Hydrochemical Characterization of Groundwater of Chanchaga and Its Environ, Minna North Central Nigeria

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Abstract- This research study focuses on hydro-geochemistry of Chanchaga area which is an integral part of Minna North Central, Nigeria. The area is underlain by the Precambrian Basement Complex such as Schist, Migmatite Gneiss and Granites. These rocks are dominantly structured in NE – SW and N – S directions. These structures have effect on both surface drainage pattern and influence the groundwater flow directions. The Hydrogeological mapping entailed the measurement of groundwater table of hand-dug wells and subsequent sampling exercises. Twenty one (21) water samples were taken for physic-chemical analysis from both hand-dug wells and hand pump bore holes including one sample from Bosso dam for standard laboratory analysis at the Federal Ministry of Agriculture, Water Quality Laboratory, Minna-Niger State. The chemical analysis revealed the concentrations of hydrochemical parameters in the following range order: Temperature (28.1 – 31.3 °C), TDS (0.06 – 0.47ppm), Electrical conductivity (0.01 – 0.96 µs/cm), pH (5.55 – 7.2), salinity (1.1 – 1.9Mg/l), Turbidity (0.8 – 37NTU), Na^+ (19.74 – 92.8Mg/l), K^+ (0.94 – 54.4Mg/l), Ca^{2+} (8.02 – 92.8Mg/l), Mg^{2+} (0.49 – 55.6Mg/l), Cl^- (11 – 156Mg/l), SO_4 (0 – 69Mg/l), HCO_3 (0 – 429Mg/l), CO_4 (0 – 98Mg/l), Cu^{2+}(0 – 13.9Mg/l) and Fe^{2+} (0 – 2.6Mg/l). From parametric comparism with WHO standards all the parameters under considerations fall below the maximum permissible limit except some very few parameters that revealed maximum concentration slightly higher to the recommended limits in some of the area. From correlation matrix Na^+ shows positive significant correlation between TDS, Cl^-, and SO_4 (r = 0.542, 0.698, 0.594) respectively, which suggest that the aquifer chemistry is control by those elemental constituents. In the same vein Mg^{2+} depict significant positive correlation between Cl^- and SO_4 (r = 0.586 and 0.461). Piper diagram revealed three different facies which can be grouped into two zones: Earth alkali freshwater and area of alkali freshwater, it can be subdivided into bicarbonate type of water and sulphate type including sulphate-chloride type. The presence of bicarbonate in the water indicates that the twenty one wells were variously sunk in Calcium bearing granite gneiss while the Carbonates are the products of reaction between Carbon dioxide and rain water. Also some location has sulphate – Chloride type which might be the resultant influence of the pollution from municipal water and waste products. Despite the low-medium enrichment of the ionic parameters present in the groundwater of the study area, still there is need for further treatment before use especially for domestic purposes.

Index Terms- Geology, Hydrogeology, Hydrochemistry, Multivariate, Basement Complex.

I. INTRODUCTION

Groundwater is the most reliable water supply source for domestic, agricultural and industrial use in Nigeria and other countries across the world. However, despite its reliability, this precious and vital resource is under increasing threats attributed to above ground anthropogenic activities related to uncontrolled urbanization, incessant waste disposal and poor land use management. Also, the usefulness of groundwater to humans essentially depends on its chemical status, thus, assessment of groundwater quality is important for socio-economic development of most developing and developed countries of the world. Groundwater quality is an important factor in the context of sustainable water management, the integrity of underlying aquifers are mainly affected by pollution from above ground sources (Kumar *et al*., 2013) particularly solid waste disposal. Uncontrolled urban growth and its resultant effect, especially in developing nations like Nigeria, can adversely affect the quality of underlying groundwater if not properly controlled (Foster *et al.,* 1998; Putra, 2008). Once groundwater is contaminated; its quality cannot be restored and it is very expensive, and difficult to clean it up (Ramakrishnaiah *et al.,* 2009).

Water pollution has seriously affected many rivers, lakes and even parts of the ocean. Minna the capital city of Niger State Nigeria is undergoing rapid development and population increases. In the last decade, these factors have put great pressure on the existing surface water supply. The first dam, (Bosso) has been found inadequate to meet the water needs of the State Capital. The new dam on Chanchaga River has not been able to solve the problems either, Hence, the government and the people have resulted into groundwater development, however without considering quality aspect of the water sources. In view of the mineralization of the schist belt terrain especially with gold, there is a need to understand the groundwater quality and type. This is what has necessitated this study to evaluate the water type and the trace metal characteristics in Chanchaga area (Radiojevic and Bashkin, 1998).

In north central Nigeria, efforts have been made to evaluate the quality and quantity of groundwater in recent years

(Olasehinde, 1999). There has been upsurge in the demand for water in the area in recent years. This necessitated the needs to find a supplement to surface water resources for rapidly growing city for an adequate management of water resources, a thorough knowledge of chemical, physical and biological properties is highly essential (Olasehinde, 1999).

Thus, there is the need for a timely and intensive research and acquisition of detailed geochemical data on groundwater in order to determine the use to which they can be put.

