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GROUNDWATER QUALITY ASSESSMENT FROM PARTS OF THE BASEMENT COMPLEX AREA OF OSHOGBO, SOUTHWESTERN NIGERIA

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ABSTRACT

The increasing population in Oshogbo metropolis with the attending rise in human generated waste and environmental pollution has created a quest in assessing the quality of the available groundwater. Therefore, drinking water must meet the desirable quality and standards, and there is need for thorough monitoring of the quality available for drinking purposes. A total of twenty (20) samples of water were randomly collected from borehole drilled into the basement complex rocks. The temperature of water samples ranges between 26°C and 29°C and an average of 27.9°C. The range of pH is from 6.7 to 7.8 with mean value of 7.2 which indicated that the water is neutral. The TDS was low and ranges between 21.3 to 50.5 mg/l with a mean value of 35.8 mg/l. Calcium has concentration ranging between 1.3mg/l and 7.2mg/l. Concentration of Magnesium ranges between 1.5mg/l and 18mg/l while concentration of sodium ranges from 1.2mg/l to 8.9mg/l and Potassium ranges from 1.2mg/l to 4.3mg/l. Chloride concentration ranges from 2.1mg/l to 8.2mg/l and Sulfate concentration ranges between 0.4mg/l and 12.0mg/l while Bicarbonate ranges from 3.7mg/l to 14.3mg/l. The geochemical data for both cation and anion shows that: Mg>Na>Ca>K and HCO_3>SO_4>Cl. Mg-HCO_3 occupied 30% of the water type analyzed, Mg-Cl took 15%, Ca-HCO_3 took 25%, while Mg-SO_4 took 30%. The major cations from the water facies indicate that Calcium and Magnesium are geogenic in origin and are as a result of interaction of water and the underlying rocks are reflective of bedrock dissolution. . Concentration of Cl^-, HCO_3^- and SO_4^{2-} can be attributed to increasing population and industrial growth within the metropolis, although the concentration is not when compared with WHO standard and Nigeria Standard standard desirable and permissible limits.

KEYWORDS: Borehole, Geochemical, Geogenic, Groundwater, Metropolis

INTRODUCTION

The increasing population in Oshogbo metropolis has created a quest in assessing the quality of the available groundwater. Therefore, drinking water must meet the desirable quality and standards, and there is need for thorough monitoring of the quality available for drinking purposes. Oshogbo is an area underlain by crystalline rocks (Dada, 1998; NGSA, 2006), and the populace depend largely on the surface water, which is supplied by the state water corporation as pipe-borne water. This source of water is not always sufficient especially during the dry season, so groundwater is an alternative source of drinking water. However, it is generally recognized that the quality of water is as important as its quantity (Abimbola et al., 1999; Adelana et al., 2003). The determination of water quality has been the interest of many researchers (Tijani and Abimbola, 2003; Ige et al., 2008; Ajibade et al., 2011; Omada et al.,2011 and Akanbi et al., 2020). Therefore, there is a vital need to assess the chemical constituents of the groundwater of part of Oshogbo metropolis.

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This is in order to ensure the well-being of residents that rely on this renewable water supply by measuring and analyzing the physicochemical parameters from representative water samples from selected boreholes and comparing them with regulatory standards for drinking purposes.

STUDY AREA

The study area in Egbedore Local Government Area is bounded by longitudes E 4°30'55'' and E 4°32'48'' and latitudes N 7°46'52" and N 7°47'47''. It covers about 5.8459 km^2 (Figure 1). Rahaman (1988) noted that southwestern Nigeria, in common with the rest of the Precambrian outcrops in Nigeria, lies in the zone of Pan-African reactivation 600±150 Ma. He grouped quartzite and gneisses as migmatite-gneiss complex and subscribed to the view that rocks of the migmatite-gneiss-quartzite complex comprises largely a sedimentary series with associated minor in igneous rocks which has been variably altered by metamorphic, migmatitic and granitic processes (Figure 2). The area has two climatic seasons within a year. The seasons are the hot dry season between November and April and the wet season May to October with temperature which ranges between 24°C and 33°C.The study area belongs to the tropical rain forest of Nigeria. The drainage pattern is dendritic and annual rainfall is about 1500mm

