinking water. The sachet water from Katsina Urban Area should be used with care as Barium and Fluoride parameters which have harmful human health effects were detected in the water. Thus, sachet drinking water in Katsina Urban Area unfortunately, is not quite safe, because some of the parameters analysed were above the maximum permissible limit set by the WHO in drinking water. It is noted that, the treatment process in Sachet water in the study area is done by "experience" and not by scientific method. This system is very dangerous and should be discarded with immediately. To prevent this, Government should provide a scientifically equipped laboratory for testing sachet water produced any company before reaching the consumer.

Keywords: Physicochemical properties, Sachet Water, Katsina

INTRODUCTION

Water is an essential component for life on Earth, which contains minerals extremely important in human nutrition (Versari et al., 2002). However, the dramatic increase in population resulted in an enormous consumption of the world's water reserves (Ho et al., 2003). Natural contamination of water resources mainly results from normal geological phenomena such as ore formation (Al Fraij et al., 1999). Nevertheless, it is observed that human activities are a major factor determining the quality of the surface and groundwater through atmospheric pollution, effluent discharges, use of agricultural chemicals, eroded soils and land use (Sillanpa¨a¨ et al., 2004). Zhao et al. (2002) noted that contamination of drinking water with heavy metals has a considerable impact on the world population health.

In the past few decades, public concerns over the quality of drinking water have grown considerably. These concerns have arisen as a result of increased awareness about environmental pollution and episodes of waterborne disease outbreaks (Anadu and Harding, 2000). According to Oyegun (1983), a large number of miseries, sickness and deaths occur due to infectious diseases which are related to open water supplies in the tropical developing countries. In developing countries there are many people without safe drinking water, which resulted in many water borne disease infections. It is predicted that by the year 2025 many African countries will experience water scarcity (WMO, 2002). The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life (Dinrifo et al., 2010). Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties. There are thus several valid reasons to be concerned about drinking water to which people in an area get access to. The need for concern for the safety of drinking water are more in the developing countries where sanitary conditions are low and poverty level is very high. This will also have a significant impact on the transmission of water transmissible diseases.

The number of people who rely on the earth's limited fresh water reserves is increasing every day; in fact scarcity of clean fresh water is one of the world's most environmental problems (Arms, 2008). As pointed out by Kofi Annan (2001), "fresh water is precious: we cannot live without it. It is irreplaceable: there are no substitutes for it. And is sensitive: human activity has profound impact on the quantity and quality of fresh water available." Today as never before, both the quantity and

Science World Journal Vol 9 (No 1) 2014
www.scienceworldjournal.org
ISSN 1597-6343

quality of our planet's fresh water are under threat. We should not be misled by the apparently abundant supply in some fortunate parts of the world (Kofi Annan, 2001). Corroborating this view is Igbozurike's (1998) appreciation of the fact that Nigeria is naturally endowed with super abundance of water resources.

Water is a very important resource in Katsina Urban Area, and the issue of water and its use has been a subject of so much research. At the 2002 World summit on sustainable development in Johannesburg (South Africa), great concern was expressed about the 1.1 billion people in the world who do not have access to safe drinking water (Cech 2005). Nigeria is known to be endowed with abundant water resources, but the non availability of potable water for drinking is a problem in many parts of the country. Katsina Urban Area lies between N120 411 4511 to N130 401 5011 and E0070 311 1011 to E0070 411 4511 in Katsina State (Figure 1). The Area is located at the centre of Hausa plains, at the extreme Northern part of Nigeria. The study area is bounded with Kaita in the North, Jibia in the west and Batagarawa in the south while it is bounded by 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. It has a total area of about 2,448km2. The area 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 (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 which has in the central part of the State (Katsina) fall within the Sudan Savanna belt and experiences a continental wet and dry climate, which is controlled by the Inter-Tropical Convergence Zone.

In Katsina Urban Area, people obtain drinking water from various sources which include tap, borehole, open well and sachet water. Sachet water is considered among the safest for human consumption. However, there is a proper lack of care in most of the companies producing this water to an extent that some sachet water taste is very bad and offensive. In the light of reported cases of water borne diseases across the areas one wonders whether this water source is really safe. Therefore to safeguard the health of people and to reduce to the barest minimum the problems of water born disease, it is essential to analyze the quality of this sachet water in this area and monitor it with a view to finding solution to the health problems associated with drinking water in an area. Thus, this paper aims to establish the levels of some physicochemical parameters in sachet drinking water in Katsina Urban Area, Nigeria. In specific terms, the research seeks to realize the following objectives: Determine the level of some physicochemical parameters in the sachet water; Compare these levels with International Standard of World Health Organization (WHO, 2011) and to look at the implication of these levels of sachet water quality on human health in the study area.

