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COMPARISONS OF SEASONAL CONCENTRATIONS OF SUSPENDED SOLIDS, SOLUTES, NITRATES AND CHLORIDES FROM DRINKING WATER SOURCES IN DUTSINMA, KATSINA STATE, NIGERIA.

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Abstract

The research was carried out to determine seasonal concentrations of Total Hardness, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Nitrate and Chloride from four sources of drinking water, which is treated tap water, boreholes, hand-pumps and well water in Dutsinma city. Data were collected through field and laboratory works and were analyzed using T-test. The suitability of water for human consumption was ascertained by comparing the results obtained with the water quality standard set by World Health Organization WHO (2006). The study revealed a number of results, most importantly: The quality of water varies slightly with the season. Some parameters recorded maximum concentrations in the dry season and others were at their maximum in the rainy season. The average values of Hardness (124.1mg/l), total Dissolved solids (259mg/l) and Nitrate (9.83mgl), were found slightly higher in the rainy season than in the dry season from all the water sources. Those of Total Suspended Solids (33.5mg/l) and chloride (46.64mg/l) were found slightly higher in the dry season than in the rainy season from all the water sources. However in both the two seasons, most of the parameters conformed to WHO and NIS water quality standards for drinking. Consequently, most of the water sources were safe for human consumption in terms of the parameters analyzed. According to the t-test conducted, all the parameters showed insignificant seasonal variation. The research recommends regular monitoring and evaluation of water quality parameters especially during the rainy season, in order to confirm their suitability for human consumption. It also recommends further research on water quality parameters not covered by this research

Key words: Comparison, Season, Concentration, Drinking water, Dutsinma.

I. Introduction

Water is one of the most important natural resources that man and other living creatures rely upon for their survival. Man survives longer without food than water (Adetunde and Glover, 2010), he requires it for domestic purposes and for growing his crops and running of his factories. In fact many thing on earth needs water to survive and water is virtually important in every aspect of our lives. Water is undoubtedly connected to life without which there is no life. This is the reason for which water must be given

necessary attention at all times. Good drinking water is not a luxury; it is one of the most essential amenities of life itself (Adetunde and Glover, 2010). According to Egbai, Adaikpoh and Aigbogun (2013), water is an essential element for life and man uses it for numerous purposes. Therefore, it must be of acceptable quality for human consumption and should be of adequate quantities for livestock and industrial uses. Natural water quality varies from place to place with the seasons, with climate and with the types of soils and rocks through which water moves. When water from rain or snow moves on the land, and through the ground, the water may dissolve minerals in rocks and soils percolate through organic materials such as roots and leaves and react with algae, bacteria and other microscopic organisms. Water may also carry plants, debris, silt and clay to rivers and streams making the water appear muddy or turbid. Each of these natural processes changes the quality and potentiality of the natural water (United States Environmental Protection Agency, USEPA, 2006).

2. The Study Area

Dutsin-ma city is found within Latitude 12°27′10″ N and 12°27′16″ N and longitude 07°29′ 56″ E and 07°30′ 04″ E. (Fig.1). The city is underlain by the basement complex area of Katsina State, which is of crystalline origin (Tukur, 2010). There are numerous granitic hills, which rise 60-200meters above the surrounding plains (Tukur, 2010). These hills are probably the result of the intrusion of older granites into the basement complex, which have undergone long period of denudation (Adamu, 2000) in (Tukur, 2010). The soil of the area is the tropical ferruginous red and brown soil of the basement complex. The soil forming materials are rock and sand materials. Brown to orange color soils consisting of sandy clay loam, overlying lateritic ironstones are found on the interfluves and upper slopes of undulating area, while on the seasonally flooded river valley floors, highly clay content heavier grey soils occur (Oguntoyinbo et al, 1983). The climate of the area is semi-arid classified as tropical wet and dry climate (AW). Two major factors influence the climate of the area, latitudinal location and continentality (distance from the sea), According to Adamu (2000) in Tukur (2010) the climate of Dutsin-ma could be described as tropical continental, with annual rainfall of about 800mm. The Temperature in April averages 30.8°c. In January, the average temperature is about 21.2°c (Isa Kaita College of Education, Weather Station 2017). Between March and May the area, experience a hot dry season climate. A warm wet season is experienced from June to September. Towards the end of the year, the area experienced a less marked season after rains, which is characterize by a decreasing rainfall and a gradual lowering of temperature. Hausa-Fulani predominantly occupy Dutsinma area. Majority of the people speak Hausa, but there are small portion of the people that speak Fulani. Large percentage of the people in the area are cultivators, with a few traders .According to the 2006 National Population census, the population figures of Dutsin-ma Local Government reached 169,671 inhabitants. (National Population Commission, 2006). The estimate of 2017 puts the population of Dutsinma local government at 220,75 people. (National Population Commission, 2017).