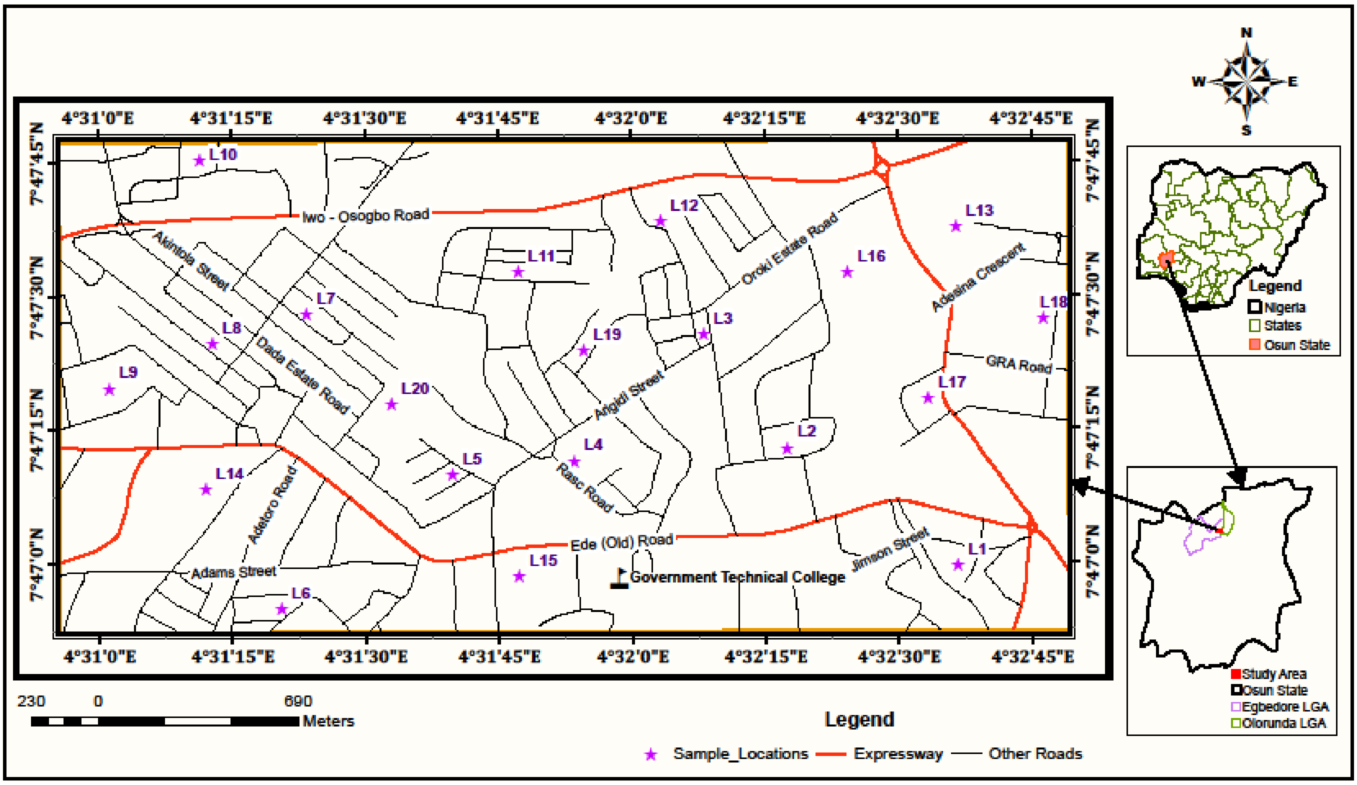

Figure 1: Location map with sampling points in the study area

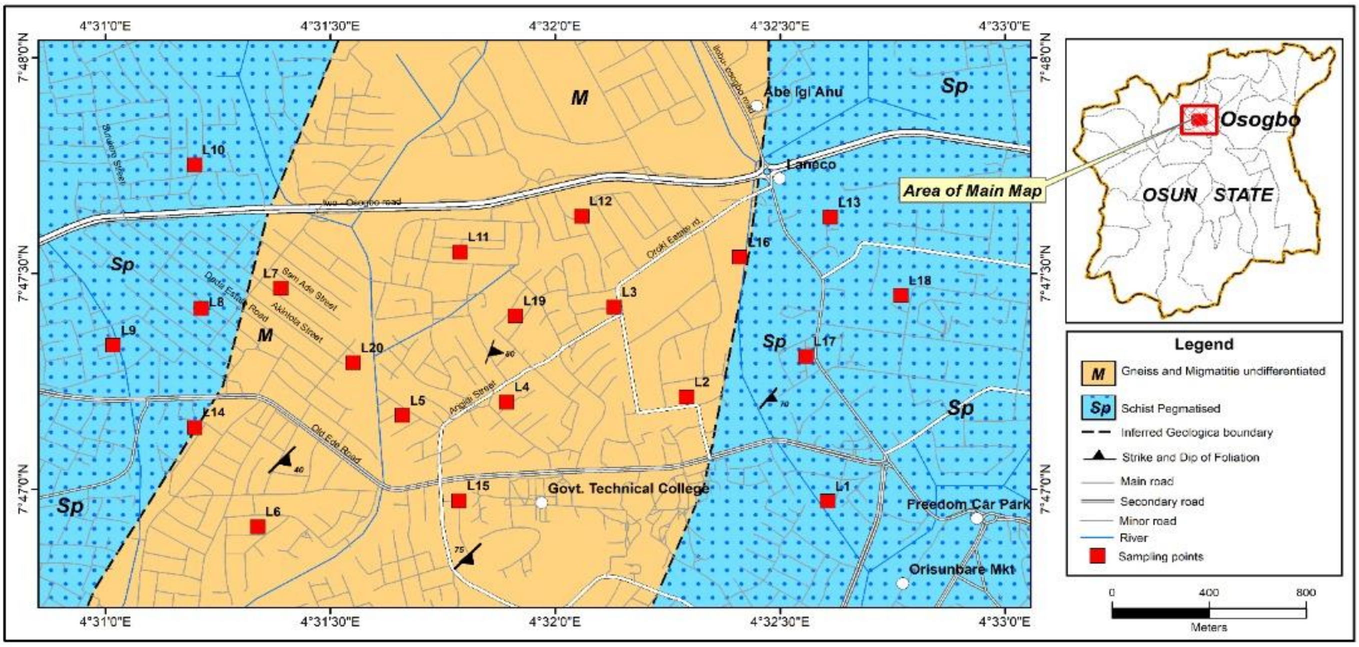

Figure 2: Geological map of the study area with sampling point of the study area

METHODOLOGY

Samples of water were collected from fresh boreholes drilled into the basement complex rocks. Twenty (20) boreholes were randomly sampled (Figure 1), p^H values of the samples were taken at the point of collection using p^H meter and conductivity meter. The cations Na^+, K^+, Ca^{2+} and Mg^{2+} concentrations were determined using PG 990 Atomic Absorption Spectrophotometer. The anions Cl^-, SO_4^{2-} concentration were determined by colorimetric method using UV spectrometer (Ademoroti,1996). Total hardness, Calcium hardness and Magnesium hardness were analyzed with titrimetry. All analyses were carried out at the Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife Nigeria.

Chemical characterization plots including Schoeller and Piper trilinear diagrams were generated for all the samples for chemical water facies classification. Also, the Sodium Adsorption Ratio (SAR) was calculated to determine its suitability for irrigation purpose using Richards'equation (1954):

