International Journal of Novel Researches in Science, Technology & Engineering
Vol. 6 No. 1 December, 2023
ISSN 2141 825X
www.oasisinternationaljournal.org

SEASONAL VARIATION IN RELATION TO PHYSICO-CHEMICAL PROPERTIES OF GROUNDWATER QUALITY FOR DOMESTIC USES

by

Shuaib-Na'Allah, B. O. and Dauda, K. A.

Agricultural and Bio-Environmental Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin, Kwara State, Nigeria.

Abstract

The qualities of groundwater resources vary naturally and widely, depending on climate, season and geology of bedrock as well as anthropogenic activities which usually resulted in environmental pollution. The study focused on the assessment of seasonal variation in the physico-chemical properties of groundwater qualities in Ara community, Ilorin, Kwara State, Nigeria. Five water samples were collected from different wells (1 and 2) and boreholes (1, 2 and 3) around the study area in both wet and dry seasons. Parameters analysed include; Temperature, Turbidity, Total Dissolved Solid (TDS), Manganese, PH, Total Alkalinity, Electrical Conductivity, Total Hardness, Filterable Solid, Iron, Calcium, Sulphate, Free Chlorine, Copper, Floride, Magnesium and Potassium. Results of the analyses showed that out of all the parameters evaluated, Electrical Conductivity, Total Hardness and Calcium have high positive significant correlation in wet season. Also for dry season only Electrical Conductivity with 0.035 p-values has high positive significant correlation. Paired sample correlation results revealed that parameters such as Total Dissolved Solid (TDS), Filterable Solid (FS), Total Alkalinity (TA), Chloride (CL), Floride (FL), Manganese, Iron, Sulphate, Calcium, Magnesium, Free Chlorine, Potassium and Calcium have highly negative significant correlation in all the Groups. Most of the parameters have their mean values within the World Health Organization (WHO) standards in both seasons; however, mean values of Iron and Total Hardness does not meet the recommended values in both seasons; and Electrical conductivity values are higher than WHO standard in dry season. The study concluded that the water, especially from Well 1 and Well 2, are more polluted during the wet season and recommended that it must be adequately treated if it is to be used for human consumption.

Keywords: Seasonal Variation, Physico-chemical, Properties, Groundwater, Quality & Domestic use

Introduction

Water is an essence food and basic component of life. The need for water is strongly ascending and has a diversified function, which is not only important for drinking purposes but is also vital for any developmental activities. Nowadays, the use and sustainability of water is getting more complex due to population growth, urbanization and industrialization. Any development is related either directly or indirectly with water utilization (Haile and Semir, 2016).

According to World Health Organization (2011), 80% of diseases in human being are caused by water. Over much of Africa, groundwater is the most realistic water supply option for meeting water demand. However, increasing demand and withdrawal, significant changes in land use pattern, vast industrial and agricultural effluents entering the hydrological cycle as well as seasonal variation affect the quality and quantity of groundwater (Idoko, 2010).

Water quality is very hard to define and to a great extent extremely subjective. It is not simply a case of the cleaner or pure the better, for example, distilled water is extremely pure chemically and so its quality can be considered as being high as it contains no toxicants or pollutants, yet it is unsuitable for portable use and it lacks the trace elements necessary for freshwater biota. Water quality can only be defined in relation to some potential use for which the limiting concentration of various parameters can be identified (Gray, 1994). The determination of groundwater quality for human consumption is important for the well-being of the ever increasing population. Groundwater quality depends to some extent on its chemical composition which may be affected by natural and anthropogenic factors (Idoko *and* Oklo, 2011).

The quality of underground water is the resultant of all the processes and reactions that act on the water from the moment it condenses in the atmosphere to the time it is discharged by a well; therefore, determination of underground water quality is important to observe the suitability of water for a particular use. The problems of underground water quality are more acute in areas that are densely populated and thickly industrialized and have shallow underground water tube wells *(*Shivram *et al.*, 2006*).*

The qualities of groundwater resources vary naturally and widely, depending on climate, season, and geology of bedrock as well as anthropogenic activities. But prolonged discharge of industrial effluent, domestic sewage and solid waste dump caused the underground water to become polluted and created health problems. The underground water is believed to be comparatively much clean and free from pollution than surface water (Patil and Patil, 2011).

Groundwater has natural deposits of contamination; however, contamination can also rise from anthropogenic activities and from the surface and groundwater interaction. The quality of groundwater is normally characterized by different physico-chemical parameters level. These parameters change widely due to various types of population, seasonal variation and ground water extraction (Ramakrishnaiah *et al.*, 2012). Hence, the need to assess the seasonal variation in the physico-chemical characteristics of groundwater water in the study area.

