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Ground Water Quality Assessment in the Basement Complex Areas of Kano State Nigeria

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Abstract: - The research aimed at assessing the quality of underground water for safe drinking in the basement complex region of Kano state. In achieving this aim a total of twenty (20) boreholes were selected at random across the state. Thirteen (13) relevant parameters on the test of water quality were taken into consideration. The research found out that underground water in the area is safe for drinking due natural filtration process that the water undergo, because, the soil chemistry and mineralogy alters the chemistry of the water there by making it safe for drinking by meeting the standard requirement of World Health Organisation (WHO) 1984. It is therefore recommended that, more boreholes should be constructed through the intervention of both government and other relevant organsations. Also surface water source should also be improve to reduce the burden that underground water source might have encountered.

Key Words: - *Borehole, Geology, Resource, Safe drinking, Underground Water, Water Chemistry.*

I. INTRODUCTION

Nigeria's increasingly urban population coupled with the desire to raise standard of living among the populace have increased the pressure on natural resources particularly water. This is witnessed by the efforts of various governmental agencies in providing water for domestic, industrial and agricultural uses. Therefore, efficient development of groundwater resources is of particular importance in northern Nigeria where due to the low rainfall and the length of dry season surface water sources are often inadequate. Correspondingly, this promoted the assessment of available groundwater resources in various parts of the country. A number of such studies for instance Dupreeze and Barber (1965) wrote on the distribution and chemical quality of groundwater in Chad and Basement complex of northern Nigeria. Egboka 1983, Ogunkoye 1986 and Ako 1988 also wrote on parameters such as water quality, aquifer transitivity, age of groundwater, table depth to surface and relative location of groundwater as potential resources.

The provision of groundwater supply in Kano state as part of a coordinated development programme for rural development is seen as an essential service imperative to the entire state's development (Macdonald's and Partners, 1986). Three governmental organisations were responsible for provision of groundwater for the entire state; namely, Water Resources Engineering and Construction Agency (WRECA), Kano State Water Board, Ministry of Water Resources. In addition, a number of local governments are also promoting their own groundwater supply programmes. Groundwater exploitation by these agencies is carried out by sinking of hand-dug, concrete limed wells and drilling of abstraction boreholes all located in geologies. However, despite the efforts of these organizations, it is estimated that out of the 7,500 hand dug wells in the state in 1981, about 3,300 had either fallen into disrepair or were in need of being re-evacuated due to collapse/slumping-cave-in e.t.c. Thus, village water supply sources essentially that consisted of seasonal streams, rainfall pools and other such reservoirs. These sources are invariably polluted and constitute hazards to health (Imerbore et al 1987). In alleviating the hardships endured by rural population, the objective of the international drinking water supply and sanitation decade will have been considerably satisfied (WHO 1990).

Groundwater has many advantages over surface water when obtained from deep sources, it undergoes natural filtration e.g. removal of bacteria and odour, also groundwater chemistry and temperature are much less. However, the long residence time of groundwater brings it into intimate contact with the country coprolite and rocks so that it tends to have higher concentration of dissolved solids than surface water and at times contains inorganic matter in concentration. Groundwater quality could vary by such spatially varying factors as lithology, texture and structure of the rocks (Ogunkoya 1986), and in areas with heavily polluted atmosphere, rain water quality is heavily altered (Horning et al, 1990).

This study investigates quality of groundwater for safe drinking, by testing parameters like PH, Electrical conductivity (EC) and Ionic concentration of Calcium (Ca), Magnesium (Mg), Iron (Fe), Chlorine (Cl), Nitrate (NO_3), Ammonium Nitrate (NH_3N), Sulphate(II)oxide (SO_4^{2-}), Silconoxide (SiO_2), Floride (F^-), Carbondioxide (CO_2) and Total Dissolve Solids (TDS) from various Precambrian Basement Complex rocks in Kano State.

II. STUDY AREA

The Nigeria Basement Complex is believed to have had structural complexity as a result of multiple folding, igneous and metamorphic activities. Kogbe (1977), the Basement Complex areas of Kano State are no exception to the above assertion. It occupies the middle and south-western portion of the entire state, roughly about 2/3 of the area. The boundary with the sedimentary area is generally well defined, although in few areas there is transition zone in which sediments are shallow. In the basement complex, the rock types encountered were predominantly granites with magmatites, gneisses and schist, and minor occurrences of quartzite, volcanic basalt and rhyolite. All these rocks belong to the Pre-Cambrian Basement Complex group. The elevation of the region above main sea level ranges from about 400 meters at the north-eastern margin to over 1200 meters at the southern tip, that is, the highest elevation occurs in the south. Elevations decrease both northwards and north-eastwards. The region is part of the high plains of the Hausa land (Motimore 1973), except for the section east of the hydrological divide the rock structure texture, lithology, mineralogy, relief and landforms are closely linked and described under conceptualization.