$$SAR = \frac{Na}{\left(\frac{Ca + Mg}{2}\right)^{1/2}}$$

Table 1: Result of physiochemical parameters

S/N	Location name	Static water level (m)	Temp-erature (°C)	p^H	EC (µmho/cm)	TDS (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	Cl^{-}(mg/l)	SO_4^{2-} (mg/l)	HCO_3^{-} (mg/l)
1	L1	8.6	28.5	6.7	64.7	36.6	2.1	1.6	6.2	1.6	8.0	10.1	7.0
2	L2	7.2	27.0	7.8	47.7	27.5	1.5	1.8	3.0	1.2	7.1	4.8	8.1
3	L3	15	28.0	7.2	45.5	21.3	4.2	2.2	1.2	2.3	7.3	0.4	3.7
4	L4	11.8	28.2	7.0	55.1	29.0	6.3	1.7	1.8	1.8	3.5	8.1	5.8
5	L5	8.2	27.4	6.9	57.9	29.8	7.2	1.9	5.0	2.5	2.8	3.1	7.3
6	L6	14.8	27.6	7.6	59.8	33.7	2.6	2.8	4.3	1.7	7.0	5.2	10.1
7	L7	4.3	27.5	6.8	50.0	27.4	4.4	1.5	3.5	3.0	3.1	5.1	6.8
8	L8	12.1	28.0	7.3	87.7	50.5	6.5	3.2	3.8	4.2	8.2	10.3	14.3
9	L9	7.5	26.5	6.9	78.5	38.1	1.5	8.0	3.8	1.6	6.0	9.2	8.0
10	L10	9.2	29.0	7.5	97.3	47.8	1.8	11.0	2.2	2.2	7.2	12.0	11.4
11	L11	6.9	28.5	7.4	89.9	40.7	1.3	16.0	1.6	1.3	4.0	8.7	7.8
12	L12	6.4	27.5	7.1	57.6	28.5	4.1	4.2	4.0	1.6	2.1	6.0	6.5
13	L13	8.7	27.0	7.0	62.8	32.5	3.8	4.1	4.3	4.1	3.4	4.5	8.3
14	L14	11.2	27.7	7.8	99.6	42.2	5.2	12.8	1.6	1.7	6.3	7.3	7.3
15	L15	13.7	28.0	7.4	52.3	32.1	2.7	2.6	1.3	1.2	4.0	8.2	12.1
16	L16	7.8	28.5	7.6	113.1	45.0	3.1	17	4.2	3.1	3.1	9.7	4.8
17	L17	5.3	27.2	7.2	91.4	42.3	6.2	7.5	6.0	4.3	3.0	10.0	5.3
18	L18	6.2	28.1	7.4	123.1	48.6	6.8	18	5.1	3.6	2.8	5.1	7.2
19	L19	7.0	28.5	6.9	73.5	36.7	4.3	5.0	8.9	2.0	3.5	4.6	8.4
20	L20	9.1	28.5	6.8	70.9	35.8	4.1	6.1	3.2	2.2	6.0	3.2	11.0
	Minimum	4.3	26.5	6.7	45.5	21.3	1.3	1.5	1.2	1.2	2.1	0.4	3.7
	Maximum	15	29	7.8	113.1	50.5	7.2	16.0	8.9	4.3	8.2	12.0	14.3
Average	9.0	27.9	7.2	73.9	35.8	4.0	6.5	3.8	2.4	4.9	6.8	8.1	8.1

RESULTS AND DISCUSSION

Physical Characteristics

The temperature of water samples ranges between 26°C and 29°C and an average of 27.9°C. The range of pH is from 6.7 to 7.8 with mean value of 7.2, which indicated that the water is neutral. The lowest value was measured at location 1 while the highest value was got at location 2 and 14. The TDS was low and ranges between 21.3 and 50.5 mg/l, with a mean value of 35.8 mg/l. The lowest value was measured at Oroki (L3) and highest value was got at Dada Estate area (L8). The colours of the samples were clear. Static water level ranges from 4.3m to 15m with mean value of 9.0m. The lowest value was got from location 7 and the highest value from location 3. The electrical conductivity values ranged from 45.5 to 123.1 µmho/cm and a mean value of 73.9 µmho/cm. Table 1 shows the physical characteristics of the water samples measured on the field at the point of collection of the samples.

The result of the chemical analyses of major cations and anions shows that Calcium has concentration ranging between 1.3mg/l and 7.2mg/l. Concentration of Magnesium ranges between 1.5mg/l and 18mg/l while concentration of sodium ranges from 1.2mg/l to 8.9mg/l and Potassium ranges from 1.2mg/l to 4.3mg/l. The result of Chloride concentration ranges from 2.1mg/l to 8.2mg/l and Sulfate concentration ranges between 0.4mg/l and 12.0mg/l while that of Bicarbonate ranges from 3.7mg/l to 14.3mg/l.

