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A Chemical and Bacteriological Assessment of Ground Water Along Parts of Minna – Lambata Road, North Central Nigeria

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Abstract: The geochemical and bacteriological assessment of ground water along parts of Minna – Suleja road was carried out .Water samples were collected (from bore holes and hand dug wells) from eight locations and transported to the laboratory within 24 hours. The physical parameters such as pH, electrical conductivity, temperature, total hardness, total dissolved solids (TDS), turbidity and colour were measured. The major ions analyzed include (Ca2+, Mg^{+}, Fe^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{-2}, HCO_3^{-2}, CO_3^{-2}, and NO_3^{-2}) while total count and E. coliform constituted the microbial aspect of the study. Results obtained show that all the parameters are below the recommended permissible value by World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ). The bactoriological analysis shows the values higher than the permissible recommended value of WHO 1993, 1984 and NSDWQ (1972) except for locations 4 and 8 which recorded zero E.coli.

Introduction

The usefulness of groundwater for various applications to a great extent depends on its physical, chemical and bacteriological composition; consequently, major agencies charged with public health services, like the World Health Organization (WHO) and Nigerian Industrial Standard have set up various permissible standards for water usage. The term water chemistry or water quality refers to the qualities of these substances (commonly called solutes) that are present in a particular water sample, making up its chemical composition (Plummer et al,2003).

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The chemistry of groundwater is controlled by factors such as hydrology and hydrogeology, the type of aquifer, the mode and source of recharge, the drainage area, and the permeability of the zone of aeration (Amadi et al 2006). Several groundwater development schemes has been executed in the area of study including boreholes and handdug wells with little or no attention paid to the geochemical characteristics of the water and its suitability for specific or general purposes. The present study represents an attempt aimed at the hydrogeochemical assessment of groundwater quality in parts of Minna-Suleja road (Paida-Sesita) and their suitability for various purposes. In the present study both handdug wells and boreholes water samples were examined and analysed

Study Area

The study area falls within the North Central basement complex of Nigeria. It is located on SE of Paiko on the much larger sheet 185 Paiko N.W. It covers a total area of about10km^2 and falls within latitude 9^0 24'53.26"N and 9^0 23'3.97"N and longitudes 6^0 44'34.50"E and 6^0 53'20.93"E . The study area covers a variety of settlements, which includes: Sabongari, Farin - doki, Paida, Mararaba, Tanga, Wabe, Sesita. Figures 1 and 2

Geomorphology (Relief and Drainage)

The area is gently undulating with few rugged outcrops with an average altitude of between 350m and 400m above sea level. The area is well drained and some seasonal steams provided good avenue for the study of the exposed rocks. The drainage pattern is mostly dendritic as is typical of granitic environment (Clive 1991)

Vegetation and Climate

The vegetation is mainly guinea savannah type as it belongs to the central savannah which is a transitional between the forest zone of Southern Nigeria and the Guinea Savannah types of Northern Nigeria. This area is characterized by tall grasses with light forest, sparsely distributed trees in dry season and evenly distributed trees in rainy season with very thick vegetation .The area lies within the middle belt of Nigeria with mean annual rainfall of about 1334mm. The highest mean monthly rainfall is usually recorded in September and the monthly temperature varies between 25^{0}C and 30^{0}C with the lowest in August and highest in March.

Methodology

The study involved both field and laboratory activities. The field work includes; collection of water samples and in-situ measurement of physical parameters such as water Ph, electric conductivity, temperature using battery thermometer and conductivity meter. Water samples were collected according to normal guide lines and tested at the Federal Ministry of Water Resources Regional Water Quality Laboratory, Minna for analysis based on manual of International Atomic Energy Agency (2004). A total of eight (8) samples were collected during in the month of March 2011. (Figure 1).

Geology of the Studied Area

The study area consists mainly of granites (Older granites) and the colour ranges from light to dark coloured. They were first distinguished from the younger granite of the Jos Plateau by Falconer (1911). He equally noticed their deformed post tectonic character, they range in size from plutons to batholiths. Texturally, it is fine to coarse grained. Some of the rocks have undergone complete chemical weathering while others are partially weathered into residual deposits such as sand. Most of the rocks in the area are intruded by quartz veins.