Location of the Study Area

Ara community is located behind Kwara State Polytechnic in Moro L.G.A of Kwara State, Nigeria. It lies between latitude 08^{o} 33' 16.4" N and longitude 04 ^{o} 38' 04.2"E and latitude 08^{o} 33' 38.4"N and 04° 38' 20.6" E of the Greenwich meridian. It lies on altitude of approximately 372m which is about 1,220 feet. Figure 1 is the satellite imagery Ara community and Figure 2 is a map of the study area.

Figure 1: Satellite imagery of Ara community

Source: www.goggle,com

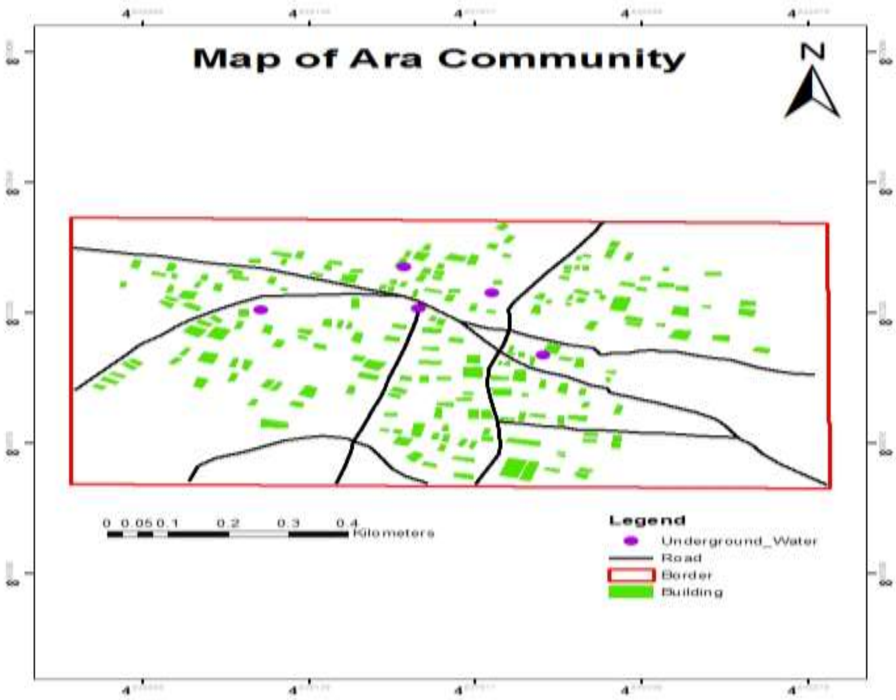

Figure 2: Map of the study area

Water Sampling Procedure

Selection of water sources was done by random sampling procedure. A total number of five groundwater samples were collected within Ara community: Two wells and three boreholes. The samples were collected separately in a sterilized bottle for rain season and dry season respectively. Before collecting the water samples, the bottle container was washed and rinsed thoroughly with water. The water samples collected were taken to the laboratory for analysis using standard methods. The Global Position System (GPS) was used to determine the coordinates of the sampled points.

Methods of Water Analysis

Physical and chemical parameters were analysed and the results of laboratory analysis obtained were compared with World Health Organization Standard (WHO):

- **(i) Temperature:** This is measured by Thermometer calibrated in various temperatures.
- **(ii) Hardness:** This was determined by infiltrating with a standard solution of ethylene diamine tetra acetic acid (EDTA).
- **(iii) P^H:** By using calibrated P^H meter.
- **(iv) Electrical Conductivity:** Conductivity meter was used.
- **(v) Total Dissolved Solid:** This was determined using multi-parameter wireless sensors.

Statistical Data Analysis

Correlation analysis was carried out using SPSS 22.0 version which is a statistical method to find relationship between variables. It was used to know increasing or decreasing tendency of the physico-chemical parameters related to the underground water samples.

Results and Discussion

Table 1 shows the coordinates of the sampling points in the study area. Similarly, Table 2 and 3 show the results of analysis of selected parameters for wet and dry season. The descriptive statistics of ground water in wet and dry season are shown in Table 4 and 5. In addition, Figure 1 to 8 shows the graphs of the seasonal variations of underground water within the study area.