II. THE STUDY AREA

The area lies within longitude 6°29´E to 6^0 38´E and latitude$9^0 26^1$N and$9^0 39^1$N. It lies South of Minna the Capital of Niger State, North central Nigeria. The area is about 342 square kilometers. The area is bounded by Bosso dam in the North, Maitumbi, Gurusu in the East, Shannu, Gbaiko Shakotta, Dutse kura in the West and Chanchaga, Kpakungu and Gurara in the South. It is highly accessible by a series of major roads such as Minna – Abuja, Minna – Kaduna, Minna – Bida, Minna – Kontagora and also by rail line that passes through Mobil – Kaduna. There are also fairly large network of minor roads that links various settlements in the area.

III. MATERIAL AND METHODS

A geological mapping was conducted by transverse methods a compass/clinometer was used for transverse and measurement of structural trends, such as dip and strike. A topographical map on a scale 1; 25,000 enlarged from Minna Sheet 164 was used. For the purpose of this study fifty – two locations were studied to determine their static water level for groundwater flow, thirty eight locations were used for determination of physical parameter. The water samples were from hand pumped boreholes, hand dug wells and one sample from Bosso dam (Table 1). Plastic bottles and bucket were used in the field. Measuring tapes and Geographic positioning system (Extrex G.P.S) and compass were used for water level measurements. Research methodology follows by collection of twenty one water samples which cover about 342 square kilometer in the study area for analysis at the Federal Ministry of Agriculture, Water Quality Laboratory at Minna in Niger State and the environment of each water samples were critically described. Prior to the transportation of samples to the Water quality laboratory the in-situ measurements of the physical parameter such as pH, Electrical Conductivity, Total Dissolve Solids, Total hardness, Turbidity, Salinity, BOD and COD were conducted. The same water samples was also used in the determination of major ions (Na^+, K^+, Ca^{2+},Mg^{2+},Cu^{2+}, Fe^{2+}, As^{2+}, Cl^-, SO_4^{2}-, HCO_3-, CO_3^{2}-) using APHA (1998) laboratory methods. The following methods were employed to determine the concentration of different chemical species in well, borehole, and stream which are: Flame photometry for Na^+ and K^+, Atomic Absorption Spectrometry for Fe^{2+}, Ca^{2+}, and Mg^{2+}, Titrimetric method for HCO_3-, CO_3^{2} and Cl^-, Calorimetric method for SO_4^{2}-.

The result of the water analysis were presented in different ways to see the relationship between the contents of various ion and to decipher the general variation in water chemistry from one location to the other from various points of accumulation in hand dug wells, boreholes and surface water. Cation and anion balance was computed to check the accuracy of the analysis, while bar chart, pie chart, Piper Trilinear and stiff diagrams were also drawn to see if there is possible classification of water within the aquifer.

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Table 1: location of well samples in Chanchaga area

Samples number	Sample location
1	Bosso dam
4	Shapata
7	Maitumbi
11	New gurusu
12	Old gurusu
13	Dana Pharmaceutical
14	Ruga Fulani
15	Soukakauta
17	Shakaouta
21	Gwadeyi
22	Kinkapa
23	Bosso area 11
26	Shanu
27	Dutse-kura gwari
29	Govt,Day Sec school
35	Tudunwada, Minna
36	Tunga Lowcost
41	Cshanchaga
42	Tunga Goro
43	Tunga Alade
44	Federal Govt, College

4.0 RESULTS AND DISCUSSION

4.1 Local Geology of the Area

The study area belongs to the crystalline basement complex of the North-Central Nigeria. About three litho-stratigraphic units were indentified during the mapping exercises which are Migmatite gneiss, Schist and Granite rock types (Figure 1). The basic structures that appear on the rock mass were Joint, Foliation, Quartzo-Feldspathic veins, fault and exfoliation that are generally trending in NE – SW directions. Migmatite gneiss are the products of clear reaction between the host rocks and they occur in high grade metamorphic terrain, which shows heterogeneity of texture and / or mineral composition not directly inherited from an igneous precursor.

They are the most extensive rocks in the locations occupying more than 30% of the study area. They are difficult to categorizing the Migmatitic rocks, because they appear to be quite persistence over entire basement complex of Nigeria. These rocks are generally classified as lit – par – lit Migmatite which are convectional in their component deposed in parallel order. They are extensively weathered and lateralized. Their mineral components are mainly Microcline, Quartz with some plagioclase, Biotite and Muscovite. They expose at Tundun Fulani and along bye- pass (Sannu, Gbaiko , Kwalkwata and Ruga Fulani).

The schist found in Chanchaga area is a part of Kusaka Schist Formation lies N – S trend, typical of schist in central Nigeria. The granitic intrusion into the schist consists of Muscovite quartz. In Paiko area very close to Danu village, a schist outcrop with Migmatite as an intrusion, showing a slumping structure.

The granite rock type covered about 70% of the location. They are basically low – lying outcrops and their grain size is in between medium-coarse grain. They are majorly biotite/hornblende granite and grano-dioritic in composition with feldspathic veins crosscutting in different structural trends.