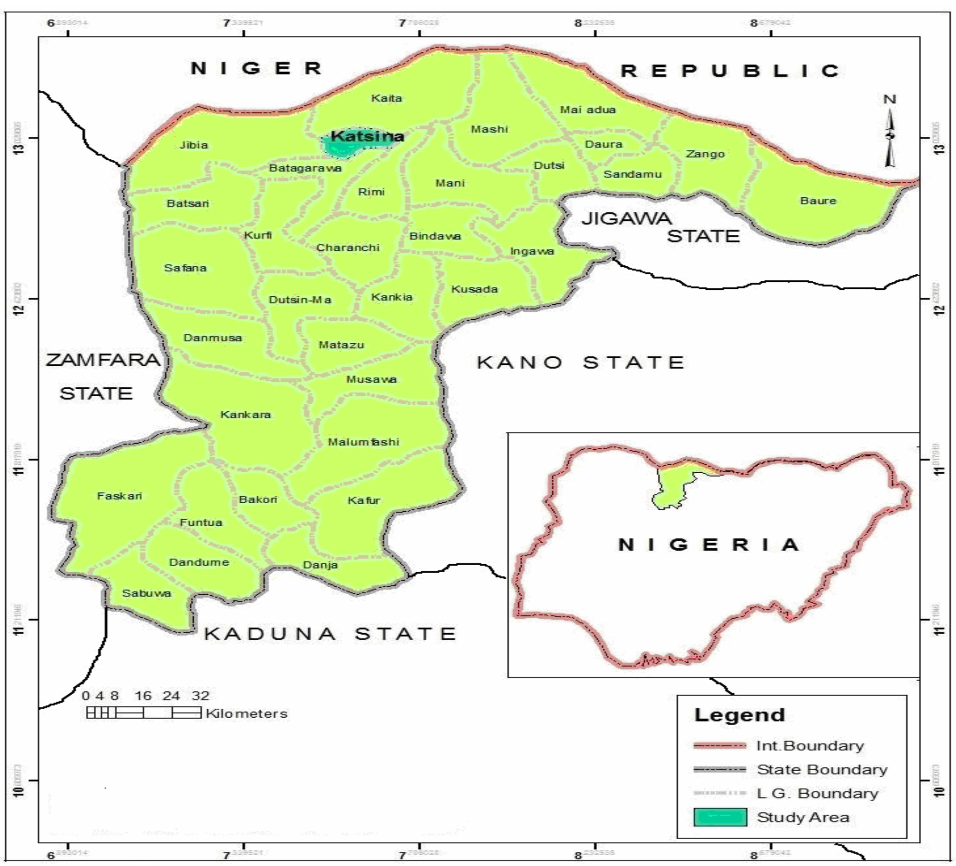


Fig. 1: Katsina State Showing Katsina Urban Area (The Study Area)

MATERIALS AND METHODS

To archive the objectives of this study, a methodology was designed that involve three stages, i.e. reconnaissance survey, samples collections and laboratory analysis. Using purposive sampling technique, 20 sachet drinking water packaging plants were selected (Figure 2). They are Maidabino (MDS), Albaba (ABS), Tamashi (TMS), Chake (CKS), Ramaf (RMS), Habil (HBS), Sa'a (SAS), Jadeed (JDS), Malwa (MWS), Amra (ARS), Wapa (WPS), Alliance (ALS), Fasbraham (FHS), N.D. (NDS), Malali (MLS), A.A. Masanawa (AAS), ABUG (ABS), Tahi (THS), Jamzee (JZS) and T.I.S. (TIS). These samples were collected in dry and wet season in the year 2013, and analyzed. The source of water for these 20 sachet drinking water samples collected in Katsina Urban Area is groundwater.

The samples were analysed in the laboratory using standard procedures: pH Meter, Electric Conductivity Meter and Systronics Turbidity Meter Tube were used to establish the pH, EC and turbidity levels respectively. Hardness of the water was measure using the titration method with Edetic Acid (EDTA) (Kenneth, 1990). The reagents used are 0.02M EDTA, pH 10 buffers and Solochrome Black T. The titration apparatus were used in the analysis.

The ions analyses were carried out using Atomic Absorption Spectrophotometer (AAS) with electrothermic atomization in graphite furnace for the determination of the total content of Ca, Na and K in the samples. Analysis of these metals determination was achieved through the method of APHA et al., (1995) for water digestion. The sachet drinking water samples were put in nitric acid washed plastic bottles. After collection, nitric acid (0.2%) was added as a preservative (WHO, 2004). The entire plastic bottles were marked and labeled to indicate each sample type and date of sampling. The samples were preserved in ice-block containing plastic coolers and transported to the laboratory for analysis.To prevent contamination by trace metals, all the glassware and plastic containers were treated with 0.01M HNO3 and rinsed with distilled water. The graphing method of Beer's law or Spectrophotometric Analysis was used to calculate the concentrations (mg/l) of the heavy metals in the water sample. To find the concentration for a solution that has an absorbance, you will first need to find the slope of the Best-Fit line. From the slope of the best-fit line together with the absorbance, you can now calculate the concentration for that solution (i.e. Concentration (mg/l) = Absorbance / Slope). Notice that the Slope of the best-fit line in this case is actually the Product of the molar absorptivity constant and the path length.

