Global Scientific JOURNALS

GSJ: Volume 10, Issue 2, February 2022, Online: ISSN 2320-9186
www.globalscientificjournal.com

Aquifer Testing and Parameter Determination of Selected Communities in Katsinala Local Government of Benue State, Nigeria

Isaac Ojodomo Agbane[1*], Ogbadu Richard Omeje[2], and Chia Ronald Aondosoo[3]

[1]Department of Geology, Federal University Lokoja, Nigeria

[2]Department of Geology, Kogi State University, Anyingba, Nigeria

[3]Benue State Rural Water Supply and Sanitation Agency, Makurdi, Nigeria

***Corresponding author:** Agbaneisaac@gmail.com

Abstract

Katsinala communities are captured between latitudes 7° 09' and 7° 20' north of the equator and longitudes 9° 15' and 9° 30' east of the Greenwich meridian and it is predominantly of the crystalline basement complex rocks of the middle Benue Trough, comprising of mainly quartzite, siliferous rocks, migmatite gneises, older granites and other undifferentiated basement rocks. Pumping test with single well was investigated for their yield, transmissivity and specific capacities in ten (10) communities of katsinala local government. Yield estimations of aquifer parameters through suitable analytical models from field data recorded as drawdown against time to obtain the change in draw down. The Cooper Jacob method was employed and the investigation showed that the area have low to moderate yield and can supply water for local to private use. The average yield of the well is 0.95 l/s with a transmissivity average of 8 m^2/day. 60% of the investigated area showed very low yield and about 40% were tested for low yield.

Keywords: Hydraulic Conductivity, Pump Testing, Transmissivity, Specific Capacity, Katsinala, Benue Trough, Cooper Jacobs

© GSJ

1.0 Introduction

Water is an indispensable substance of life; everyone needs water to stay alive. Therefore the abundance and scarcity of water are a factor of utmost concern to everyone since life obviously depends on it. However, due to the geology of certain areas, the distribution of water is not even all through the earth space. The major source of water for the industrial, household, and irrigation practice in Benue State, Nigeria is underground water and it made the evaluation of the aquifer parameters very important. The value of the aquifer depends intrinsically on its ability to store and transmit water.

The borehole has become the major source of water for both the urban and rural areas of Benue State of Nigeria and through the interventions of the Federal and State Government; the number of boreholes for water supply is on the high side but faced with the problem of unproductivity. To curb this prevailing problem, understanding the geology and behavior of the aquifer hosting the earth's water becomes very vital. Hydro-geologists determine the hydraulic characteristics of water-bearing formations, by conducting pumping tests. A pumping test is conducted to examine the aquifer response, under controlled conditions, to the abstraction of water.

The basic principle of a pumping test is that if we pump water from a well and measure the pumping rate and the drawdown in the well then we can substitute these measurements into an appropriate formula and can calculate the hydraulic characteristics of the aquifer [13]. The Practical determination of good hydraulics or the yield of aquifers is necessary to enable practicing engineers and drilling contractors to make a sound decision on well design and construction for most situations [1].

Few researchers had worked on study area and the report of the hydraulic conductivity, transmissivity and specific capacity values of some parts of Konshisha Local Government area are 6.1 x10 -2 -6.45x10 -1 m/day, 0.49-4.52 m^2 /day and 18.41-117.92 m^2 /day respectively [2]. Similarly, report of wells around Azare area by [3] shows that The transmissivity, fell between 7.39 x 10-6 and 3.55 x 10-4 m^2 /sec and hydraulic conductivity ranged from 5.62 x 10-7 to 42.54 x 10-5 m/sec, while the average specific capacity was 2.10 x 10-4 m^3 /sec/m. This obviously shows that the yield from the boreholes around that area cannot serve the agricultural, industrial and household need of the people. These amongst others are the report of well productivity in Benue state, Nigeria.

Furthermore, an evaluation of the aquifer characteristics of Nanka sands was conducted by [4].

The transmissivity and hydraulic conductivity values were 0.48 to 19.50 m^2 /day and 0.06 to 3.75 m/day respectively. Based on this note, the main objective of the work is to provide information regarding the availability and quantity of water in storage, the depth at which the water can be abstracted. This was done by yield estimations of aquifer parameters through suitable analytical models from field data recorded. This will be useful for proper management of ground water resources in the study area.