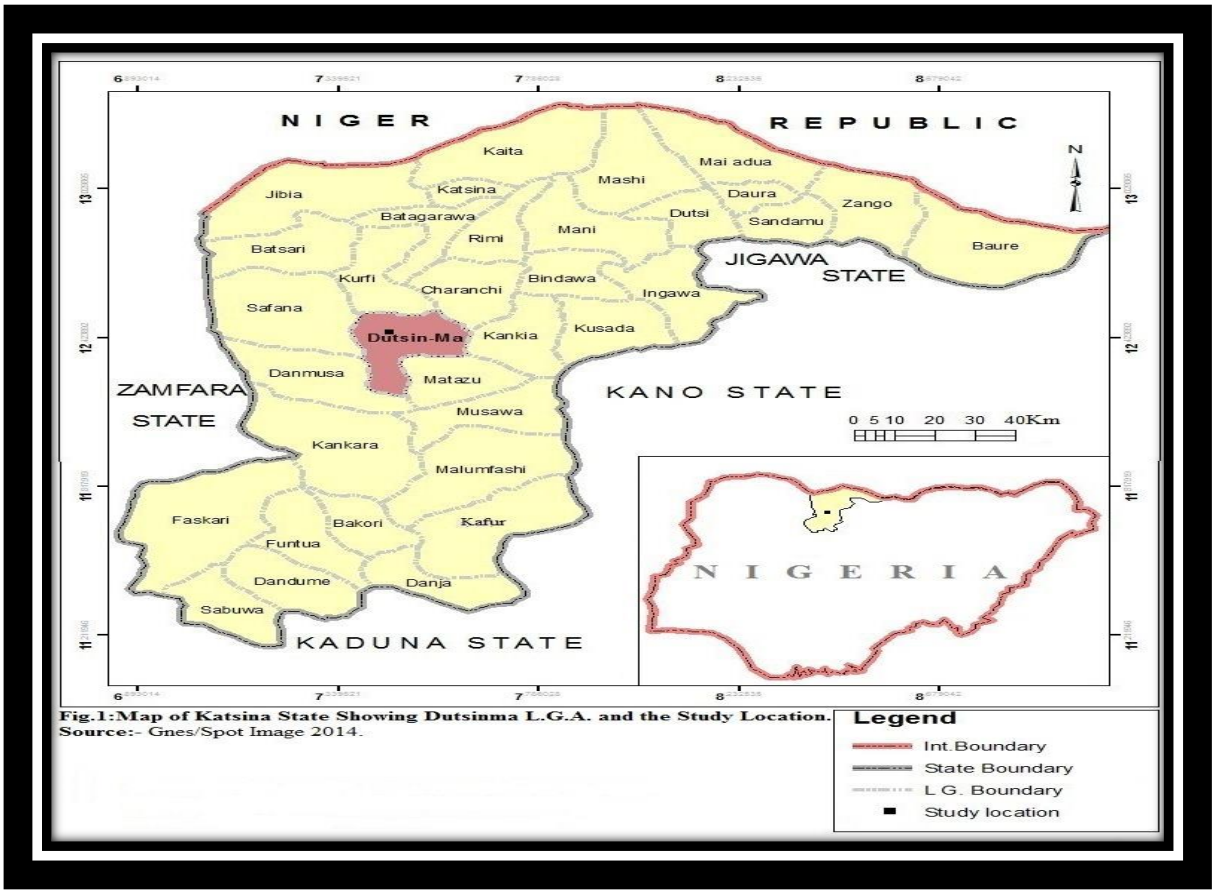

Fig.1:Map of Katsina State Showing Dutsinma L.G.A. and the Study Location.
Source:- Gnes/Spot Image 2014.