Barium (Ba) was measured in the laboratory using Turbidimetric method with powder pillows: 2 to 100 mg/L with HACH DR3900 Spectrophotometer machine. Reagent used is BariVer® 4 Barium Reagent Powder Pillows while the required apparatus are a Beaker (50-mL) and two Sample cells (10 mL square), matched pair (HACH, 1997). Fluoride (F-) was measured in the laboratory using USEPA SPADNS Method: 0.02 to 2.00 mg/L F– with the used of HACH DR3900 Spectrophotometer machine. Four (mL) of SPADNS Reagent Solution and ten (mL) of Water, deionized were used as the reagents (HACH, 1997).

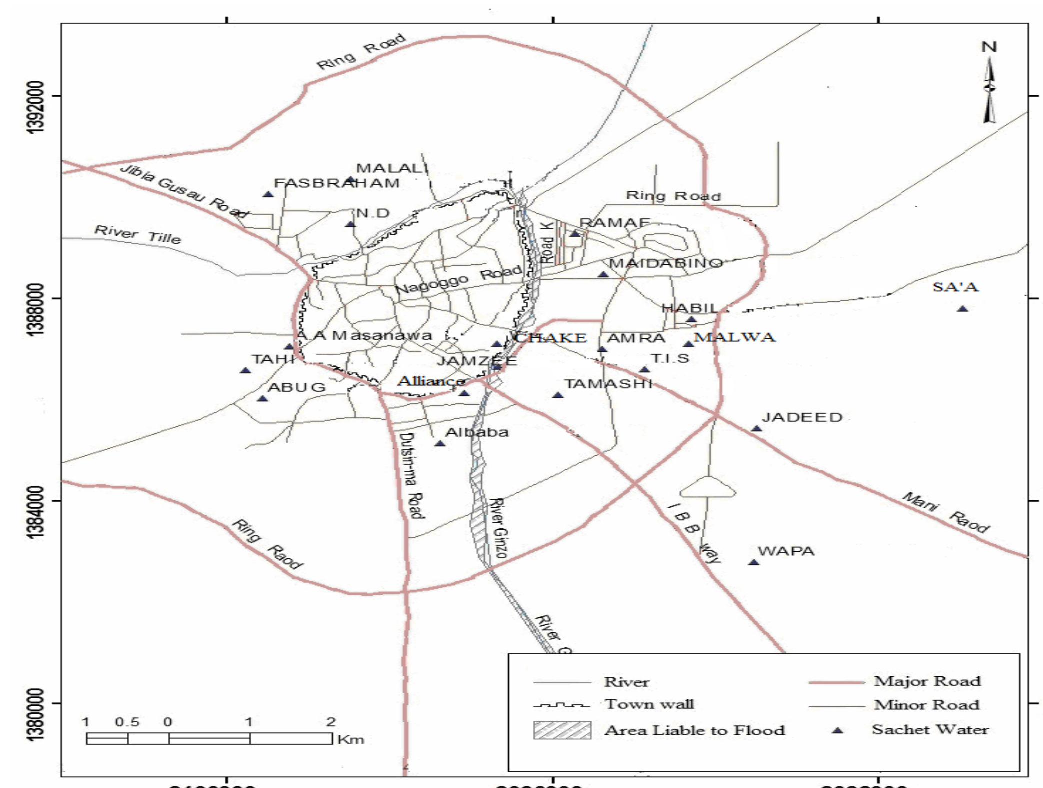


Fig. 2: Katsina Urban Area Showing Samples Location

RESULTS AND DISCUSSION

Table 1, presents the physical parameters obtained from analysis of sachet drinking water samples from Katsina Urban Area. Table 1 depicts clearly that there is a generally narrow range in pH values between the twenty samples of sachet water types. In all the sachet water samples, pH values ranged between 5.09 – 8.4 and 5.83 – 7.9 with an average value of 6.4±0.8 and 6.8±0.7 in dry and wet season respectively. The pH of sachet water samples is higher in wet season (in most of sampling locations) than those obtained in dry season. The highest pH value (both season) was observed in Wapa sachet water (WPS) with 8.4, while the lowest pH of 5.09 was reported in Albaba sachet water (ABS) which is more acidic and none of the sachet water sample has a value that is above 8.5. These findings corroborate by the results of (Ruma, 2011), who reported pH of the water samples ranging from 6.46 to 7.58 selected sachet water in Urban Katsina, Nigeria. It was found that in 60% (dry season) and 30% (wet season) sachet water samples, pH values were below the prescribed level of 6.5 by WHO. These indicate that the sachet water in dry season is more acidic than wet season samples. Hence, seasonal variation influences the quality of the sachet water in the study area, pH wise. Compared with the WHO (2011) standard, the average pH values of dry and wet season sachet water samples are within the pH maximum permitted levels of 6.5 – 8.5 for drinking water. No health-based guideline value is proposed for pH (WHO, 2011). Hence, pH has no direct adverse effect on human health.