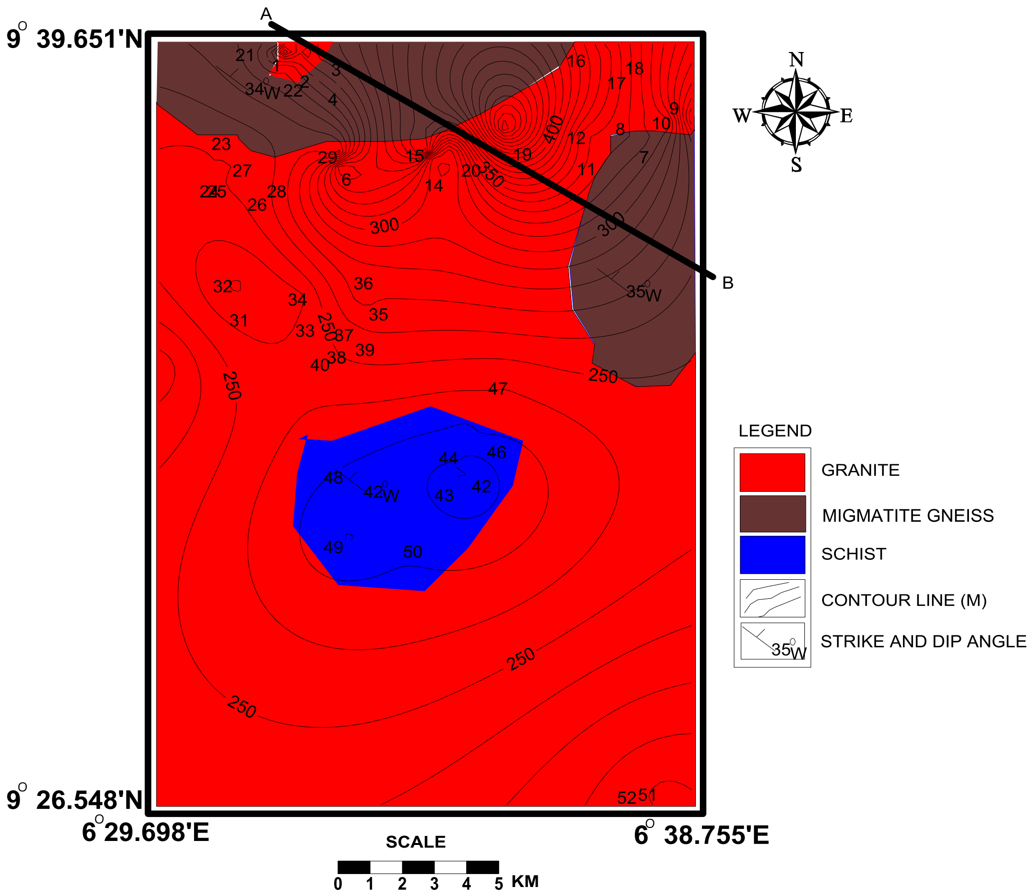

Figure 1: Geological Map of the Study Area

4.2. Structural geology of Chanchaga Area

Fault: They are displacement within a rocks body. The outcrops along Maitumbi consist of different Fault like Dextral and Sinistral (Plate 1, 2, & 3).

Plate 1: Dextral faulting on Granite rock at Matumbi along Sarkin Pawa road

Plate 2: Sinistral faulting on Granite rock at Matumbi along Sarkin Pawa road

Plate 3: Fault plane on Migmatite -gneiss

Plate 4: Tension gash on schist rock

Joint

They are the most prominent structures in the study area, joint are said to be fracture with negligible displacement, which evidence in breaking down of rocks into boulders in Maitumbi as a tensional gash joint observed within the outcrops (Plate 5).

Plate 5: Joint on granite rock cut across along Sarki pawa road

The rock units are well foliated especially the Migmatite-Gneissic rock types. But the occurrence of such foliation is rather weak the fabric tends to be homogenized in Tudun Fulani and Bosso area (Plate 6).

Plate 6: Foliation on Migmatite and Schist at Tudun Fulani and Bosso area

4.3 Hydrogeology of Chanchaga Area

Aquifers in the study area are generally characterized by fractured and weathered overburden. Groundwater occurrence in this Basement terrain is hosted within zones of weathered regolith and fracture planes which often are not continuous in vertical and lateral extent (Figure 2). The surface water occurs as Rivers and stream. These are recharged by precipitation and run-off from highland during wet season. Most of the stream are seasonal and hence, dry up during dry season. Others flow all round the year which are perennial in nature. Most of those few perennial streams get recharged from fracture or seep in the underlying fractural basement rock as rivers / streams are observed to be structurally controlled. Most of the wells and borehole varies in depth from 2 – 57meter respectively.

The tributary of river Chanchaga flow from North – South are Dendritic pattern, the river also flow from East – West which likely to be fracture controlled. And the Northern part of the areas signifies Radial pattern because of the presence of ridge in the area which is shown in figure 3.