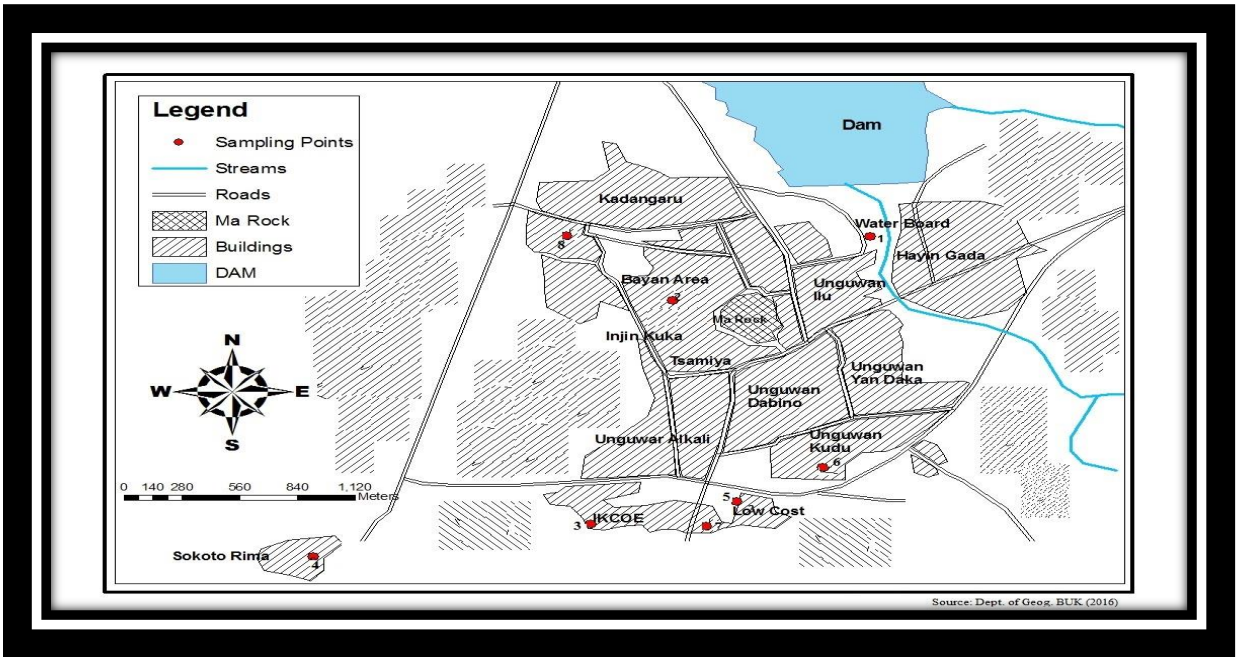

Fig 2: Dutsinma City Showing Eight Sampling Points

3. Materials and Methods

3.1 Sampling techniques

A purposive sampling technique was adopted and samples were drawn from the four water sources. During reconnaissance survey, eight sampling points were selected; two for each of treated tap water, hands pumps, boreholes and open wells. The sampling points selected were water treatment plant (point 1) and Bayan area (point 2) for the treated tap, Isah Kaita College of Education (point 3) and Sokoto Rima (point 4) for Boreholes, Low-cost Housing Estate (point 5) and Unguwar 9 Kudu (point 6) for hand pumps, and police station open well (point 7) and Zubairu Primary School open well (point 2) for the open concrete wells (Fig.2). Eight water samples were drawn from eight sampling points selected; two samples were collected from each source. Sampling collection was carried out thrice in the rainy season and thrice in the dry season respectively, making a total of forty eight (48) water samples for the study (24 samples in the rainy season and 24 samples in the dry season). Water samples were collected from tap water, boreholes, hand pumps and open wells. Sample's collection for the dry season was carried out in the month of January, February and April 2016. For the rainy season, the samples were collected in the month of July, August and September 2016. Water samples were collected using sterilized 2-liter plastic containers, thoroughly washed and acidified with nitric acid and clearly marked and labeled after the sampling points, time and date. The containers were further rinsed with the sample water at the sites of the sample collection before the samples were collected to avoid contamination. This was in accordance with Balarabe,Oladimeji and Abubakar (1998), Nirmala et al, (2012), Abed, Hussain and

Pradhan (2011), Agbaire, Akporido and Akporhonor (2014), Nwaichi, Monamu and Njoku (2013) and Makwe and Chup (2013) . All samples were collected between 8:00am to 10:00am and kept in coolers filled with ice blocks before they were finally conveyed to the laboratory where they were analysed for all the selected parameters.

3.2 Laboratory Analysis

Parameters analyzed in the laboratory were Hardness, total suspended solids, total dissolved solids, nitrates and chlorides. These parameters were tested using standard laboratory techniques. Hardness test was carried out by titration using the following apparatus, delivery tube, counter (table clock), dropper, buffer solution and man – ver – 2 hardness reagents. Suspended solids test was carried out by titration method. The method involved separation of suspended solids by titration on glass disc followed by drying at 105^{o}C. The apparatus used include vacuum flask, titration support (stand) with clamps and filters washed dried at 105^{o}C.

$$\text{Results} = SS = \frac{M1 - Mo \times 100}{V}$$

Where, V = measured volume (100ml)
Mo = mass
M1 = weight of filter, cake and dish

Total dissolved solids were determined through HACH titration method with TDS conductivity meter using beaker, distilled water and the sample. Nitrates were determined by comparative method using HI 3874-0 reagent. The vessel was filled to 10ml mark with the sample water and one packet of HI 3874-0 reagent. The cover was replaced correctly and the mixture was shaken vigorously for one minute and then waits for four minutes for the colour to develop. The cover of the vessel was removed and colour comparator tube was filled with 5.0ml of treated sample. The colour that matches the solution in the tube was determined. To convert the reading to Mg/l of Nitrate, the reading was finally multiplied with the factor of 1.43. Chlorides were determined using Silver Nitrate Solution. 1ml Potassium Chromate K_2Cro_4 was added to 100ml of water sample and titrated with 0.01ml standard Silver Nitrate solution to a pinkish yellow end.

$$\text{Cl Mg/l} = \frac{\text{Ml of } AgNo_3 \times F \times 1000mg \times 1000}{\text{Ml of Sample}}$$

3.3 Statistical Techniques/Methods

For the purpose of this research, t-test was used to analyze the results obtained from the laboratory to determine whether there is significant difference in the quality of drinking water in the study area between the two seasons. Bar graphs were also used to show comparison of water quality between the seasons.