Table 1: Coordinates of the Sampling Points in the Study Area

Degree, Min and Sec		Decimal Degree		GPS Point		
x longitude	**Y latitude**	**x longitude**	**y latitude**	**x longitude**	**y latitude**	**z elevation**
4 38 19.03	8 34 15.89	4.638620	8.571081	680338	947817	372.8
4 38 16.31	8 34 21.76	4.637864	8.572711	680254	947997	370.2
4 38 11.58	8 34 24.25	4.636549	8.573404	680109	948073	364.8
4 38 12.38	8 34 20.28	4.636772	8.5723	680134	947951	369.9
4 38 03.91	8 34 20.15	4.634419	8.572265	679875	947946	365.0

Table 2: Result of Analysis for Wet Season

S/No	Parameter	A	B	C	D	E
1	Temperature	29.8	29.2	29.2	28.7	29.8
2	Turbidity	6.1	4.6	4.0	4.0	9.5
3	pH	8.3	7.1	6.9	7.0	8.4
4	TDS	72	124.0	92	24	61
5	Electrical Cond.	163.0	278	166.8	85.9	112.8
6	Filterable Solid	85	154	56	70	41
7	Total Alkalinity	250	215	38	60	78
8	Chloride	22.1	8.9	10.6	8.2	15.2
9	Floride	8.6	ND	0.71	6.4	0.71
10	Manganese	0.9	0.31	ND	0.6	0.30

11	Iron	0.22	0	ND	0.08	0.13
12	Sulphate	25.7	38.6	0.21	0.12	0.41
13	Calcium	21	38.7	8.96	3.80	2.44
14	Magnesium Hardness	24	9.7	1.6	6.4	9.84
15	Total Hardness	195.3	272.8	68	92.7	54
16	Calcium Hardness	78.6	118.61	21.94	34.7	18.41
17	Chlorine	6.09	0.34	0.18	0.28	0.31
18	Potassium Hardness	210	91	40	32	61.9
19	Copper	0.12	0.32	0.1	0.06	0.04

Table 3: Result of Analysis for dry season

S/No	Parameter	A	B	C	D	E
1	Temperature	31.4	31.4	32.1	32.4	31.4
2	Turbidity	2.40	1.9	2.8	1.3	3.6
3	pH	7.80	7.5	7.6	6.9	7.1
4	TDS	587	496	798	324	148
5	Electrical Cond.	1594	1208	1694	714	259
6	Filterable Solid	689	750	410	128	92
7	Total Alkalinity	280	304	120	84	71
8	Chloride	12.3	6.5	3.4	2.8	1.9
9	Floride	0.41	ND	0.13	0.35	0.21
10	Manganese	0.2	0.1	ND	0.5	0.30
11	Iron	0.11	0.26	0.05	0.07	0.21
12	Sulphate	12.3	18.9	ND	2.8	3.20
13	Calcium	22	6.0	8.41	6.10	7.81
14	Magnesium Hardness	35	83	6.4	2.3	3.4
15	Total Hardness	44	18	20	12	16
16	Calcium Hardness	18	5.6	8.0	3.2	4.1
17	Chlorine	0.04	0.12	0.02	0.14	0.10
18	Potassium Hardness	108	94	2.1	1.6	0.40
19	Copper	0.09	0.14	0.03	0.13	0.08

A- Well 1, B-Well 2, C-Borehole 1, D-Borehole 2 and E-Borehole 3

Temperature of water samples have a mean value of 29.34 ^{0}C for wet season and 31.74 ^{0}C for dry season is shown in Table 4 and 5. This shows that temperature is lower in the wet season than in the dry season. These values are within the permissible level of World Health Organization (WHO, 2011) standard. Figure 1 shows the seasonal variation in temperature of groundwater in the study area. Temperature in water quality is used as a good measure of contamination as it has marked effect on bacteria and chemical reaction rate in water.

Table 4: Descriptive Statistics of Groundwater in Wet Season

Parameters	Symbol	Min	Max	Mean
Temperature	°C	28.70	29.8	29.34
Turbidity	Tu	4.00	9.50	5.64
Ph	pH	6.9	8.4	7.54
Total Dissolved Solid	TDS	24.00	124.00	74.6
Electrical Conductivity	EC	85.9	278	161.3
Total Alkalinity	TA	38.0	250	128.2

Chloride	Cl	8.2	22.10	138.0
Floride	F	0.00	8.60	3.28
Manganese	Mn	0.00	0.90	0.42
Iron	Fe	0.00	0.22	0.086
Sulphate	SO_4	0.12	38.60	13.00
Calcium	Ca	2.44	38.70	14.98
Magnesium	Mg	1.60	24.00	10.31
Total Hardness	TH	54.00	272.80	136.56
Calcium Hardness	CH	18.41	118.61	54.45
Chloride	Cl	0.18	6.09	1.44
Potassium	K	32.00	210.00	86.98
Copper	Cu	0.04	0.32	0.128