The geochemical data for both cation and anion from Schoeller diagram (Figure 3) shows that: Mg>Na>Ca>K and HCO_3>SO_4>Cl. This is presented in figure 3 and 4 respectively and it shows Mg^{2+} and Ca^{2+} as the dominant cations while HCO_3^- and SO_4^{2-} are the dominant anions. The abundance of Mg^{2+} indicates weathering of basement complex rocks and high concentration of HCO_3^- reveals the dissolution of carbon dioxide gas or dissolution of carbonates rocks underground (Figure 3). Table 2a reveals that all the water samples have low salinity hazard, and hence may be excellent for irrigation purposes (Table 2b), according to Wilcox (1955).

The data were compared with water quality standard by World Health Organization (WHO, 2004) and Nigerian Industrial Standard (NIS, 2015) (Table 3). The mean concentration of the analytes was generally low in all the locations. The generally low concentration of ions makes the water samples good and safe for drinking (Elueze et al., 2004).

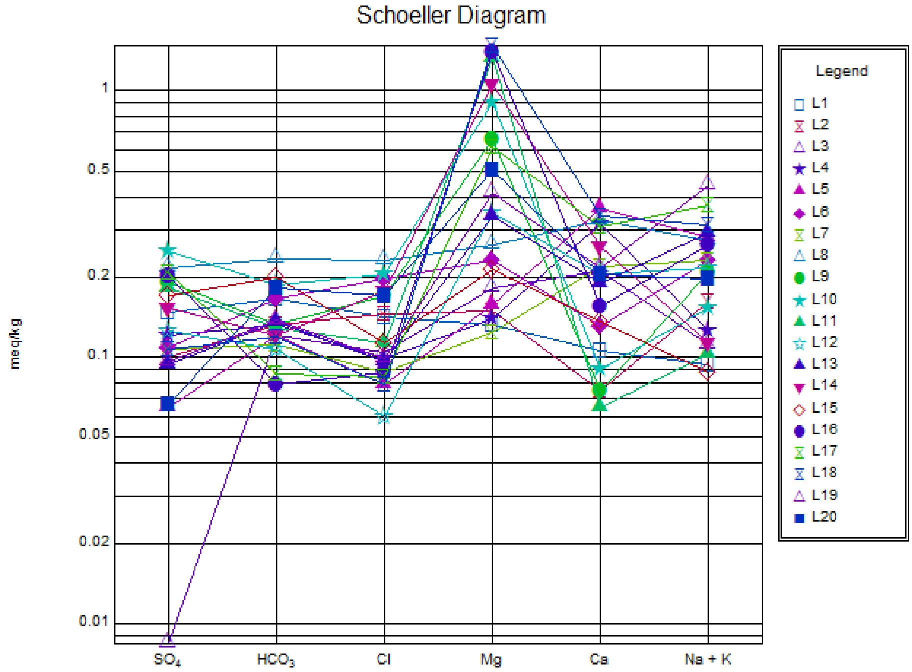

Figure 3: Schoeller Diagram showing Chemical ions in the Water Samples

Table 2a: Classification of the water quality for Irrigation

S/N	Sample Location	Sodium Adsorption Ratio	Salinity Hazard	Water Class
1	E4°32'36.5'' N7°46'59.6''	784×10^{-3}	Low	Excellent
2	E4°32'17.2'' N7°47'13.0''	391×10^{-3}	Low	Excellent
3	E4°32'7.9'' N7°47'25.7''	118×10^{-3}	Low	Excellent
4	E4°31'56.8'' N7°47'12.6''	164×10^{-3}	Low	Excellent
5	E4°31'39.6'' N7°47'9.9''	428×10^{-3}	Low	Excellent
6	E4°31'20.3'' N7°46'54.8''	441×10^{-3}	Low	Excellent
7	E4°31'23.3'' N7°47'28.0''	368×10^{-3}	Low	Excellent
8	E4°31'12.6'' N7°47'24.9''	305×10^{-3}	Low	Excellent
9	E4°31'1.0'' N7°47'19.7''	273×10^{-3}	Low	Excellent
10	E4°31'11.2'' N7°47'45.4''	136×10^{-3}	Low	Excellent
11	E4°31'47.0'' N7°47'32.9''	83.7×10^{-3}	Low	Excellent
12	E4°32'3.1'' N7°47'38.3''	332×10^{-3}	Low	Excellent
13	E4°32'36.3'' N7°47'37.7''	365×10^{-3}	Low	Excellent
14	E4°31'11.8'' N7°47'8.4''	85.9×10^{-3}	Low	Excellent
15	E4°31'47.1'' N7°46'58.6''	135×10^{-3}	Low	Excellent
16	E4°32'24.1'' N7°47'32.7''	207×10^{-3}	Low	Excellent
17	E4°32'33.1'' N7°47'18.4''	383×10^{-3}	Low	Excellent
18	E4°32'46.1'' N7°47'27.4''	233×10^{-3}	Low	Excellent
19	E4°31'54.3'' N7°47'23.8''	692×10^{-3}	Low	Excellent
20	E4°31'32.7'' N7°47'17.9''	234×10^{-3}	Low	Excellent