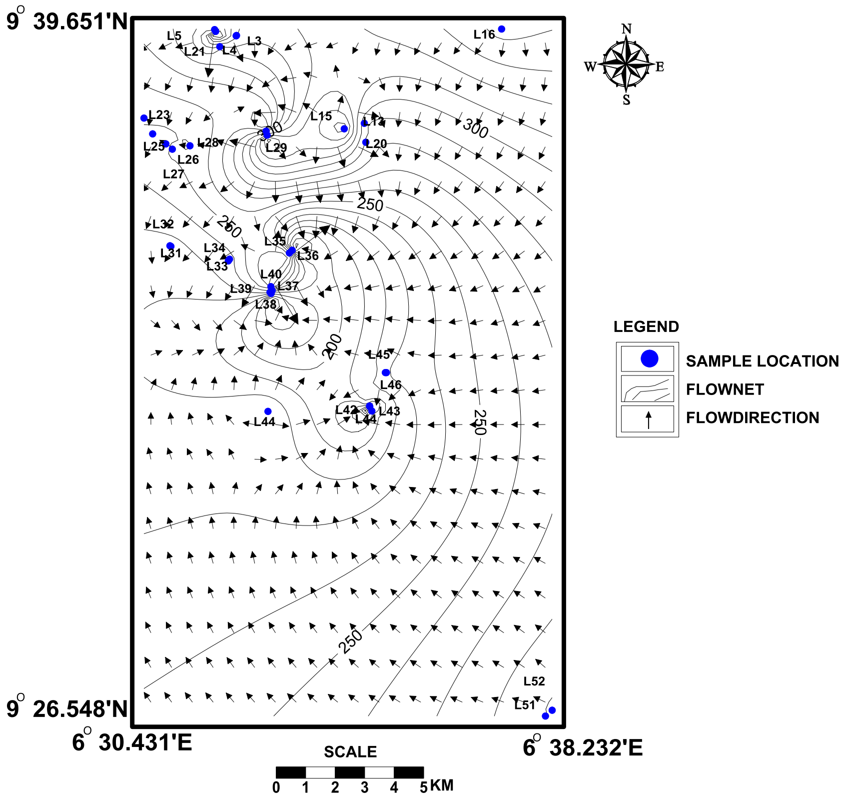

Figure 2: Vector map (Flow direction) of Chanchaga Area.

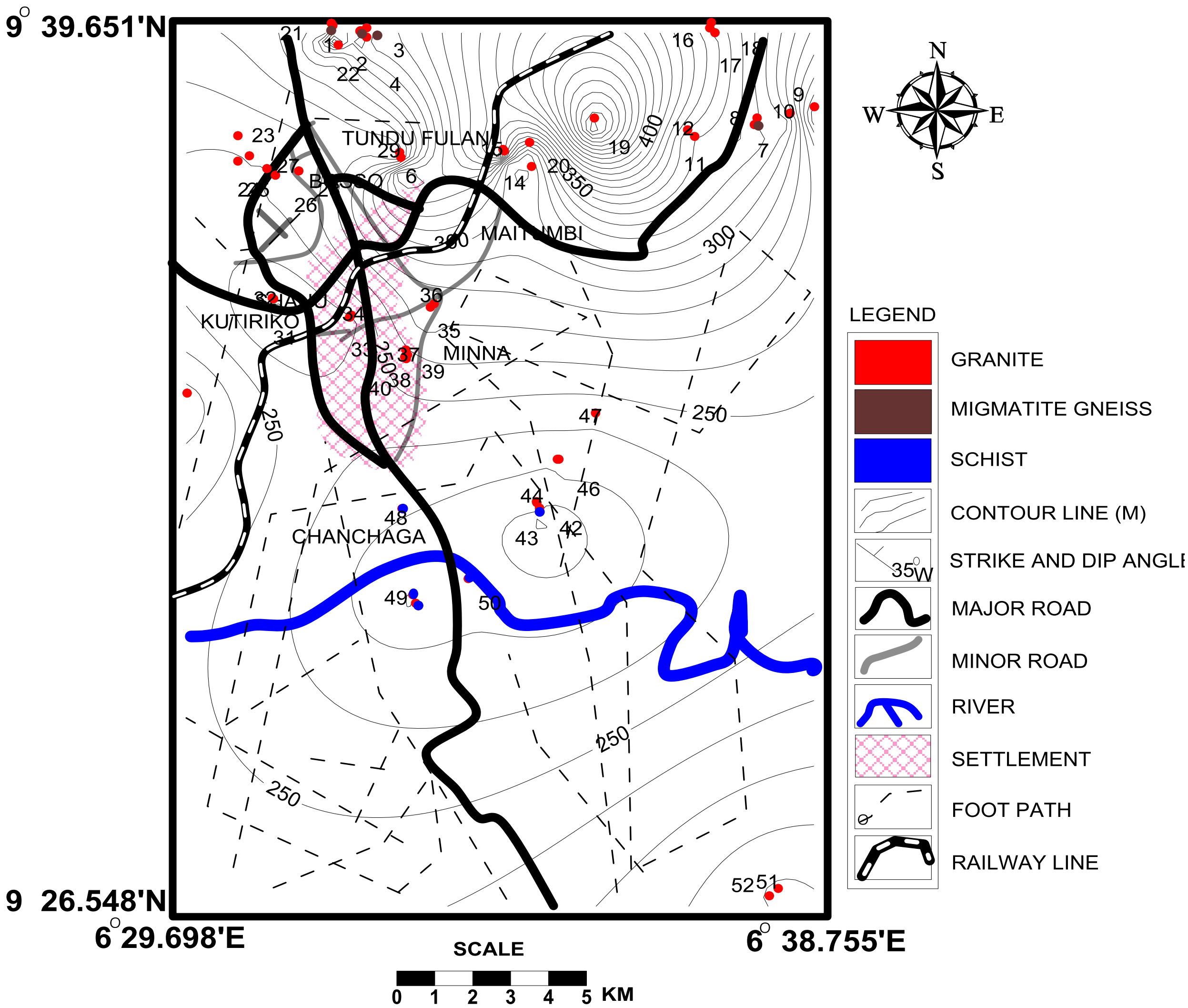

Figure 3: Fact Map of the well and borehole samples in Chanchaga Area

4.4 Physical and Chemical analyses

The results of physical and chemical analyses of water samples in mg/l are presented in table 2 - 3.