4. Results and Discussion

The averages of the results for the two seasons were taken and presented in the tables below:

Table 1: Results of Physiochemical Analysis of Water Samples collected in Dry Season (Dec 2015 – April 2016)

	Sampling Points							
Parameters	1. Water Treatment Plant	2. Bayan Area Treated Tap	3. I.K.C.O.E Dutsinma Borehole	4. Sokoto Rima Borehole	5. Low coast Hand Pump	6. Unguwar Kudu Hand Pump	7. Police Station Mosque Open Well	8. Zubairu Primary School Open Well
Hardness (Mg/l)	47.50	43.55	48.00	112.00	59.00	96.33	305.00	144.00
TSS (Mg/l)	52.00	27.00	19.00	29.00	30.00	22.00	43.00	46.00
TDS (Mg/l)	102.40	168.50	166.52	106.10	121.00	128.00	650.00	210.00
Nitrate (Mg/l)	2.90	2.50	2.90	4.90	5.56	1.90	14.00	9.40
Chloride (Mg/l)	16.90	19.10	15.50	11.40	18.36	16.10	210.24	66.50

Source: Field and Laboratory Analysis (Dec 2015 – May, 2016)

Table 2: Results of Physiochemical Analysis of Water Samples collected in Rainy Season (June – Sept, 2016)

	Sampling Points							
Parameters	1. Water Treatment Plant	2. Bayan Area Treated Tap	3. I.K.C.O.E Dutsinma Borehole	4. Sokoto Rima Borehole	5 .Low coast Hand Pump	6. Unguwar Kudu Hand Pump	7. Police Station Mosque Open Well	8. Zubairu Primary School Open Well
Hardness (Mg/l)	56.25	75.40	105.20	86.75	94.00	75.20	380.00	120.10
TSS (Mg/l)	31.00	36.00	15.00	20.00	20.00	29.00	16.00	22.00
TDS (Mg/l)	120.50	117.20	211.30	103.50	116.54	288.20	790.00	331.13
Nitrate (Mg/l)	2.00	1.50	2.00	2.20	13.40	19.00	22.00	16.50
Chloride (Mg/l)	18.22	20.25	14.2	11.20	17.20	27.00	202.20	55.22

Source: Field and Laboratory Analysis (June – Sept, 2016)

Table 3: Water Quality Standards for Drinking Water

S/No	Parameters	NIS (2007)	FME (1997)	WHO (2006)
7	Hardness (Mg/l)	150	200	500
8	TSS (Mg/l)	-	>10	-
9	TDS (Mg/l)	500	500	1000
11	Nitrate (Mg/l)	50	10	50
12	Chloride (Mg/l)	250	250	200

Source: FME (1997), NIS (2007) and WHO (2006)

Table 4: Result of t-test showing seasonal variation in water quality

	Pair	Mean	STD. Error	STD. Deviat	N	d.f	T	p≤0.05	Rmk
Hardness	Wet season	124.11	37.21	105.24	8	7	1.255	0.250	NS
	Dry season	106.92	31.07	87.88					
TSS (Mg/l)	Wet season	23.63	2.67	7.54	8	7	-2.055	0.079	NS
	Dry season	33.50	4.24	11.99					
TDS (Mg/l)	Wet season	259.80	81.73	231.16	8	7	1.938	0.094	NS
	Dry season	206.57	64.66	182.89					
Nitrate (Mg/l)	Wet season	9.83	3.10	8.78	8	7	1.781	0.118	NS
	Dry season	5.51	1.48	4.20					
Chloride	Wet season	45.69	22.89	64.73	8	7	-0.459	0.660	NS
	Dry season	46.76	24.18	68.40					

STD. Error = Standard Error, STD. Deviat = Standard Deviation, d.f.=Degree of Freedom, SIG = Significant, NS = Not Significant. Decision: If P-Value is less than significance level (0.05), then there is significant difference between the two seasons.

Hardness (Mg/l):- The values of hardness obtained ranged between (43.55 mg/l – 305.00 mg/l) in the dry season with point 7 (305.00 mg/l), point 8 (144.00 mg/l), point 4 (112.00 mg/l), point 6 (96.33 mg/l) point 5 (59.00 mg/l), point 3 (48.00 mg/l), point 1 (47.50 mg/l) and point 2 (43.55 mg/l). In the rainy season, the values of hardness ranged between (56.25 mg/l to 380.00 mg/l). The maximum values (380.00 mg/l) were found in sampling point 7 and minimum value (56.25 mg/l) was found in point 5. Higher values of hardness were obtained in the rainy season except for sampling points 8 (144 mg/L) and 4 (122 mg/L) with higher values in the dry season. This finding was similar to that of Lawal et-al (2014) and Makwe and Chup (2013). The quality of the water according to t-test showed in significant seasonal variation. The values of hardness obtained from all samples were within the recommended standards. All the water samples analyzed had fallen within WHO (2006) standard for hardness of (500 mg/l). In addition to this, all samples conformed to the NIS (2007) and FME (1997) of (150 mg/l) and (200 mg/l) except sample 7 that was found above NIS (2007) and FME (1997) recommended levels.