Table 5: Descriptive Statistics of Groundwater in Dry Season

Parameters	Symbol	Min	Max	Mean
Temperature	°C	31.4	32.4	31.74
Turbidity	Tu	1.3	3.6	2.4
pH	pH	6.9	7.8	7.38
Total Dissolve Solid	TDS	148	798	470.6
Electrical Conductivity	EC	259	1694	1093.8
Total Alkalinity	TA	71	304	155
Chloride	Cl	1.9	12.3	5.87
Floride	F	0.13	0.35	0.26
Manganese	Mn	0.1	0.5	0.28
Iron	Fe	0.05	0.26	0.14
Sulphate	SO_4	2.28	18.9	9.73
Calcium	Ca	6	8.41	9.25
Magnesium	Mg	2.3	83	30.77
Total Hardness	TH	12	44	23.71
Calcium Hardness	CH	3.2	18	8.59
Free Chloride	FCl	0.02	0.14	0.08
Potassium	K	0.04	108	44.88
Copper	Cu	0.08	0.13	0.10

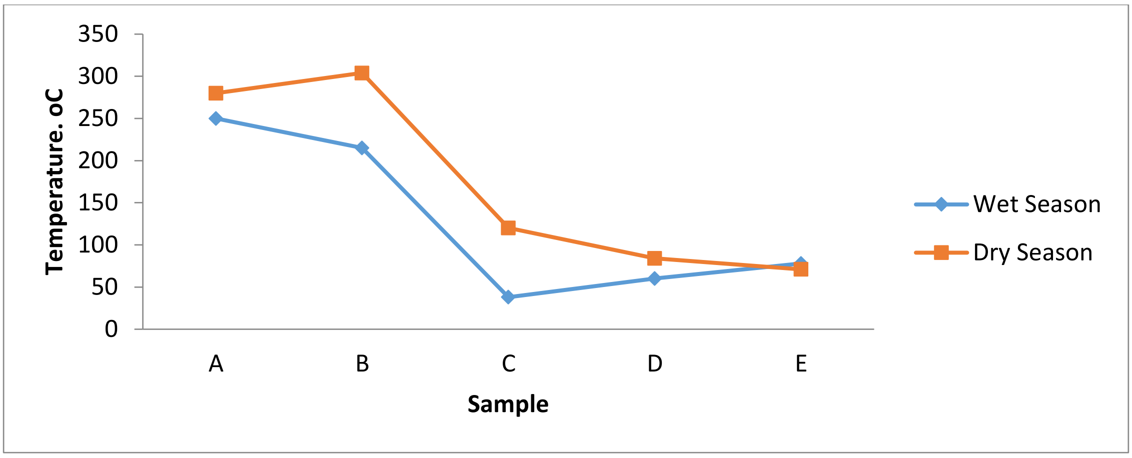

Figure 1: Seasonal Variation in Temperature of Groundwater in the Study Area

The concentration of turbidity in water samples as shown in Table 4 and 5 reveals the mean value of 5.64 ftu with the minimum of 4 ftu and maximum of 9.5 ftu in wet season. In the dry season the mean value of the turbidity is 2.40 ftu with minimum of 1.30ftu and maximum of 3.60ftu. The cause of turbidity in groundwater may be traced to dissolved clay and mud material. Turbidity level is noted to be higher in wet season than the dry season as shown in Figure 2. Lower Turbidity value during the dry season are probably due to less groundwater recharge and the filtration (Makwe and Chup, 2013) and this is in agreement with the work of Nilojan and Rajendran (2023).

