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Estimation of Ground Water Potentials in Bauchi Metropolis, Bauchi State, Nigeria.

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ABSTRACT

This study aimed at estimating underground water potential in Bauchi Metropolis a case study of Gwallameji, behind NITEL Office, opposite emergency ward, Old GRA opposite Niima and Shafa Gidan Mai). Rainfall, temperature and humiditydata of the study area were collected from the meteorological center, Bauchi, pumping test were conducted on the existing Boreholes.Also, geophysical survey on the existing Boreholes to determine their Resistivity Values was carried out. The pumping test was conducted using constant head, while geophysical survey was conducted using Schlumberger array and five vertical electrical sounding (VES) points were sounded. The draw down and their corresponding residual draw down are plotted respectively.Data collected are interpreted using Win Resist 2 software. The results show that the rainfall pattern couple with temperature and relative humidity record contributes to the ground water storage, the average depth to water table in the crystalline basement in the study area is 4.2m and the average yield of 0.87 l/sec. (52.2 l/min.), This was determined from the results obtained in the area. The average transmissibility in the study area is 7.90X10-3 m2/sec with the resistivity value ranges from 24.8 to 847.1 ohms-meter and their permeability are about moderate to low and the storability in the basement complex is reasonable; it ranges from 1.002x10-3 to 1.008x10-3. The findings clearly reveal the reliability of ground water potential in the metropolis. This investigation should be extended to other areas in Bauchi hitherto not covered in this work.

Key words: Underground, borehole, resistivity, basement, permeability.

I. INTRODUCTION.

Groundwater is the main source of water for much of the rural population of sub-Saharan Africa, particularly those in the drought-prone semi-arid regions Okereke (1997). Groundwater is a fundamental component of the water resources for domestic, industries and drinking purpose. The exploitation and sustainability of this resource is key to human survival and economic development. Large areas of sub-Saharan Africa are underlain by crystalline basement rocks and much research has been undertaken on groundwater storage and flow within this aquifer and how best to develop and protect water supplies (Emenike, 2007).

The development of groundwater in the study area is beset with problems of failed (Abortive) boreholes. The groundwater in the basement complex terrain is mainly contained in the porous and permeable weathered zones. The groundwater yield from the weathered horizon is often supplemented by the accumulated groundwater in the fractured and jointed column of the Basement complex rocks(Okolie, 1999).

The hydrogeological and hydraulic investigation involves monitoring the static water level, depth of well/borehole and calculation of aquifer parameters such as Transmissibility, Specific capacity, hydraulic conductivity, Storability which were used to evolve a groundwater potential map of the study area (Leduc 2009).

The properties of water make it suitable for human beings to survive in differing weather conditions. Water is characterized by complex anomalous properties that differentiate it from other substances. Water is the universal solvent due to its polar nature. It dissolves a large number of different chemical substances (Shamang, 2005).

Despite the long history of groundwater extraction throughout civilization, it has only been during recent decades that the use of groundwater has grown exponentially. Most people depend on groundwater for their daily supplyOyewoye (1963). Although every society has its own problems and Bauchi is not an exception yet the very recent challenges of ground water in various locations have been a challenge for the government and the people of Bauchi state.

Even with the supply of water to people of the metropolis by the State Water Board through the Gubi Dam treatment plant, yet other locations where reticulation could not reach suffer inadequate water supply due to abortive wells/boreholes. This necessitated this investigation which will provide viable solution to the water need of the study area.

II. Methodology.

Hydrogeological map of the study area was obtained showing the bore hole locations in the study area.The map reveals the fractured areas.

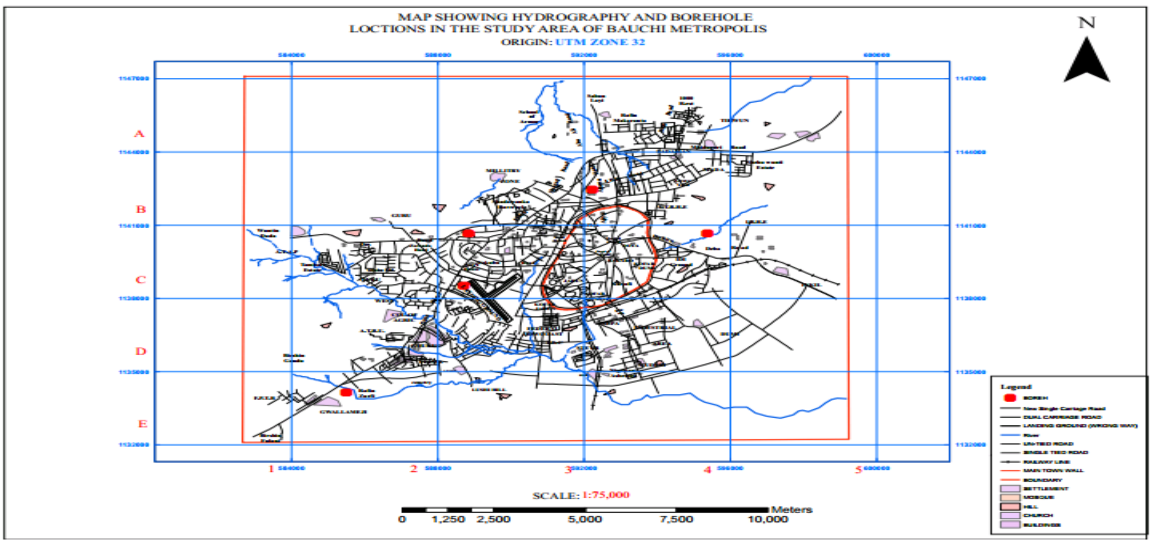

Fig 1: Showing bore hole locations in Bauchi.

