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HYDRAULIC CHARACTERISTICS OF THE BASEMENT AQUIFERS OF CHARANCHI AND ENVIRONS

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ABSTRACT
This study was aimed at the determination of hydraulic characteristic of water bearing units in Charanchi and environs. A total of twelve (12) pumping test data were collected from Rural Water Supply and Sanitation Agency (RUWASSA), Katsina state and Adenter Nigeria limited. The pumping tests were carried out by pumping the boreholes at a constant rate for between 12 and 24 hours. The available pump test data were used to evaluate hydraulic properties of the aquifer at 12 locations. These properties are transmissivity (T), and specific capacity (Q/s). Theis approximation method was used; the drawdown values obtained for the pumping phase were plotted against the time on a semi-log graph sheet to determine the slope ∆s. The value of the slope obtained for the individual borehole was used in computing the transmissivity and specific capacity of the aquifer in the study area. The Hydraulic properties calculated from the pumping test data shows that, the Transmissivity ranges from 2.5×10^{-4} *to* 1.4×10^{-4} m^2/s *and specific capacity from* 9.1×10^{-5} *to* 1.3×10^{-4} m^2/s*. Comparing the transmissivity values with Gheorghe"s classification of transmissivity, the result of transmissivity indicates that the area has a transmissivity value that belongs to low and negligible potential while that of Krasny belong to the low to very low potential. The low values of transmissivity can be due to several factors which include boreholes drilled within clayey weathered aquifer, or crystalline rock with limited fractures and poor porosity and permeability of the parent material from which the weathered aquifer was derived among other factors. For Specific capacity, the potential yield of the borehole is low which can be due to the inadequate time of pumping during the pumping test of the boreholes and poor development and completion of the boreholes.*

KEYWORDS: *Hydraulic characteristics, Transmissivity, Specific capacity, Charanchi*

1.0 INTRODUCTION

Water is a vital resource for human existence and the growth of any community is a function of the availability of basic infrastructures such as potable water, good road, electricity and industries (Ajibade, 2003; Mac Donald, 2005; Amadi, 2010). Due to its quantity and quality, groundwater is one of the major sources of water supply for various purposes (Hussaini *et al.,* 2022). Charanchi and environs experienced an increase in population which keep increasing yearly and ultimately increase the water demand, as such it is necessary to assess groundwater potential in the area. A very important aspect of groundwater potential assessment is to determine hydraulic characteristics of the aquifer (Okeke and Omoko, 2017). This is largely dependent on the availability of reliable data from a pumping test. Aquifer is any geological material that is porous and permeable and it has characteristic which include Hydraulic conductivity (K), Transmissivity (T) and Storativity (S) (Micheals and Eduvie, 2023). These characteristics provides information to identify the various water producing units for groundwater prospecting and management of the aquifer system (Micheals and Eduvie, 2023). Despite the numerous studies carried out on the geology, structures, groundwater potential and hydrochemical assessment of Katsina town (e.g., Bala, 1999; Bilkisu, 2011; Bello, 2011 and Ayendele, 2017); none of the above workers conducted a study on the hydraulic characteristics of the aquifer in the area and hence the need to bridge the study gap by undertaking a detailed study on the aquifer characteristics which will in turn provide data and information in relation to the groundwater development in the area.

1.1 Location, Extent and Accessibility of the Study Area

The study area is situated in the central part of Katsina state and it is 32km away from Katsina town. It is located between latitude 12° 30' 00'' to 12° 45' 00''and longitudes 7°30'00'' to 7°45'00'' covering an area of 770km^2 (Figure 1). The area can be accessed by minor roads; Birchi-Rawayau-Ganuwa-Danjakko road and Ajiwa-Banye-Charanchi road. It can also be accessed by major road that include Kafin soli-Sagawa-Fakuwa-Koda-Charanchi road and Yakasai-Kafin Kwarare road (Figure 1). The study area can also be accessible through various footpath that traverses the area.