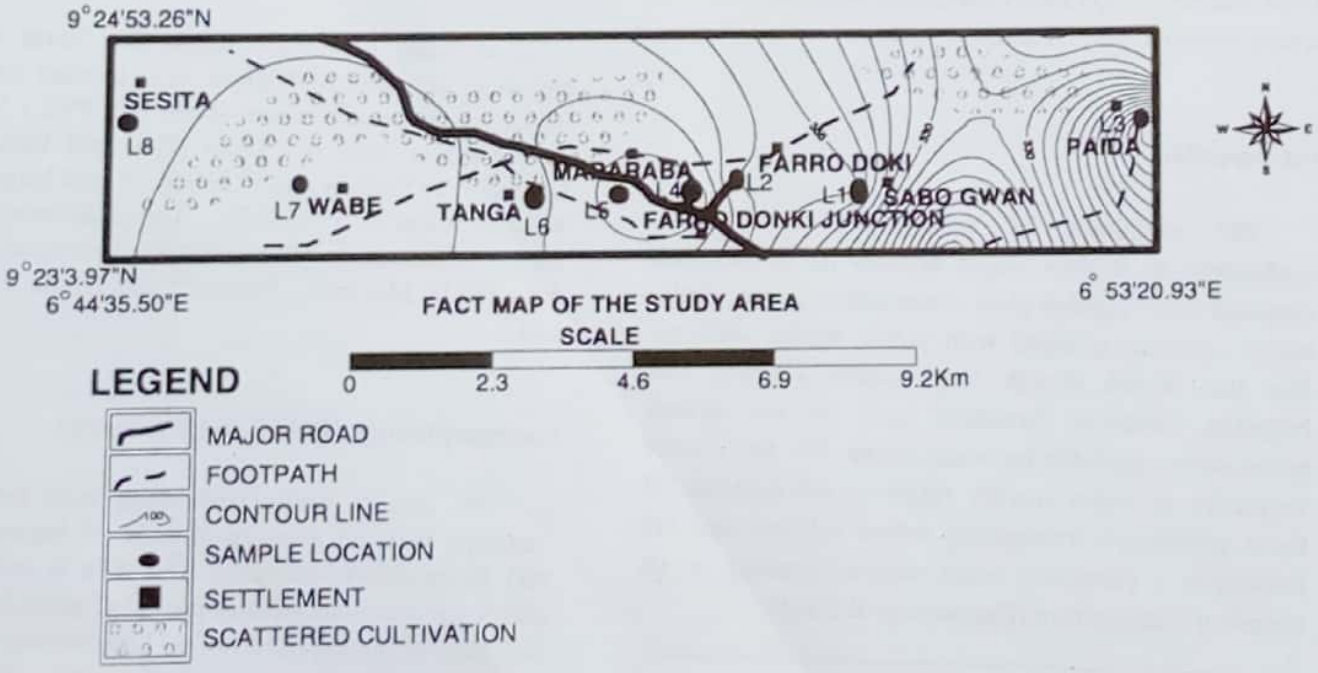

Figure 1: Map of the Study Area

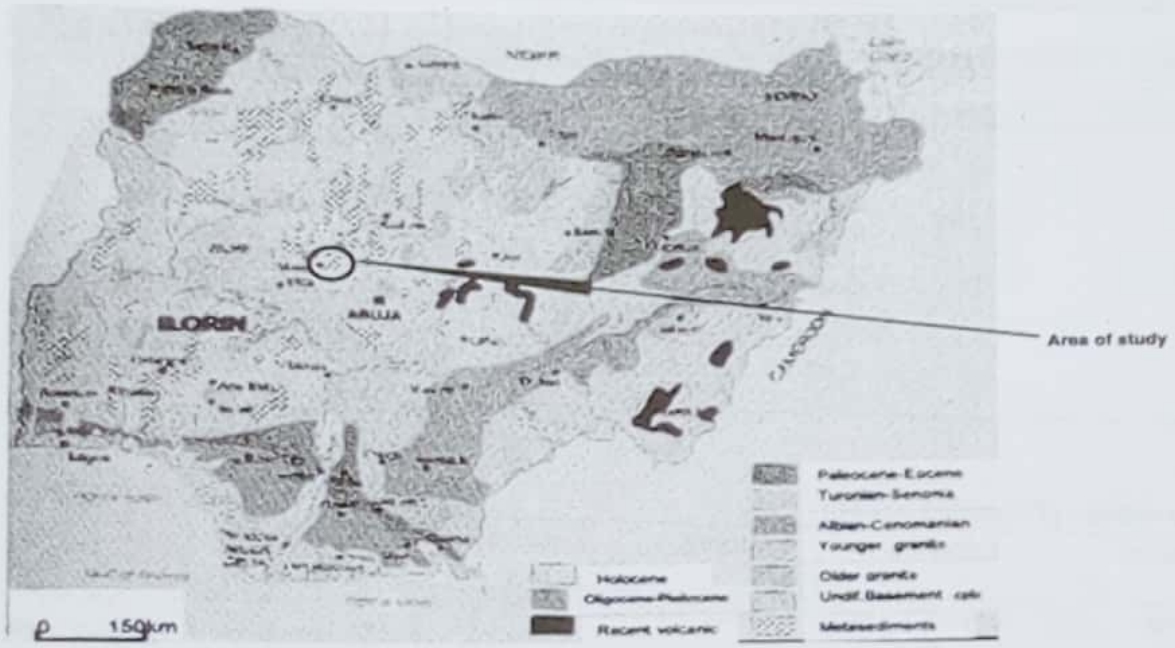

Figure 2: Geological map of Nigeria showing the study area

Result Presentation and Discussion

Table 1: Result of Physico – Chemical Analysis

PARAMETER	UNIT	1	2	3	4	5	6	7	8
Sulphate	mg/l	4	1	9	0.0	0.0	0.0	0.0	0.0
Chloride	mg/l	36.98	32.98	19.49	14.49	127	20.49	18.49	22.49
Magnesium	mg/l	6.59	3.17	11.23	7.33	44.93	0.73	2.93	0.73
Calcium	mg/l	18.05	5.21	18.05	33.69	4.01	9.23	10.83	19.65
Iron	mg/l	0	0.01	0.015	0.0	0.0	0.0	0.01	0.0
Sodium	mg/l	15	8.5	8	8	0.5	4	6.5	7.5
Potassium	mg/l	6.03	1.34	1.34	2.68	0.0	1.34	0.67	2.09
Nitrite	mg/l	0.005	0.01	0.005	0.005	0.005	0.05	0.05	0.015
pH	mg/l	6.34	5.37	6.79	7.83	5.43	6.48	4.46	6.49
Conductivity	µs/cm	371	114	226	334	30	111	166	255