The Rainfall Data for eleven (11) years between 2011 to 2021 were collected from the meteorological center, Old Airport in Bauchi, Bauchi State of Nigeria and analyzed. The meteorological elements of concern include Rainfall, Minimum Temperature., Maximum Temperature and Humidity.

The electrical resistivity method is the single the most important method used in hydro- geological investigation and it is useful because the resistivity of a formation is largely dependent upon its moisture content. The Schlumberger configuration or arrangement of electrical resistivity was then used.The survey is based on evaluating the apparent resistivity Ra**.**

Electrical Resistivity prospecting method has been used in determining groundwater potential Areas of Gwallameji, Old GRA, Behind Nitel office, Mudalawal Market, Gidan Mai of Bauchi Metropolis, Bauchi State, using the Vertical Electrical Sounding (VES) method at different selected points within the Metropolis. A total of five (5) VES points were investigated in the study areas. Schlumberger array with Resistivity meter (McOHM-EL Model 2119) was used in the Geophysical survey. The Data was interpreted with the software called WinResist2.

The pumping test data was analyzed byCooper-Jacob's Method wherethe modified non-steady state formula was applied thus:

$$S = \frac{2.25 T t0}{r^2\ S} \qquad (1)$$

It follows that transmissibility:

$$T = \frac{2.30\ Q}{4\pi\Delta_s} \qquad (2)$$

III. Results and Discussion.

3.1. Results Presentation.

Bauchi Metropolis entirely is controlled climatically by two main factors, namely altitude and the position across the path of the season migration of Intertropical Convergence Zone (ITCZ). These causes seasonal alternation depending on which of them is dominant. As a result of this, there is a period of wet season alternation with very dry season in the study area, classifying it as wet dry tropical climate region. The wet season starts in late April and ends in early October with the highest rainfall in August, while the dry season is from late October to early April.

As shown in figure1, the rainy season mostly startsfrom the month of April and ends by September/October of every year depending on its pattern. July and August have the highest mean monthly rainfall of 187.67mm and 250.53mm, while April and October have the lowest of 0.72mm and 18.76mm.