The EC ranged between 56 – 323 ohm/cm (dry season) and 62 – 271 ohm/cm (wet season). The mean values of electric conductivity (EC) in dry and wet season sachet water samples are: 161.1±72.6 ohm/cm and 145.2±53.9 ohm/cm respectively (table 1). The highest EC value was recorded Malali sachet water (MLS) with 323 ohm/cm and the lowest value of 56 ohm/cm was in Jadeed sachet water (JDS) (Table 1). Also, it was noticed that all the sachet water both dry and wet season samples were within the WHO prescribed level of 400 ohm/cm. There is no health standard guideline with conductivity (WHO, 2011). Hence, EC has no direct adverse effects to human health in the study area, as the values in the sachet water are within the permissible limit set by the WHO.

The turbidity level in the sachet water samples has equal range and average values of 5 – 5 ntu in both dry and wet seasons (Table 1). WHO recommended safe permissible limit for turbidity in drinking water is 5 ntu. All the sachet water samples analysed were considerably within the limit of 5 ntu permitted by WHO (2011) in drinking water.

Table 1: Physical Parameters Values in Sachets Drinking Water

SAMPLES	pH Dry	pH Wet	EC (uS/cm) Dry	EC (uS/cm) Wet	Turbidity (ntu) Dry	Turbidity (ntu) Wet	Hardness (mg/l) Dry	Hardness (mg/l) Wet
MDS	5.55	7.35	172	175	5	5	96	88
ABS	5.09	6.73	89	62	5	5	80	64
TMS	6.61	6.9	296	204	5	5	368	152
CKS	6.41	6.79	126	117	5	5	192	136
RMS	7.3	7.8	108	144	5	5	200	216
HBS	6.1	7.13	100	87	5	5	136	32
SAS	7.4	7.9	110	110	5	5	248	200
JDS	6.3	7.38	56	106	5	5	96	64
MWS	6	6.89	80	83	5	5	88	48
ARS	6.2	7.79	249	210	5	5	344	160
WPS	8.4	7.68	158	146	5	5	216	192
ALS	7.3	5.83	147	118	5	5	144	144
FHS	6.5	5.85	163	124	5	5	64	72
NDS	6	5.86	232	213	5	5	104	216
MLS	5.2	5.91	323	271	5	5	248	168
AAS	5.6	5.89	141	129	5	5	120	240
AGS	6.9	6.63	216	205	5	5	160	112
THS	6	5.9	167	147	5	5	88	200
JZS	6.4	6.49	196	163	5	5	136	64
TIS	7.1	6.7	92	89	5	5	306.4	72
Mean	6.4	6.8	161.1	145.2	5	5	171.7	132
Min.	5.09	5.83	56	62	5	5	64	32
Max.	8.4	7.9	323	271	5	5	368	240
Stan Dev.	0.8	0.7	72.6	53.9	0	0	91.01	65.6
Above limit level (WHO Standard) in Percentage	60	30	0	0	0	0	15	0

Hardness in drinking water is mainly due to carbonates, bicarbonates, sulphates and chlorides of Ca and Mg. In this study, values of hardness across the twenty sachets water sampling locations, both dry and wet seasons vary between 32 – 368 mg/l. The mean values of hardness in dry and wet season sachets water samples respectively varied from 171.7±91 to 132±65.6 mg/l. The variation in total hardness between the sampling locations is higher in the dry season than wet season.
The highest total hardness of 368 mg/l was recorded in TAMASHI sachet water sample in the dry season (Fig.3). The study found that 15% of (dry season only) sachet water samples had hardness values higher than WHO's maximum permissible limit in drinking water (Table 1). Thus, most of the sachet water samples analyzed in this study (both dry and wet season) are considered safe for drinking hardness wise. However extremely lower values (less than 20 mg/l) are considered as undesirable, health wise (WHO, 1997). In this study, none of the samples analyzed has hardness values that are below 20 mg/l.

