AN APPRAISAL OF CERTAIN CHARACTERISTICS OF AQUIFER IN CHIKUN LOCAL GOVERNMENT AREA OF KADUNA, NIGERIA

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Abstract

Borehole productivity is often associated with some hydraulic characteristics of aquifers. This paper seeks to appraise some of these characteristics with respect to the supply of portable water for semi-urban inhabitants in the Chikun Local Government Area of Kaduna State, Nigeria. Data obtained from 19 completed and producing boreholes in the study area showed that the aquifer has average specific capacity of 2.78 l/min/m, while the average yield is 32.32 l/min of water with higher yields occurring mainly in fractured zones. The regression line of yield on saturated thickness gave a coefficient of 0.385, while the correlation coefficient is 0.148. Also, the regression line of yield on saturated thickness has a coefficient of 0.105 with a correlation coefficient value of 0.011. The regression and correlation coefficients, in both cases, showed low and positive values which are indicative of weak linear relationship between the parameters considered. The results, therefore, suggested that regolith thickness and saturated thickness do not significantly affect the yield (or productivity) of regolith aquifers.

Index Terms: Aquifer, Yield, Regolith, Drawdown, Static Water Level

1.0 INTRODUCTION

The development of groundwater in most parts of the country is due to continuous increase in population and corresponding increase in demand for water for both domestic and industrial supplies. The problem of shortage of water supply is even more serious in rural locations where individuals and settlements do not have access to large portable water supply schemes, leading to the increased demand for water from other sources, especially groundwater. Despite this, groundwater potential in the Basement rocks is not well defined as it occurs in a complex manner. Thus, borehole productivity is often associated with certain aquifer hydraulic parameters like specific capacity, drawdown, regolith thickness, bedrock type, saturated thickness and screen length among others (David and Offrey, 1989; Hazel et al, 1992). The main purpose of this paper is to appraise some aquifer characteristics of the groundwater in Chikun Local Government Area of Kaduna State, Nigeria with respect to the supply of portable water for semi-urban inhabitants in the area.

1.1 The Study Area

The Chikun Local Government Area of Kaduna State, Nigeria is located geographically between latitudes 10° 03.00'N and 10° 50.00'N, and longitudes 6° 40.00'E and 7° 50.00'E. Annual rainfall ranges between 850mm to 1200 mm. The mean monthly temperature varies between 20°C and 29°C, depending on the season, but may increase up to 35°C at the end of the dry season. The vegetation of the area is of the northern Guinea Savanna type, characterized by patches of woodland, herbs and grasses with few widely scattered deciduous trees, although continuous cultivation, bush burning and grazing activities have greatly modified the natural vegetation cover and composition. The area is drained by a network of rivers, the drainage pattern is dendritic and the streams are all subject to seasonal water level fluctuations ((Nassef and Olugboye, 1979; FMI, 2000). Figure 1 shows the study area with the drainage pattern and some borehole locations.