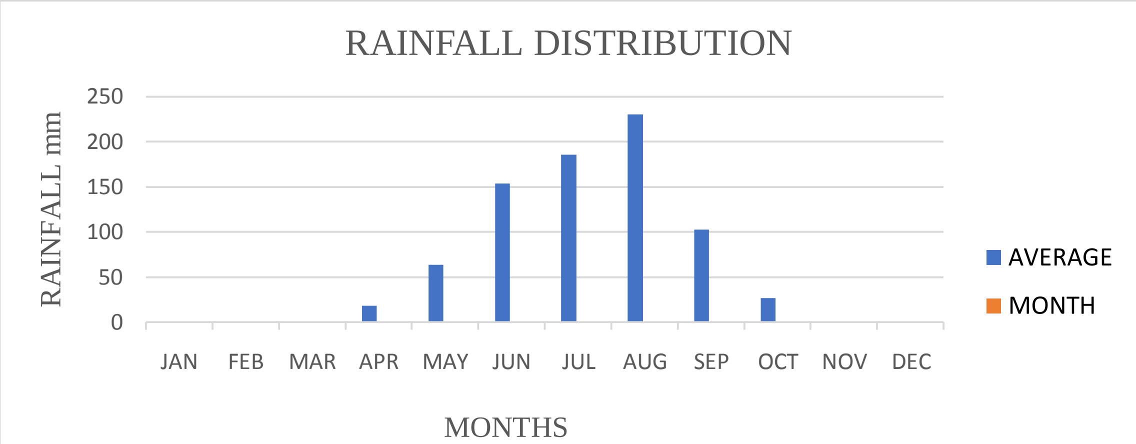

FIG.2: AVERAGE MONTHLY RAINFALL OF THE STUDY…

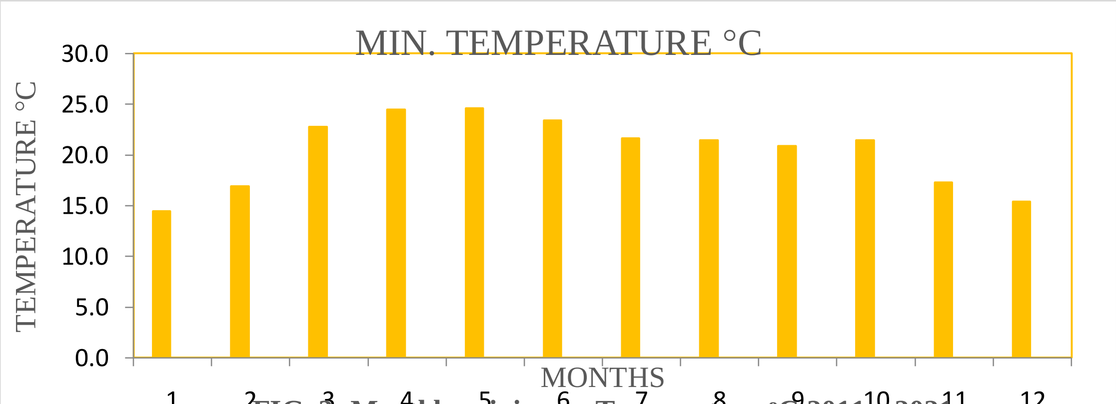

FIG. 3: Monthly minimum Temperature °C 2011 – 2021

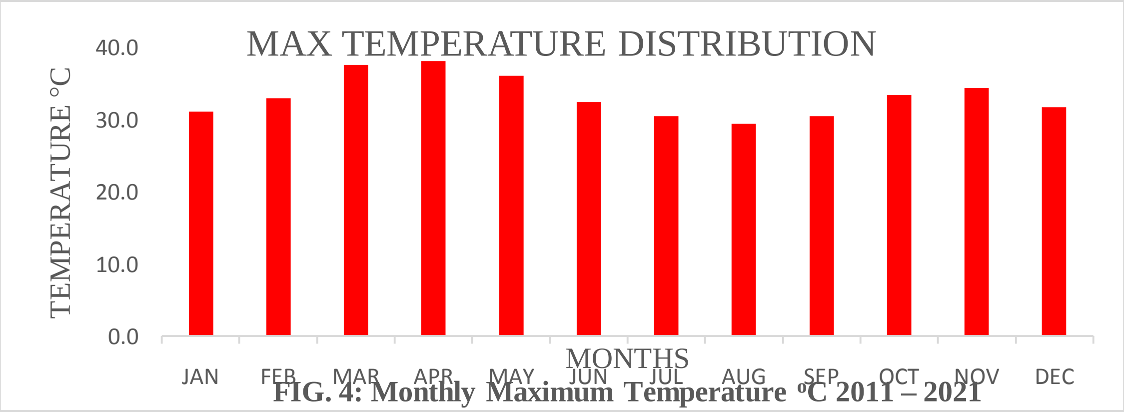

FIG. 4: Monthly Maximum Temperature °C 2011 – 2021

There are two distinct seasons; hot and dry season with north easterly winds between February and May, cool and wet season between June and September with southwesterly winds and cool dry dusty and windy harmattan season from October to January of each year.

Bauchi is hottest in the month of April with average temperature of 38.1^{o}C, while the coldest months are December and January, when temperature falls to 14.4^{o}C

The mean monthly relative humility for 2011-2021 is shown in figure 4, indicating high levels of relative humidity in the month of July of about 87.8%. It drops to 26.7% in the harmattan season.

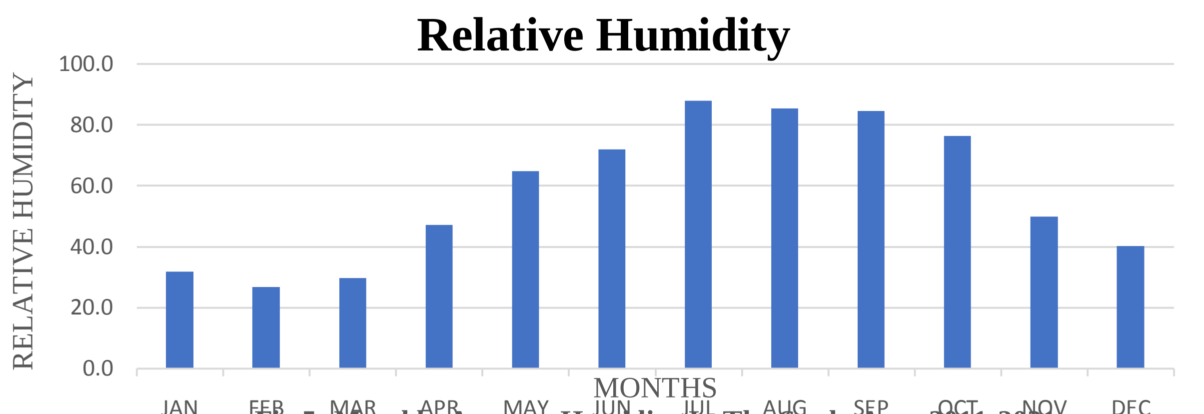

Fig.5: Monthly Average Humidity In The Study Area 2011-2021

The boreholes in the study areas were subjected to pumping test, and their draw down are plotted against time with their corresponding residual draw down from figure 6 -15 to show their respective response to pumping.