TDS	mg/l	181.6	76.4	151.4	223.8	20.1	74.4	111.2	170.9
Dissolved Oxygen	mg/l	12	8.86	9.34	10.2	7.23	8.98	9.2	10.91
Alkalinity	mg/l	40	12	48	101	9	29	45	77
Hardness	mg/l	72.1	26	91.1	54.04	194.2	20.02	39.03	46.04
Nitrate	mg/l	0.54	0.0	1.07	0.0	0.54	0.0	0.00	0.00
Amonia	mg/l	0.12	0.0	0.24	0.00	0.12	0.00	0.00	0.00
Turbidity	NTU	7.02	1.28	12.13	1.87	1.62	3.98	0.68	7.59
E-Coliform	cfu/100r	7	24	96	0	27	32	2	0
Total Coliform	cfu/ml	162	149	224	24	82	146	58	29

Table 2: Mean Concentration of Ions (mg/l)

Ions	Range	Mean
Ca^{2+}	4.01 – 33.96	14.8
Mg^{2+}	0.73 – 44.93	9.71
Na^{+}	0.5 – 15.0	7.25
K^{+}	0.0 – 6.03	1.92
HCO_3	1.23 – 4.43	2.35
CO_3^{2-}	0.00 – 0.00	0.00
SO_4^{2-}	0.00 – 9.00	1.75
Cl^{-}	14.49 – 127.0	36.55
NO_3	0.00 – 1.07	0.27
Fe^{2+}	0.00 – 0.015	0.0004