The state lies within the tropical savannah zone of Nigeria. Temperatures are high throughout the year, the mean maximum temperature is between 27^o-35^o C and the mean minimum temperature is between 16-21^o C. The annual rainfall varies from 1200mm in the south to 650mm in the north. Indeed, there are two main seasons – rainy season starts by May or June and ends in October or November while dry season is from November to April.

III. METHODOLOGY

Samples of water were collected from boreholes drilled into the various Basement Complex rocks in the State. In all, twenty boreholes were randomly sampled – five from each of quartzite, granite, gneiss and schist areas. Total of thirteen parameters were chosen base on those found to be relevant to the study area (Macdonald's et al, 1986) and taking into consideration World Health Organisation Current (1984) Geneva reviewed chemical parameters in drinking water standard for developing countries, hence, justify reason for the choice.

The PH value of all the samples were taken shortly after collection, using a PH Meter, while electrical conductivity of the water samples was measured with a Conductivity Bridge Meter.

The Calcium (Ca^{2+} and Magnesium (Mg^{2+}) concentration were determined using the atomic absorption spectrophotometer. The total iron concentration was determined by calorimetric method using throglycollic acid which reduces iron (III) to iron (II) and forms a reddish purple. In the case of chloride concentration, it was determined by titration with a standard solution of silver nitrate using an indicator of 8% potassium chromate solution, the appearances of red precipitate signifies the titration end point. The total silica was determined in all samples by colorimetric method using acidified sodium molybdate (Na_2 MaO_2) and acidified stannous chloride solution ($SnCl_2O$). The intensity of the blue colour formed was matched with the Standard Aquameck Silica Colour Scale and corresponding concentration read off in mg/1.

In all samples sulphate (SO_4) concentration was determined turbidinate method while the nitrate nitrogen and ammoniac nitrogen were determined by calorimetric method respectively.

Finally, the total hardness was determined by titration with sodium dihydrogen ethylendiamine tetracetate dehydrate – (E.D.T.A. – Salt, N_{a2} H_2 C_{10} H_{12} O8 H_2 $2HO_2$) using Eriochrome black T as indicator. The samples were analysed at Water Resources Engineering and Construction Agency (WRECA) Chalawa Quality Control Laboratory, Kano.

The data collected for this research includes the lithologic or geology of the twenty (20) boreholes taken as samples. There are depth drilled, borehole yields rock at zone of abstraction or fracture (screen position) and Rock Samples encountered from the surface to the bottom of each borehole sample.

The statistical tools that would be employed in this study are both descriptive and inferential mean and standard deviation is also used in the analyses of the data.

RESULT PRESENTATION DISCUSSION AND ANALYSIS

Table 1: Chemical Water Quality Parameters of the Boreholes

Borehole No	PH	EC	Ca^{2+}	Mg^{2+}	Fe	Cl^-	NO_3-N	NH_2-N	SO_4^{2-}	S_1O_2	F^-	CO_2	TDS
1	7.6	150	23.49	10.41	0.05	7.40	3.95	1.20	0.95	0.90	0.06	0.01	160
2	6.4	45	8.00	0.0	0.01	5.00	3.00	0.10	0.50	1.00	0.07	0.15	45.0
3	6.6	32	3.60	4.38	0.01	4.94	1.20	0.62	0.71	1.78	0.15	0.11	40.0
4	5.7	44	2.70	4.38	0.50	2.47	0.00	0.08	0.50	0.50	0.01	0.04	45.0
5	6.0	45	21.63	7.67	0.00	9.87	0.00	0.50	0.30	1.20	0.05	0.62	35.0
6	6.8	100	9.22	4.41	0.02	3.95	2.10	0.10	0.60	1.50	1.50	0.06	0.00
7	6.8	95	9.91	2.19	0.10	5.92	2.30	0.00	0.50	1.60	0.02	0.08	100
8	6.0	64	6.31	4.00	0.01	5.43	0.20	0.62	0.65	2.60	0.30	0.06	68
9	6.3	74	53.17	14.79	0.20	24.60	2.10	0.05	2.86	1.60	0.05	0.16	80
10	6.3	150	36.00	10.95	0.07	5.12	0.12	0.00	0.00	1.50	0.03	0.24	160
11	5.5	70	55.88	14.79	0.01	35.6	2.05	0.00	0.00	0.90	0.05	0.07	85
12	6.4	140	31.54	20.18	0.10	5.43	0.07	0.00	0.00	2.05	0.02	0.20	130
13	6.5	150	10.81	6.02	0.00	6.91	1.50	0.00	0.00	0.90	0.07	0.02	162
14	7.1	110	63.08	51.98	0.00	57.74	2.60	0.14	0.60	0.90	0.04	0.09	120
15	6.0	195	95.53	40.08	0.05	99.1	4.20	0.00	0.00	1.05	0.04	0.16	254
16	6.5	45	19.25	6.54	0.01	8.65	2.50	0.12	0.06	1.05	0.08	0.13	50
17	6.7	154	53.12	41.45	0.01	46.8	0.04	0.14	___	1.10	0.08	0.65	160
18	6.5	120	2.20	3.40	0.08	37.6	4.50	0.16	0.80	3.50	0.03	0.16	125
19	6.3	190	19.83	9.31	0.02	7.40	2.60	0.20	0.30	1.70	0.05	0.20	200
20	6.3	120	2.70	3.29	0.00	4.40	0.28	0.00	0.05	1.50	0.05	0.02	130