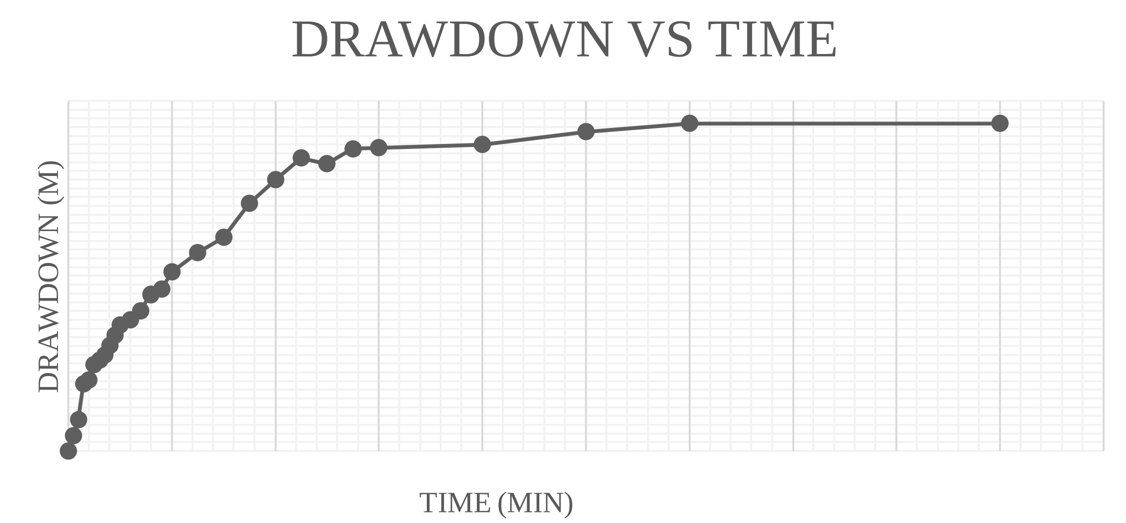

FIG.6: RAFIN ZURFI, GWALLAMEJI DRAWDOWN VS TIME

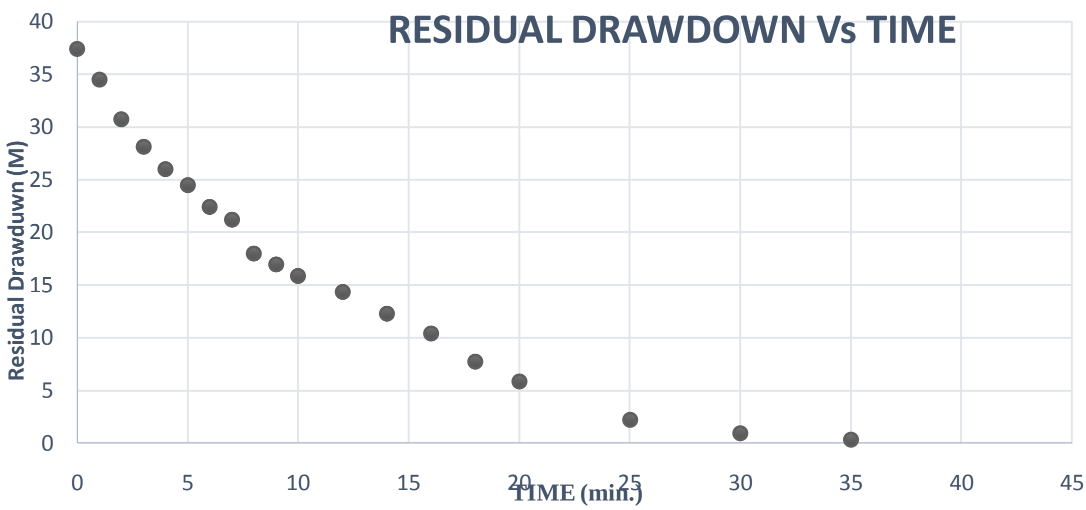

Fig.7: RAFIN ZURFI, GWALLAMEJI RESIDUAL DRAWDOWN Vs TIME

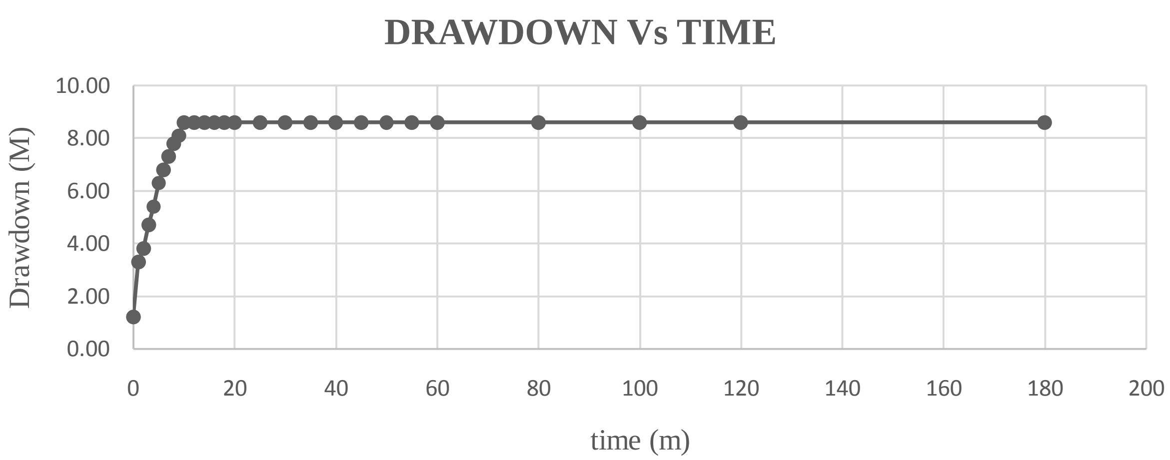

Fig.8: BEHIND NITEL OFFICE DRAWDOWN Vs TIME

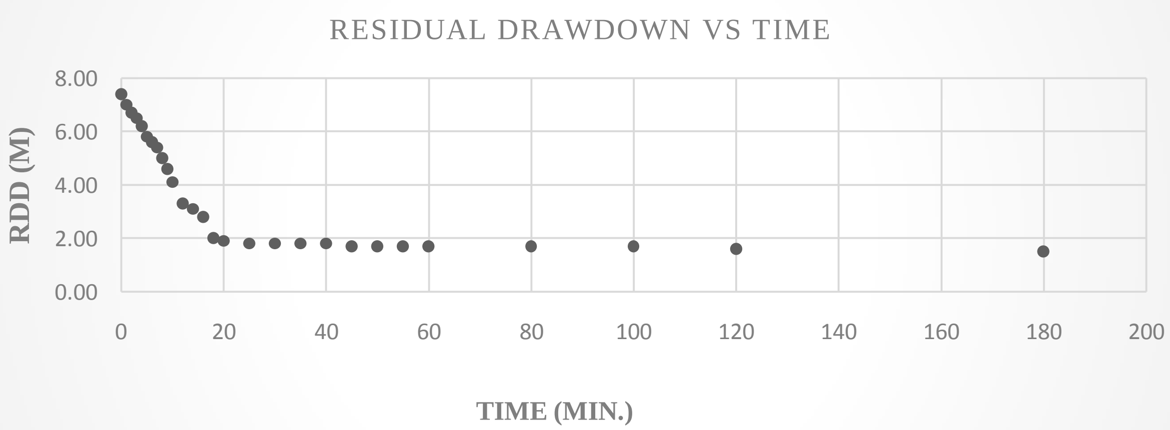

Fig.9: BEHIND NITEL OFFICE RESIDUAL DRAWDOWN Vs TIME

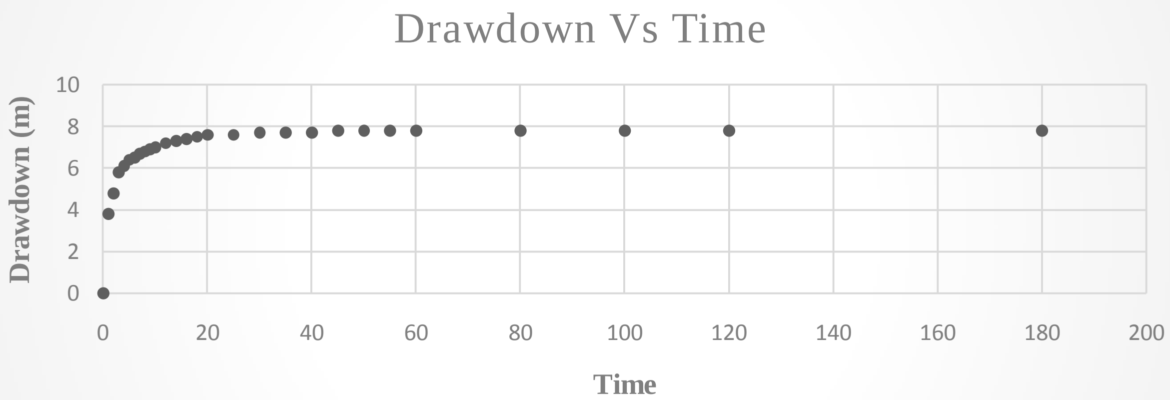

Fig.10: OPP. EMERGENCY DRAWDOWN Vs TIME

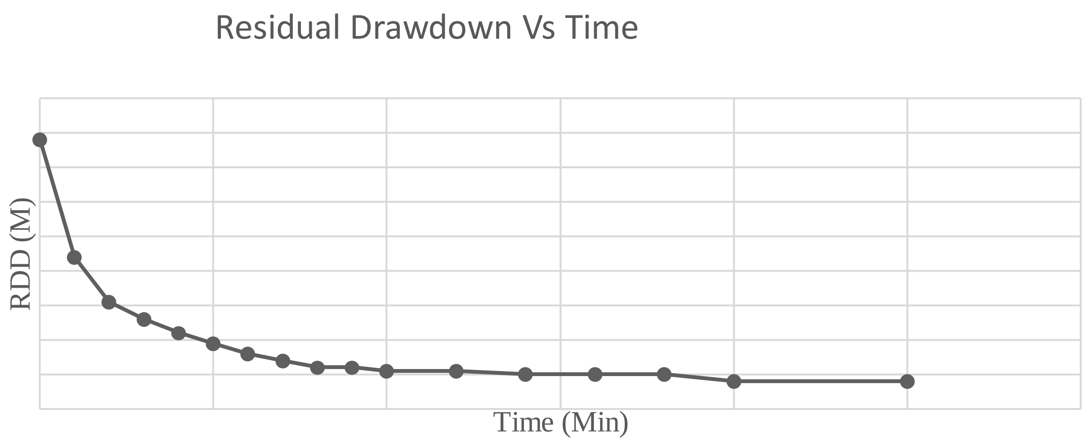

Fig.11: OPP. EMERGENCY RESIDUAL DRAWDOWN Vs TIME

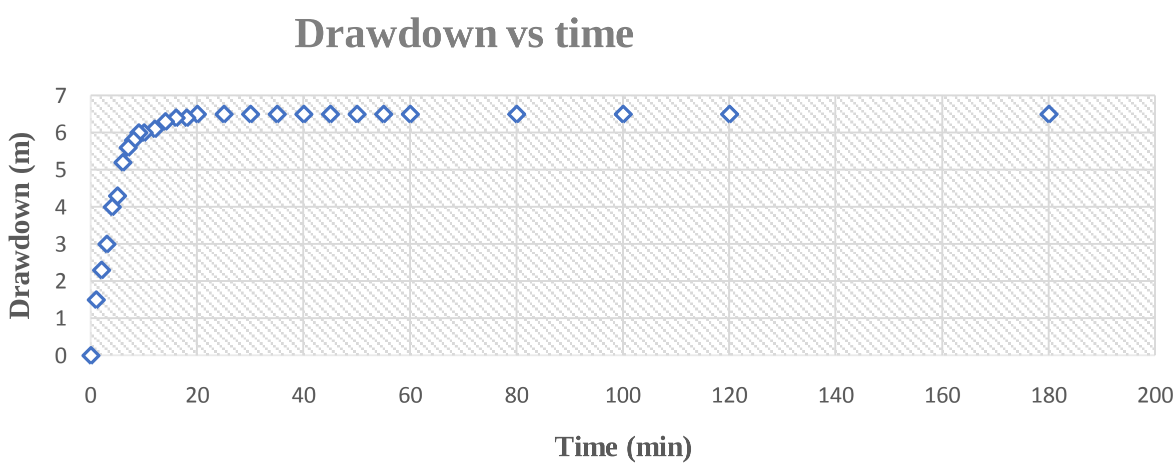

Fig.12: OPP. NI'IMA DRAWDOWN Vs TIME

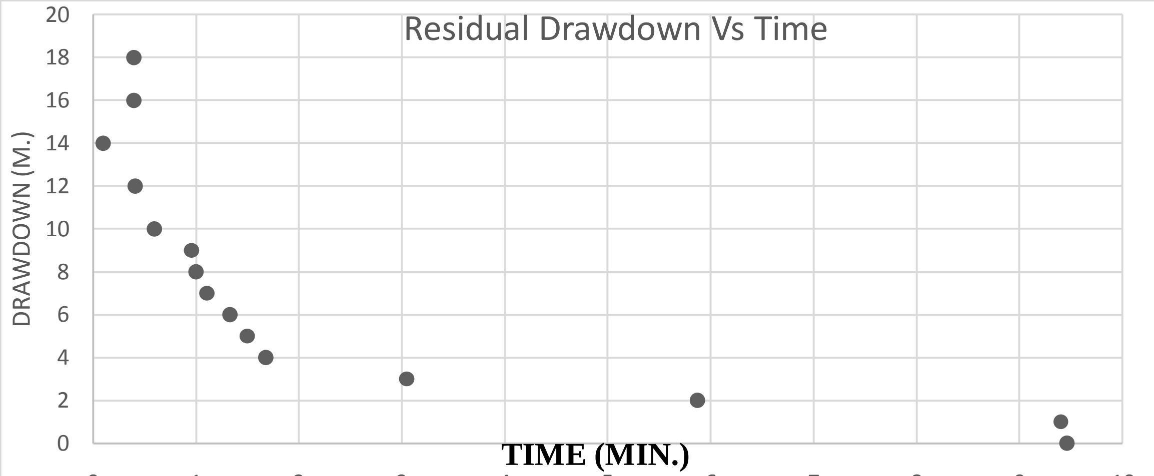

