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Evaluation of Physicochemical Properties of Sachet Water Quality Vended Along Song-Gombi Route, Adamawa State, Northeastern Nigeria

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ABSTRACT: People need safe drinking water to survive; hence, the quality of drinking water is crucial. Nigerians' ambition to consume sachet water has made it possible to analyse the quality of various sachet water brands, hence, the objective of this paper was to evaluate the physiochemical properties of sachet water quality vended along Song-Gombi Route, Adamawa State, Northeastern Nigeria using appropriate standard methods by collecting 10 brands of sachet water labeled 1-10. The pH readings of all 10 different brands of sachet water, which ranged from 6.75 to 7.91, were within the allowable limit. The allowed limit was met by the turbidity result, which ranged from 0.32 to 4.90 NTU, and the TDS, which ranged from 0.00 to54.00 mg/L. There was a range of 31-34^{0}C, 131-202µS/cm, and 23.99-71.98 mg/L for temperature, conductivity, and chloride, respectively. Atomic Absorption Spectroscopy (AAS) Buck Scientific VPG, 210 model was used to determine the concentrations of Pb, Cu, Mn, Mg, and Cd. With the exception of Mn, which was found in two brands of sachet water, sample 8 (0.60 mg/L) and sample 10 (0.84 mg/L), the findings of the metal concentration tests were below the WHO/SON acceptable limit. None of the samples had any Pb. These findings indicate that high quality standards must be followed. Additionally, evaluating market samples at random will be an effective method for determining whether the quality meets the necessary requirements.

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Keywords: pH; Sachet water; physiochemical properties; heavy metals; portable water quality; safe drinking water.

Water is one of the most important and abundant compounds of the ecosystems. All living organisms on earth need water for survival and growth. As of now, only Earth is the planet having about 70% of water. However, due to increased human population, industrialization, use of fertilizers in the agriculture and man-made activities, it is highly polluted with different harmful contaminants. Therefore, it is necessary that the quality of drinking water should be checked at regular time intervals. As a result of contaminated drinking water, the human population suffers from various water borne diseases. It is difficult to fully understand the biological phenomenon because the chemistry of water reveals much about the metabolism of the ecosystem and explains the general hydro-biological relationship (Basavaraja *et al.*, 2011). The availability of good water is an indispensable feature for preventing diseases and improving quality of life (Patil *et al.*, 2012). Natural water has an innate mechanism to maintain its purity after every natural use, but it is unable to do so at the rate at which humans add several pollutants and toxins flowing from industry, agriculture, domestic, and other sources. Therefore,

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humans are bound therefore to continuously monitor the impact of this activity on natural freshwater continuously (Adefemi *et al.,* 2010). The increased use of the metal based fertiliser in agricultural revolution of the government could result in a continued rise in the concentration of metal pollution in fresh water reservoirs due to water runoff. Also, faucal pollution of drinking water causes water-borne disease which have led to the death of millions of people (Krishnan, 2008). Water is a necessity for all living beings, which there would be no life (Adefemi *et al.,* 2010). Most biological phenomena occur in a water medium, and therefore, wherever water exists in nature, it always holds life. It is an essential circulation of body fluids in plants and animals, and it is the key substance for the existence and continuity of life through reproduction and different cyclic processes in nature (Adefemi *et al.,* 2010). According to (Deuzaune, 2007) sachet water is any commercially processed water that is produced, packaged, and sold in sealed food-grade containers with the intention of being consumed by humans. In Nigeria, sachet water production began in the late 1990s. Today, the fastest-growing industry in Nigeria is the production of sachet water, thanks to scientific technological advancements. Two essential basic components are required to produce sachet water: a water source (often tap or borehole water) and packaging materials. Water is piped into ground surface reservoir tanks with different capacities from taps or boreholes. The water in the reservoir tanks is left for a whole day. Subsequently, it is pumped into tanks for coagulation, flocculation, and sedimentation, where coagulating agents like alum are added. After passing through an amount of sand and industrial filters, the sediment water is fed into a disinfection tank where chemicals are added for disinfection. The cleaned water is fed into an automatic water.

