GROUNDWATER QUALITY OF DUTSEN WAI, NORTH WESTERN NIGERIA

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ABTRACT
Groundwater quality was obtained by analysing water samples from 22 hand dug wells at different locations for both physical and chemical parameters. The work was carried out studying various geological formations by analysing hand specimen of different rock samples and through thin section analysis, geological map of the study area was updated. Groundwater configuration maps using various measurements obtained from the wells were also obtained. Results show that the area has fine to medium grained biotite granite, ignimbrite and migmatites. The groundwater flows are parallel to the hydraulic gradient and perpendicular to the water table contours and flows from area of recharge to area of discharge. The depth of water table is thicker at the recharge area and thinner at the discharge area. The concentration of all elements analysed fall within the WHO standard except for nitrates which ranges between 6.0 to 12.0mg/l but falls above WHO standards. This is due to organic sources and agricultural practices in the area. Schoeller and Piper plots show that the water types to be the NaSO42- and the Ca (Mg) HCO3 water type and belong to freshwater classification.

KEYWORDS: *Groundwater quality, Dutsen wai, Groundwater configuration maps*

INTRODUCTION

Fresh water is a requirement of all living beings but its availability in its natural form is threatened by the activities of man. This has lead to the mixing of many pollutants with the natural water, among these are the artisanal mining engaged upon by many without formal training. This may lead to environmental catastrophes. Water quality refers generally to various chemical, physical, and biological characteristics. The required "quality" of water depends greatly on the purpose for which it is intended (e.g. drinking, swimming, or fishing), but it is mostly linked to drinking water standards. The influence and importance of water quality on society are illustrated by the acute human health problems related to lead poisoning as experienced in Zamfara state.

The groundwater occurrence and accessibility has been inconsistent due to variation in geology and climatic conditions. Both, the unmanaged utilization as well as excessive groundwater exploitation are exclusively responsible for lowering of groundwater levels, and in some instance its degradation resulting from the nature of its usage. The Banke complex has been a tin producing area for over fifty years and so. This still continue but presently at local level especially at Dutsen Geny where the locals were seen mining cassiterite and wolframite as shown on the plate below.

Plate 1: Artisanal Miners Mining Cassiterite at Dutsen Genya

The present study attempts a study of the hydrochemistry of the Dutsen Wai area with the sole aim of determining the suitability of the water for domestic and agricultural uses.

The Study Area

The Dutsen Wai area is located within the Nigerian basement complex almost entirely underlain by the migmatite gneiss complex which was later intruded by the Mesozoic Anorogenic Younger Granites extrusive (Banki complex). The banke complex, located 45 km east of Dutsen wai, 20 km Northwest of Ririwai and 15 km north east of Kudaru complex (Fig. 1) belongs to the group of the Jurassic Anorogenic ring complexes of Nigeria. It occupies an area of about 228 Km^2 of which over a third consist of basement rocks enclosed within the ring structure.

The area is drained by River Banki and its tributaries running from the northern region to the southern part of the study area.

GENERAL GEOLOGY / HYDROGEOLOGY OF THE STUDY AREA

Geology of Crystalline Basement Complex Rocks

The crystalline basement rocks are composed of hard, crystallized or re-crystallized rocks of igneous and metamorphic origin. They occur as granites, gneisses, migmatites, schists, phyllites, pegmatites or quartzites.

In Nigeria, the basement complex is one of the major litho-petrological components that make up the Geology of Nigeria. According to Obaje (2009), it is part of the Pan-African mobile belt and lies between the West African and Congo cratons, and South of Toureg shield. It is intruded by the Mesozoic calc-alkaline ring complexes (Younger granites) of the Jos-Plateau and is uncomformably overlain by Cretaceous and Younger sediments. It was affected by the Pan African Orogeny (600ma). Within the basement complex of Nigeria four (4) major lithological units are found namely:-

- The migmatites-gneisses complex
- Metasediments and metavolcanics rocks

schist belt
- The Older Granites (Pan African granitoids)
Undeformed Acid and Basic dykes

Hydrogeology of Basement aquifers

Basement aquifers developed within the weathered overburden and fractured bedrock of crystalline rocks of intrusive and /or metamorphic origin that are mainly of Precambrian age (Wright and Burgess, 1992).