Source; Laboratory Analysis 2013

Table 2: Mean and Standard Deviation of the Various Chemical Parameters

Rock Type		PH	EC	Ca	Mg	Fe	Cl^-	NO_3-N	NH_2N	SO_4^2	SiO_2	F	CO_2	TDS
QZ	□	6.7	63.2	11.9	5.4	0.1	5.9	1.6	0.5	0.6	111	0.1	0.2	65.0
	δ	0.6	49	9.9	3.9	0.1	2.8	1.7	0.5	0.2	0.4	0.1	0.2	53.3
GR	□	6.6	123.4	39.2	16.8	0.04	45.9	1.6	0.1	0.4	1.3	0.1	0.1	133.5
	δ	0.3	45.3	35.9	16.0	0.05	86.1	1.3	0.14	0.7	0.7	0.2	0.1	50.8
SCT	□	6.6	126	34.2	13	0.03	7.5	0.9	0.0	0.02	1.3	0.3	0.04	113
	δ	0.2	20.8	17.3	2.2	0.01	0.4	0.3	0.0	0.03	1.1	0.5	0.05	11.5
GN	□	6.7	125	18.0	8.0	0.2	10.0	0.9	0.04	0.01	1.7	0.1	0.1	129
	δ	0.3	56.3	9.6	6.8	0.2	8.4	0.3	0.07	0.01	0.6	0.04	0.1	55

Source: Data Analysis 2013

Key;

Borehole Number	Geology of the Area found	Abbreviation of the Geologic Formation
1 – 5	Quartzite	QZ
6 – 10	Granite	GR
11 – 15	Schist	SCT
16 – 20	Gneiss	GN

Table 1 and 2 show the pattern of the groundwater quality parameters of the four rock types where samples are obtained for this study. They show that values for conductivity, alkalinity and Total Dissolve Solids (TDS) appeared to be lower in quartzite areas while those in granites, schist and gneiss appear to have similar patterns with no apparent striking differences. The patterns of PH and free carbon dioxide (CO_2) also portray similar range of concentration in the four rock types.

PH values ranged from an average 6.7 in granite area to 7.6 in areas under schist with lowest individual values of 6.0 in (borehole No 8 and 15) granitic areas, and highest 7.6 in quartzite area (borehole No 1) though with little concentration of bases and carbons, PH could be reasonably said to be constant, thus within the general acceptance range. Conductivity ranges between averages of 63.2m^{sm-1} in quartzite areas to 126m^{sm-1} in Schist areas. Conductivity peaks are observed mainly in schist, gneiss and granite areas, highest individual sample value is 195m $^{sm-1}$ (borehole No 15) in granitic area.

Free carbon dioxide was lowest in gneiss areas (Ẋ = 0.1 Mg/L) and normally higher in quartzite areas (Ẋ = 0.2 Mg/L). Generally, low values were recorded in all the various geologic areas.

Nitrate-Nitrogen (NO_3-N) concentration were similar and showed a decreasing trend from a maximum of 4.2 Mg/L on a granite area (borehole No 15) to nil in areas under lain by schist.

Calcium values range from an average of 11.9 Mg/L in gneiss areas to 39.0 Mg/L in areas underlain by granite rocks. The highest individual value of 95.53 Mg/L (borehole No 15) occurred in granite areas while the lowest value of 2.2 Mg/L was recorded for the same area. Generally, samples from gneiss areas tend to have much lower values of calcium concentration. Peak and minimum values tend to occur in quartzite, granite and schist areas.