Fig.13: NI'IMA RESIDUAL DRAWDOWN Vs TIME…

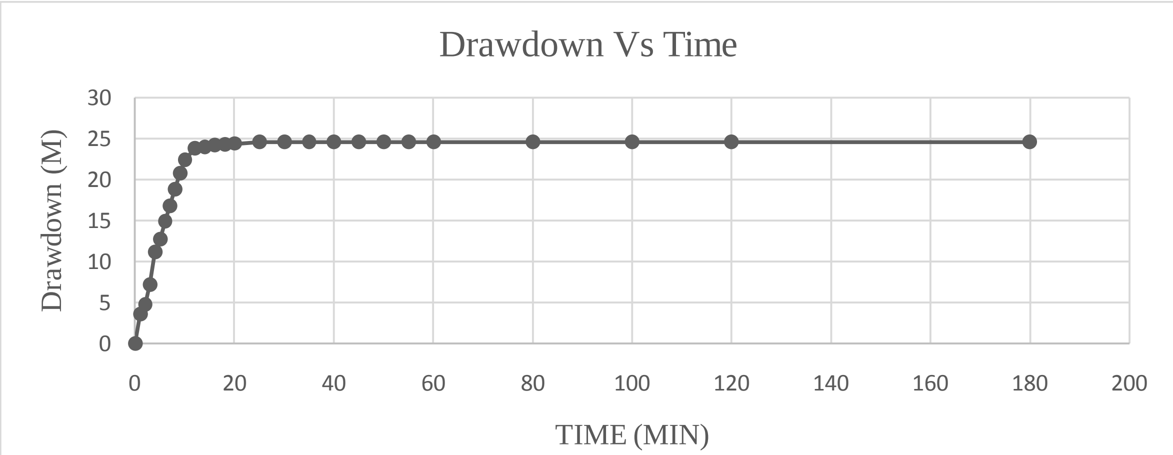

Fig.14: OPP. SHAFA, JOS ROAD DRAWDOWN Vs TIME

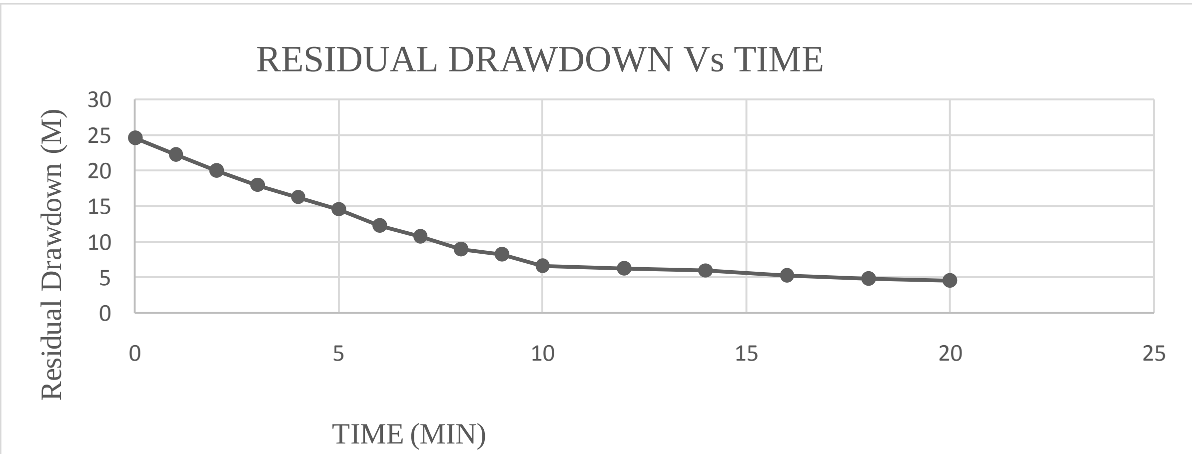

Fig.15: RESIDUAL DRAWDOWN Vs TIME

Boreholes are completed in moderately and poorly decomposed gneisses and granites and in fractured pegmatite, aplite and quartz veins, with general depths of20 to 50 meters and yields 10 to 40 liters per minutes. Water level are within 25 meters to the surface. Success rates of 65 - 70% are achieved, following the geophysical survey.

3.**2 Discussion of Results.**

Bauchi Metropolis is located in the high relief features and the run off is relatively high, while the infiltration rate is low. Figure 2 shows the annual rainfall pattern, which reveals that the maximum amount of rainfall occurs in the months of July and August, as a result of the gradual buildup of rain which essentially begins from March with trace of the rain, the soil profile acquires its maximum moisture by August, at this point, most of the shallow wells have their highest water levels. This contributes significantly to the ground water storage through infiltration and percolation process, the resource gains access through the basement fractures. The ground water demand at these periods are also reduced due to the high availability of surface water for all of human and plant need.The geological features, in addition to the adverse climatic condition of the area, control the ground storage. The area is underlain by the crystalline basement complex, where the occurrence of ground water is due largely to the development of secondary porosity and permeability by weathering or fracturing of the parent rocks (Schiffler 2000).

The temperature variation in the study area is characterized by minimum and maximum temperatures as shown in fig. 3 and 4 respectively. The least temperature of 29.4^{0} c was recorded in the month of August. This corresponds with the period of highest rainfall where the ground got saturated, resulting into the cooling of the entire study area.