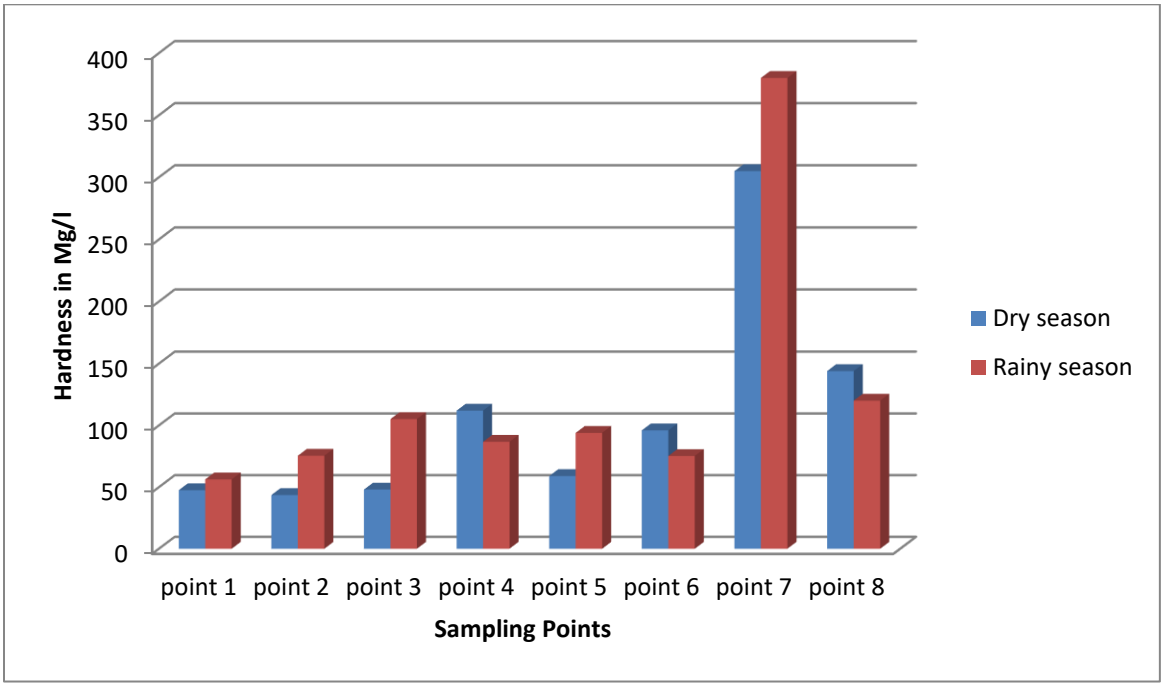

Figure 1: Seasonal variation in total hardness
Source: Field and Laboratory Analysis (December 2015 – Sept, 2016)

Total Suspended Solids TSS. (mg/L):- The values of total suspended solids were found in the range (19.00 mg/l to 52.00 mg/l) in the dry season in the order P3 < p6 < p2< p4 <p5 mg/L) in the rainy season in the order p3< p7 < p4 < p5 < p6 < p1 < p2 with point 2 having the maximum value (36.00mg/l) and point 3 having the minimum value (15.00 mg/l). TSS values were found higher in the dry season in all the sampling points except
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< p7 < p8 < p1, that is, point 1 with the maximum value (52.00 mg/l) and point 3 with the minimum value (19.00 mg/L). The values ranged between (15.00 mg/L to 36.00 sampling points 6 and 2 with TSS values higher in the rainy season. This contradicted the findings of Efe et-al (2005), Makwe, and Chup (2012). The result of the t-test showed insignificant seasonal variation between the two seasons