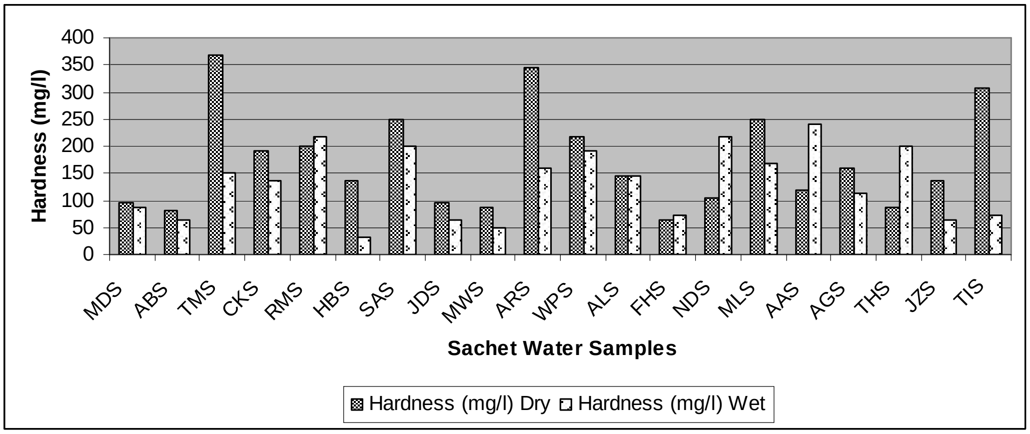


Fig. 3: Hardness level in the Sachet Water of Katsina Urban Area

Tables 2 present the chemical parameters (Ca, Na, K, Ba and F) in the sachet water samples analysed during dry and wet seasons. The pattern of distribution of Ca, Na, K, Ba and F in the sachet drinking water samples analyzed across the 20 selected sample in dry and wet season indicates that the values of the parameter ranges between 1.6 – 19.76 mg/l and 0.2 – 149.8 mg/l for Ca; 0.02 – 0.05 mg/l and 0.02 – 0.3 mg/l for Na; 0.01 – 0.05 mg/l and 0.01 - 0.25 mg/l for K; 3 – 25 mg/l and 5 – 15 mg/l for Ba; and -0.97 – 14.95 mg/l and -0.56 – 2.01 mg/l for F, respectively (Table 2).
Amra sachet water (ARS) has the highest level of Ca (149.8mg/l), while N.D. sachet water (NDS) has the lowest value of Ca (0.2 mg/l) (Fig.4). Only 10% of wet season sachet water samples have Ca values above 25mg/l. Calcium play important roles in bone structure, muscle contraction, nerve impulse transmission and blood clotting. Some 99% of body calcium is in the bone, which is 40% calcium (WHO, 2009). The higher the calcium loss, the greater is the risk of osteoporosis, coronary artery disease, high blood pressure and a long list of degenerative diseases generally associated with premature aging (Combs and Nielsen, in WHO, 2009). However, values exceeding 25 mg/l of calcium in drinking water have human health implication, according to WHO 2004 guideline. All the average values of dry and wet season sachet water samples in Katsina Urban Area have Ca concentrations below 25 mg/l as recommended by WHO (2011) in drinking water. Hence, the water is free from health hazards and if excess (Ca), it can cause depression of the function of muscles and nervous tissues.

Table 2: Chemical Parameters Levels in Sachets Drinking Water

SAMPLES	Ca (mg/l) Dry	Ca (mg/l) Wet	Na (mg/l) Dry	Na (mg/l) Wet	K (mg/l) Dry	K (mg/l) Wet	Ba (mg/l) Dry	Ba (mg/l) Wet	F (mg/l) Dry	F (mg/l) Wet
MDS	3.02	2.42	0.02	0.05	0.01	0.1	5	13	2.18	0.24
ABS	1.6	0.61	0.02	0.09	0.03	0.25	8	14	0.52	1.09
TMS	4.03	0.4	0.05	0.02	0.02	0.06	5	10	0.27	0.23
CKS	9.68	14.31	0.02	0.3	0.03	0.05	4	13	1.12	2.01
RMS	8.06	9.07	0.05	0.13	0.03	0.07	5	10	1.15	1.64
HBS	3.23	130.85	0.04	0.11	0.01	0.01	25	15	1.13	1.56
SAS	19.76	0.61	0.02	0.02	0.01	0.1	4	8	1.57	0.42
JDS	3.63	0.4	0.05	0.04	0.01	0.16	11	11	14.95	-0.22
MWS	3.02	7.46	0.04	0.29	0.01	0.04	17	10	0.91	0.34
ARS	8.47	149.8	0.05	0.04	0.01	0.01	12	9	-0.97	-0.26
WPS	3.63	2.42	0.02	0.02	0.02	0.1	8	11	0.57	1.46
ALS	7.26	0.4	0.04	0.02	0.01	0.04	4	5	0.38	0.32