Table 2: Results of the physical parameters of water from Chanchaga area

S/N	Temp(⁰C)	pH	TDS (ppm)	Conductivity(µs/cm)	Salinity(Mg/l)	Turbidity(NTU)
1	28.3	7.20	0.06	0.13	01.1	9.06
4	28.7	6.75	0.20	0.40	01.4	1.46
7	31.1	6.58	0.23	0.46	01.4	0.80
8	29.5	5.76	0.11	0.23	01.2	0.81
11	29.1	6.17	0.19	0.38	01.3	1.43
12	29.0	5.77	0.08	0.16	01.2	1.41
13	29.1	5.55	0.07	0.13	01.1	1.40
14	29.7	7.05	0.18	0.36	01.3	25
17	30.1	7.00	0.11	0.22	01.1	5.75
15	30.9	7.05	0.45	0.90	01.8	1.38
21	29.2	7.12	0.35	0.69	01.6	3.45
22	28.8	6.39	0.29	0.58	01.5	1.47
23	29.6	6.74	0.09	0.19	01.2	1.37

27	30.7	6.93	0.19	0.39	01.3	1.95
29	30.7	6.56	0.21	0.44	01.4	2.75
35	31.2	6.85	0.47	0.96	01.9	1.06
36	31.3	7.03	0.19	0.39	01.4	6.11
41	28.1	6.91	0.41	0.83	01.8	2.12
42	29.1	6.57	0.42	0.85	01.3	1.39
43	29.9	6.94	0.18	0.01	01.3	37
44	28.5	6.34	0.12	0.25	01.7	3.47

Table 3: Results of the chemical parameters of water from Chanchaga area in mg/ l

S/N	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cu^{2+}	Fe^{2+}	Cl^-	$SO4^{2-}$	HCO_3^{2-}	CO_3^{2-}
1	37.51	7.50	64.28	2.44	0	1.06	15	19	101	0
4	61.2	2.81	45.70	9.27	2.65	0.04	19	8	187	0
7	19.74	0.94	22.44	25.86	0.18	0.12	73	0	268	0
11	25.67	0.94	21.61	10.25	0.28	0.03	16	3	378	36
12	36.53	4.69	36.53	27.82	0.40	0.06	12	1	429	24
13	45.41	43.11	45.41	55.63	0.12	0.02	83	25	97	36
14	92.79	14.06	92.79	44.90	0.8	0.15	156	37	140	0
15	30.60	4.69	24.84	6.83	0.23	0.05	26	3	134	0
17	23.69	1.87	10.42	3.42	0.6	0.03	11	0	8	98
21	72.06	31.86	8.02	39.53	0.44	0.48	61	7.0	138	0
22	63.18	6.56	16.83	24.4	0.43	0.53	62	5.0	121	50
23	33.56	30.95	20.85	2.93	0.44	0.03	33	1.0	159	0
26	29.62	0.94	54	0.49	0	0.12	28	18	0	32
27	54.29	1.87	25.65	1.95	3.37	0.12	38	28	0	72
29	41.46	8.43	20.04	13.65	2.5	0.58	36	32	126	0
35	72.06	24.37	73.74	6.83	1.17	0.06	59	15	266	46
36	61.20	17.81	24.05	14.75	0	0	47	41	254	0
41	85.88	30.93	24.05	9.76	4.77	0.2	76	53	259	72
42	83.91	35.61	30.46	4.88	0.42	0.12	81	69	118	38
43	57.26	54.36	26.45	8.3	1.93	2.61	62	53	196	0
44	26.65	25.30	12.02	15.13	13.9	0.11	19	33	167	0

4.5 Physical parameter

Table 2 present the values of various physical parameters which will be discuss as follows:

Temperature: The temperature is a function of the sources of water. The groundwater temperature of the collected samples varies between (28 – 31^{o}C), and it is above the recommended limit of 25 ^{o}C (WHO, 2006). This might result to moderate dissolution of elemental constituent within the aquifer system.

pH: The pH of water is a measure of acidic or basic nature of water. The pH of the analyzed samples varies between 5.5 – 7.20, the average concentration of pH values is 6.6, which indicate acidic to neutral nature of the water and this is below the recommended range of 6.5 – 8.5 (WHO, 2006), which are shown in table 2.

The Electrical Conductivity: Is use to estimate the total amount of dissolve salts or solid in water and is measured in ohms / cm. The range of conductivity in this research study falls between 0.13 – 0.96 ohm/cm, the average concentration were 0.5 ohm/cm. Sample 35 shows the highest value which indicate the high amount of soluble material of water at that point, (table 2).

Total Dissolve Solids: Comprises of inorganic salts and little amounts of organic matter that dissolved in water. These originated from the following: natural sources, sewage, urban runoff and industrial wastewater. Concentrations of total dissolve solid in water vary considerably in different geological regions, owing to differences in the solubility of minerals. The analyzed samples revealed concentration ranges from (0.06 – 0.47 ppm) with the average concentration of 0.3ppm which is below the permissible limit of 500mg/l (WHO, 2006). These has provides a rough indication of the overall suitability of water for whatever purpose.