It can be noticed that from fig.5, the relative humidity of this area is equally highest within the months of July and August this is owing to the high moisture level both on land and theatmospheric water vapour

Fig.6shows the chart of drawdown against time of the RafinZurfi area where the pumping test at the initial stage of zero-time depth is 5.1m, while pumping began after first 10 minutes of pumping, the drawdown is 36.4m, then the borehole stabilized at 120minute of starting, in which the rate of water extracted equal to the rate of water flow in to the borehole, that is the dynamic water level (DWL) of the Well. The total depth of the Well is 50m, which indicate that the borehole has the water column of 7.5m after stabilizing.

The result obtained in fig.7,show the residual drawdown against time in RafinZurfiwhere the water is rising after pumping stopped at the first 10 minutes, the water rouse from 12.5m at zero minutes to a stage of stability at the depth of 7.3m with the recovery period of 25minute. while at 6.0m, the time was at 30 minutes of stopping the pump. The water is about to become static with residual drawdown of 0.9m.

Thedrawdown of the borehole behind Nitel is also shown in fig. 8, in which at the first 10 minutes of the pumping test, the borehole stabilized at the depth of 8.6m, while the dynamic water level (DWL) attained, which the residual draw down in figure 9, shows the water column of the borehole is 36.4m, this indicate that the borehole has adequate water column and the aquifer is very productive.

From fig. 10, the borehole located opposite the hospital emergency unit shows significant change in the drawdown in the first 10 minutes.Water level rouse to 5.3m from the 8.60m, while at first 20 minutes the rise is at 3.0m thus, attaining static level up to 30 minutes at which the water is very sluggish at 2.7m. On the other handthe residual drawdown shown in fig. 11reveals the extraction of water at the first 10 minutes is at the 10.3m, while the borehole came to stabilized at the first 30 minutes at the depth of 11.1m with the total depth of the borehole at 44.9m, the water column is 33.8m which indicate the borehole has enough and very productive aquifer.

The borehole located opposite Niima hospital shown in fig.12 revealed how the water rouse after pumping stopped in relation to time taken. The pumping stopped at drawdown of 11.1m but after the first 18 minutes becomes static at 4.2m, this show that the aquifer is fast recharging since the well is about to become static within the first 25 minutes of stopping the pumping operation as shown in fig.13

Fig. 14 show the drawdown of the borehole near Shafafilling station at Jos road. The extraction of water at the first 10 minutes is at 9.0m, while at 20 minutes the borehole attained the dynamic water level at 9.5m.The total depth of the borehole is 28m, the water column is 18.5m, which show that the borehole has enough water to supply at the flow rate of 1.0 l/sin 3 hours of pumping.

From fig.15, the residual drawdown after stopping rouse at a very high speed with the drawdown from 9.5m to 3.5m at first 10 minutes, then 3.4m at first 18 minutes of stopping pumping. This indicate that the borehole has a high recharge, since the flow rate in the last 2 hours is 1.0 l/s, which shows a quick recharge from the aquifer.

The result obtained and interpreted reveal that all the Vertical Electrical Sounding (VES) have potential for ground water exploration due to low resistivity and high conductivity in those VES points. From the study area, the resistivity value ranges from 24.8 to 847.1 ohms-meter, the nature and lithology units are. Topsoil, highly weathered basement, weathered basement and fresh basement.

Also, the basement complex formation in the study area, is mainly weathered and in some portion, the weathering is not too deep, e.g., quartzite is in the weathered zones, fractured and joints are also found on the basement in the study area.

The average depth to water table in the crystalline basement in the study area is 4.2m and the average yield of 0.87 l/sec. (52.2 l/min.).

The average transmissibility in the study area was found to be $7.90X10^{-3}$ m^2/sec.which happens to be of negligible potential according to Kumar, (2003), and their permeability is about moderate to low, sometimes very small.

Finally, the storability in the basement complex ranges from $1.002x10^{-3}$ to $1.008x10^{-3}$**.** This valueis reasonable, and when abstracted it can meet the demand of the populace.

IV. Conclusion

Groundwater recharge in Bauchi Metropolis solidly depend on the rainfall and to some degree inflowing seepage and leakage from other sources. In some areas, it is influenced by proximity nearest to rivers. It was observed that Aquifers with good recharge may have minor drawdown with high recovery rates. Also, the average depth to water table in the crystalline basement in the study area is 4.2m and the average yield of 0.87 L/sec. (52.2 L/min.), this was determined from the results obtained in the area. The average transmissibility in the study area is $7.90X10^{-3}$ m^2/secwhich happen to be of negligible potential, and their permeability is about moderate to low, sometimes very small. The storability in the basement complex is at reasonable ranges from $1.002x10^{-3}$ to $1.008x10^{-3}$. The average aquifer thickness in the area study area was approximately 2m, and the boreholes depth range from 30 to 50m. Generally, Bauchi Metropolis is located on the crystalline Basement which comprised moderately and poorly decomposed gneisses, granite, fractured pegmatite and quartz, based on that, the geophysical survey result shows Bauchi metropolis has potential ground water that can sustain the metropolis using Boreholes, to complement the supply of water from the main treatment plant by the State Water Board.

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