Magnesium values were lower in quartzite areas with an average concentration of 5.4 Mg/L, and an average value of 16.8 Mg/L was recorded in a granite area. The samples with the highest individual value of 41.45 Mg/L (Borehole No 17) occurred in a granite area and a nil value was recorded in quartzite and schist areas.

Chlorine concentration ranges from an average of ($\dot{X}$ =4.00 Mg/L) in schist area t ($\dot{X}$ =45.9 Mg/L) in granite areas. Individual sample concentration in al thirty-one boreholes ranges from 4.00 Mg/L in gneiss area to 74.8 Mg/L (borehole No 23) in older granite areas.

As indicated in table 2, the concentration of sulphate, silicate and floride generally have low values without any significant difference. The result thus, shows that there are differences in the various geologies and chemical parameters of thirty-one borehole waters analysed. More importantly ionic concentrations of Magnesium (mg), Calcium (Ca) were found; consequently conductivity and PH tend to have linkage with underlying rock types (geology) of the area.

IV. DISCUSSION

The quality of groundwater is commonly determined by factors other than the source rocks. Other factors such as the chemistry of the saprolite (Ogunkoye 1986) through which groundwater percolated, nature of chemical reactions between the water and the minerals in associated rocks and saprolite and the velocity of the water body are very essential though rare in occurrence. In basement complex areas, groundwater can move from one aquifer to another and the quality may be modified by each in turn. These notwithstanding the background value of the chemical elements in groundwater should have some direct bearing to the geology of the environment from which it is taken. This is especially true where the water accumulates and remains fairly long enough to attain chemical equilibrium with the country rocks and saprolite (Freez and Cherry 1979). Thus, one may expect the concentration of a particular iron in water from similar or identical geological background to be similar.

The Nigerian basement complex is achieved to have had structural complexity as a result of multiple folding, igneous and metamorphic activities (Kogbe 1977). Kano State basement complex is no exception to this observation. Complex foliations and lineation exist among the different of the rock types and in addition to these differences of rock mineralogy exist over small depths, thus affecting chemical composition of groundwater. Borehole-geology obtained from the thirty one samples goes to confirm this assertion. For instance, in borehole number one in a quartzite area (table 1) shows existence of laterite from 0-3 meters, 3-16 meters decomposed granite and at fourty three meters in quartzite. Similarly, in a typical gneiss area (borehole No 3) looking at the geology or drillers log, one could observe; 0:15m laterites plus silt, 15-31m pink granite and 31-48m fractured gneiss. Even though the hand pump is tapping groundwater from purely gneiss area one would expect water seeping from upper layers of pink granite to contain some dissolved materials inherent in granite hence may influence the chemistry of such waters.

The PH of the water samples from rock types ranges from an average of 6.7 to 6.0 in granite and schist areas respectively. In borehole No 8 and 15 granite areas, comparatively could be said to be neutral even though there are some bases and calcium especially in quartzite areas. Using the criteria of Taylor (1958) one could suggest that all the thirty-one samples tasted are free from inorganic or organic acid.

V. CONCLUSION AND RECOMMENDATION

Due to the natural filtration process of the soil and weathered material, water by the time it reaches the water table is practically always of a good chemical quality and on comparing the results of the analyses with the US and WHO drinking water standards; the water is safe for domestic consumption.

The geology of the study area and the degree of weathering, influence the ground water chemistry, because of different mineralogy and degree of weathering. Consequently, different minerals are eventually weathered and leached down to the water table thereby altering the groundwater chemistry.

Calcium is the most dissolved action in water while floride, chloride and iron are the least dissolved irons. The extremely low concentration of nitrate-nitrogen (N03-N) in all the samples suggests that there are little or no pollutions from sewage sources.

No aquifer study is ever complete; therefore, as more groundwater quality data become available, the understanding of the subject should develop further and mathematical model should be evolve in order to gain insight to the complexities underlying the study of groundwater quality in any particular area.

The recent establishment of the Federal Ministry of Water Resources is very endearing development in Nigeria. The ministry shall in addition to other duties, provide the much needed leadership in the harnessing and management of the country’s water resources.

However, it is considered that this study has identified the important features of groundwater quality in parts of the Basement Complex Areas of Kano State. Therefore, the government, Nongovernmental organisations and wealthy individuals come to the aid of maintaining the existing boreholes and sinking of new ones, for this will help to reduce the vulnerability people may have as result of poor drinking water.

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