Assessment of Groundwater Potentials in Ningi Area of Bauchi State, Nigeria

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***Abstract:* - The determination of aquifer characteristics and groundwater potentials of the Ningi area of Bauchi state, Nigeria was carried out by analysing pumping test data. Boreholes depth within the study area ranges from 17.5 to 45.5 metres. The average static water level is about 11.8 metres. The yield varies according to borehole locations from as little as 13.62 to over 79.49 m^3/d. Generally, borehole sunk into the Crystalline Basement and Basement Foreland give low yields. About 50% of the boreholes yield between 13.62 to 50 m^3/d while the remaining 50% yield between 50-100 m^3/d. The total yield of the boreholes is about 479.52.m^3/day. This can sustain a population of 19,181 base on water supply standard of 25 litres per day for rural communities (Babatola, 1997). Considering the total population of 23,511 people (NPC, 2014) that are currently getting their domestic water from these boreholes, this shows that aquifers from the 10 sampled boreholes have very low groundwater potentials in terms of yield. This is an indication of future water crises in these areas, if the population keep increasing.The specific capacities of boreholes in the study area were computed and the results showed that they vary between 4.36 and 346 m/day (Table 1). Estimates of transmissivity obtained from pumping test analysis show that transmissivity (T) range from 1.16 to 63.35, with about 50% of the area having transmissivity of the aquifers ranging from 0 to 10 m^2/d and only about 10 % (Yada Gungume) having transmissivity above 50 m^2/d. Using Krasny (1993) standards (Table 1) to interpret transmissivity of groundwater in the study area indicates low to intermediate potentials.**

***Keywords:* Basement Foreland, Groundwater, Pumping Test, Aquifer, Transmissivity, Ningi, Bauchi, Nigeria**

I. INTRODUCTION

Groundwater is a vital source of water throughout the world. Water from beneath the ground has been exploited for domestic use, livestock and irrigation since the earliest times. Due to growing demand, successful methods of bringing the water to the surface have been developed and groundwater use has grown consistently over the years. According to Chow, Maidment, and Mays, (1988), groundwater is the water beneath the ground surface contained in void spaces (pore spaces between rock and soil particles, or bedrock fractures). Vincent *et al*, (2009) stated that groundwater occurs in unconsolidated and consolidated bedrock geologic formations.

Basement aquifers, which comprised of Crystalline Basement and Basement Foreland are of particular importance in tropical and sub-tropical regions both because of their widespread extent and accessibility and because there is often no readily available alternative source of water supply, particularly for rural populations (Wright and Burgess, 1992).Crystalline Rock is a solid, dense rock where groundwater is stored in joints, crevices, and cracks. Crystalline basement rocks are present over large parts of Africa and Asia. They comprise ancient igneous and metamorphic rocks over 550 million years old. Unweathered basement rock contains negligible groundwater, but significant aquifers develop within the weathered over-bedrock (Wright and Burgess 1992). Basement aquifers occur within the weathered residual overburden (the regolith) and the fractured bedrock (Wright and Burgess 1992).

Ningi area is underlaid by the basement complex rocks, mainly granitic in composition (Offodile, 2014), and in different stages of metamorphism, either as gneisses, migmatites, and quartzite (Figure 1). Bauchi State Agricultural Development Project (BSADP, 1988) defined two hydrogeological units in this area that present fundamental differences in their lithologic and structural conformation, the Crystalline Basement and Basement Foreland (See Figure 2).

The Basement Foreland hydrogeological unit occurs in the northern part of Ningi, while the southern part is predominantly Crystalline Basement. This study is set to assess the groundwater potentials of aquifers in the Crystalline Basement and Basement Foreland of Ningi area. This is with the hope that the results of the investigation will be useful to government, policy makers and other stakeholders in designing appropriate rural water supply schemes.