Table 4: Summary of Hydrochemical Parameters

Parameters	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness	STD Error
Temp	28.1	31.3	29.6	0.99981	1	0.317	0.501
pH	5.55	7.2	6.6	0.47861	0.229	-1.034	0.501
TDS	0.06	0.47	0.3	0.13011	0.017	0.749	0.501
Conductivity	0.01	0.96	0.5	0.27784	0.077	0.629	0.501
Salinity	1.1	1.9	1.4	0.23974	0.057	0.784	0.501
Turbidity	0.8	37	5.3	9.00496	81.089	2.943	0.501
Na^+	19.74	92.8	50.20	22.33254	498.742	0.427	0.501
K^+	0.94	54.4	16.6	16.08092	258.596	0.836	0.501
Ca^{2+}	8.02	92.8	33.3	22.02478	485.091	1.373	0.501
Mg^{2+}	0.49	55.6	15.7	15.31626	234.588	1.383	0.501
Cl^-	11	156	48.2	34.55561	1194.00	1.511	0.501
SO_4	0	69	21.5	20.4123	416.662	0.808	0.501
HCO_3	0	429	168.9	111.71494	12480.00	0.6	0.501
CO_4	0	98	24	30.10648	906.4	1.031	0.501
Cu^{2+}	0	13.9	1.7	3.08761	9.533	3.453	0.501
Fe^{2+}	0	2.61	0.3	0.58761	0.345	3.373	0.501

4.6 Chemical parameters

Sodium: It is one of the essential constituent of rock forming minerals; hence its primary source in water is the weathering of plagioclase feldspar. The average concentration of sodium is 52.81 Mg/l, which is below the recommended limit of 150Mg/l (WHO, 2006).

Potassium: Element usually liberated from the weathering of Orthoclase microcline and Biotite in the basement rocks. The average value measured is 27.65 Mg/l, which is generally below the recommended limit of 75Mg/l in table 4.4 (WHO, 2006). Potassium and Sodium are alkali metals; they readily dissolve in water because of their ionization potentials and its rate of mobility. Thus it always almost depict low concentration where there is no contribution from anthropogenic sources in an aquifer systems especially potassium.

Calcium: This metal is relatively high in both rocks and water. The range falls between 8.02 – 92.79Mg/l while the average concentration is 33.3Mg/l with a maximum permissible limit of 75Mg/l (WHO, 2006). It can be inferred that calcium is not in excess; hence, the water is still good for drinking. The source of calcium is from the dissolution of mineral like apatite, amphibolites, and pyroxene.

Magnesium: Occur as Carbonates, Hydroxides, Oxide, Phosphate and Silicates. As Carbonate, Hydroxides, Oxides and Phosphates, the mineral is hardly soluble in water. Order compounds of Magnesium are readily soluble. Magnesium has the same effect on water as calcium, producing hard water. This study revealed its range between 0.49 – 55.63Mg/l with a mean of 15.7mg/l, which is below the recommended limit of 150mg/l (WHO, 2006).

Iron: When excess iron is ingested, it results in inhibition of activities of many enzymes. The range of concentration falls between 0.00 - 2.61mg/l with the means of 0.3mg/l. It is one of the most abundant elements on the earth, but show low level of solubility when it come in contact with water except in high temperate or humid environment. In most cases it has no reported serious medical challenges when consume in a concentration slightly above drinking water quality standard.

Chloride: They formed from natural sources, sewage and industrial effluents and urban runoff. They are the major dissolved constituent of most natural waters, though it is not healthy for oral consumption when is in excess of concentration. The average concentration measure was 48.2mg/l and the range concentration (11 – 156mg/l). Generally low concentrations indicate the purity of low soluble salt in the area. All these value are within the range of maximum permissible limit of 150mg/l (WHO, 2006).

Carbonate: The concentration of carbonate in most samples are 0 mg/l except location 11, 12 and 13 (36mg/l, 24mg/l and36mg/l) which are borehole and uncover well at location 17, 22, 26, 27, 35, 41 and 42 respectively(98, 50, 32, 72, 46, 72 and 38mg/l). Which may be due to dissolution of carbonate rocks? Which is lower than that of WHO standard of highest desirable level of 200mg/l and maximum permissible level for domestic purpose is 500mg/l respectively.

Bicarbonate: This show up when carbon dioxide dissolved in water. Their presence has been found to be highly dependent on the pH of the water, because when a pH is 8.2 and above set in HCO_3^- loses its hydrogen to become carbonate. The range concentration falls between 0.00 – 429mg/l with mean concentration of 168.9Mg/l.

4.7. Trace Elements

Arsenic: This is found widely in the earth's crust, but in the study area the concentration of Arsenic is negligible.

Copper: is an essential nutrient which contaminates drinking water. It has various uses, its' concentration in the water was much in primary sources and most of these are corrosion of internal copper plumbing. It ranges in concentration from 0mg/l – 34.6mg/l, which indicates high concentration of copper in the water of the research area.

Iron: The concentration of iron ranges from 0 – 13.9mg/l and the average concentration of 1.7mg/l. These is majorly attributed to the natural dissolution of iron from the regolith.