It is believed that, in weathered regolith groundwater is found in intergranular spaces between mineral grains, while in unweathered basement rocks it is stored in interconnected systems of fractures, joints and fissures that are associated with regional tectonism. However, poor connectivity of the bedrock fractures and low permeability, results in significant local variations in yield and this can cause local variation of the hydraulic conductivity within the same rock mass, over short distances.

The aquifer systems developed are:-

1. Alluvial aquifer; alluvial material overlies the weathered overburden and create a distinct intergranular aquifer type. These elongated aquifers follow rivers or drainage lines with limited width and depth, which vary according to the topography and the climate.
2. Composite aquifer; comprising of a variable thickness of regolith overlying bedrock.
3. Fractured aquifer; composed mainly of crystalline materials (i.e. igneous and metamorphic rocks) characterized by an intact and relatively unweathered matrix with a complex arrangement of interconnected fracture systems.

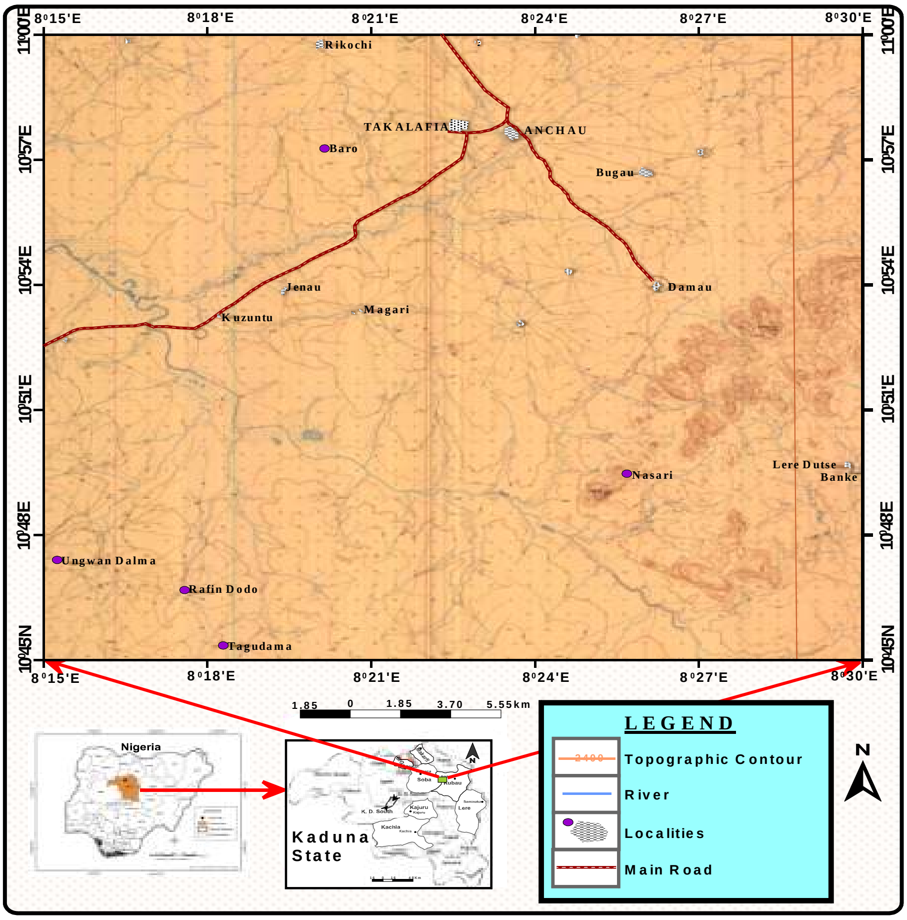

Figure 1: Location map of the study area

Material and Methods

The field work which entails both litho logical and hydrogeological mapping was carried out both at the on-set of dry season (signifying peak dry season) and the peak of rainy season (signifying peak rainy season). But sample collection for hydrochemistry was done during the dry season and was done in accordance to APHA (1995) specifications. Physical parameters which include; pH, Temperature, Dissolved Oxygen, Turbidity, Salinity and Electrical Conductivity were measured in situ, then followed by water samples collection. The method of analysis was done by collecting 22 water samples in 0.5 litre plastic containers from various hand dug wells for physico chemical analysis. The water samples were neutralised using dilute nitric acid before taking to the multi-user lab of ABU Zaria for analysis using the AAS machine.