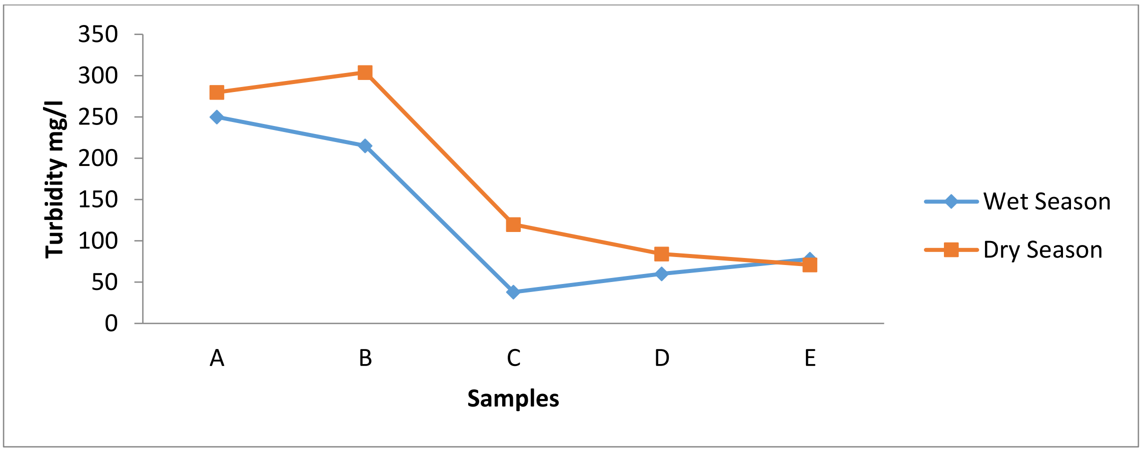

Figure 2: Seasonal Variation in Turbidity of Groundwater in the Study Area

The measurement of P^H is one of the most frequently used tests in water chemistry. The P^H of groundwater in the study area has a mean value of 7.5 with minimum and maximum values of 6.9 and 8.4 for wet season; also for dry season, the mean value is 7.4 with minimum and maximum of 6.9 and 7.8 respectively, as shown in Table 4 and 5. This suggests that the P^H is lower in dry season than wet season as shown in Figure 3. This may be because of the effect of rainfall combined with carbon dioxide in the wet season and it can influence the water toward acidity, which is in line with the work of Ishaku (2010).

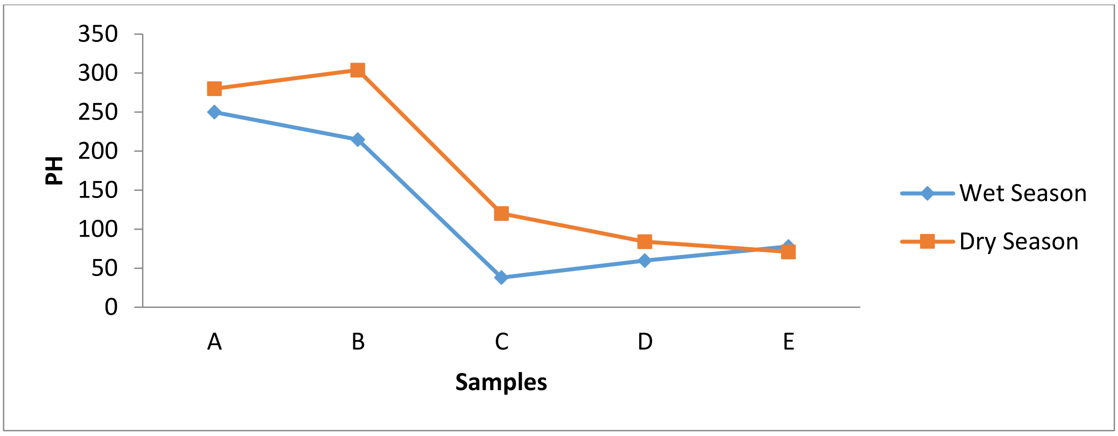

Figure 3: Seasonal Variation in P^H of Groundwater in the Study Area

Electrical conductivity (EC) is the capacity of water to conduct electrical current. It is directly related to the concentration of salt dissolved in water. The electrical conductivity has a minimum value of 85.9 µs/cm and maximum value of 278 µs/cm in wet season with mean value of 161.3 µs/cm; while in dry season it has a minimum value of 259 µs/cm and maximum of 1694 µs/cm with a mean value of 1093 µs/cm as shown in Table 4 and 5. The seasonal variation shows that the electrical conductivity was high during dry season and low during wet season as shown in Figure 4. When compared with World Health Organization Standard (WHO) standard for both season, it exceeded the limit of 1500 µs/cm.

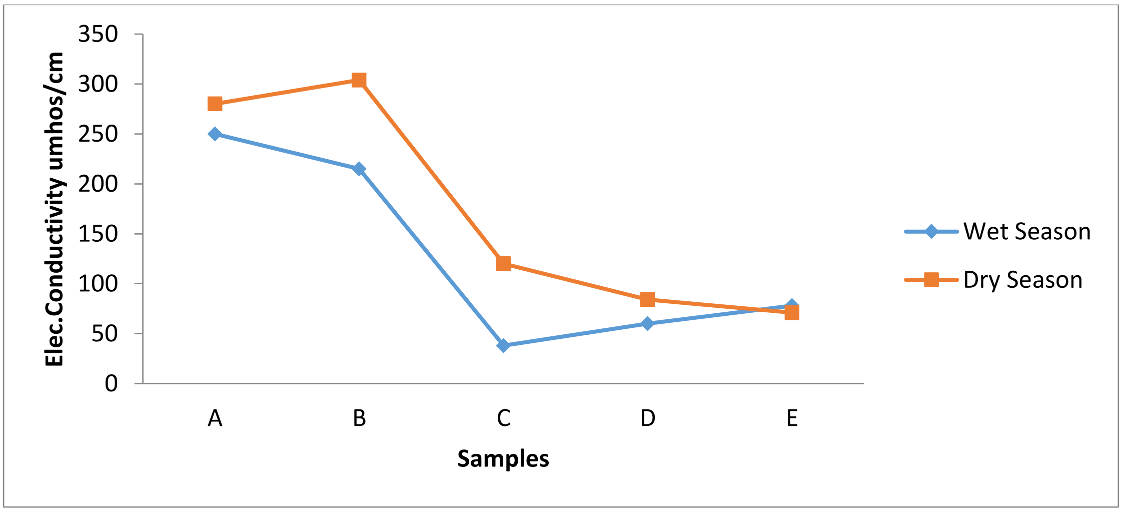

Figure 4: Seasonal Variation in Electrical Conductivity of Groundwater in the Study