4.8 Correlation Matrix

From table 5 correlation factors revealed positive significant relationship between total dissolve solids, conductivity and salinity (r = 0.960, 0.771) respectively. This depicts the dependency of the three constituent in the groundwater of the study area, which indicate that electrical conductivity of water depend on the dissolve mineral salts in the groundwater body. Turbidity show positive significant relationship with Iron (Fe^{2+}) (r = 0.749) which suggest that cloudy nature noticed on the groundwater samples might be from the dissolved Fe constituents.

Na^{+} shows positive significant correlation between TDS, Cl^{-}, and SO_4 (r = 0.542, 0.698, 0.594) respectively, which suggest that the aquifer chemistry is control by those elemental constituents. In the same vein Mg^{2+} depict significant positive correlation between Cl^{-} and SO_4 (r = 0.586 and 0.461), Table 5.

Table 5: Correlation Matrix

Parameters	Temp	pH	TDS	Cond.	Salinity	Turbidity	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4	HCO_3	CO_4	Cu^{2+}	Fe^{2+}
Temp	1	0.264	0.222	0.199	0.149	0.032	-0.046	-0.13	-0.162	0.015	0.035	-0.14	0	-0.011	-0.29	-0.01
pH	0.264	1	.371*	0.312	0.302	0.346	0.04	-0.07	-0.314	-.529**	-0.353	-0.01	-0.31	0.138	-0.05	0.301
TDS	0.222	.371*	1	.960**	.788**	-0.171	.542**	0.34	-0.219	-0.067	0.204	0.141	0.19	0.165	-0.05	-0.05
Conductivity	0.199	0.312	.960**	1	.771**	-.386*	.486*	0.171	-0.186	-0.047	0.156	0.044	0.165	0.208	-0.05	-0.3
Salinity	0.149	0.302	.788**	.771**	1	-0.184	0.333	0.322	-0.253	0.013	0.052	0.033	0.264	0.004	.405*	-0.08
Turbidity	0.032	0.346	-0.171	-.386*	-0.184	1	-0.088	0.323	-0.116	-0.228	-0.08	0.196	-0.05	-0.252	-0.04	.749**
Na^+	-0.046	0.04	.542**	.486*	0.333	-0.088	1	.428*	0.353	0.235	.698**	.594**	0.005	0.086	-0.06	0.093
K^+	-0.132	-0.07	0.34	0.171	0.322	0.323	.428*	1	-0.051	0.237	.404*	.580**	0.026	-0.136	0.158	.448*
Ca^{2+}	-0.162	-0.314	-0.219	-0.186	-0.253	-0.116	0.353	-0.05	1	0.164	.431*	0.117	-0.02	-0.135	-0.24	-0.03
Mg^{2+}	0.015	-.529**	-0.067	-0.047	0.013	-0.228	0.235	0.237	0.164	1	.586**	-0.07	0.152	-0.211	-0.11	-0.11
Cl^-	0.035	-0.353	0.204	0.156	0.052	-0.08	.698**	.404*	.431*	.586**	1	.461*	-0.05	-0.067	-0.15	0.057
SO_4	-0.137	-0.008	0.141	0.044	0.033	0.196	.594**	.580**	0.117	-0.066	.461*	1	-0.12	0.014	0.28	0.328
HCO_3	0	-0.31	0.19	0.165	0.264	-0.053	0.005	0.026	-0.016	0.152	-0.05	-0.12	1	-0.231	-0.01	-0.05
CO_4	-0.011	0.138	0.165	0.208	0.004	-0.252	0.086	-0.14	-0.135	-0.211	-0.067	0.014	-0.23	1	-0.04	-0.25
Cu^{2+}	-0.289	-0.053	-0.049	-0.045	.405*	-0.035	-0.058	0.158	-0.242	-0.106	-0.148	0.28	-0.01	-0.038	1	-0.01
Fe^{2+}	-0.008	0.301	-0.053	-0.298	-0.081	.749**	0.093	.448*	-0.03	-0.107	0.057	0.328	-0.05	-0.253	-0.01	1

4.9 Hydrochemical Facies Characterizations

A need developed to find a more convenient way to water compositions by identifiable categories and this is where the concept of hydrochemical facies was developed. Hydrochemical facies are distinct zones that have cation and anion concentrations describable within defined composition categories.

Piper Diagram cations, expressed as percentages of total cations in milli-equivalents per litre

Plots as a single point on the left triangle and anions similarity expressed as percentages of total anions, appear as a single point in the right triangle. These two points are then projected into the central diamond-shaped are parallel to the upper edges of the central area. This single point is thus uniquely related to the total ionic distribution. The Piper Diagram also conveniently reveals similarities and differences among groundwater samples. Those samples with similar qualities will tend to plot together as groups.

From the piper diagram, in figure 4, samples 1, 7, 11 and 12 are mostly bicarbonate water, while samples 13, 14 and 26 are mostly sulphate type (Earth Alkali fresh water with high Alkali). Samples 4, 15, 17, 22, 23, 35, 36, 44 are mostly bicarbonate water and samples 21, 27, 29, 41, 42, 43 are mostly sulphate – chloride water type (Areas of Alkali fresh water). The water type in the study area can be grouped into two zones which are:

(a) Earth alkali fresh water with high alkali, these can also be subdivided into bicarbonate type of water and sulphate type of water.
(b) Areas of alkali fresh water can also be subdivided into bicarbonate water type and sulphate – chloride water type.