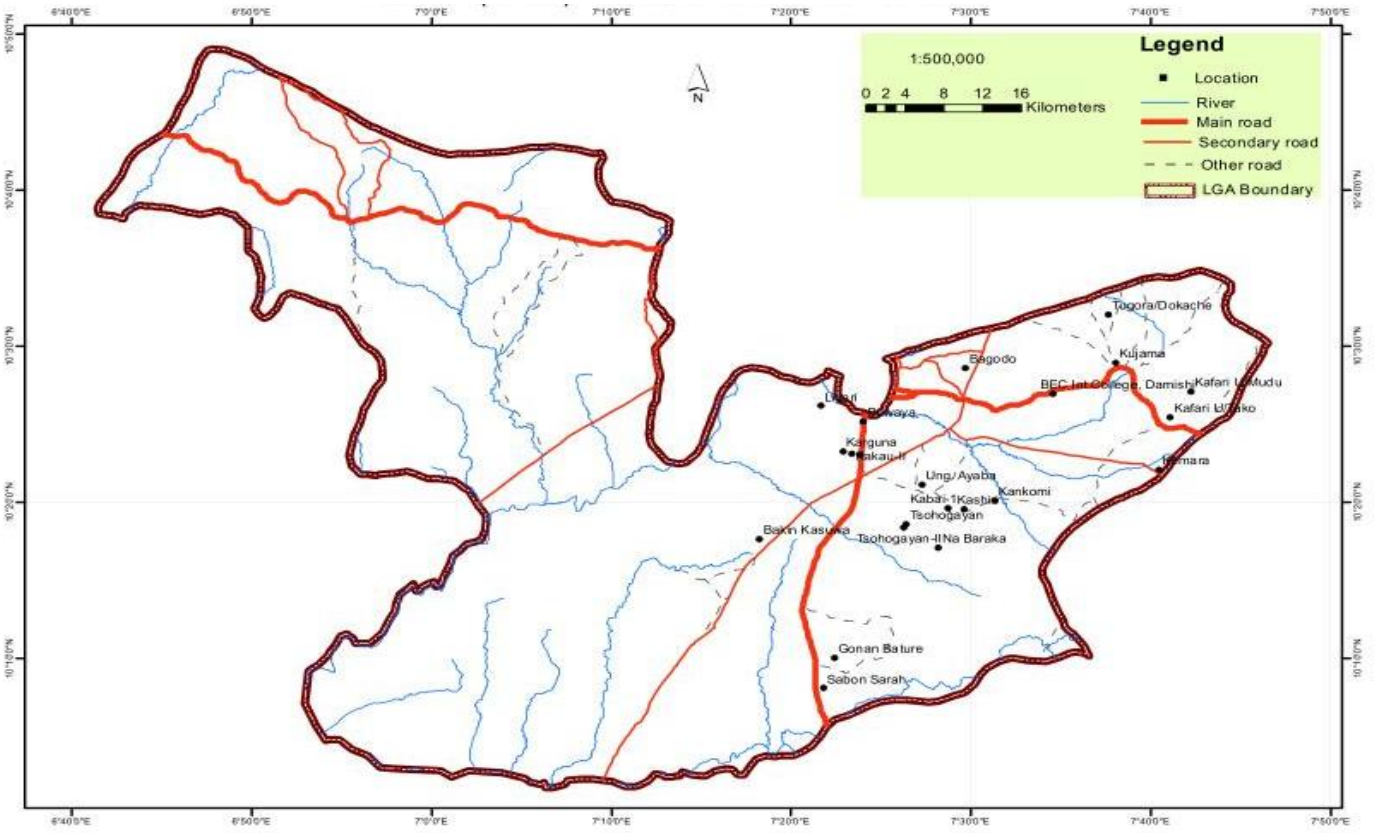

Figure 1: Drainage (Rivers) Map of Chikun Local Government Area of Kaduna State, Nigeria

Geologically, the area is underlain by the undifferentiated Basement complex rocks consisting of metasediments with pebble beds and the Older Granites as can be seen in the Geologic map presented as Figure 2. They are characterized by a variety of structures and textures, and they consist of ferruginous quartzites, amphibolites and pelitic slightly migmatized schists. The Older granites are characterized by lofty topography and inselbergs with lithological varieties of rock formation believed to have been emplaced during the Late Palaeozoic era (Ajibade and Wright, 1988; Oluyide, 1995). Earlier studies revealed that in parts of Kaduna State, groundwater in exploitable quantities sufficient for rural water supply occurs in the Kaduna River basin in three forms: the river alluvium which is irregularly distributed throughout the state, the Newer basalts with associated alluvial deposits which are limited to Kafanchan and Manchok areas in the south, and the weathered zone of the Basement Complex which is the most extensive, and oftentimes poorly aquiferous (WAPDECO, 1991; Eduvie and Olaniyan, 2013). But in spite of these conditions, groundwater supply is still a reliable source of domestic and industrial water supplies in the state (Olaniyan and Olabode, 2012).

2.0 METHODOLOGY

The required data on aquifer hydraulic characteristics such as depth to basement, static water level, screen length, pumping rate, drawdown, yield, specific capacity regolith thickness and saturated thickness were obtained from nineteen (19) existing completed borehole data. Also geophysical data based on electrical resistivity investigation, as well as geological description of subsurface lithology were obtained for the well locations across the local government area. These data formed the basis upon which the geoelectric and geologic characteristics, on one hand, and the aquifer hydraulic characteristics, on the other hand, of the groundwater were deduced in this study.