2.0 Geology of the Study Area

Benue State is situated between Latitudes 6o 30'N and 8o 15'N and Longitudes 7o 30'E and 10o 00'E with land area of about 34,059 km2 and a population of 2,780,398 by 1991 Census and 4,253,541 by 2006 estimate. Benue State experiences two distinct seasons, the wet season and the dry season. The rainy season lasts from April to October with annual rainfall in the range of 1120 to 1500 mm. The dry season begins in November and ends in March. The climate is characterized by high temperature regime, ranging from 27-380 C as mean annual. Relative humidity is between 60-80%. It has a vegetation cover of the guinea savannah type [1]. Katsina-Ala is a local government area of Benue state with land mass of 2,402km and population of 224,718 at the 2006 census. It is bounded by latitudes 7^o 09' and 7^o 20' north of the equator and longitudes 9o 15' and 9^o 30' east of the Greenwich meridian and has generally low lying to gently undulating terrain [13]. The area is drained majorly by River Kastina-Ala. The geology of the study area is predominantly of the crystalline basement complex rocks of the middle Benue Trough, comprising of mainly quartzite, siliferous rocks, migmatite gneises, older granites and other undifferentiated basement rocks[5]. As shown in Fig.1, the north of Katsina-Ala is a complex sedimentary formation while the main town located along river Katsina-Ala bank comprise of alluvium deposit. These sediments comprise of sandstones, clays/sandy clays and Eze-Aku shale group [13]. They are of Turonian age: a period of marine transgression in Nigeria when the sea covered large parts of the eastern and northern Nigeria [6].The aquifer units in the area and other similar basement complex areas are believed to be derived essentially from the weathered and/ or fractured rocks [5].

© GSJ

GSJ: Volume 10, Issue 2, February 2022
ISSN 2320-9186

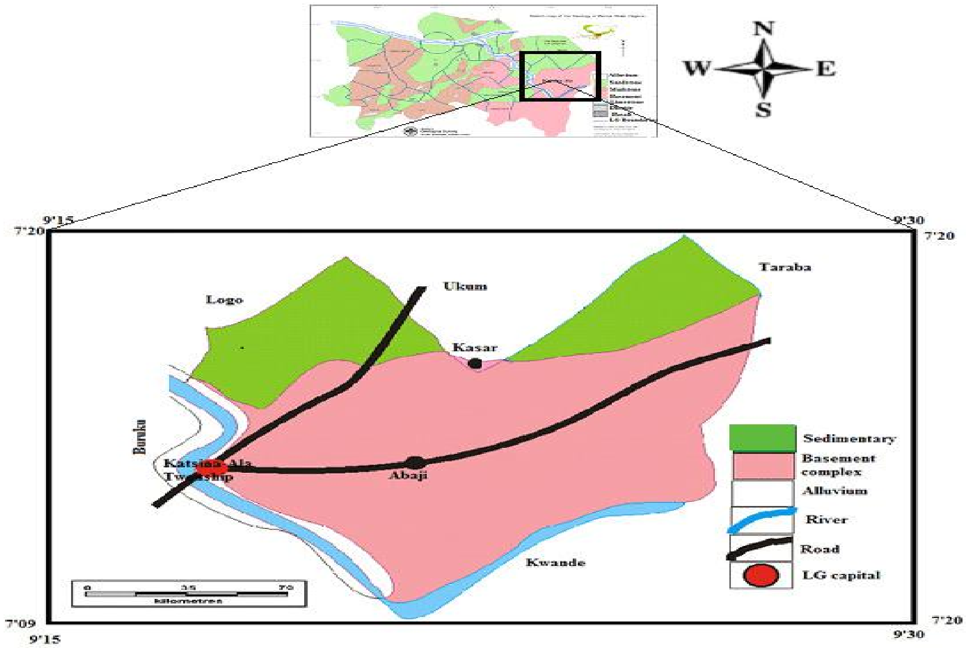

Fig.1: Geology of study area [7].

© GSJ

3.0 Methodology

3.1 Data Collection

Two main sources of data were used to achieve the study objectives. They are the primary and secondary sources of data.

Primary Source of Data Collection: These were got from the field. Geological and geophysical surveys were carried out for the determination of the ground water potential, drilling of the boreholes and pump testing was carried out.

Note: All data used was acquired by Benue state rural water supply and sanitation agency (BERWASSA).