Sealing machine after passing through industrial micro filters and a UV steriliser (Musa and Ahononu, 2013). Many occurrences of typhoid, diarrhea, and other water-borne illnesses have been linked to the use of sachet water (Ifeanyi *et al.,* 2006) The population suffers from a variety of water-borne illnesses as a result of using contaminated drinking water; hence, it is imperative that the quality of the water be tested regularly (American Public Health Association, (1998). Because certain sachet water companies could not use the proper methods of treatment, there are concerns over the safety and legitimacy of some of the sachet water produced. Consequently, the objective of this paper was to evaluate the physiochemical properties of sachet water quality vended along Song-Gombi Route, Adamawa State, North-eastern Nigeria.

MATERIALS AND METHODS

Description of the Study area: Sampling Points: The Coordinates of sachet water samples collection are indicated in Table 1

Sample Collection: Water sachets from ten (10) distinct brands were gathered. Each sample was chosen at random from a variety of small stores and street vendors in Girei, Federal Housing Bajabure Estate, Sangere Futy, and Girei town in Adamawa State. The sachet bag had no visible opening, indicating that the samples were gathered under acceptable conditions. Within an hour after collection, the samples were brought to the laboratory for examination. Temperature, pH, and electrical conductivity are examples of parameters with very low stability that were measured in the field using a field kit. Subsequently, the samples were brought to the laboratory for additional parameter examination.

Table 1: Samples and Sampling Coordinates

S/N	Coded Sample Names	Coordinate
1	ZTW	N9° 20’39.02532” E012° 30’37.58328”
2	FTW	N9° 20’29.11388” E12° 30’37.61388”
3	MTW-1	N9° 20’28.79231” E12° 30’35.64709”
4	DTW	N9° 20’10.63914” E12° 30’34.48717”
5	AZW	N9° 20’27.04488” E12° 30’19.16892”
6	ATW	N10° 16’31.8” E011° 09’20.4”
7	MTW-2	N9° 19’2.75412” E012° 28’12.91188”
8	JTW	N9° 19’5.61612” E12° 28’28.73388”
9	HTW	N9° 18’54.09468” E12° 28’23.69028”
10	FTW	N9° 19’2.75412” E12° 28’12.91188”

Preparation of Aqueous Stock Solutions: Analytical grade compounds were all were used. To create all of the solutions utilized in this investigation, the required amount was dissolved in distilled water. The water utilized to prepare the solutions was demonised and distilled.

Iron solution: $FeCl_3.6H_2O$ (0.483g) was weighed and dissolved in 100ml of distilled water in 1000 ml volumetric flask. It was made up to the mark. Thus, we obtain a 1000 ppm standard solution.

Copper solution: $Cu(NO_3)_2.3H_2O$ (3.803g) was weighed and dissolved in 5 ml of concentrated HNO_3 in a volumetric flask. It was made up to 1000ml with distilled water, giving a 1000 ppm copper standard solution.

Zinc solution: ZnO (1.244g) was weighed and dissolved in 5.00 ml of water then 25 ml concentrated HNO_3 was added and made up to 1000 ml with distilled water giving 1000 ppm zinc solution.

Magnesium solution: MgO (0.101g) was weighed and dissolved in 5.00 ml of deionized water. It was dissolved in a minimum number of 6M HCl and then diluted to the mark with deionized water giving 1000 ppm magnesium standard solution.

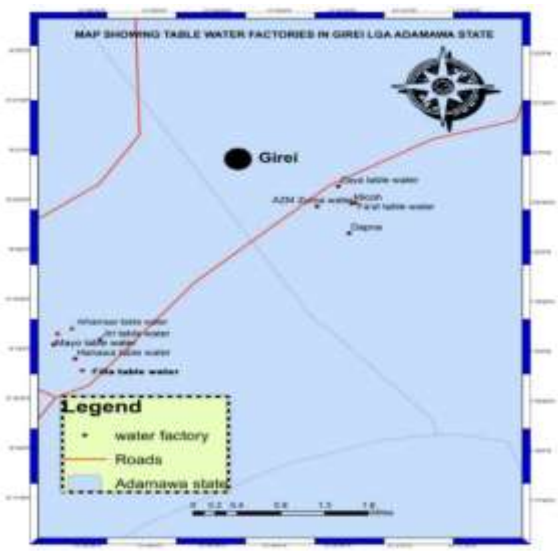

Fig 2: Map of Girei Local Government Showing the study area
Source: Administrative Map of Adamawa State, Nigeria (2018)

Calibration curves: For every metal, five working standards were created by serially diluting the stock solution. An atomic absorption spectrophotometer was used to aspirate both the blank solution and these standards. Subsequently, the absorbance versus sample concentration calibration curves were plotted.