Table 3: Inventory of Sample Location

S/N	Source	Location	Latitude	Longitude	Description
1	Hand dug Well	Sabon gari-Farin-Doki	N09^{0}23^{1}36.7^{11}	E06^{0}50^{1}49.0^{11}	Well located in sparsely residential environment. Agrarian set-up, poor disposal of solid and liquid waste.
2	Hand dug Well	Ferin- Doki	N09^{0}23^{1}39.6^{11}	E06^{0}49^{1}480^{11}	Well located in a village square with poor disposal of solid and liquid waste
3	Hand dug Well	Paida	N09^{0}24^{1}05.6^{11}	E06^{0}53^{1}18.7^{11}	Agrarian set- up and typically village like settlement, sparsely populated.
4.	Hand dug Well	Farro Doki Junction	N09^{0}23^{1}31.7^{11}	E006^{0}49^{1}30.1^{11}	Well located in a small residential environment. Low economic activities and unplanned waste disposal.
5.	Bore hole	Mararaba	N09^{0}23^{1}34.6^{11}	E006^{0}48^{1}48.3^{11}	Well located in a public market, within a densely populated environment. drainage system and waste disposal very poor.
6	Hand dug Well	Tanga	N09^{0}23^{1}32.4^{11}	E006^{0}48^{1}07.1^{11}	Well located in a sparsely residential environment. A pit latrine located about 6m from the well.
7.	Bore hole	Wabe	N09^{0}23^{1}38.'5^{11}	E006^{0}46^{1}08.8^{11}	Well located in a public area for the villagers. No economic activities and waste disposal around the vicinity.
8.	Bore hole	Sesita	N09^{0}24^{1}13.1^{11}	E006^{0}44^{1}35.5^{11}	Well located very close to mosque, no waste disposal around the vicinity.

Table 4: Comparison of Element with WHO and NDWQs Standard (mg/l)

Ions	Range	Mean	WHO (permissible) Max. acceptable (mg/l)	NDWQs Max. acceptable (mg/l)
Ca^{2+}	4.01 – 33.96	14.8	75.0	–
Mg^{2+}	0.73 – 44.93	9.71	150.0	0.20
Na^{+}	0.5 – 15.0	7.25	200.0	200
K^{+}	0.00 – 6.03	1.92	20	–
HCO_3	1.23 – 4.43	2.35	120	–
CO_3^{2-}	0.00 – 0.00	0.00	120	–
SO_4^{2-}	0.00 – 9.00	1.75	100	100
Cl^{-}	14.49 – 127.0	36.55	250	250
NO_3	0.00 – 1.07	0.27	50	50
Fe^{2+}	0.00 – 0.015	0.0004	0.3	0.3