FHS	**1.6**	**0.4**	**0.04**	**0.23**	**0.01**	**0.06**	**4**	**9**	**0.86**	**0.22**
NDS	**5.04**	**0.2**	**0.02**	**0.04**	**0.02**	**0.06**	**3**	**11**	**1.16**	**0.53**
MLS	**2.82**	**0.4**	**0.04**	**0.04**	**0.05**	**0.17**	**3**	**14**	**0.39**	**-0.56**
AAS	**4.03**	**0.2**	**0.04**	**0.04**	**0.02**	**0.12**	**3**	**8**	**0.6**	**0.08**
AGS	**3.43**	**2.22**	**0.02**	**0.14**	**0.02**	**0.01**	**12**	**11**	**2.17**	**0.1**
THS	**2.82**	**12.7**	**0.02**	**0.27**	**0.01**	**0.04**	**5**	**10**	**1.15**	**-0.41**
JZS	**9.48**	**0.61**	**0.05**	**0.04**	**0.01**	**0.06**	**4**	**8**	**1.12**	**1.07**
TIS	**2.82**	**1.84**	**0.02**	**0.04**	**0.02**	**0.04**	**4**	**10**	**2.57**	**0.56**
Mean	**5.4**	**16.9**	**0.03**	**0.1**	**0.02**	**0.08**	**7.3**	**10.5**	**1.7**	**0.5**
Min.	**1.6**	**0.2**	**0.02**	**0.02**	**0.01**	**0.01**	**3**	**5**	**-0.97**	**-0.56**
Max.	**19.76**	**149.8**	**0.05**	**0.3**	**0.05**	**0.25**	**25**	**15**	**14.95**	**2.01**
Stan Dev.	**4.2**	**42.5**	**0.01**	**0.1**	**0.01**	**0.06**	**5.7**	**2.4**	**3.2**	**0.7**
Above limit level (WHO Standard) in Percentage	**0**	**10**	**0**	**0**	**0**	**0**	**100**	**100**	**25**	**15**

None of the 20 sachet water samples have Na value above the permitted level set by the WHO in drinking water (Table 2). Sachet water samples have Na concentrations below the 200mg/l recommended by the WHO in drinking

water. Sodium may affect the taste of drinking water at levels above 200 mg /L (Saleh et al., 2001). CHAKE sachet water with 0.3mg/l has higher Na cation concentration (Fig. 5). The higher K value of 0.25mg/l (Fig. 6) was found in ALBABA sachet water. According to the WHO guidelines K concentration in the drinking water must not exceed 12 mg/l. All the sampled sachet water, of the 20 samples both in dry and wet seasons has K concentrations below the recommended level by the WHO in drinking water (Table 2).

The Ba values are, in general, comparatively higher in the sachet water. The highest Ba concentration of 25mg/l was recorded in Habil sachet water (HBS). There is generally a consistent pattern of distribution of this parameter across the twenty sachet drinking water samples analysed, for all of the samples have values that are above 0.7mg/l in both seasons (Fig.7); although there values vary considerably between the 20 samples during dry season. 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 drinking water samples analysed in Katsina Urban Area can be considered as unsafe for human consumption in terms of this parameter (Ba).

Jadeed sachet water (JDS) has the highest F concentration of 14.95mg/l (Fig. 8). About 25% (dry season) and 15% (wet season) sachet water samples have values above 1.5mg/l, the permissible limit for F concentration in drinking water is 1-1.5 mg/l according to the WHO (2011). Epidemiological evidence shows that concentrations above this value carry an increasing risk of dental fluorosis, and that progressively higher concentrations lead to increasing risks of skeletal fluorosis, that is bone and teeth (WHO, 2003). Low concentrations provide protection against dental caries, both in children and in adults. The protective effects of fluoride increase with concentration up to about 2 mg of fluoride per litre of drinking-water; the minimum concentration of fluoride in drinking-water required to produce it is approximately 0.5 mg/l (WHO, 2011). The analyses have revealed that the average F value of wet season samples is below the WHO guideline, while that of the dry season is above it. Thus, the high fluoride concentrations in the sachet drinking water (particularly dry season samples) have serious health implication, people in the study area as their bones and teeth, especially those of children and adults may be badly affected**.**