Secondary Source of Data Collection: These were obtained through internet, academic journals, textbooks, research paper and related literatures. Data obtained include; Geology of the area, literature review data, well performance evaluation etc

Pumping tests were carried out for ten (10) boreholes located at different communities of Katsinala area of Benue State for the evaluation of the aquifer parameters. Constant rate pumping test method with a single well was adopted which comprises of two phases-the pumping phase and non-pumping or recovery phase. Before the commencement of the pumping test, the static water level was measured using electric water level probe (dipper) and thereafter 1Hp submersible pump was installed and the rise in water level noted. During the pumping phase, the water was pumped at constant rate from a suitable local datum (top of casing) and water level response (drawdown) was measured and recorded using dipper and stopwatch. The flow rate was measured soon after the start of the test, and at intervals during the test using a known volume of container. The dynamic water levels in the borehole was measured in the intervals of 30 seconds for 10 minutes elapsed, 2 minutes for 10 minutes elapsed, 5 minutes for 20 minutes elapsed, 10 minutes for 40 minutes elapsed, and 20 minutes for 40 minutes elapsed, making it a total elapsed pumping time of about 120 minutes. The second phase which is the non-pumping or recovery phase started at the end of the pumping phase when the pump was switched off, the stopwatch was restarted and the water level recovery was measured at the same intervals as for measuring the drawdown.

3.2 Data Processing

© GSJ

The yield of the borehole (y) was determined during pump testing on the field and the change in draw down (Δs) was derived by plotting the drawn down against the corresponding time of pumping.

The aquifer parameter measurement (Transmissivity and specific capacity) was derived from cooper Jacobs's method.

Transmissivity (T) = $\frac{2.303Q}{4\pi\ \Delta s}$

Specific capacity (Sc) = $\frac{Q}{\Delta s}$

Where T is the transmissivity measured in meter square per day, Q is the discharged rate measured in meter cube per day, ΔS is the slope of drawdown versus log of time (change in drawdown per logarithmic cycle), Sc is the specific capacity measured in meter square per day.

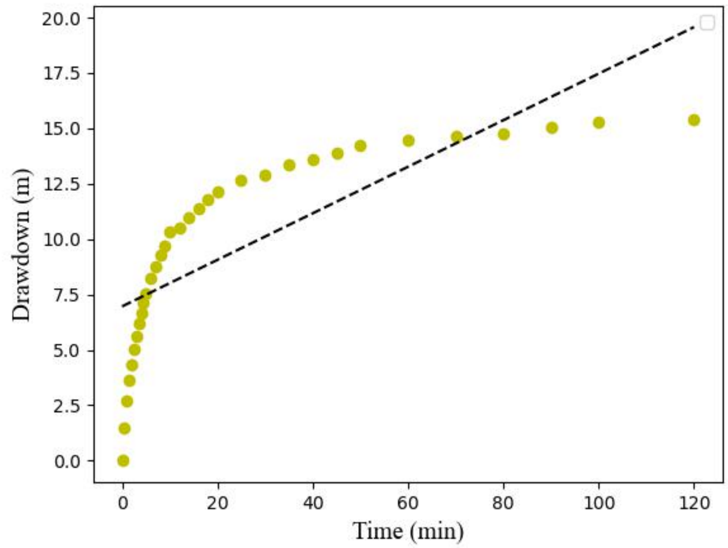

Fig. 2: Jacob straight line on drawdown versus log time (Ashuwa Community).

Table 1: Summary of the pumping test data and computed specific capacity and transmissivity values

Location (Community)	**Coordinates**	**Static Water Level (m)**	**Borehole Depth (m)**	**Discharge Rate (m^3/day)**	**Slope of Drawdown/ Time Curve (m)**	**Specific Capacity (m^2 /day)**	**Transmissivity (m^2 /day)**
Gwanyi	7.177282N 9.283735E	39.58	51	76.03	15.23	4.99	0.92
Mbaauna II	7.474993N 9.479213E	39.58	53	76.03	15.23	4.99	0.92
Mbagbaka/Imande Kwator	7.490948N 9.517813E	40.09	50	73.44	17.15	4.28	0.79
Mbaakpe	7.190752N 9.5028133E	40.1	50	77.76	19.66	3.95	0.73
Shikaan Dangi	7.190882N 9.619483E	44.92	45	64.8	22.87	2.83	0.52
Mbagundu II	7.423158N 9.474912E	11.81	49	84.67	2.02	41.91	7.69
Ashuwa	7.21884N 9.49073E	21.83	50	90.72	8.12	11.17	2.04
Gboraya I	7.163485N 9.286585E	35.66	55	77.76	22.73	3.42	0.63
PHC Gbenger	7.733368N 8.768419E	11.81	50	86.4	1.99	43.41	7.96
Mbanyikyaa	7.175215N 9.38311E	40.09	50.45	73.44	17.15	4.28	0.79

© GSJ

5.0 Result and Discussion

The result obtained from the processing of the pump testing data as shown in table five (1) indicated that the area has very low yield with only well mbaagudu II, Ashuwaa and PHC Gbenger showing low yield while Gwanyi, Mbaauna II, Mbagbaka/Imande, Mbaakpe, Shikaan Dangi, Gboraya I and Mbanyikyaa are showing very low yield based on [8] classification. The discharge rate averaged 0.89L/s. It was observed that most of the tested well have very low to low and cannot supply reasonable amount of water. The transmissivity value for the study area ranged between 0.52 m^2/day to 7.69 m^2/day and the results obtained showed the aquifers of the study area fall within very low to low transmissivity based on [10] classification. Based on the transmissivity of the aquifers, it can be inferred that the wells are satisfactory for limited consumption except for Mbaagundu II and Ashuwa community that has low transmissivity.