Figure 5 shows the seasonal variation in Total Hardness of groundwater in the study area. The mean of total hardness in the water sample shows the same value of 136.56 mg/l for both dry and wet season as shown in Table 4 and 5. The analyses show that its concentration is within World Health Organization Standard (WHO) standard of drinking water both for wet and dry season. This is because of the solvent action of rain water coming in contact with soil, and rock is capable of dissolving calcium and magnesium that promote water hardness.

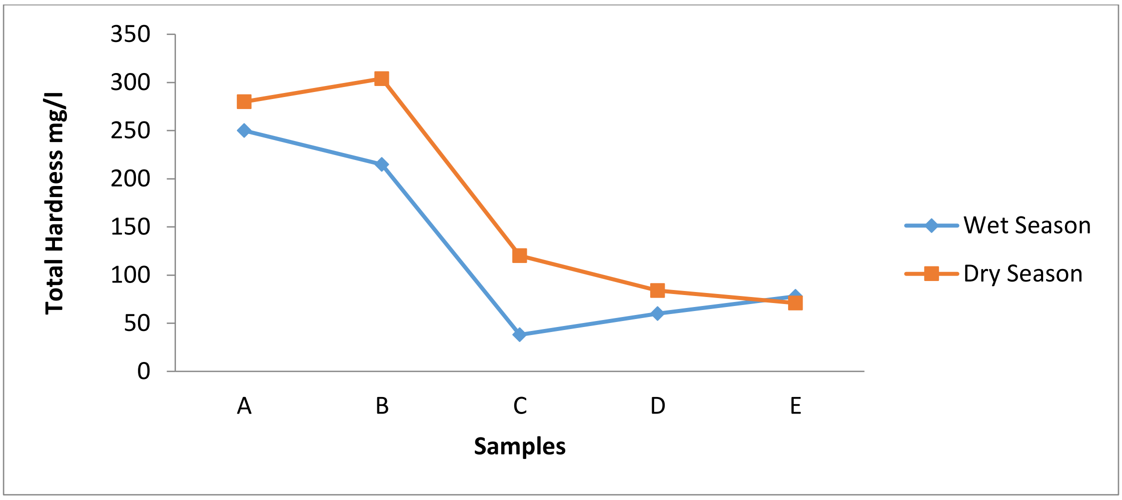

Figure 5: Seasonal Variation in Total Hardness of Groundwater in the Study Area

The result of analyses shows that chloride concentration in water samples for wet and dry season are all within the World Health Organization Standard (WHO) prescribe limit of 200 to 600 mg/l for drinking water. Chloride concentration in groundwater has a mean of 138mg/l with minimum and maximum of 8.2 and 22.10mg/l in wet season. In dry season it has a mean of 5.38 mg/l with minimum and maximum of 1.90 and 12.3mg/l as shown in Table 4.and 5. This may be attributed to the local environment of the groundwater. Figure 6 shows the seasonal variation in chloride of groundwater in the study area.