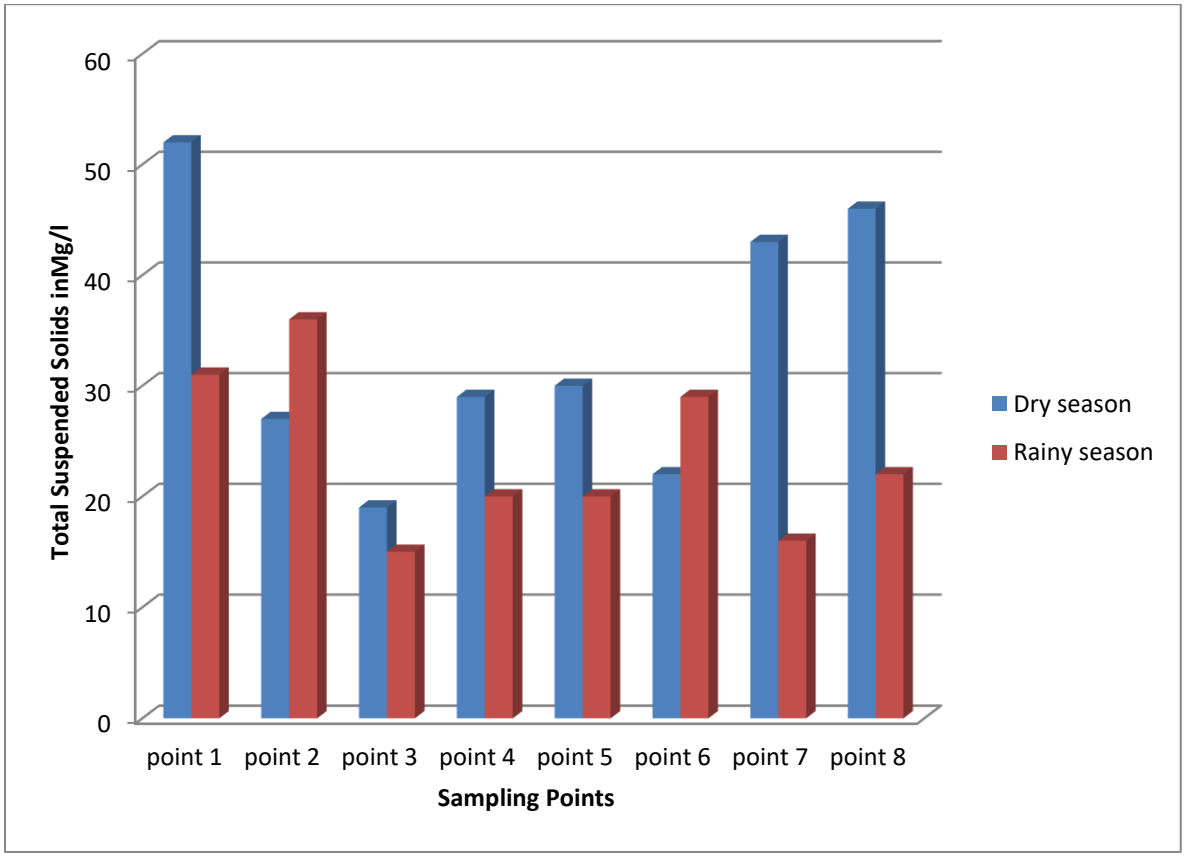

Figure 2: Seasonal variation in total suspended solids
Source: Field and Laboratory Analysis (December 2015 – Sept, 2016)

TDS (mg/L) :- Total dissolved solids of the water samples were found to be in the range of (102.40 mg/L to 650.00 mg/l) in the dry season in the order p1 < p4 < p5 < p6 < p3 < p2 < p8 < p7 with point 7 having the highest value (650.00 mg/l) and point 1 having the lowest value (102.40 mg/L). The values ranged between (103.50 mg/L to 790.00mg/l) in the rainy season in the order p4 < p5 < p2 < p1 < p3 < p6 < p8 < p7. Maximum values (790.00 mg/L) were found in point 7 and minimum values (103.50) were from point 4. Sampling points 2, 4 and 5 revealed lower values of TDS in the rainy season and higher values in the dry season. While in comparison, points 1, 3, 6, 7 and 8 showed lower TDS values in the dry season and higher values in the rainy season. The seasonal variation in TDS according to t-test

was insignificant. With the exception of point 7, all the points revealed TDS values within the allowable limits of NIS (2007) and FME (1997). According to WHO (2006), all the points had fallen within standard.

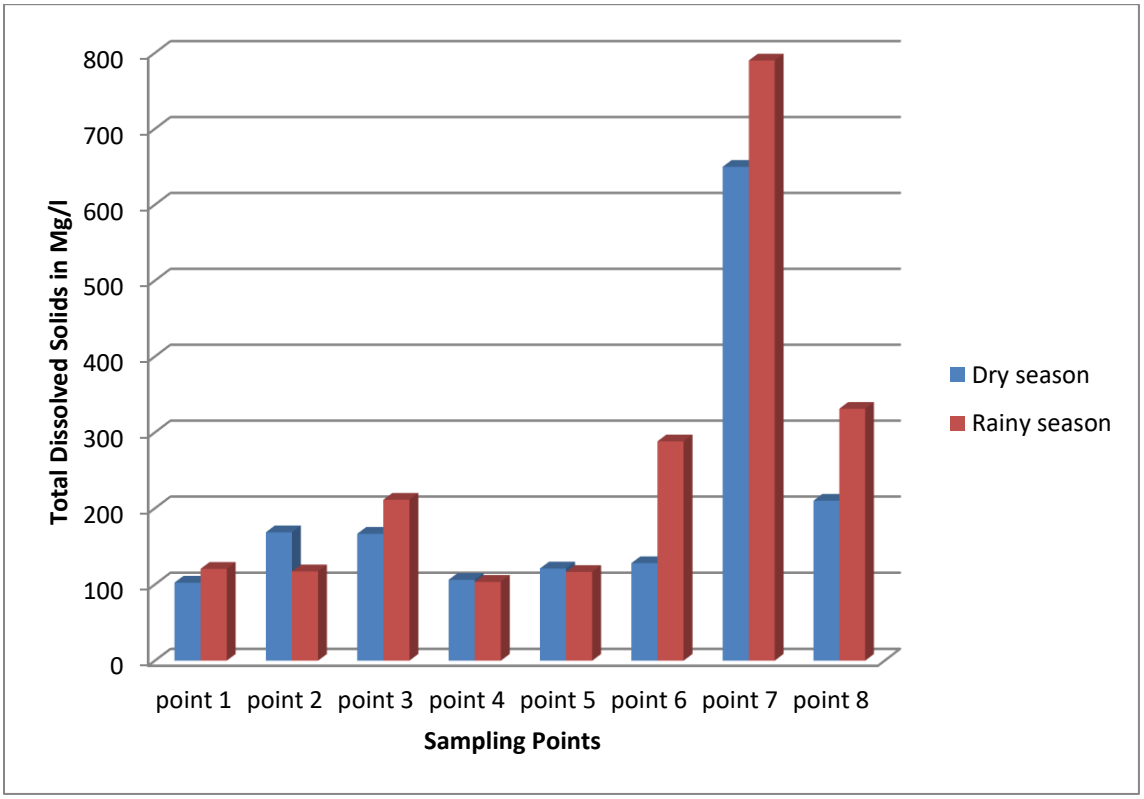

Figure 3: Seasonal variation in total dissolved solids
Source: Field and Laboratory Analysis (December 2015 – Sept, 2016)