Determination of Physicochemical Parameters: The degree of heavy metal contamination of water is mostly determined by the physicochemical characteristics of the water. Using standard procedures, the following physicochemical variables were measured: temperature, pH, electrical conductivity, turbidity, alkalinity, total hardness, total dissolved solid, and chloride (Ifeanyi *et al.,* 2006).

Temperature: This was determined in situ using a mercury in glass thermometer (Maitera *et al.,* 2011)

Turbidity: The turbidity of the water sample was determined using turbidity metre as described by (Sheshe and Magashi, 2014).

pH value: The pH of the water samples was determined using a portable pH metre after being standardised with buffers of pH 4.0 and 9.2. After the calibration, the pH electrode was immersed in the water sample contained in a 50 ml beaker and the measurement was read as appeared on the screen of the machine. The reading was allowed to stabilize. The pH electrode was wiped with tissue paper and thereafter cleaned with distilled water before dipping into another sample (Ademoroti, 1996).

Determination of Metals: The following heavy metals; Iron (Fe), Lead (Pb), Cadmium (Cd), Copper (Cu) and zinc (Zn) were determined using AAS (Buck Scientific, VPG 210).

Determination of conductivity: The AOAC-approved standard approach was used to assess the conductivity of the sachet water samples. The Wagtech International water proof conductivity meter (S/N:1172813 396/01) was used to measure the conductivity of the sachet water after the water sample had been decanted into a sterile beaker. After submerging the electrode in water, a reading of 2-3 was obtained (Halilu *et al.,* 2011).

Determination of Total Dissolved Solid (TDS): The sample was poured into a sanitized beaker, and the total dissolved solid was measured by placing an electrode inside the water sample and recording the measurement using a Hanna instrument (H12400) (Halilu *et al.,* 2011).

Total hardness: This was determined using the Eriochrome Black T indicator and EDTA titration method as outlined in the Hydrology Project by the governments of the Netherlands and India in 1999.
Methods: After giving the sample a good shake, 25 ml was taken and mixed with 50 ml of distilled water. Two milliliters of buffer solution were added, and after adding two drops of eriochrome black T indicator immediately, the mixture was titrated with EDTA every 5 minutes. The end point is indicated by blue.

$$\text{Total hardness (mg } CaCO_3\text{/L)} = \frac{A \ x \ B \ x \ 1000}{ml \ of \ sample}$$

Where A = ml EDTA titrated for sample; B = mg $CaCO_3$ equivalent to 0.78 ml EDTA titrant

Determination of chlorides: The Morh Method was used to determine this. The foundation of this procedure is the titration of chloride using standard silver nitrate with potassium chromate as an indicator. The following formula was used to obtain the chloride concentration.

Chloride (mg/l) = $\frac{A\ x\ M\ x\ 70900}{Volume\ of\ Sample}$ (1)

Where A = cm^3 of titrant used; M = Molarity of silver nitrate solution (0.0282 M)

Determination of total alkalinity: After transferring 100 mL of the sample into a conical flask and adding two drops of phenolphthalein indicator, the mixture was titrated with regular H_2SO_4 until the end point was reached. The titrated combination was once more given two drops of methyl orange, and the titration was carried out until the methyl orange end point (US-EPA, 1983; APHA-AWWA-WPCF 1985). The Total Alkalinity is calculated by equation 2.

Total Alkalinity (mg $CaCO_3$) = $\frac{A\ x\ B\ x\ 1000}{ml\ of\ sample}$ (2)

Where, A=Vol. of standard H_2SO_4; B= Titre of the standard acid

RESULTS AND DISCUSSIONS

Comparison of the Results Obtained for Physicochemical Parameters for the Samples and WHO/SON Maximum Permissible Limit:

Temperature: As can be observed in Table 2, the lowest and maximum values for the temperatures measured from the sachet water samples vary from 31.0 to 34.0 ºC. The values presented in this study fall within the WHO/SON suggested range. Water temperature readings do fluctuate seasonally, although this could be due to the weather in a certain area and time of year.

pH: To determine whether water is naturally acidic or alkaline, a pH test was performed. Based on the water samples, the pH ranges from 6.69 to 7.91 at the minimum and maximum values indicated in Table (2). (World Health Organization (2008). recorded a similar outcome. According to (Murtala *et al.*, 2014), these values fall within the acceptable range.