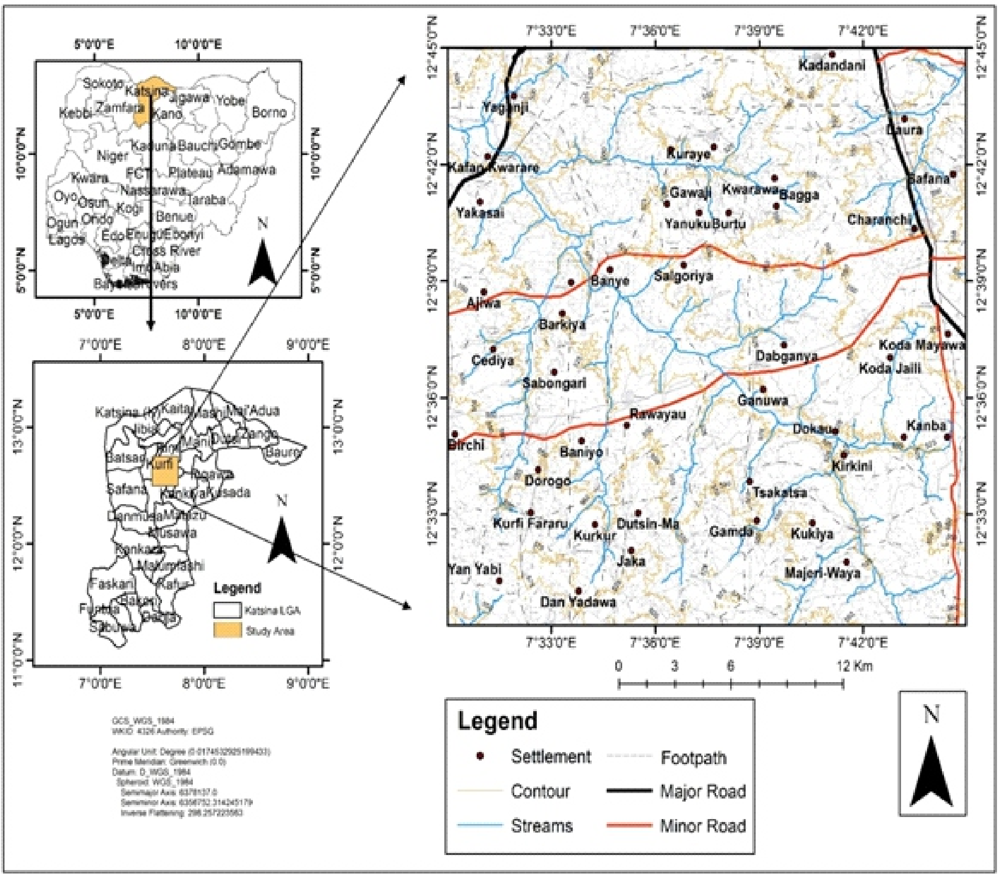

Figure 1: Location and accessibility map of the study area.

1.2 Geology and Hydrogeology of the Study Area

The study area belongs to the basement complex of the north-western Nigeria and it is underlined by the porphyritic biotite granite, Medium grained biotite granite, fine grained granite, migmatitic gneiss and granitic gneiss. The Porphyritic biotite granite is the most abundant rock type in the study area covering the Northern and Western part of the study area followed by the Medium grained biotite granite, granitic gneiss , migmatitic gneiss and fine grained granite (Figure 2). The groundwater in the area is located in the basement aquifers which are unconfined with the average thickness of 8.76 m. The source of the recharge is mainly from precipitation, while discharge is through dug wells, boreholes or spring sources.