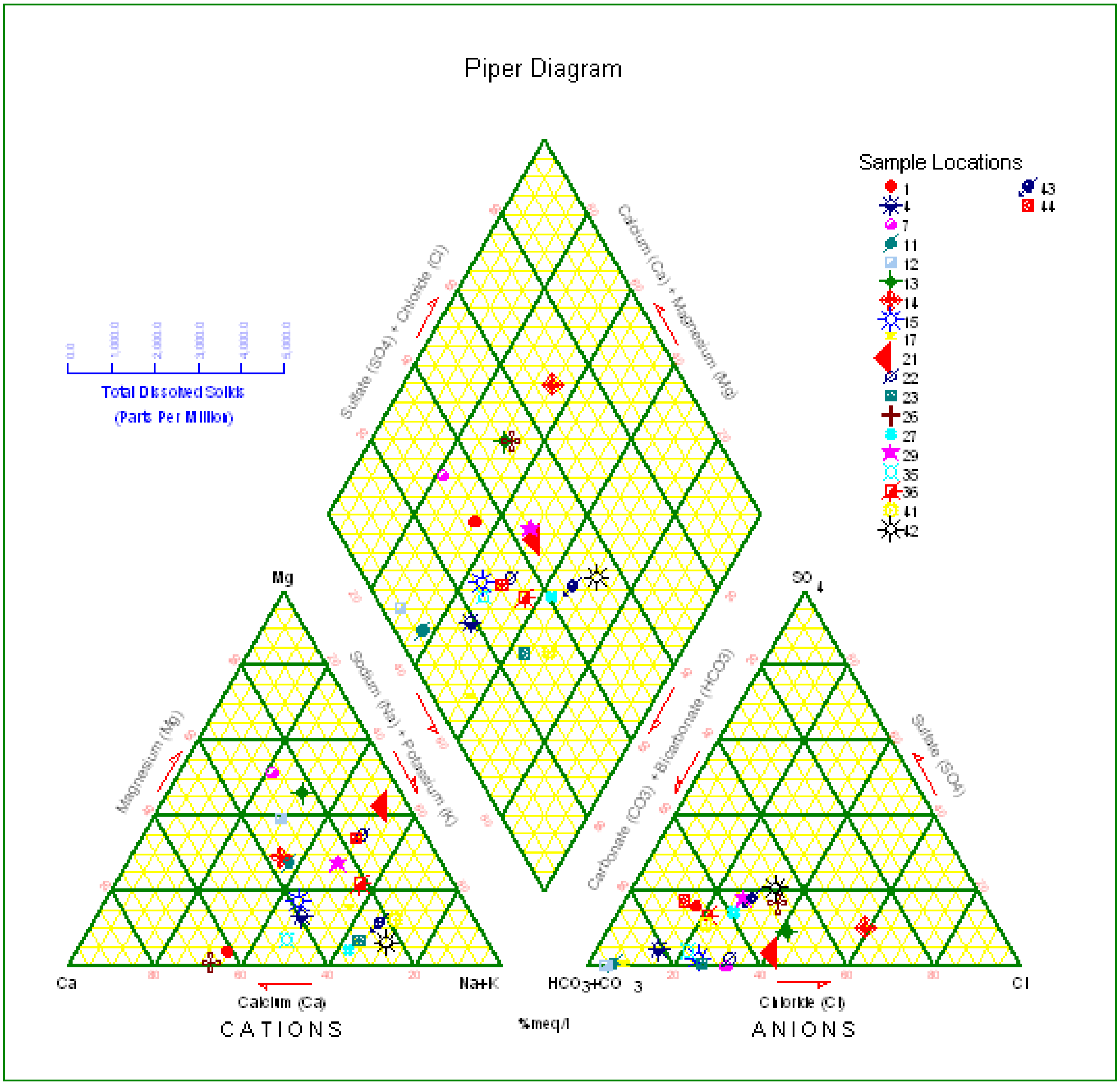

Figure 4: Piper diagram of Geochemical Analysis of Water Samples from the Study Area

IV. CONCLUSION

Groundwater samples in part of Minna North Central Nigeria in the basement complex area have been analyzed for cation and anions concentrations and they were compared with the recommended limit by World Health Organization for domestic water purposes. From the comparism the groundwater of the area revealed concentrated values that were below the maximum permissible limits. The chemical parameters revealed three different facies of the water in the area which are: sulphate water, bicarbonate water and sulphate- chloride. The presence of bicarbonate in the water indicates that the twenty one wells were variously sunks in Calcium bearing granite gneiss while the Carbonates are the products of reaction between Carbon dioxide and water. Also some location has sulphate – Chloride type which is influenced by the pollution from municipal water and waste products. Based on the above studies, thus the water from Hand dug wells are of fairly good quality in Minna North Central.

Field observations and measurements revealed two categories of aquifer type, the consolidated weathered overburden materials which shows overlying minimum and maximum thickness above the underlying crystalline basement rock types of about 2 – 12m and the fracture planes which often are not continuous. The flow direction obtained from sketched map of water table revealed the essential flow in the NE-SW directions.

They are been meeting the needs of the communities as a supplement to municipal water supply, therefore the recommendations below should be considered seriously by health officials.

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