Electrical conductivity: Table (2) displays the electrical conductivity values obtained from the sachet water samples, with the minimum and highest values ranging from 131 to 202 μS/cm. All the values reported in this investigation fall under the WHO's recommended maximum allowable limits for drinking water, which is 1000 μS/cm. (World Health Organization (2008) and (Murtala et al., 2014) found similar results.

Turbidity: The amount of solid materials in the suspended state determines the turbid of the water, it is a measurement of the water's capacity to emit light. The test is used to determine the waste discharge's quality in terms of colloidal matter. As shown in Table (2), the turbidity values obtained from the sachet water samples range from 0.32 to 4.90 NTU at the minimum and maximum levels. A similar outcome was achieved by (Eric and Catherine, 1997). It was discovered that every sample fell within the WHO/SON maximum allowable range (5.00 NTU). The risk of digestive disorders increases with turbidity (Dzik, 1989).

Total alkalinity: This represents the water's ability to neutralise acids. Natural waters mostly contain bicarbonates, carbonates, and hydroxide compounds of sodium, potassium, and calcium. Usually, the bicarbonate ion is present. Table (2) displays the alkalinity values obtained from the sachet water samples, with the minimum and highest values ranging from 40 to 300 mg/L. The WHO/SON criterion for consuming high-quality water was met by all samples of the sachet water in terms of total alkalinity. The results of (Eric and Catherine, 1997) and (World Health Organization 2008) are consistent with this.

Total Dissolved Solid (TDS): As indicated in Table (2), the total dissolved solid value obtained from the sachet water samples ranges from 0.00 to 54.00 mg/L at the minimum and highest values. The data presented in this investigation fall within the 500 mg/L maximum allowable limit range for drinking water as established by WHO/SON. This is consistent with what (World Health Organization 2008) found.

*Total Hardness***:** Table (2) displays the range of values for total hardness obtained from the sachet water samples, with the minimum and maximum values being 31.20 - 53.04 mg/L. The results of (Eric, and Catherine, 1997) and (World Health Organization 2008) are consistent with this. It was determined that every sample fell within the WHO/SON maximum allowable limit. The multivalent metal ions that are produced when minerals dissolve in water are typically the cause of hardness in water. Nonetheless, it has been noted that there is an inverse link between cardiovascular illnesses and water hardness (Agency for Toxic Substance and Disease Registry (ATSDR), 2012).

Chlorides: Table (2) displays the chloride values obtained from the sachet water samples, with the minimum and highest values ranging from 23.99 to 71.98 mg/L. Every sample taken from the sachet water was verified to be below the WHO/SON maximum allowable standard (250 mg/L). The most stable elements in water are chlorides, which are mostly untouched by most of physiochemical and metabolic reactions that occur naturally. Consequently, the water concentration value serves as a relevant measurement in the water sample.

Table2. Mean values of physicochemical parameters for Sachet water samples compared with WHO/SON standard for drinking water

S/N	Parameter	WHO SON	ZTW	FTW	MTW-1	DTW	AZW	ATW	MTW-2	JTW	HTW	FTW
1	Temp. ºC	Ambient	33	32	31	32	33	33	34	34	34	32
2	pH	6.5-8.5	7.91	7.29	6.75	7.37	7.79	7.33	7.36	6.69	6.96	7.48
3	E.Cond µS/cm)	1000	189	202	190	131	142	153	135	138	161	146
4	Turb (NTU)	5.0	1.27	4.11	1.67	0.32	1.57	2.08	4.90	1.08	3.04	1.43
5	Alkalinity(mg/L)	400	40	50	120	70	50	130	300	100	60	200
6	T.Hard (mg/L	150	31.20	34.32	53.04	34.32	49.92	43.68	46.00	35.88	34.32	43.68
7	TDS (mg/L)	500	0.00	36	54	25	34	29	27	26	38	46
8	Chloride (mg/L)	250	23.99	47.99	67.99	31.99	55.98	71.98	47.99	59.98	47.99	39.99
9	Cadmiun(mg/l)	0.03	0.01	0.03	0.02	0.01	0.03	0.03	0.01	ND	0.02	0.02
10	Mg (mg/L)	30	0.45	0.95	1.09	0.95	0.91	0.96	0.97	0.96	0.92	1.11
11	Mn (mg/L)	0.5	0.18	0.12	0.25	0.09	0.25	0.13	0.14	0.60*	0.17	0.84*
12	Lead (mg/L)	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13	Copper (mg/L)	2.0	0.20	0.20	0.21	0.24	0.48	0.36	0.37	0.41	0.45	0.47