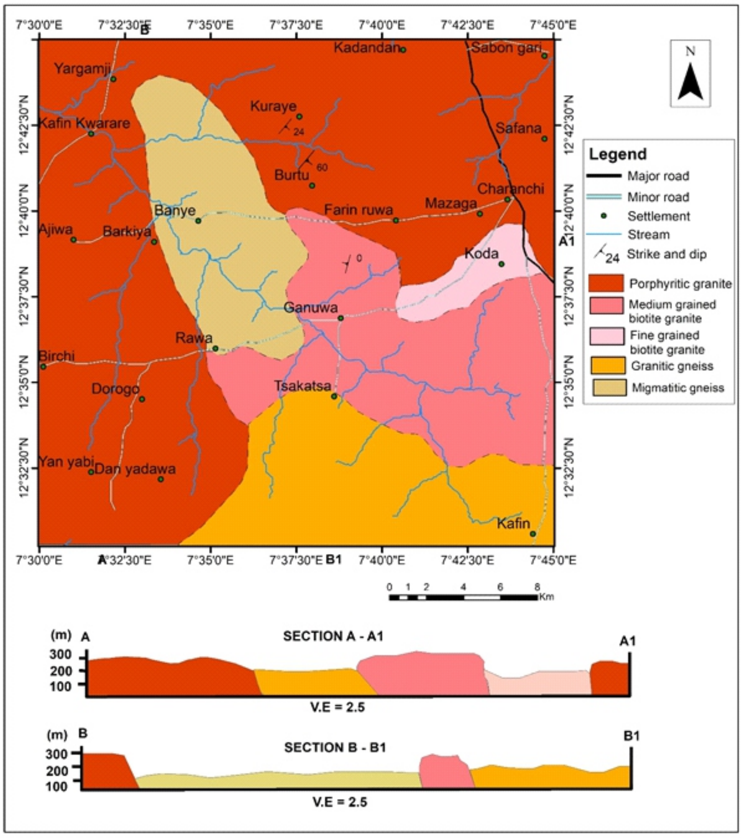

Figure 2: Geological map and cross sectional view A-A1 and B-B1 of the study area.

2.0 Materials and Methods

Twelve (12) available pumping test data were collected from Katsina state Rural Water Supply and Sanitation Agency (RUWASSA) and Adenter Nigeria limited. The pumping tests were carried out by pumping the boreholes at a constant rate for between 12 and 24 hours. The available pump test data were used to evaluate hydraulic properties of the aquifer at 12 locations. These properties are transmissivity (T), and specific capacity (Q/s). The Hydraulic conductivity could not be determined because there was no available data on the thickness of the aquifer. The Theis (1935) approximation method was used; the drawdown values obtained for the pumping phase were plotted against the time on a semi-log graph sheet to determine the slope Δs. The value of the slope obtained for the individual borehole was used in computing the transmissivity of the aquifer materials in the study area. Early pumping time was avoided when the slope was determined, because most of the time represents water that is released from well bore storage which tend to mask the real water flowing from aquifer storage. For this study the mid and late times drawdown values were used, the best straight line obtained from joining the drawdown values was considered and the slope per log cycle was calculated. The transmissivity was determined by using the modified Theis non-equilibrium equation of Cooper- Jacob (1946) given as Equation (1):

$$T \frac{2.30Q}{4\pi \Delta S} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, T = Transmissivity in m^2/s
Q= Borehole Discharge or Yield in l/s
Δs= Slope
The aquifer properties of the boreholes were derived using the following procedure:-
(BH 1: Ganuwa)
Data: - Q=0.32 l/s = $0.32\times10^{-3} m^3/s$ Δs= 23.2
1. Transmissivity,

$$T = \frac{2.30Q}{4\pi \Delta S}$$

$$T = \frac{2.30 \times 0.32 \times 10^{-8}}{4 \times 3.132 \times 23.1}$$

$$T = \frac{0.000736}{145.7}$$

T= $0.00000505 m^2/day$
T= $5.05\times10^{-5} m^2/day$
2. Specific capacity

$$Cs = \frac{Q}{S}$$

$$Cs = \frac{0.32 \times 10^{-8}}{35.2}$$

Cs= 0.0000091
Cs= $9.1\times10^{-5} m^2/s$

3.0 Results and Discussion

The result of the aquifer characteristics is summarized and presented in Table 1. While Table 2 provides Gheorge Standards for Transmissivity and Table 3 the Standard of Transmissivity by Krasny (1993).

Table 1: Aquifer Properties of Pump tested Boreholes in the Study Area

Sample ID	Location name	Depth (M)	SWL	Discharge (l/s)	Drawdown per log cycle	Transmissivity		Specific capacity (m^2/s)
						(m^2/s)	(m^2/day)	
BH1	Ganuwa	57	16.80	0.32	23.2	5.05×10^{-5}	0.43	9.1×10^{-5}
BH2	Kuraye A	35.45	3.25	0.32	15.8	7.4×10^{-5}	0.63	1.3×10^{-4}
BH3	K/soli	43	12	0.32	4.7	2.5×10^{-4}	0.2	3.5×10^{-4}
BH4	Hayin Fulani	30	18.13	0.27	12.4	7.9×10^{-5}	0.68	2.2×10^{-4}
BH5	Kuraye B	30	9.70	0.25	20.8	4.4×10^{-5}	0.38	7.4×10^{-5}
BH6	Walawa	54	31.20	0.34	8.8	1.4×10^{-4}	1.20	2.2×10^{-4}
BH7	Rawayau A	60.	25.50	0.30	13.6	8.0×10^{-5}	0.69	1.0×10^{-4}
BH8	Rawaayu B	50	26.13	0.40	10.8	1.3×10^{-4}	1.12	2.9×10^{-4}
BH9	Dinkawa	63	11.70	0.31	18.8	6.1×10^{-5}	0.52	1.2×10^{-4}
BH10	Dutsen Hutaw	65	15.30	0.34	25.2	5.0×10^{-5}	0.4	7.8×10^{-5}
BH11	Kirkini	55	17.90	0.25	18.6	4.0×10^{-5}	0.42	6.9×10^{-4}
BH12	Kukiya	58	12.6	0.25	25.36	3.5×10^{-5}	0.31	7.0×10^{-5}