Nitrates (mg/L):- The results of nitrate ranged from (1.90 to 14.00 mg/l) in the dry season in the order p6 < p2 < p1 < and p3 < p4 < p5 < p8 and p7. Lower values were detected from point 2 (1.90 mg/l) and higher values were detected from point 7 (14.00 mg/l). In the rainy season, the values of nitrate ranged from (1.50 mg/l to 22.00 mg/l). Highest values were detected from point 7 (22.00 mg/l) and lowest values (1.50 mg/l) from point 2. The results of nitrate between the two seasons did not show significant seasonal variation because the p-value (0.118) is greater than the significance level (0.05). Comparison of the results with water quality standards revealed that, all the results for both seasons conformed to WHO (2006) and NIS (2007) water quality standards of (50 mg/l) as found by Funtua et-al (2014). This finding however disagreed with that of Yisa et-al (2012), Adejuwon et-al (2011), Ayantobo et-al (2013) and Nwaici et-al (2013). In the case of FME (1997) standard of (10 mg/l), only point 7 deviated from the recommended level in the dry season, while in the rainy season, points 5, 6, 7 and 8 were above the (FME 1997) standards. However the FME (1997) standard on nitrate (10 mg/L) is so strict compared to WHO (2006)

and NIS (2007) with nitrate standard of (50 mg/L). This indicated that, most of the water sources are suitable for human computation in terms of nitrate.

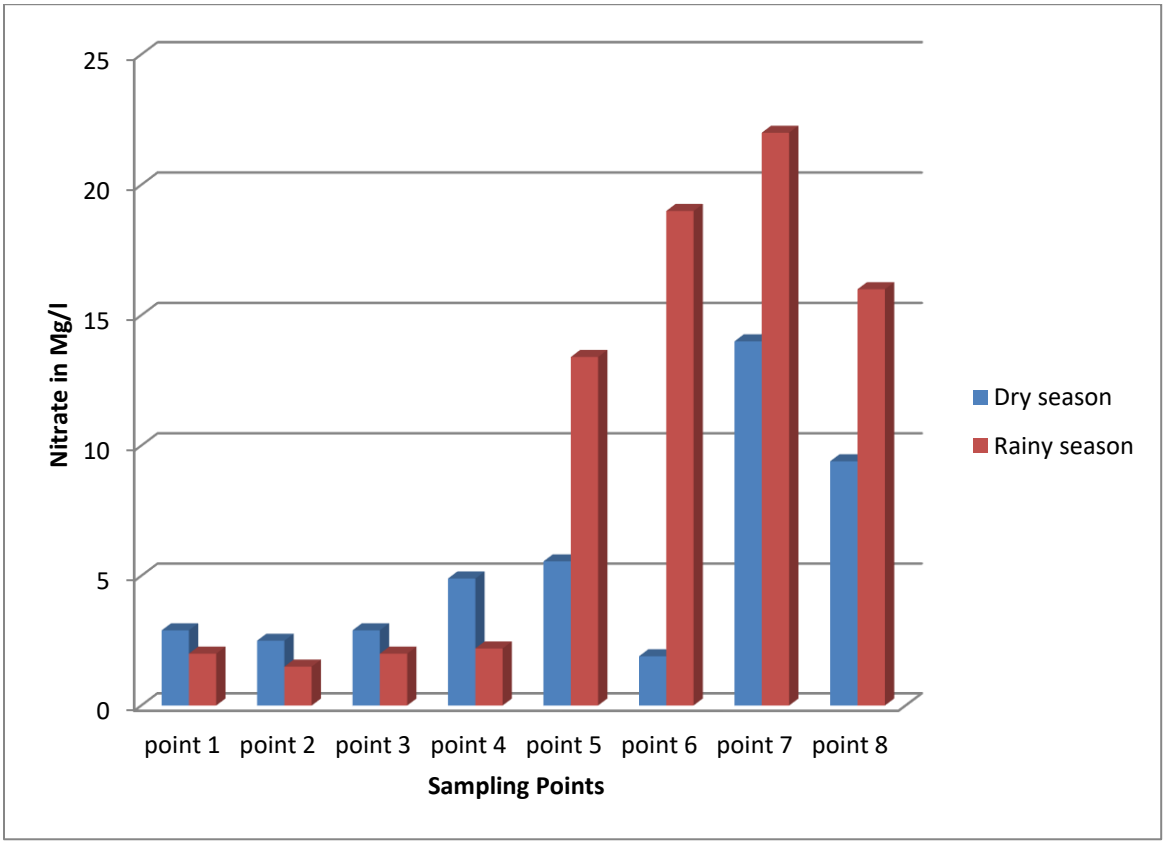

Figure 4: Seasonal variation in nitrate
Source: Field and Laboratory Analysis (December 2015 – Sept, 2016)