Table 2b: Classification of water quality for Irrigation (Wilcox, 1955)

Sodium Adsorption Ratio	Salinity Hazard	Water class
0 – 10	Low	Excellent
10 – 18	Medium	Good
18 – 26	High	Permissible
>26	Very High	Doubtful

Table 3: Comparison of mean concentration of analyte with WHO and NIS standard

Analyte	Range	Mean	WHO 2004	NIS 2015
Ca(mg/l)	1.3 – 7.2	4.0	7.5 – 200	-
Mg(mg/l)	1.5 – 18	6.5	50 – 150	0.2
Na(mg/l)	1.2 – 8.9	3.8	2.0 - >200	200
K(mg/l)	1.2 – 4.3	2.4	1.0 - >12	-
Cl(mg/l)	2.1 - 8.2	4.9	200 – 400	250
SO_4(mg/l)	0.4 – 12.0	6.8	30 – 50	100
HCO_3(mg/l)	4.8 – 14.3	8.1	200 – 600	-
p^H	6.7 – 7.8	7.2	6.5 – 9.0	6.5 – 8.5
Temperature °C	26.6 – 28.5	27.9	-	-
Conductivity (µmho/cm)	45.5 – 123.1	73.9	250	1000
TDS (mg/l)	21.3 – 50.5	36.3	500 – 1500	500

Water Facies Types

Plots of the hydrochemical parameters of the water samples on Piper trilinear diagram (Figure 4) indicates the presence of Mg-HCO_3^-, Ca-HCO_3^-, Mg-Cl and Mg-SO_4water types and also indicates Mg^{2+} and Ca^{2+} as the dominant cations while HCO_3^- and SO_4^{2-} are the dominant anions in several samples of the groundwater. The presence of Mg-HCO3 and Ca-HCO3 in the water is as a result of precipitation, during the travel of rainfall through soil, sediment, and rock to reach an aquifer, the water dissolve additional solid. As they increases in the water, it can lead to harness of the water.

Mg-HCO3 occupied 30% of the water type analyzed, Mg-Cl took 15%, Ca-HCO3 took 25%, while Mg-SO4 took 30%. This is presented in the pie chat in Figure 5. Table 4 shows the different water types at the various locations. Figure 6 shows the water type distribution map, indicating relationship of different water types against various locations.