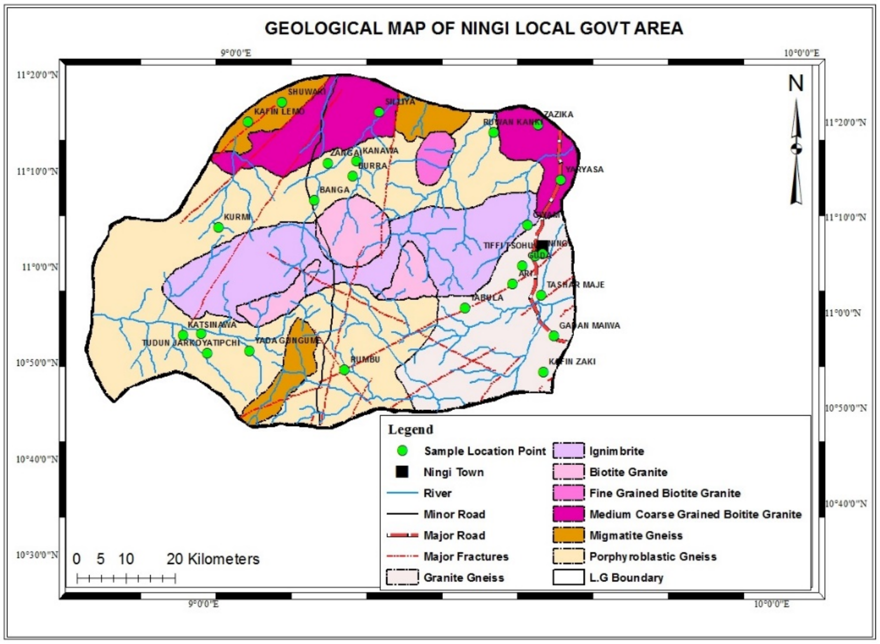

Figure 1: The Geology of Ningi Local Government Area

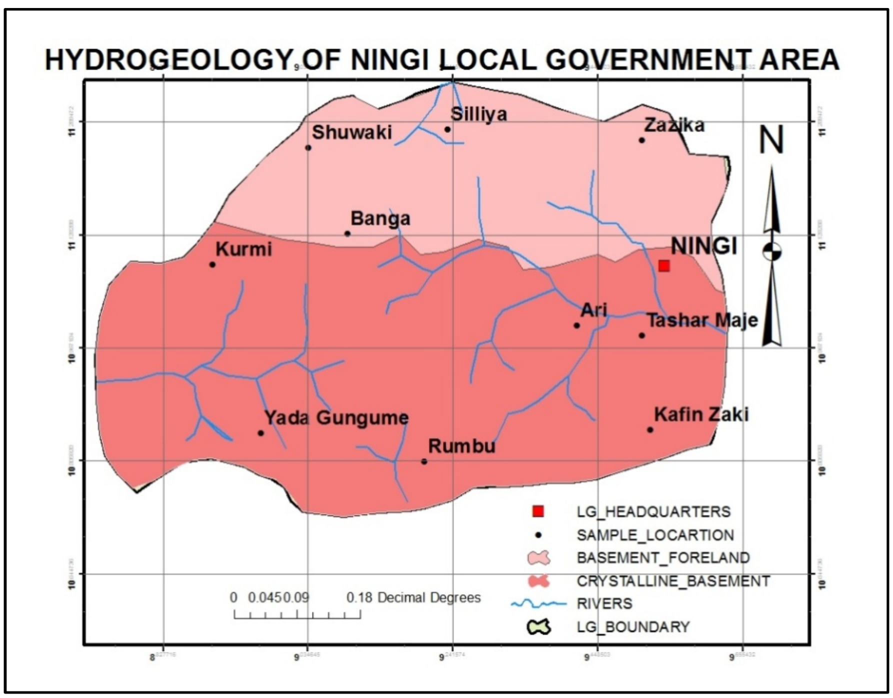

Figure 2: The Hydrogeology of Ningi Local Government Area

II. MATERIALS AND METHODS

Pumping test was conducted on ten boreholes within the study area, while the lithology logs of the ten boreholes where obtained from Rural Water and Sanitation Agency (RUWASA). Information on the geological and hydrogeology of Bauchi State were obtained from available maps from Bauchi State Agricultural Development Project (BSADP). BSADP defined five hydrogeological units in the state that present fundamental differences in their lithologic and structural conformation (BSADP, 1988). However, this particular study focuses only on the Crystalline Basement. The logs enabled the establishment of the subsurface stratification, casing and screen positions, static water levels and aquifer textural properties while the aquifer pumping test data for each borehole comprised 3 to 4 stage step-drawdown tests, single stage and recovery measurements. These were used to determine aquifer hydraulic properties such as transmissivity (T), hydraulic conductivity (K) and specific capacity (Cs). Pumping test data analysis was based on the Cooper-Jacob's (1946) non-equilibrium graphical method. This method has been found suitable where the abstraction well itself serves as the observation well, as is the case in the present study. By this method, the transmissivity (T) is given by:

$$T = \frac{2.303Q}{4\Pi \Delta S} \quad ......(1)$$

Where Q = discharge or yield (m^3/sec).

ΔS = change in drawdown over one log cycle.

This formula is useful because some of the boreholes are confined while others are semi-confined. The average drawdown for the ten boreholes is about 10.75m. The hydraulic conductivity (K) was calculated from

$$K = \frac{T}{b} \quad ....(2)$$

Where T = as in (1) above

B = aquifer thickness (equivalent to the total screen length).

The specific capacity (Cs), a measure of well productivity, was computed from:

$$Cs = \frac{Q}{S} \quad ....(3)$$

Where Q = as in (1) above