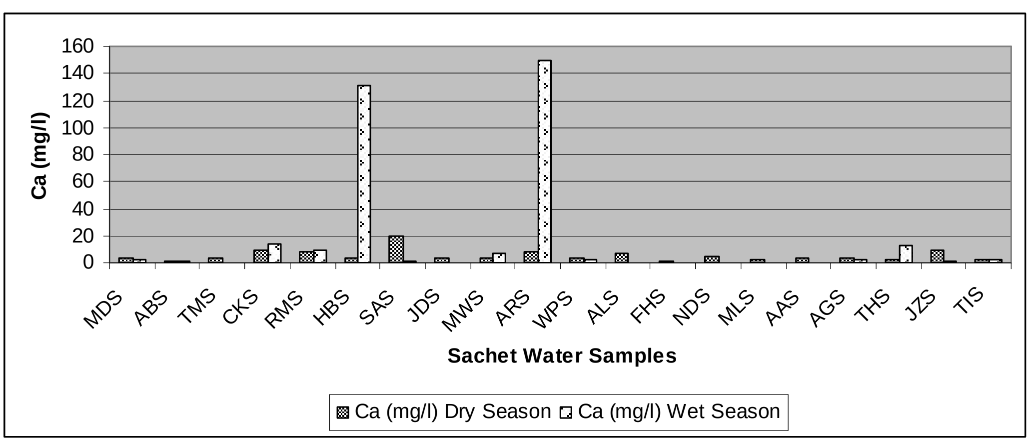
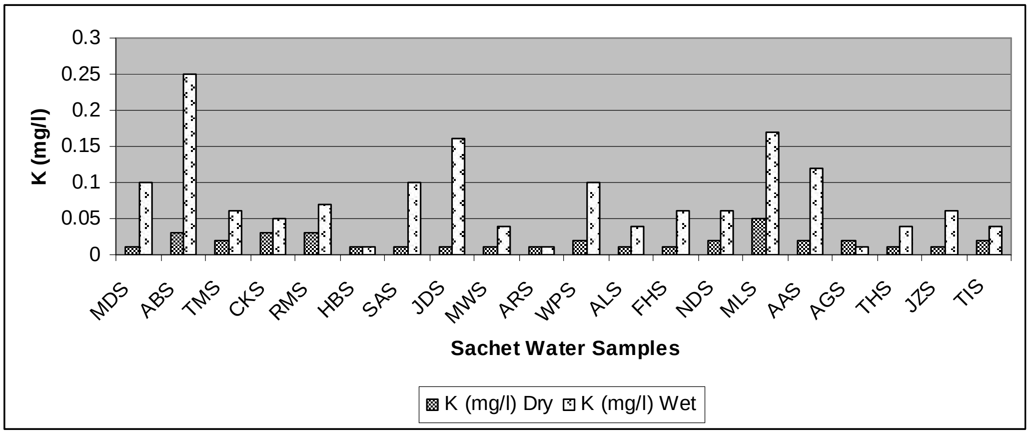