Table 2: Gheorghe Standard for Transmissivity

Transmissivity Range (m^2/day)	Transmissivity Potentials
>500	High potential
50-500	Moderate potential
5-50	Low potential
0.5-5	Very low potential
<0.5	Negligible potential

Table 3: Standard for Transmissivity by Krasny (1993)

$T(m^2/day)$	Designation of Transmissivity	Groundwater supply potential
1000	Very high	Withdrawal of great regional importance
100	High	Withdrawal of lesser regional importance
10	Intermediate	Withdrawal for local water supply (small community's plants etc.)
1	Low	Small withdrawal for local water supply (Private consumption etc.)
0.1	Very low	Withdrawal for local water supply with limited consumption
	Impermeable	Sources for local water supply are difficult if not possible to ensure.

The analyzed result show that the transmissivity in the area ranges from 2.5×10^{-4} to 1.4×10^{-4} m^2/s as shown in Table 1. Using the Gheorghe‟s classification of transmissivity in Table 2, in six of the boreholes (Kuraye A, Hayin Fulani, Walawa, Rawayau A and B and Dinkawa), which represent 50% of the pump test borehole, the transmissivity values in these areas are within the very low potential while the remaining 50% (Ganuwa, Kafin Soli, Kuraye B, Dutsen Hutawa, Kirkini and Kuki) belong to Negligible potential. However, using the classification by Krasny (1993) in Table 3, two of the samples (Walawa and Rawayau B) which represent 16.6% of the pump test boreholes, the designation for the transmissivity in these areas is low which correspond to Small withdrawal for local water supply (Private consumption, etc.). While in the remaining eight which represent 83.4%, the transmissivity in these areas is very low which correspond to Withdrawal for local water supply with limited consumption. This result is in close agreement with other research work on hydraulic characteristic of the aquifer in the north western Nigeria, such as (Tahir, 2015) that reported a transmissivity value that ranged from $6.02x10^{-5}$ m^2/s to $5.30x10^{-5}$ m^2/s in basement complex of Kano area and Abusu, (2014) that reported a value that ranged from 0.68 to $2.98m^2/day$ in Kankara and environs, North Western Nigeria. Low values of transmissivity are associated with boreholes drilled within clayey weathered aquifer, or crystalline rock with limited fractures (Tahir, 2015). Also, it can be attributed to the poor porosity and permeability of the parent rock from which the aquifer material was derived especially for the basement complex aquifers (weathered/fractured rocks), and the shallowness of the wells which terminate in Clayey sand or Silt aquifers with low yield (Hamidu *et al.,* 2017). Another possible reason include poor borehole design and the use of feldsphatic materials as gravel pack which weathers into clay over time. The specific capacity values in the study area ranges between 9.1×10^{-5} to 1.3×10^{-4} m^2/s. For Specific capacity, the time of pumping during the constant discharge phase of pump test was not enough to make meaningful conclusion. This is because, under normal circumstances, period of pump test should not be less than 24 hours. In some pump test data used for this work; the time of pumping was not up to 3 hours; therefore, the duration was too short, and consequently the aquifer was not stressed sufficiently to know its actual specific capacity.

4.0 CONCLUSION

The hydraulic characteristics of the aquifer in the area showed that they have poor performance which results from low porosity and permeability and crystalline nature of the rocks in the area. Other factors include boreholes drilled within clayey weathered aquifer and poor borehole design and the use of feldsphatic materials as gravel pack which weathers into clay over time.

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