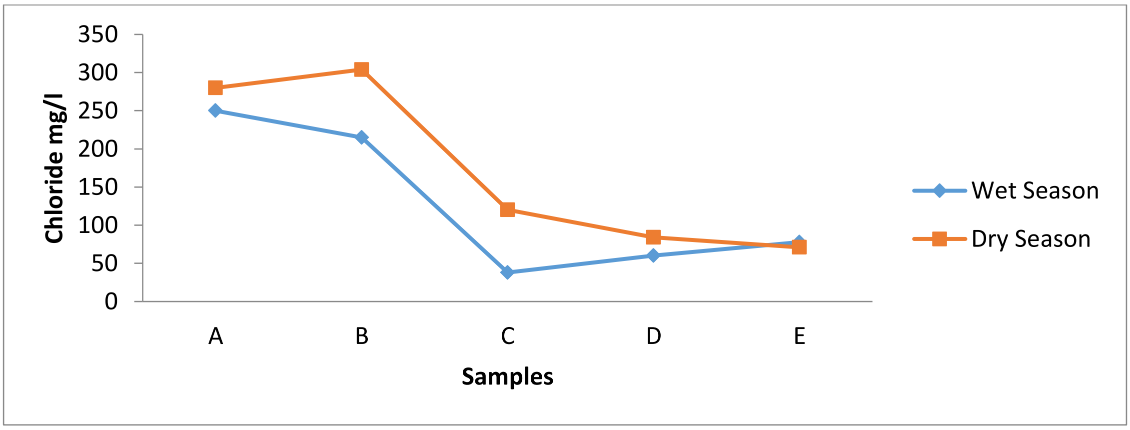

Figure 6: Seasonal Variation in Chloride of Groundwater in the Study Area

The Total Dissolve Solid (TDS) of water determines the combined content of all organic and inorganic substances present in the water samples. It exhibits a range of disparity with a minimum of 24 mg/L and maximum of 124 m/L in wet season and in dry season. It was 148mg/L and 798Mg/L for the minimum and maximum respectively as shown in Table 4 and 5. The Total Dissolve Solid (TDS) of water during the steady period shows significant higher values during the dry season when compared to wet season as shows in Figure 7. The Total Dissolve Solid TDS of all samples were within the WHO standard of 500 mg/L for drinking water except for the dry season with maximum of 798 mg/L. The water samples of high Total Dissolved Solid (TDS) makes them unsuitable for drinking purpose.

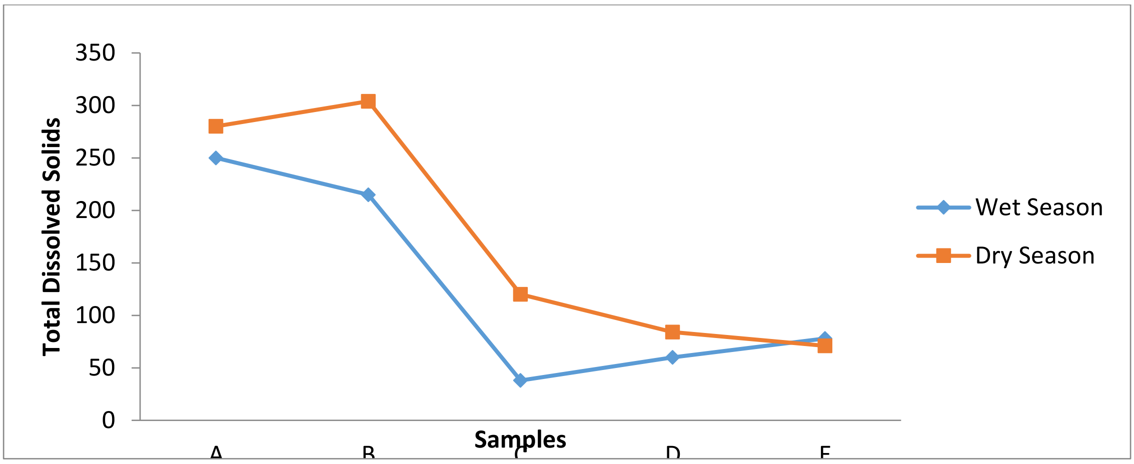

Figure 7: Seasonal Variation in Total Dissolved Solids of Groundwater in the Study

The total alkalinity ranged from 38 to 250 mg/L during the wet season and ranged from 84 to 280 mg/L in the dry season as shown in Table 4 and 5. Figure 8 shows high value in dry season and low value in wet season with the value exceeded the World Health Organization Standard (WHO) standard of 120mg/l except for the boreholes in wet season and boreholes 2 and 3 in dry season.

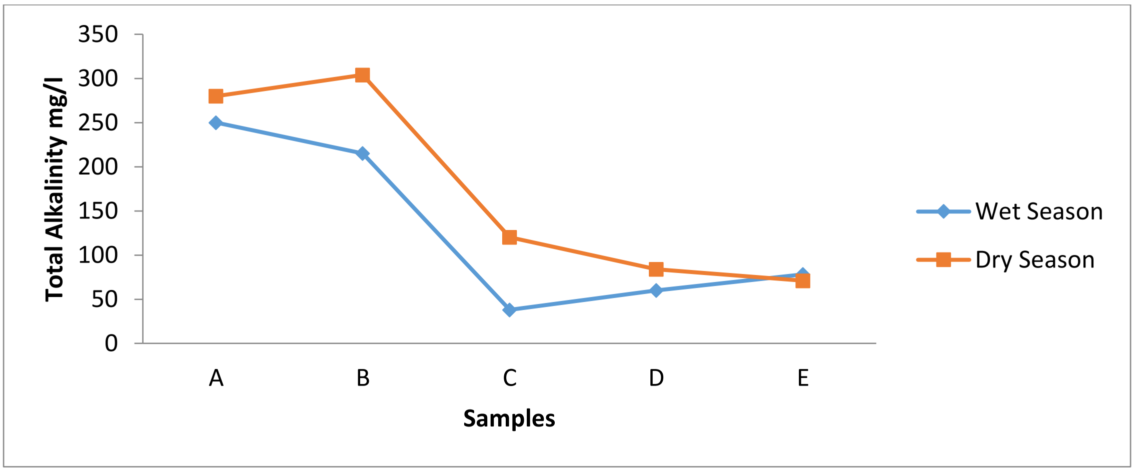

Figure 8: Seasonal Variation in Total Alkalinity of Groundwater in the study Area