RESULTS AND DISCUSSIONS

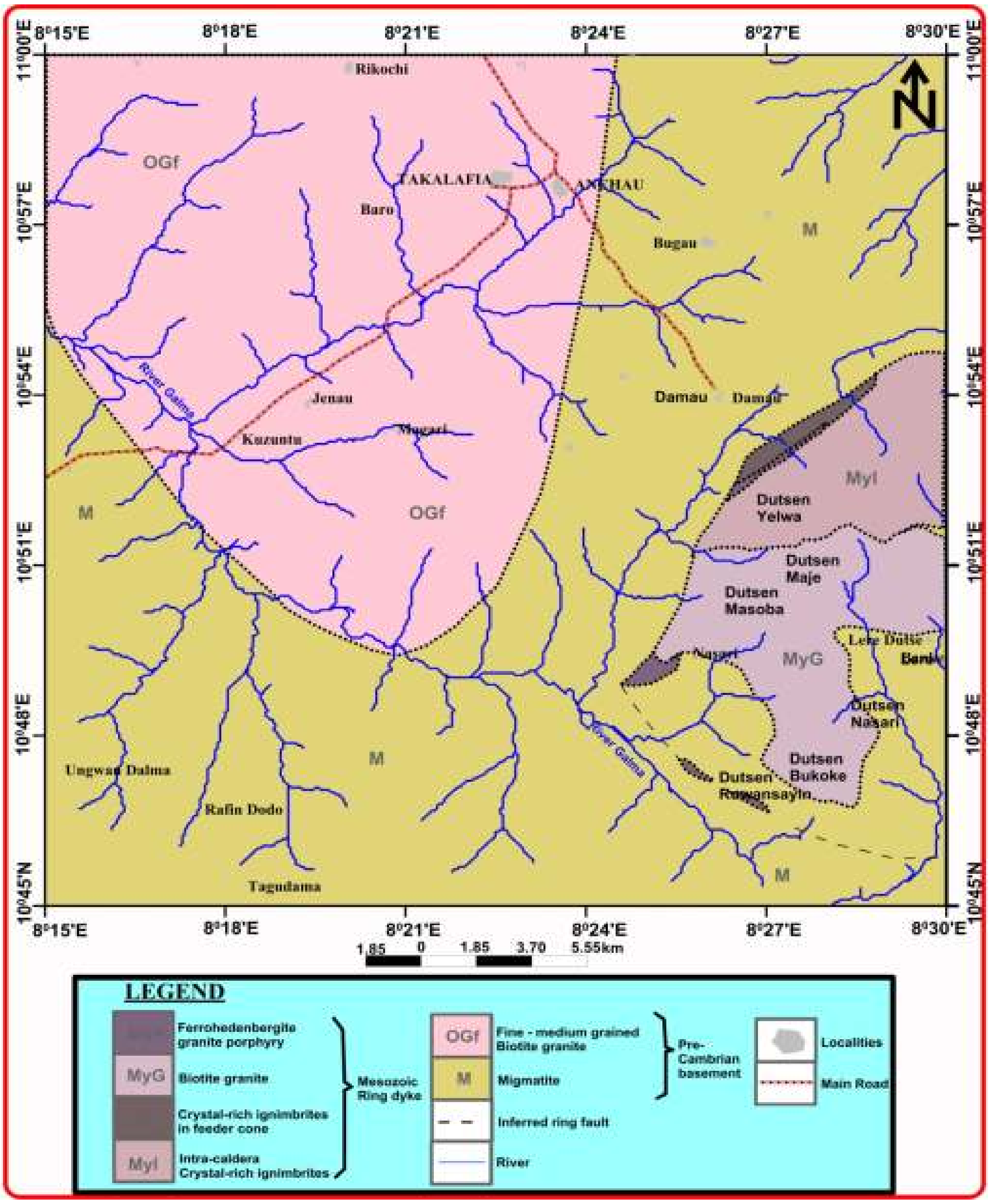

FIGURE 2: Geological map of the study area

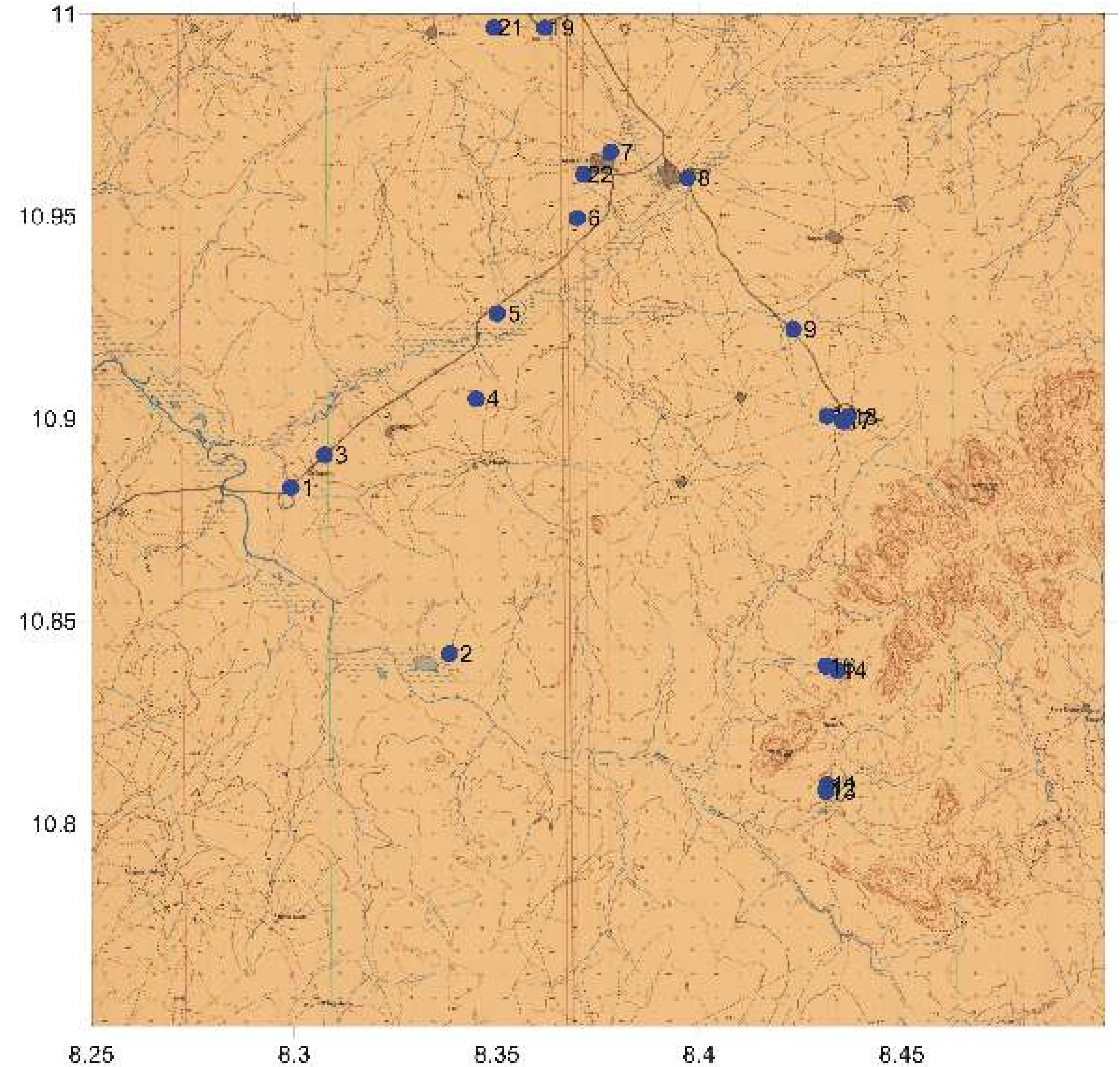

Figure 3: Map showing Sampling location

TABLE 1: The results of the peak dry season test of the physical parameters are as follows:

WELL NO	LAT.	LONG.	pH	COND. mS/m	TEMP. °C	SALINITY (mg/l)	TURB. (NTU)	DISSOLVED OXYGEN (mg/L)
1	10°52.985	8°17.950	9.46	10.6	26.3	0.0	438.3	49.97
2	10°50.516	8°20.259	9.35	13.6	28.8	0.0	55.0	43.88
3	10°53.468	8°18.452	9.36	10.1	26.9	0.0	76.9	48.45
4	10°54.299	8°20.691	9.48	0.103	27.5	0.5	158.0	24.84
5	10°55.563	8°21.008	9.12	33.4	26.8	0.1	119.9	46.56
6	10°56.974	8°22.197	9.21	7.5	26.6	0.0	109.9	30.17
7	10°57.568	8°22.689	9.20	13.6	27.6	0.0	39.5	31.22
8	10°57.568	8°22.689	9.21	41.8	28.0	0.2	14.9	40.10
9	10°53.327	8°25.393	9.20	10.5	28.9	0.0	121.4	43.49
10	10°54.043	8°25.894	9.39	17.2	27.9	0.0	37.2	8.40
11	10°48.580	8°25.829	9.05	23.6	27.7	0.1	262.8	26.95
12	10°48.524	8°25.882	9.18	31.5	27.9	0.1	50.5	45.77
13	10°48.483	8°25.879	9.16	46.3	27.1	0.2	90.3	38.36
14	10°50.277	8°26.049	9.05	43.7	28.0	0.2	432.7	45.06
15	10°50.321	8°26.041	9.32	20.1	27.6	0.0	71.1	46.72
16	10°50.340	8°25.873	9.29	39.4	27.1	0.1	136	23.63
17	10°53.965	8°26.120	9.32	54.0	26.6	0.2	17.3	39.76
18	10°54.034	8°26.202	9.40	48.4	26.7	0.2	16.7	41.62
19	10°59.797	8°21.701	9.27	15.5	25.9	0.0	22.9	48.93
20	11°00.081	8°22.573	9.27	4.1	26.0	0.0	176.3	27.30
21	10°59.802	8°20.954	9.16	7.4	26.4	0.0	155.7	41.59
22	10°57.623	8°22.286	9.12	6.4	27.8	0.0	59.4	25.44

Table 2: Results for chemical analysis data for peak dry season

S/N	CO_{3-} (mg/l)	HCO_{3-} (mg/l)	Cl- (mg/l)	NO_3 (mg/l)	SO4 (mg/l)	K (mg/l)	Na (mg/l)	Ca (mg/l)	Zn (mg/l)	Pb (mg/l)	Cu (mg/l)	Mg (mg/l)	Hg (mg/l)
1	0.00	0.3334	0.6500	6.000	2.67	7.60	5.10	0.068	0.061	0.00	0.013	1.133	1.202
2	000	0.8667	0.5500	7.0000	4.83	4.30	14.00	4.593	0.005	0.00	0.00	1.701	1.164
3	0.00	0.8667	0.4500	6.0000	13.75	5.20	2.00	7.174	0.109	0.00	0.00	1.290	1.006
4	0.00	8.2004	18.0000	15.0000	5.00	120.00	68.00	59.183	0.129	0.00	0.00	8.572	1.25
5	0.00	0.3334	1.2000	10.0000	1.50	18.00	17.00	8.481	0.031	0.00	0.00	2.946	1.105
6	0.00	0.6000	0.6000	12.0000	0.50	4.10	3.40	5.302	0.014	0.00	0.00	0.660	0.824
7	0.00	1.0000	9.0000	8.0000	2.00	5.60	3.40	20.052	0.013	0.00	0.00	0.448	0.990
8	0.00	1.5334	2.0500	8.0000	9.17	12.00	36.00	32.991	0.015	0.00	0.00	4.435	1.019
9	0.00	0.5334	0.7000	8.0000	13.67	4.50	9.40	13.773	0.012	0.00	0.00	1.528	1.060
10	0.00	0.8667	0.9000	10.0000	0.67	8.50	8.30	26.289	0.035	0.00	0.00	1.310	1.093
11	0.00	0.4667	1.2000	6.0000	2.67	13.0	19.00	3.639	0.034	0.00	0.00	2.700	1.273
12	0.00	0.6001	1.1500	10.0000	0.67	7.40	23.00	19.826	0.020	0.00	0.00	3.441	1.063
13	0.00	0.4667	1.8000	26.0000	2.67	14.0	41.00	21.805	0.028	0.00	0.00	5.786	1.283
14	0.00	0.3334	1.4000	25.0000	2.33	14.00	33.00	19.865	0.034	0.00	0.00	3.012	1.301
15	0.00	0.7334	0.9500	12.0000	2.17	7.20	23.00	5.993	0.034	0.00	0.00	1.354	1.278
16	0.00	1.4667	2.0000	10.0000	7.17	18.00	41.00	6.821	0.022	0.00	0.025	2.786	1.482
17	0.00	2.8001	1.6500	5.0000	2.50	20.00	30.00	60.678	0.040	0.00	0.00	5.246	1.350
18	0.00	2.0668	1.3500	7.0000	1.83	33.00	19.00	47.784	0.057	0.00	0.007	5.391	1.583
19	0.00	0.4000	1.0500	11.0000	0.67	3.00	18.00	5.491	0.012	0.00	0.00	1.633	1.266
20	0.00	0.5334	0.4500	7.0000	10.50	3.10	6.00	1.410	0.013	0.00	0.002	0.625	1.655
21	0.00	0.8000	0.4500	6.0000	9.17	3.50	14.00	1.855	0.005	0.00	0.00	0.665	1.676
22	0.00	0.4667	0.5500	5.0000	4.67	2.80	6.40	2.742	0.004	0.00	0.00	0.961	1.674