S = maximum drawdown

III. RESULTS AND DISCUSSIONS

Two major hydrogeological units characterized the groundwater systems in Ningi area. The Basement Foreland and Crystalline Basement. The Basement Foreland hydrogeological unit occurs in the northern portion of the study area (See Fig 1). This unit is characterized by varying amount of sedimentary formations, mainly Keri-Keri, overlying crystalline rocks, in which the sedimentary formations are generally less than 10 metres thick (BSADP, 1988). In almost all cases, the boreholes in the Basement Foreland are completed in the decomposed crystalline rock. Four of the sampled boreholes lies within the Basement Foreland hydrogeological unit. This include Shuwaki, Silliya, Zazika and Banga. Depth range from 17 to 35 metres and the average depth is 28.6 metres. Static water level ranges from 7 to 16.7 metres and the average static water level within the Basement Foreland is 12 metres. Yields in Basement Foreland are generally low. Almost all the 4 boreholes were rated at less than 100 m^3/d. the average yield is 64.59 m^3/d.

The Crystalline Basement hydrogeological unit lies entirely within the southern part of the study area (See Figure 2). The formations penetrated were mainly migmatites and gneisses which are cut by pegmatite, aplite and quartz veins and weathered to varying depths. The water bearing zones are: fractures in the poorly decomposed rock; intergranular permeability in moderately decomposed coarse grained igneous and metamorphic rocks and fractured pegmatite, aplite and quartz veins within highly and moderately decomposed gneisses and migmatites (BSADP, 1988). The yield or discharge (Q) values within the Crystalline Basement hydrogeological unit are generally low, most in the range of 13.8 to 79.5 m^3/d. The mean discharge value for the six boreholes within this hydrogeological unit is 36.9 m^3/d. Borehole depth within the Crystalline Basement range from 17 to 45.5 metres and the average depth is 32.8 metres. Static water level is generally low across all locations, except TashanMaje which has higher static water level of 21.2 metre.