In addition, the correlation coefficients (r) between the variables were calculated using person's correlation method and with their corresponding values (r). Out of nineteen correlations for wet season, it is obvious that ECD has high positive correlation with 0.07 p-values, THD with 0.044 p-values, CaHD with 0.034 p-vale which implies that they have significant correlation. For dry season, it also has high positive correlation of ECD with 0.035 p-values which implies a significant correlation. TDS, FS, TA, Cl, Fl, Mn, Fe, SO_4, Mg, Cl, K and Ca are highly negatively correlated in the dry season. TDS, Tu, pH, TA, TH, CO_3, SO_4, K, Mg, Na and Fl all have negative significant correlation during wet season. Therefore, the following parameters were highly negatively correlated in the water samples TDS, FS, Tu, Cl, Fl, Mn, Fe, SO_4, Ca, Mg, Cl, K and Ca.

Conclusion

The study has shown that season variation can have influence on the concentration of physic-chemical properties of groundwater in the study area. The result of the analysis shows that most of the parameters have higher mean values in wet season in all the water samples except for electrical conductivity, total hardness and total alkalinity which have higher mean values during the dry season, which result in soil saturation and consequently resulting in reduced filtration. Paired sample correlation result review that the parameter such as Total Dissolved Solid (TDS), Electrical Conductivity (EC), sulphate and iron have no significant variation in all the samples, with other parameters showing different levels of seasonal variation across the groups. Most of the parameters have mean values within the World Health Organization Standard. The study concluded that the water, especially from Well 1 and Well 2, are more polluted during the wet season and recommended that it must be adequately treated if it is to be used for human consumption and others groundwater in this study area is safe for human consumption but should be properly monitored.

References

Gray, N.F. (1994). *Water Technology. An introduction for Scientists and engineers. Development of civil, structural and environmental engineering*, Trinity College, university of Dublin.

Haile, A. S. and Semir, A. (2016). Groundwater Exploration for Water Well Site Locations Using Geophysical Survey Methods. *Journal of Hydrology Current Research.* ISSN: 2167-7687. DOI: 10.4172/2157-7587.1000226.

Idoko, O. M. (2010). Seasonal Variation in Iron in Rural Groundwater of Benue State, Middle Belt Nigeria. *Pakistan Journal of Nutrition*, 9(9), 892-895.

Idoko O. M. and Oklo, A. (2011). Seasonal Variation in Physico-Chemical Characteristics of Rural Groundwater in Benue State, Nigeria. *Journal of Asian Scientific Research*, 2(10), 574- 586.

Ishaku, J. M. (2010). Groundwater quality monitoring in Jimeta-Yola area, northeastern Nigeria. Paper presented at the conference of the Nigeria Association of Hydrogeologist (NAH) Ibadan

Nilojan,T and Rajendran, M. (2023). Assessment of groundwater quality and its suitability for drinking in Mannar Island. *3rd international symposium on agriculture 2023 faculty of agriculture*, eastern university Sri Lanka.

Makwe, E. and Chup, C. D., (2013). Seasonal variation in physico-chemical properties of groundwater around Karu abattoir. *Ethiopian journal of* *environmental studies and management*, 6(5): 489-497.

Patil, V. T. and Patil, P. R. (2011). Groundwater Quality of Open Wells and Tube Wells around Amalner Town of Jalgaon, District, Maharashtra, India. *Electron J Chem* 8(1):53–78.

Ramakrishnaiah, C. R., Sadashivaiah, C. and Ranganna, G. (2012). Assessment of Water Quality Index for Groundwater in Tumkur Taluk, Karnataka State, India. *E-Journal of Chemistry*, 6(2), 523-530.

Shivran, H. S., Dinesh, K. D. and Singh, R. V. (2006). Improvement of Water Quality through Biological Denitrifaction. *Jour. Of Environ. Sci. Engr*. 48 (1): 57-60.

WHO. (2011). Guidelines for drinking-water quality. World health organization, 216: 303-304.

www.Googlemap.com (2023): Imagery showing the Project area and the dam.