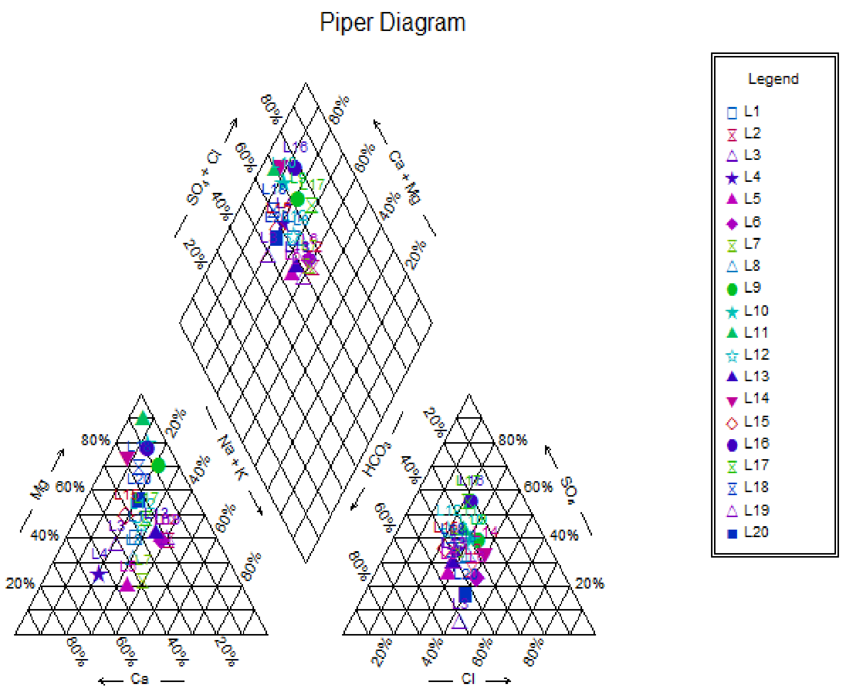

Figure 4: Classification of water types for the water samples in the study area on Piper's (1944) Trilinear Diagram

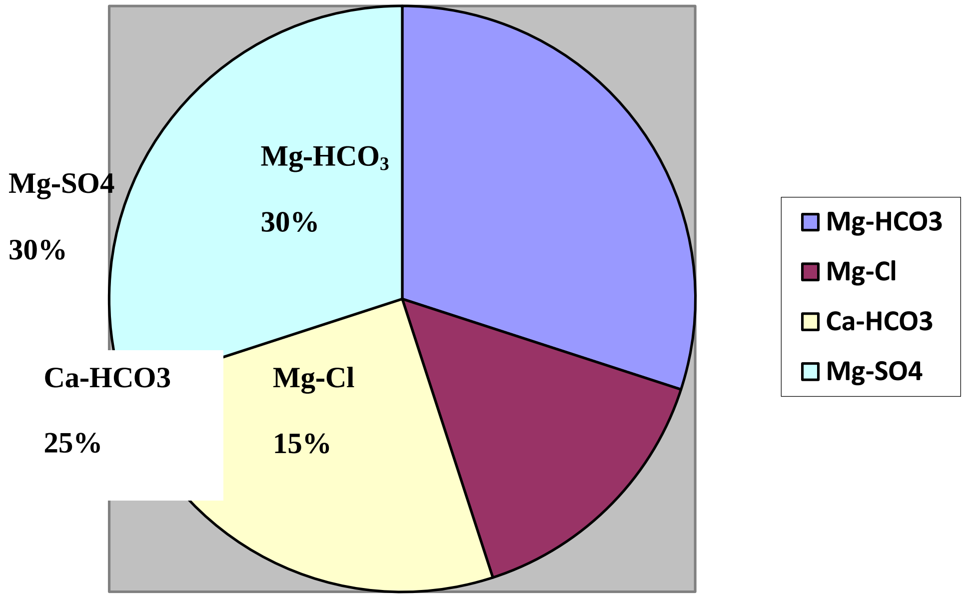

Figure 5: Pie chart showing percentage distribution of each water type

Table 5: Water types for the study area

S/N	Location	Water type
1	E4°32'36.5'' N7°46'59.6''	Mg-HCO_3
2	E4°32'17.2'' N7°47'13.0''	Mg-Cl
3	E4°32'7.9'' N7°47'25.7''	Ca-HCO_3
4	E4°31'56.8'' N7°47'12.6''	Ca-HCO_3
5	E4°31'39.6'' N7°47'9.9''	Ca-HCO_3
6	E4°31'20.3'' N7°46'54.8''	Mg-Cl
7	E4°31'23.3'' N7°47'28.0''	Ca-HCO_3
8	E4°31'12.6'' N7°47'24.9''	Ca-HCO_3
9	E4°31'1.0'' N7°47'19.7''	Mg-SO_4
10	E4°31'11.2'' N7°47'45.4''	Mg-SO_4
11	E4°31'47.0'' N7°47'32.9''	Mg-SO_4
12	E4°32'3.1'' N7°47'38.3''	Mg-SO_4
13	E4°32'36.3'' N7°47'37.7''	Mg-HCO_3
14	E4°31'11.8'' N7°47'8.4''	Mg-Cl
15	E4°31'47.1'' N7°46'58.6''	Mg-HCO_3
16	E4°32'24.1'' N7°47'32.7''	Mg-SO_4
17	E4°32'33.1'' N7°47'18.4''	Mg-SO_4
18	E4°32'46.1'' N7°47'27.4''	Mg-HCO_3
19	E4°31'54.3'' N7°47'23.8''	Mg-HCO_3
20	E4°31'32.7'' N7°47'17.9''	Mg-HCO_3