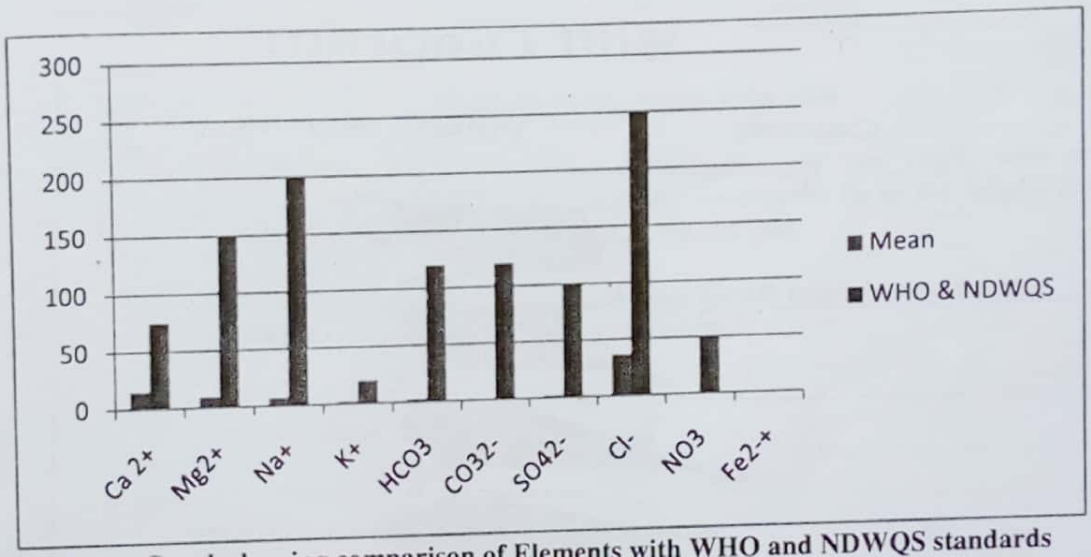

Fig 3: Bar Graph showing comparison of Elements with WHO and NDWQS standards

Table 5: Mean Concentration Microbial Elements

Parameters	Range	Mean
Total coliform count (cfu/ml)	24-224	109
E-coliform (cfu/100ml)	0-96	23

Table 6: Comparison of Microbial element with WHO and NDWQs standard

Parameters	Mean	Maximum allowable	
		WHO	NDWQs
Total coliform(cfu/ml)	109	10	10
E Coliform (cfu/100ml)	23	0	0

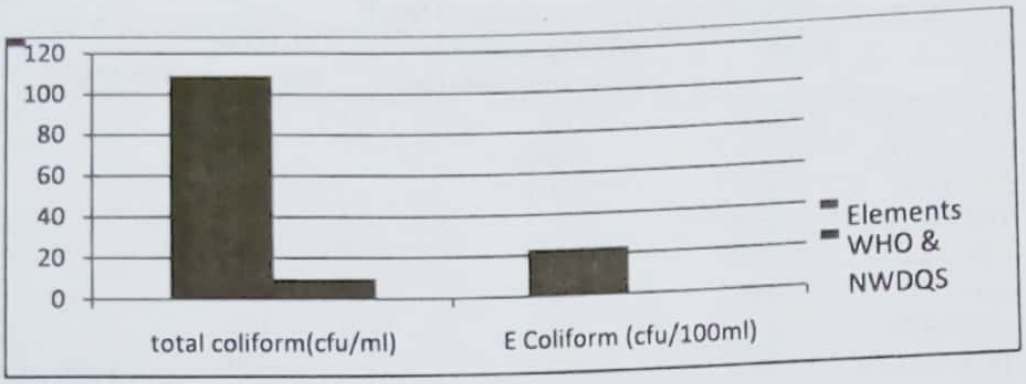

Figure 4: Bar graph showing the comparison of microbial elements with WHO standards and NDWQS.