The specific capacity of the tested well ranged from 2.83m^2/day – 41.9 m^2/day which shows low to medium specific capacity and has groundwater supply potential for private consumption to local water supply importance [10]. The borehole depths ranged from 45m – 55 m or an average borehole depth of 50m.

© GSJ

Table 2: Borehole Yield Ranges according to Akinwumiju [8]

Class	Class interval	Groundwater Potential
1	0.0 – 0.5	Very Low
2	0.5 – 1.0	Low
3	1.5 – 2.0	Moderate
4	2.0 – 2.5	High
5	>2.5	Very High

Table 4: Classification of Transmissivity Magnitude [10]

Magnitude of Transmissivity (m^3/day)	Class	Designation	Specific Capacity (m^2/day)	Groundwater Supply Potential
>1000	I	Very high	>864	Regional importance
100 – 1000	II	High	86.4 – 864	Lesser regional importance
10 – 100	III	Intermediate	8.64 - 86.4	Local water supply
1–10	IV	Low	8.64 – 0.864	Private consumption
0.1 – 1	V	Very low	0.0864 – 0.864	Limited consumption
<0.1	VI	Imperceptible	<0.0864	Very difficult to utilize for local water supply

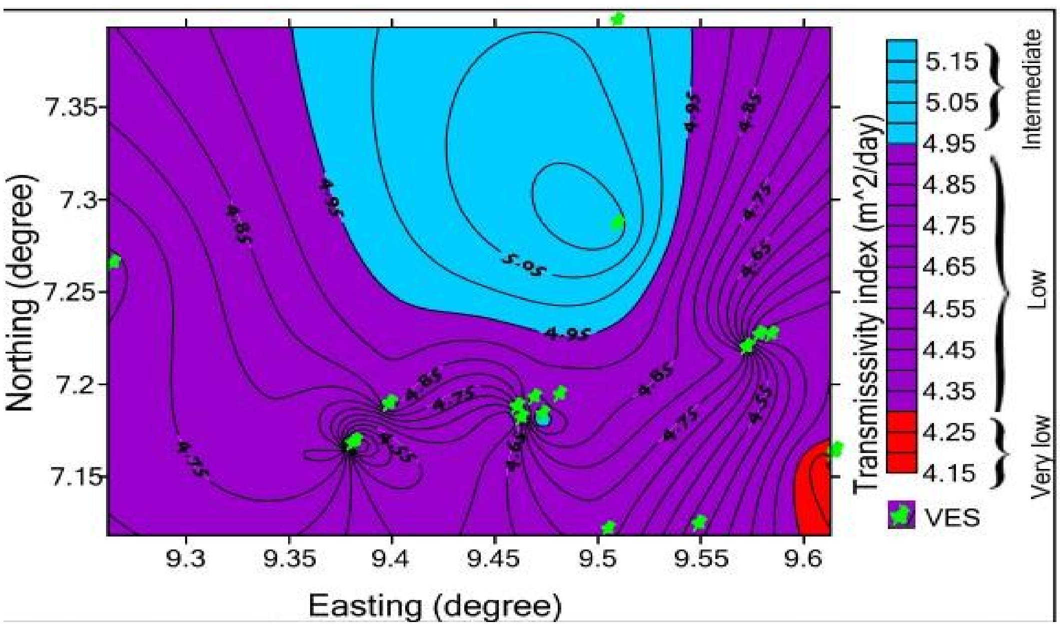

Fig. 4: Transmissivity map of katsinala [13].