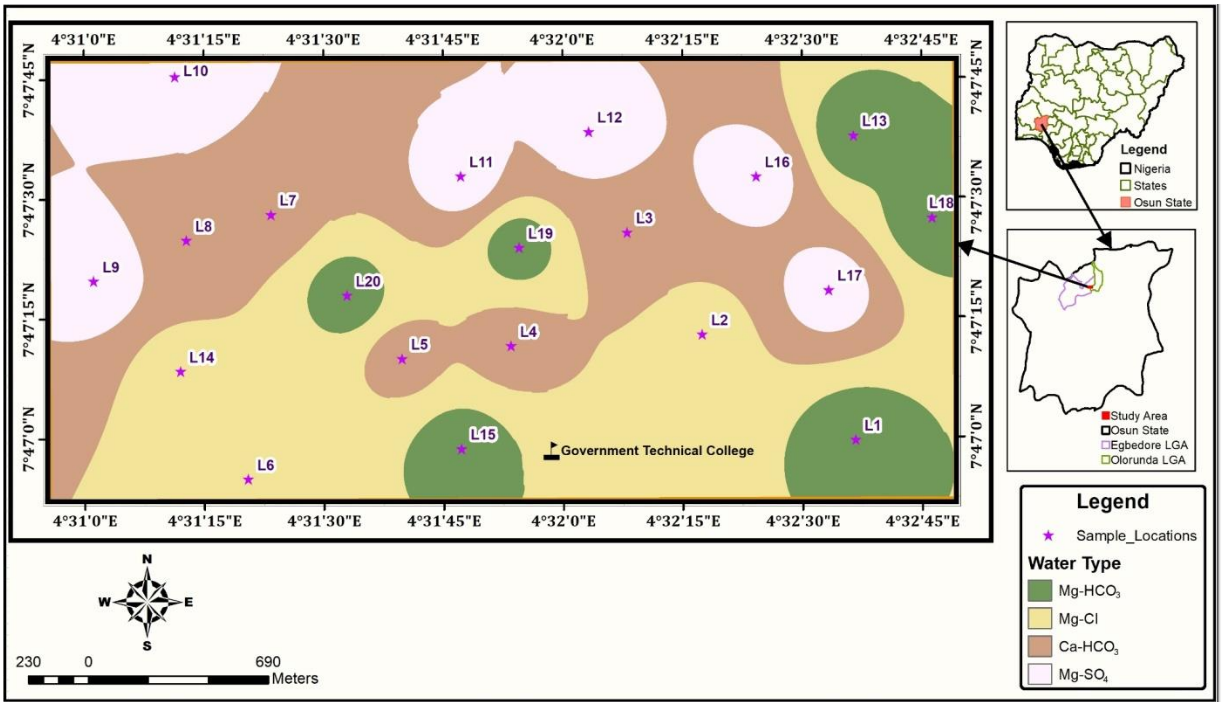

Figure 6: Water type distribution map

CONCLUSION

Water quality evaluation of the groundwater in part of Oshogbo metropolis shows that the conductivity, p^H, Total Dissolved Solid (TDS), Mg^{2+}, Na^+, Ca^+, K^+, Cl^+, SO_4^{2-}, HCO_3^- are within the WHO(2004) and Nigerian Industrial Standard (NIS,2015) desirable and permissible limits and indicate that the water in the study is good and safe for drinking. All the water samples have low salinity hazard, and may be excellent for irrigation purpose. The major cations from the water facies indicate that Calcium and Magnesium are geogenic in origin and are as a result of interaction of water and the underlying rocks and are reflective of water derived from fresh rock and weathering of basement complex rocks.Concentration of Cl-HCO_3^- and SO_4^{2-}can be attributed to increasing population and industrial growth within the metropolis, although the concentration is not Water with low ionic concentration is believed to be safe for human consumption. The graphical interpretations also show that the water in parts of Oshogbo metropolis is Mg^{2+} + Ca^{2+}- HCO_3^- water type, hence, safe for drinking. However, monitoring of groundwater quality including bacteriological analysis should be undertaken periodically

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