Interpretation of groundwater chemistry

The geochemical evaluation of groundwater can be understood by plotting the concentration of major cations and anions in the piper diagram (Piper, 1944). In this diagram the relative abundance of cations i.e. Na+K, Ca and Mg in % meq/l is plotted on the cation triangle followed by the relative abundance of anions i.e. $Cl+NO_2=NO_3$, SO_4^- and HCO_3+CO_3 in % meq/l is plotted on the anion triangle. The central diamond-shaped field (quadrilateral field) is used to show overall chemical character of the water (Piper, 1944). Thus, the piper diagram directly deciphers the groundwater quality, and as a result it is commonly used as an effective tool to specify different water-types. In general, piper diagram reveals six types with nine combinations, according to ionic placement in the diamond field. The Piper's trilinear diagram (Piper, 1944) prepared for the samples from the study area is presented in Figure 7. The plots of the chemical data on Piper's trilinear diagram show that non carbonate alkalis exceed 50% in the groundwater samples of the study area.

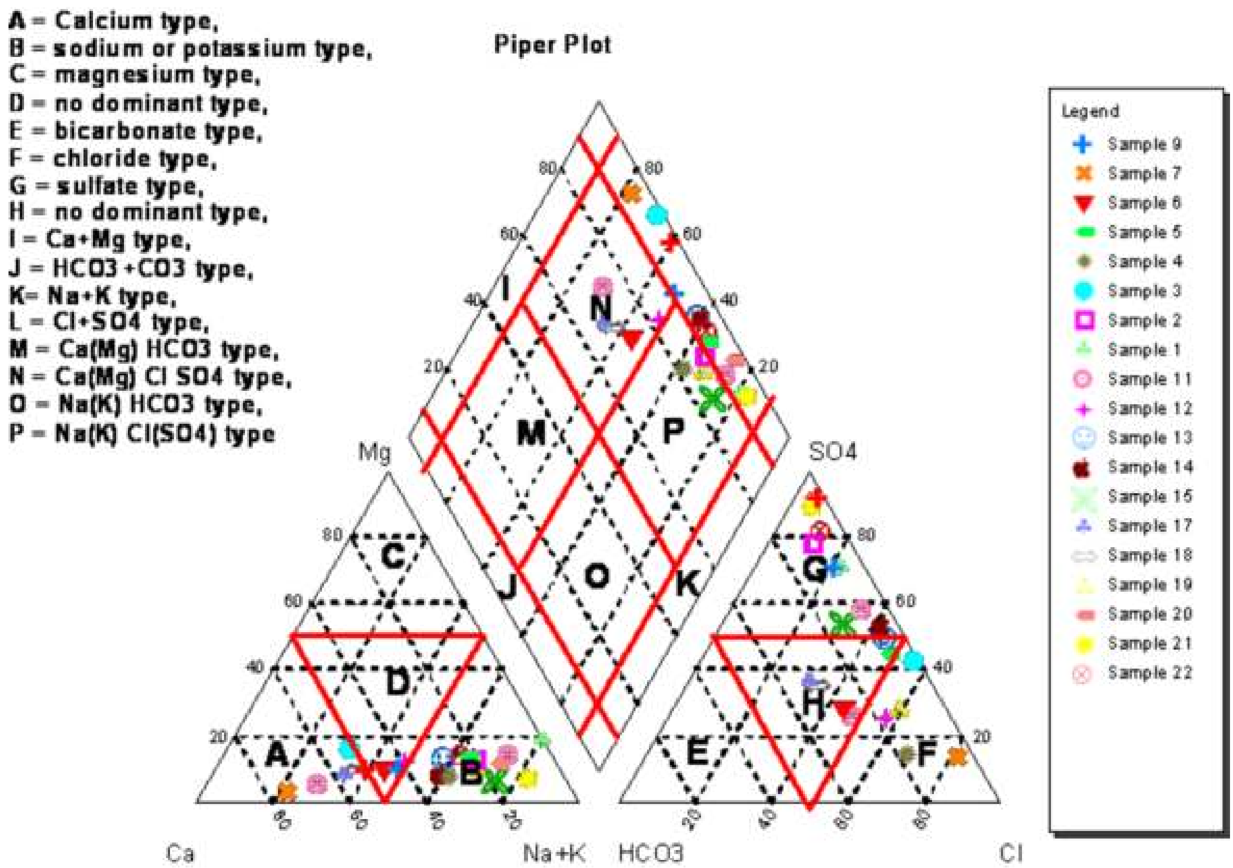

Figure 7: Piper trilinear diagram showing variation of milliequivalent percentages of major ions in water samples.