*Key: * were observed to be more than the WHO maximum tolerance limit for drinking water and ND is not detected*

Comparison of the Results Obtained for Heavy Metals in the Samples and WHO/SON Maximum Permissible Limit.: The maximum allowable level set by the WHO/SON was compared to the findings about the quantities of metal ions (Cd, Cu, Mn, Mg, and Pb) in water samples procured from various sachet water vendors. Below are the results presented as a bar chart (Figures 3–7).

Cadmium: As shown in Figure 3, the lowest and greatest numbers of cadmium metal ions extracted from the sachet water samples ranged from 0.01 to 0.03 mg/L. The WHO has set a maximum tolerance level of 0.03 mg/L. All of the samples' levels of cadmium metal ions were found to be within the World Health Organization (WHO) maximum allowable limit for drinking water. This is consistent with what (World Health Organization, 2008) found in Copper. All samples were found to be below the World Health Organization maximum permissible limit (2.0 mg/L) for drinking water. Copper is an essential nutrient; however, at high doses, it has been shown to cause stomach and intestinal distress, liver, kidney damage, and anemia (World Health Organization (2008). The minimum and maximum concentrations of copper obtained from the sachet water samples are shown in figure 4 and range from 0.2 to 0.48 mg/L.

Lead: Lead levels were not detected in the sachet water samples, as shown in Figure 5. the maximum permissible limit (0.01 mg/L) for drinking water set by the World Health organization. High lead levels have many harmful effects on consumer health. Lead cumulatively affects infants (children under the age of six), with pregnant women and foetuses especially at risk for adverse health effects. Many symptoms, such as dullness, restlessness, irritability, headache, muscular tremor, can indicate acute lead intoxication. These symptoms are often linked to blood lead levels of 80–100 µg/dl in children and 100–120 µg/dl in adults (World Health Organization, 2008).

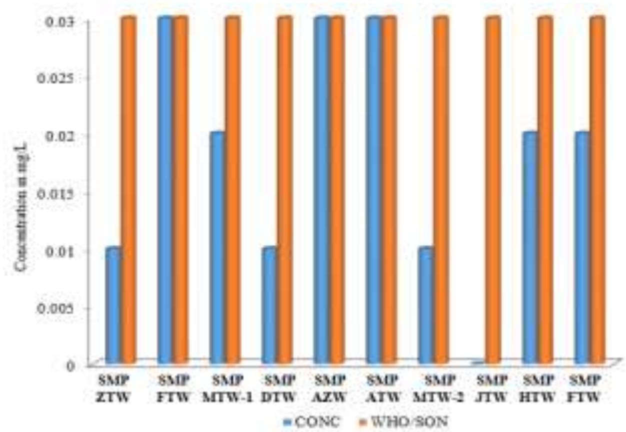

Fig 3. Comparison of Cadmium concentrations in mg/L in sachet water to the maximum limit by WHO/SON

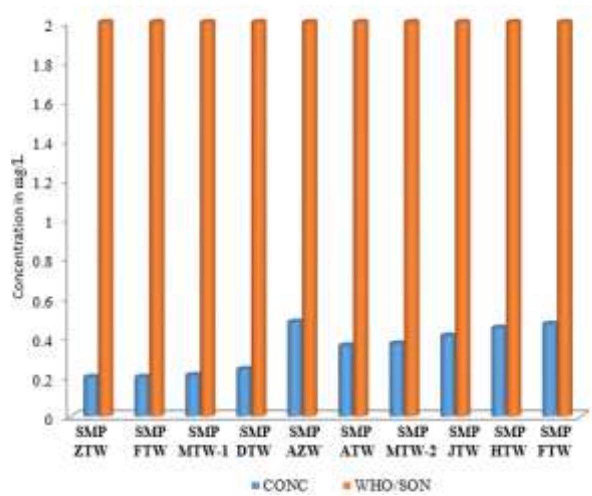

Fig 4. Comparison of Copper concentrations in mg/L in sachet water with the maximum limit by WHO/SON

Manganese: As shown in Figure 6, the lowest and maximum concentrations of manganese metal ions extracted from the sachet waters range from 0.09 to 0.84 mg/L. For manganese metal ions, the WHO/SON maximum allowable level is 0.5 mg/L. Every sample, except samples H and J, was found to be below the World Health organization (WHO) maximum allowable limit for drinking water. The two brands of sachet water may have a high Mn content because of the source from which the water is sourced. In addition to harming the brain, manganese impairs memory and learning. According to (Ifeanyi *et al.*, 2006) the EPA has concluded that a child exposed to 1mg/L of Mn in drinking water for 10 days is not likely to experience any negative consequences.