Chloride (mg/l):- The concentration of chloride according to the result varied from (11.40 mg/l to 210.24 mg/l) in the dry season. Point 4 had the lowest value (11.40 mg/l) and point 7 had the highest value (210.24 mg/l). The concentration ranged from (11.20 mg/l to 202.20 mg/l) in the rainy season. Lower values were observed from point 4 (11.20 mg/l) and higher values were observed from point 7 (202.20 mg/l). The values of chloride were slightly higher in the dry season than in the rainy season. However, the result of t-test revealed that, there is insignificant seasonal variation in the quality of water between the two seasons. Contrary to the findings of Nirmala et-al (2012), Nwaichi et-al (2013) and Mary- Helen et-al (2011), the results of chloride for all the seasons compared well with all the standards of FME (1997), NIS (2007) and WHO (2006). This revealed the suitability of water sources for human consumption in terms of chloride.

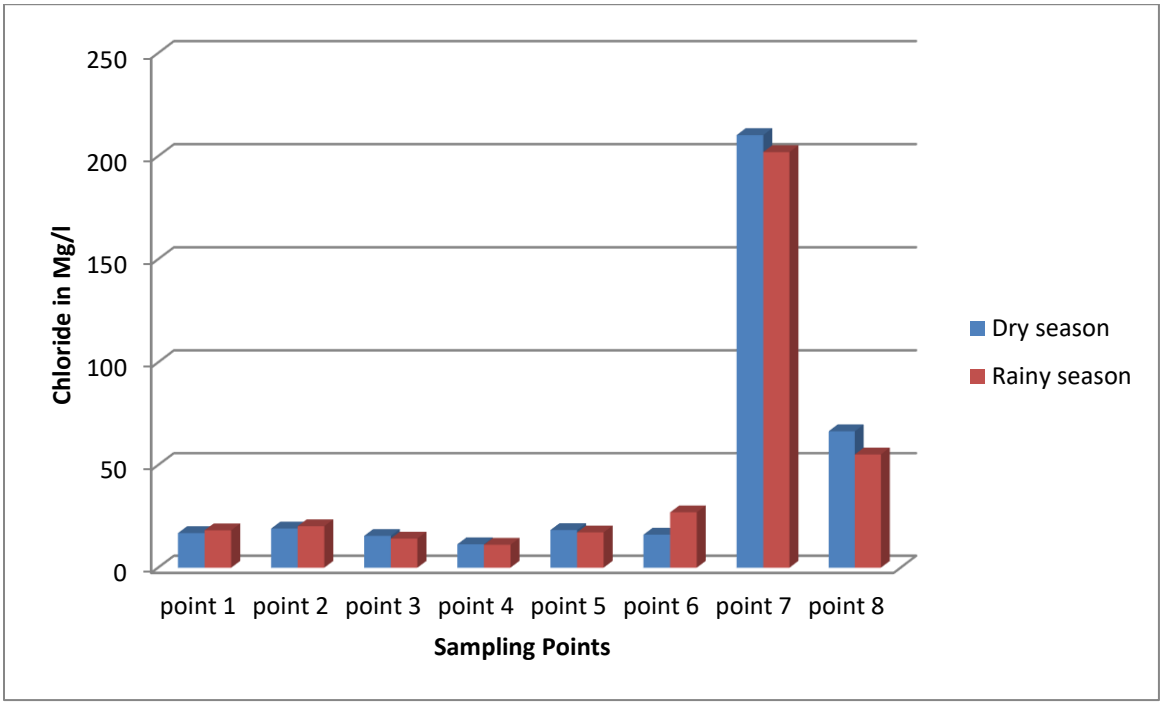

Figure 5: Seasonal variation on chloride
Source: Field and Laboratory Analysis (December 2015 – Sept, 2016)

5. CONCLUSION

The quality of water varies slightly with the season. Some parameters recorded maximum levels in the dry season and others were at their maximum in the rainy season. The average values of Hardness (124.1mg/l), total Dissolved solids (259mg/l) and Nitrate (9.83mgl) were found slightly higher in the rainy season than in the dry season. Those of Total Suspended Solids (33.5mg/l) and chloride (46.64mg/l) were found slightly higher in the dry season than in the rainy season. However, in both seasons, most of the parameters did not deviate from recommended water quality standards for drinking. According to the t-test conducted, all the parameters showed insignificant seasonal variation.

6. Recommendations

i. There is the need for regular monitoring and evaluation of water quality parameters to ascertain their eligibility for human consumption and other uses.

ii. More treatment should be given to the water sources especially during rainy season to meet the required standard.

iii. Well water should be properly covered, as some of the wells in the study area are open throughout the year.

iv. Boreholes should be maintained regularly to ensure steady supply of water.

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