In general, boreholes depth within Ningi area as shown on Table 1, ranges from 17.5 to 45.5 metres. The average static water level is about 11.8 metres. The yield varies according to borehole locations from as little as 13.62 to over 79.49 m^3/d (Table 1). About 50% of the boreholes yield between 13.62 to 50 m^3/d while the remaining 50% yield between 50-100 m^3/d. The total yield of the boreholes is about 479.52.m^3/day. This can sustain a population of 19,181 base on water supply standard of 25 litres per day for rural communities (Babatola, 1997). The total yield of the boreholes is about 479.52.m^3/day. This can sustain a population of 19,181 base on water supply standard of 25 litres per day for rural communities (Babatola, 1997). Considering the total population of 23,511 people (NPC, 2014) that are currently getting their domestic water from these boreholes, this shows that the water from the boreholes is not sufficient enough to meet the water need of the people.

The specific capacities of boreholes in the study area were computed and the results showed that they vary between 4.36 and 346 m/day (Table 1). Estimates of transmissivity obtained from pumping test analysis show that transmissivity (T) range from 1.16 to 63.35, with about 50% of the area having transmissivity of the aquifers ranging from 0 to 10 m^2/d and only about 10 % (Yada Gungume) having transmissivity above 50 m^2/d. Using Krasny (1993) standards (Table 1) to interpret transmissivity of groundwater in the study area, the aquifer systems in the area indicates low to intermediate potentials.

Table 1: Hydraulic Characteristics of Boreholes from Basement Foreland and Crystalline Basement

S/No	Location	Formation	Depth (m)	Screen Interval	Aquifer Thickness (m)	Static Water Level (m)	Dynamic Water Level (m)	Drawdown m	Est. Yield (m^3/d)	T m^2/d	K m/day	Specific Capacity m^2/d/m	S
1	Silliya	Basement Foreland	35.2	21.0-33.0	11	16.7	19.4	2.7	79.49	1.45	0.1	4.36	5.62
2	Shuwaki	Basement Foreland	26.6	17.0-26.6	9.5	7	18.9	11.9	79.49	15.2	0.79	189.3	4.14
3	Zazika	Basement Foreland	21.5	14.0-20.0	6	10.2	10.8	0.6	64.8	2.37	0.27	29.7	7.26
4	Banga	Basement Foreland	31.1	24.0-30.0	6	14.4	27.6	13.2	34.56	3.95	0.25	21.6	2.15
5	Ari	Crystalline Basement	45.5	36.5-44.5	10	4.5	36.8	31.8	18.14	11	0.27	139.5	0.44
6	TasharMaje	Crystalline Basement	34.6	27.5-34.5	7	15.5	32.7	17.2	13.82	16.9	0.89	212.6	0.72
7	Yada Gungume	Crystalline Basement	36.4	28.0-36.0	8	21.2	32.6	11.4	38.02	63.35	4.18	346	2.51
8	KafinZaki	Crystalline Basement	37.7	28.0-37.0	9	14.9	25.7	10.8	19.01	3.58	0.16	45	0.836
9	Rumbu	Crystalline Basement	17.5	9.0-16.5	7.5	9	14.4	5.4	52.7	19.29	2.3	239	6.36
10	Kurmi	Crystalline Basement	25	15.0-23.0	8	4.5	7	2.5	79.49	1.16	0.08	14.59	5.28
	Average		31.11		8.2	11.79	22.59	10.75	47.95	13.83	0.93	124.17	3.53

Note: T=Transmissivity, K= Hydraulic Conductivity, S=Storativity

IV. CONCLUSION

Based on the result of pumping test analysis of boreholes in the area, the study determined the hydrogeological characteristics of aquifers of the area in terms of borehole depths, water bearing zones, estimated yields, water levels, transmissivity, hydraulic conductivity, specific capacity and storativity. Groundwater occurs locally at various depth in the two formations due to variation in lithology, physiography and structure. The paper provided a general overview of hydrogeological conditions as well as detailed assessment of all potential aquifers within the Crystalline Basement and Basement Foreland aquifers of Ningi area of Bauchi state.

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