Magnesium: As seen in figure 7, the lowest and highest magnesium concentrations found in the sachet water samples varied from 0.45 to 1.11 mg/L. Every sample was found to be below the World Health Organization (WHO) maximum allowable limit for drinking water. This is consistent with what **(**World Health Organization (2008). found.

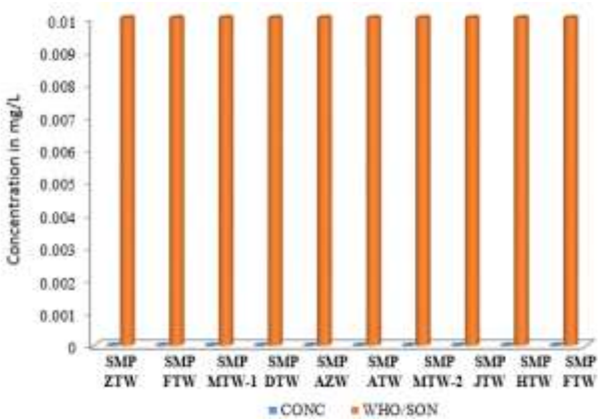

Fig 5. Comparison of lead concentrations in mg/L in sachet water with the maximum limit by WHO/SON

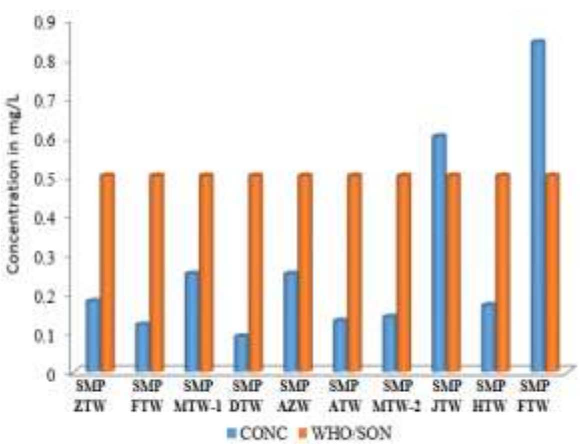

Fig 6. Comparison of Manganese concentrations in mg/L in sachet water to the maximum limit by WHO/SON

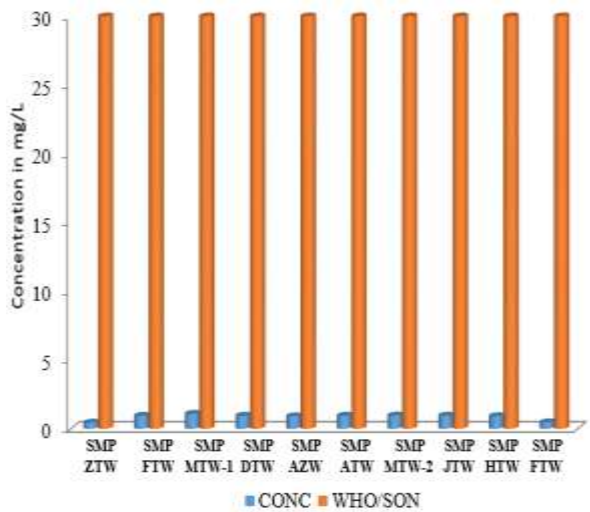

Fig 7. Comparison of Magnesium concentrations in mg/L in sachet water to the maximum limit by WHO/SON

Conclusion: Water is an indispensable resource for the sustenance of life. Owing to rapid urbanization, water supply in developing countries (including Nigeria) is inadequate, resulting in the sourcing of water from various avenues. The Physicochemical quality of the sachet sampled from Girei local government area of Adamawa state as determined in this study can be said to be of acceptable limit for human consumption, except for manganese in samples 8 and 10 which were found to be above the acceptable limit.

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