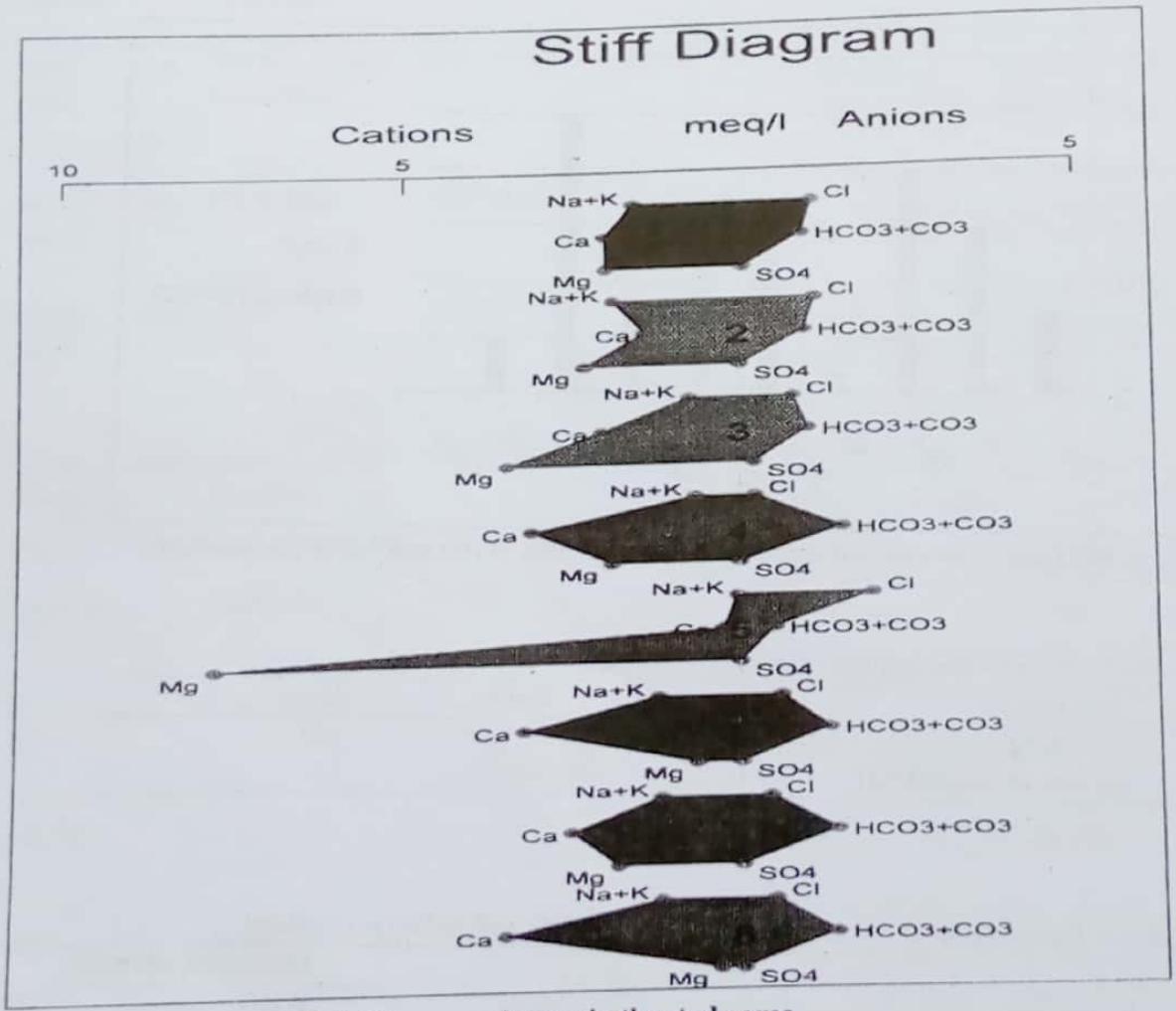

Figure 5: Stiff Plot for groundwater in the study area

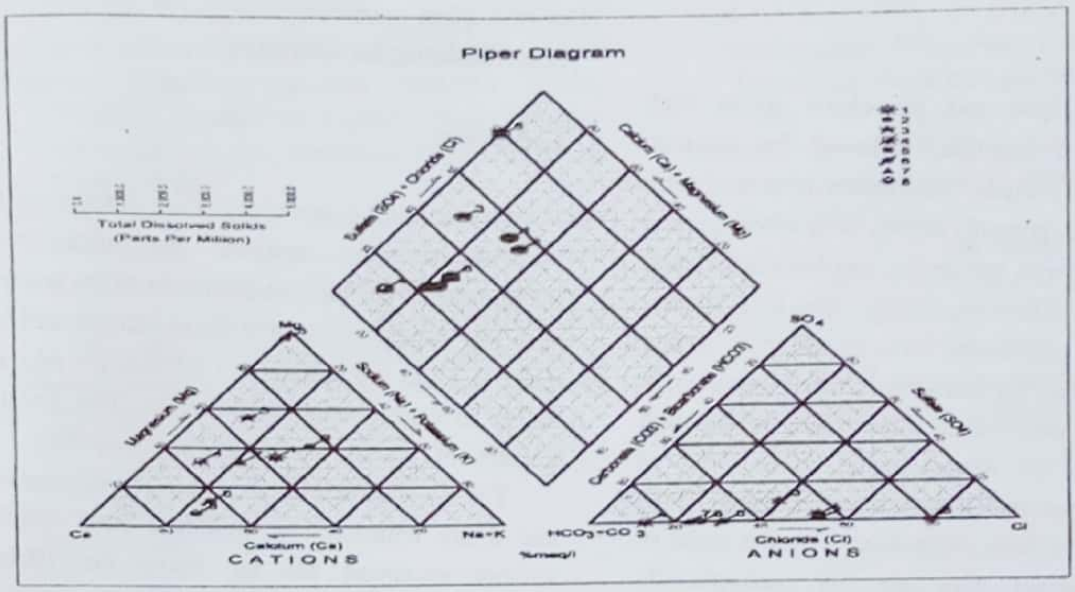

Figure 6: Piper plot for groundwater characterization in the study area

The determined values of the major constituents in milligrams per liter (mg/l) were re-calculated to milliequivalents per litre (meq/l). And the percentage of the major constituents for all the samples in miliequivalent per litre (meq/l) were used for the plotting of piper diagram and the stiff plot.