Borehole No.	Yield (l/s)	Designation	T (m^2/day)	Designation	Sc (m^2/day)	Designation
Gwanyi	0.88	Low	0.92	Very Low	4.99	Private consumption
Mbaauna II	0.88	Low	0.92	Very Low	4.99	Private consumption
Mbagbaka/Imande	0.85	Low	0.79	Very low	4.28	Private consumption
Mbaakpe	0.90	Low	0.73	Very low	3.95	Private consumption
Shikaan Dangi	0.75	Low	0.52	Very Low	2.83	Private consumption
Mbagundu II	0.98	Low	7.69	Low	41.91	Local water supply
Ashuwa	1.0	Moderate	2.04	Low	11.17	Local water supply
Gboraya I	0.88	Low	0.63	Very Low	3.42	Private consumption
PHC Gbenger	1.0	Moderate	7.96	Low	43.41	Local water supply
Mbanyikyaa	0.81	low	0.79	Very low	4.28	Private consumption

Table 5: summary of the aquifer parametre interpretations of the study area.

© GSJ

Conclusion

The determination of hydraulic parameters in some communities of Katsinala local government of Benue state was carried out using pumping test results obtained from the study area. The specific capacity, conductivity, transmissivity and aquifer yield was determined and the result showed that most of the well recorded very low yield and availability of groundwater for limited use and such aquifers will not yield enough water for area supply but can be used for within the community of investigation where the demand is not usually high. It is recommended that the determined hydraulic characteristics can be utilised by any underground water prospector for a well-informed prediction of the expected yield of the groundwater in storage in any of the aquifers within the study area. The area should be properly guided from incessant abstraction of groundwater for use not relevant to the community.

Acknowlegements: My profound gratitude goes to the entire staff of Benue State Rural Water Supply and Sanitation Agency for the data. Special appreciation to Mr. Omeje Ilemona Sunday whose guidance and mentorship made this work a success.

Note: The authors declare no conflicts of interest.

References

[1] Akpen, G. D., M. I. Aho, and M. G. Adejo. "Aquifer characteristics of some local government areas of Benue State, Nigeria." *Nigerian Journal of Technology* 38.1 (2019): 233-241.
[2] Jika, H.T. and Tse, A. C. "Determination of Hydraulic Characteristics of an Aquifer Capacity from Pumping Test: A case study of Konshisha Area, Central Nigeria", Scientia Africana, Vol.13, Number 2, pp 136-145, 2014.
[3] Tse, A. C; Amadi, P. A. "Hydraulic Properties from Pumping Tests Data of Aquifers in Azare Area, North Eastern Nigeria." Journal Applied Science Environmental Management, Vol. 12, Number 4, pp 67- 72, 2008.
[4] Okoro, E. I., B. C. E. Egboka, and A. G. Onwuemesi. "Evaluation of the aquifer characteristic of Nanka Sands using hydrogeological method in combination with Vertical Electrical Sounding (VES)." Journal of applied sciences and environmental management 14.2 (2010).
[5] Offodile, M. E. (2002).Groundwater study and development in Nigeria. Mecon Geology and Engineering Services Ltd.: Jos, Nigeria, 1-453.
[6] Reyment, R. A. Aspect of Geology of Nigeria. Ibadan University press, 122p, 1965.
[7] Aquifers Characterization and Classification Using Electromagnetic and Galvanic Resistivity Methods in Basement Complex, Katsina-Ala, Central Nigeria – Scientific.
[8] Akinwumiju A.S, Olorunfemi, M.O and Afolabi, O., (2016) GIS-Based Integrated Groundwater potential assessment of Osun drainage Basin, Southwestern Nigeria. Ife Journal of Science vol. 18, no. 1: 163.
[9] Singhal B. B. S and Gupta R. R (1999). Applied Hydrogeology of Fractured Rocks. P. 154.
[10] Krasny, J., (1993). Classification of Transmissivity Magnitude and Variation. Groundwater 31(2), 230-236.
[11] Terhemba, B. S., Daniel, O., David, M., Chukudebelu, J. U., & Ezema, P. O. (2016). Aquifers Characterization and Classification Using Electromagnetic and Galvanic Resistivity Methods in Basement Complex, Katsina-Ala, Central Nigeria. Int. J. Sci. Technolodge, 4, 10-21.
[12] Offodile, M. E. (2002).Groundwater study and development in Nigeria. Mecon Geology and Engineering Services Ltd.: Jos, Nigeria, 1-453.

[13] Terhemba, B. S., Daniel, O., David, M., Chukudebelu, J. U., & Ezema, P. O. (2016). Aquifers Characterization and Classification Using Electromagnetic and Galvanic Resistivity Methods in Basement Complex, Katsina-Ala, Central Nigeria. Int. J. Sci. Technolodge, 4, 10-21.
[14] Balasubramanian, K. R., R. Ajith Krishnan, and S. Suresh. "Spatial orientation effects on flow boiling performances in open microchannels heat sink configuration under a wide range of mass fluxes." *Experimental Thermal and Fluid Science* 99 (2018): 392-406.

© GSJ