The Piper's trilinear diagram (Figure7) shows that the groundwater contains dominant of Na and Ca for the Cations and SO_4^{2-} and Cl for the anions and it falls within group P and can be called a Na-SO_4^{2-} water type and group M which is the Ca(Mg) HCO_3 water type and belongs to freshwater. The interpretation is based on (Back and Hanshaw, 1965) water types.

Using Schoeller's semi – logarithmic diagram, an attempt have been made to subdivide the water into groups according to the various ionic concentrations (Schoeller, H.1955). On the average, the water belongs to the same group. On the whole, the ionic concentration of the groundwater here is typical of crystalline and magmatic rock regions

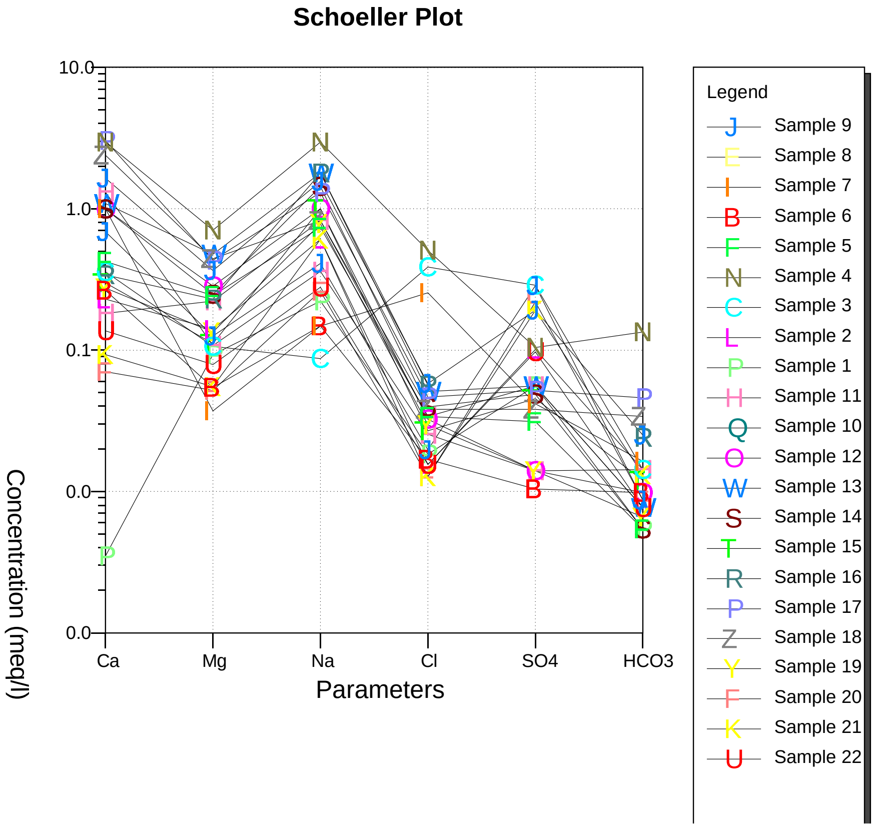

Figure 8: Schoeller semi-logarithm plot of groundwater-chemistry data

Conclusion

The depth of the water table is highly variable in the area, and from the elevations mapped and studied in detail, the depth to water level in wells coincides with the water table. Its pattern is usually a subdued replica of the surface topography, reaching its highest elevations beneath the watersheds and then flows towards the valleys into streams.

The result of water analysis showed the water in the study area is of meteoric origin and is potable for both domestic and agricultural use based on the W.H.O. But, based on the standard of water from Nigerian drinking water standard, it is slightly contaminated probably by residential pollution and agricultural activities.

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