Table 7: Parameters and Maximum Allowable Limit and Their Health Impact when Excess

Parameters	Unit	NDWQS Maximum Permissible Levels	Health Impact
Colour	TCU	15	None
Odour	-	Unobjectional	None
Taste	-	Unobjectional	None
Temperature	Celsius	Ambient	None
Turbidity	μTu	5	None
PH	-	6.5 – 8.5	None
TDS	mg/l	500	None
Calcium (Ca^{2+})	mg/l	75	Causes water hardness thereby resulting to heart diseases
Chloride (Cl^-)	mg/l	250	None
Conductivity	mg/l	1000	None
Hardness	mg/l	150	None
Iron (Fe^{2+})	mg/l	0.3	None
Magnesium (Mg^{2+})	mg/l	0.20	Consumer acceptability.
Nitrate (NO_3)	mg/L	50	Cyanosis, blue baby syndrome (infants under 3 months)
Nitrite (NO_2)	mg/l	0.2	"
Sodium (Na^+)	mg/l	200	None
Sulphate (SO_4^{2-})	mg/l	100	None
Total Coliform	Cfu/ml	10	Indication of fecal contamination
E-Coliform	Cfu/100ml	0	Urinary track infections, bacteramia, meaningitis, diarrhea, acute renal failure and haemolytic anaemia

(Source: Nigeria Standard for Drinking Water Quality, 2007)

Discussion

The bar graphs and pie charts shows high concentration of chloride, followed by calcium, magnesium and sodium. Magnesium in groundwater from igneous rock primarily derives from ferromagnesian minerals like olivine, pyroxenes, amphiboles and dark coloured micas (Herman, 1978). The bicarbonates, sulphate and potassium have a slightly higher concentration than the carbonates which occur more or less as trace elements in water. Also, the stiff plot indicates water of almost equal composition of probably common recharge source and origin. Three water types have been recognized from the result of the piper diagram, they are: (i) predominantly bicarbonate water type (ii) bicarbonate-sulphate and (iii) Sulphatic water types. Idris (2010) identified bicarbonate and sulphate water types in the northern sector of the Middle Bida Basin.

The temperature of the analysed samples ranges from 27.0^0C to 31^0C. Water for drinking purpose has a better fresh taste at lower temperature of about 15^0C. The pH value ranges from 4.46 to 7.83 which fall between acidic and neutral water. The pH of 4.46 recorded in location 7 is rather out of range.

The pH values affect the mobility of most elements. Only Na, K, No_3 and Cl^- ions remain in solution through the entire range of pH values found in normal groundwater (Offodile, 2002).Therefore, water of very low pH carries high concentration of ferric and ferrous ions. Ferrous ions remain stable under this condition and will oxidize to ferric ion at high pH. Values of E. Coliform ranges from 0/100cfu/ml to 96/100cfu/ml, while the value of total coliform ranges from 24 cfu/ml to 224/ml with a mean concentration of 23 cfu/100ml for E. Coliform and 109 cfu/ml for total coliform respectively. NDSWQS provides for zero microbial requirement for E-coli only locations 4 and 8 conform with. The total Coliform count of permissible level of 10 cfu/ml were generally count in all locations with the highest value of 224 cfu/ml recorded at location 3. This is as a result of the poor sanitary practices by the people as observed during the field work.

Conclusion

The chemical composition of the water reveal that the tested water samples are predominantly bicarbonate water. The characteristics of the group are very low concentration of sodium, calcium and total dissolve solid, yet sodium and calcium are relatively higher in concentration than cations. This could be traced to the granitic background of the aquifer.

The E-coliform with the exception of location 4 and 8 are unfavourable while the Total Coliform without exception are far above the 10cfu/ml recommended.

The water quality might need improvement through adequate treatment and security measures to reduce anthropogenic influence on the water quality should be considered.

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