Fig. 4: Calcium (Ca) level in the Sachets Water of Katsina Urban Area



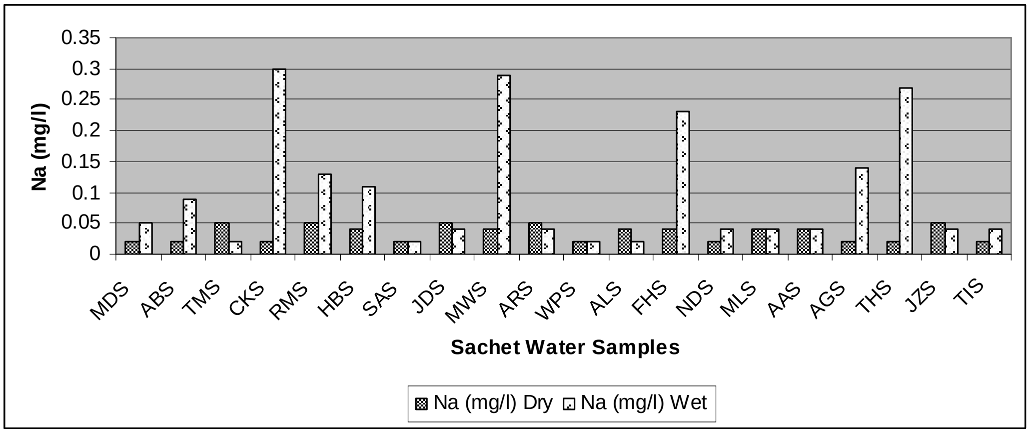


Fig. 5: Sodium (Na) level in the Sachets Water of Katsina Urban Area

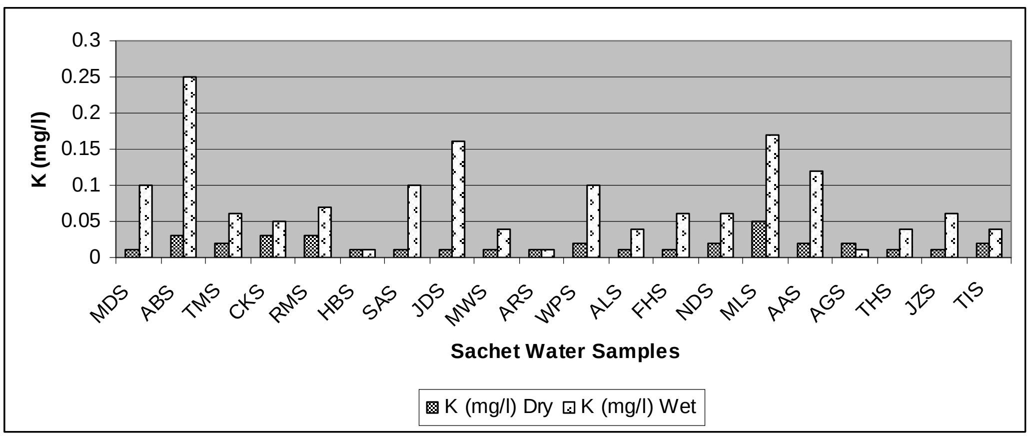


Fig. 6: Potassium (K) level in the Sachets Water of Katsina Urban Area

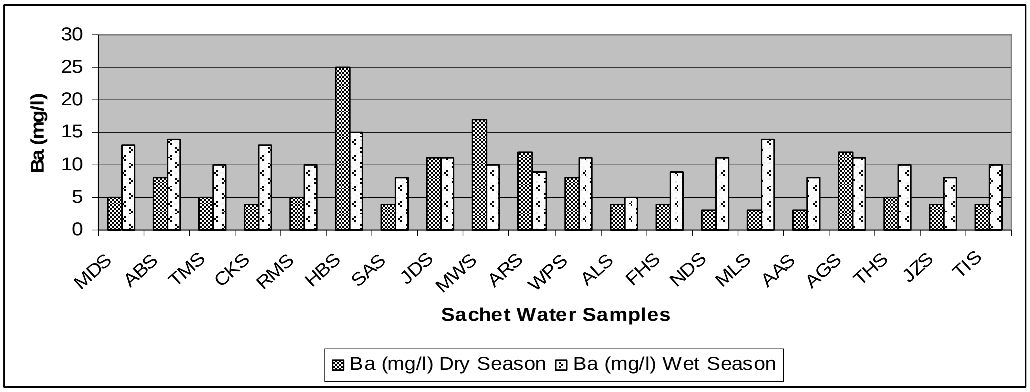


Fig. 7: Barium (Ba) level in the Sachet Water of Katsina Urban Area

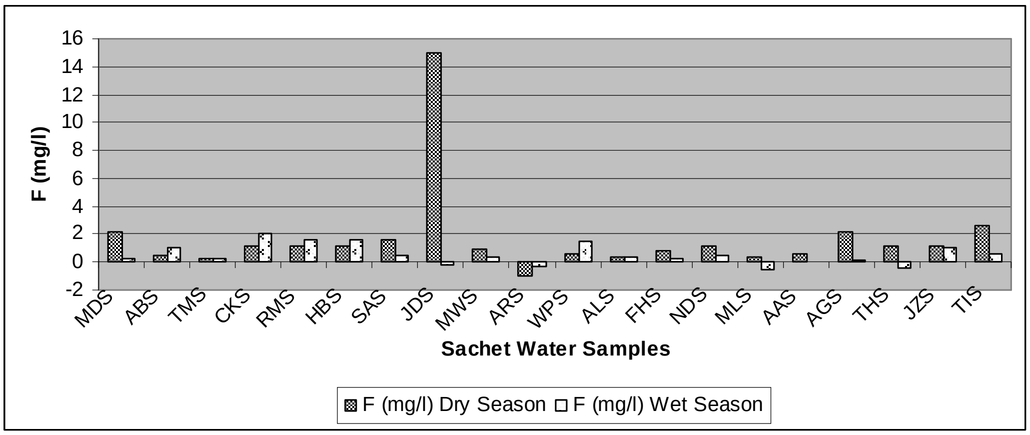


Fig. 8: Fluoride (F) level in the Sachets Water of Katsina Urban Area

CONCLUSION

Water is the essence of basic survival. Without it, life on Earth would cease to exist. When the quality of drinking water is good, human health is also good. The results obtained are supportive with the conclusions that, the pH, EC, Turbidity, Hardness, Ca, Na and K average values of the sachet water samples analysed in dry and wet seasons of Katsina Urban Area are within the acceptable limits set by WHO (2011) for safe drinking water; on the other hand, the mean values of Ba during dry and wet seasons are above the maximum permissible levels, and thus, they may have adverse effect on human health of the study area. However, not all the average values of F in both seasons' water samples are within the acceptable limits set by the WHO in drinking water.

The sachet water from Katsina Urban Area should be used with careful consideration as Barium and Fluoride which have harmful human health effects were detected in the water. Thus, sachet drinking water in this study area unfortunately, is not as safe as is generally believed, because some of the parameters analysed are above the maximum permissible limit set by WHO in drinking water.

It is noted that, the treatment process in Sachet water in the Katsina Urban Area is done through experience and not by scientific method. This practice is very dangerous and risky approach. To prevent this, Government should provide a scientifically equipped laboratory for testing and its use mandatory for any company intending to produce sachet water. In addition, government should ensure that all the sachet water manufacturing companies should register with Government Agencies responsible for safe drinking water.

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