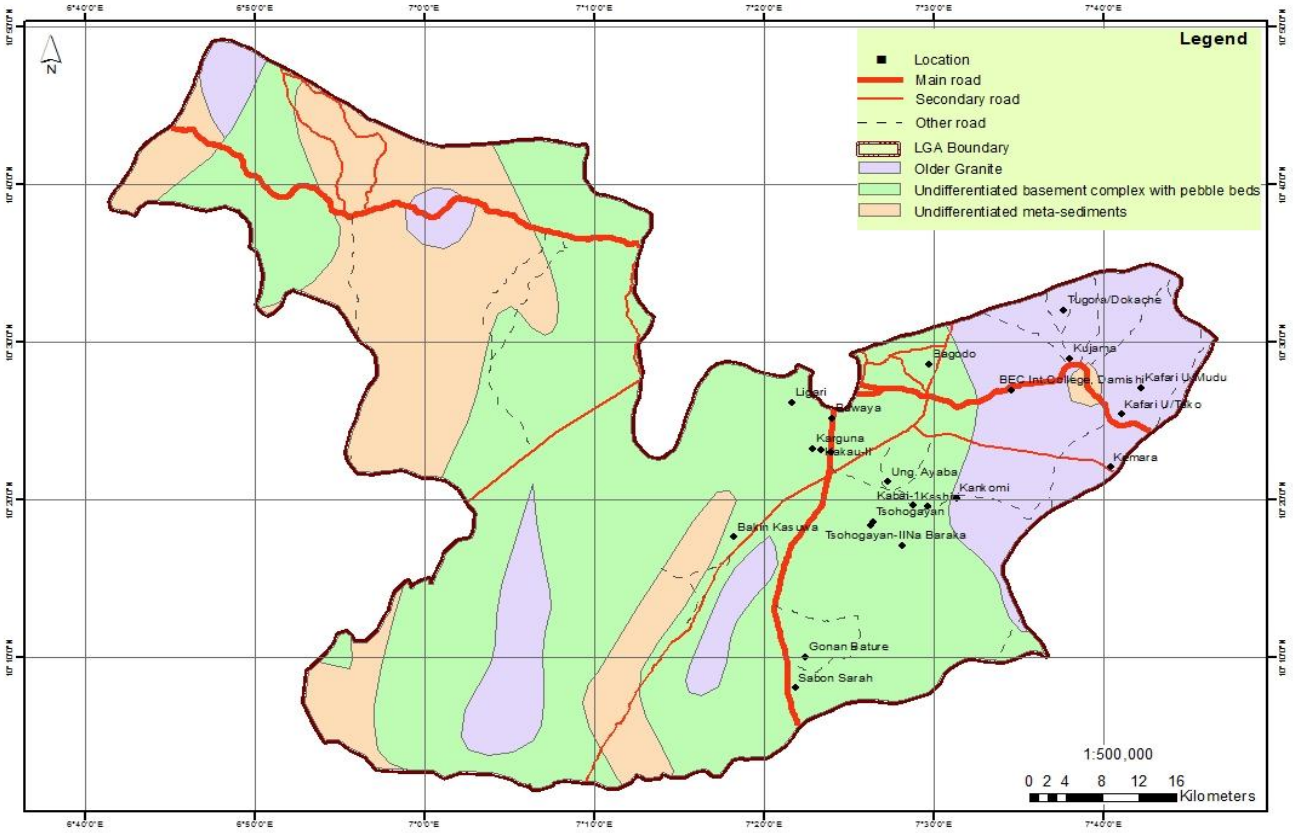

Figure 2: Map Showing the Geology of Chikun Local Government Area of Kaduna State, Nigeria

3.0 RESULTS AND DISCUSSION

3.1 Geoelectric and Geologic Characteristics

Four to five layers were delineated across the area based on the geoelectric and well logging data obtained from 19 completed and producing water wells in the area. The uppermost layer consists generally of an orange brown lateritic to kaolinitic clay with resistivity values of 90 Ωm to 1000 Ωm, and from the surface to 3.0m thick. This layer is underlained by a light-brown micaceous kaolinitic silty clay layer down to 13m depth with resistivity of 150 to 1500 Ωm. The third layer is the pink-brown gravelly silty clay from 13m depth to 20m depth ranging in resistivity from 100 to 1200 Ωm. This is followed by the weathered biotite granite gneiss, with resistivity range of 60 to 220 Ωm and extending from 20m to 35m depth below the surface. The bottommost layer penetrated is the fresh basement rock consisting mainly of biotite granite gneiss whose bottom was not reached during drilling operation. These characteristics are favourable for groundwater occurrence and exploitation in the area, provided that the basement complex rocks are weathered or sufficiently fractured as revealed in all the prospective drilling sites.

3.2 Aquifer Hydraulic Characteristics

The summary of the hydraulic parameters of the groundwater aquifer obtained from nineteen (19) boreholes situated across the entire Chikun Local Government Area of Kaduna State in Northern Nigeria is presented in Table 1.

The static water level across the study area range from 3.0 to 13.5m, with an average value of 6.79m. The Depth to Basement rock varies from 11.0m from the ground surface down to 30.0m with an average of 20.32m. While the pumping rate varies from13.0 to 60.0 l/min, the drawdown ranges from 4.6 to 25.5m. The yields of the boreholes in the area range from 10.0 to 67.0 l/min, with an average of 32.32 l/min. The low values are typical of Basement rocks which are naturally poor aquifers, while the high values are believed to reflect the degree of fracturing of the parent bedrock. The Specific capacity generally gives a better indication of aquifer performance than yield since it also reflects aquifer transmissivity and thickness (Uma and Kehinde, 1994). The

range of values for specific capacity in the area is 0.60 to 13.1 l/min/m, with an average value of 2.78 l/min/m. These values could also be attributed probably to the variations in degrees of fracturing, grain-size and texture of the bedrocks and of the regolith. The average values for screen length, regolith thickness and saturated thickness are 16.42m, 20.32m and 44.16m respectively.

Table 1: Aquifer Hydraulic Characteristics for Chikun Local Government Area

Parameter	Unit	Minimum Values	Maximum Values	Average
Static Water Level	m	3.0	13.5	6.79
Depth to Basement	m	11.0	30.0	20.32
Pumping Rate	l/min	13.0	60.0	27.84
Drawdown	m	4.6	25.5	12.99
Yield	l/min	10.0	67.0	32.32
Screen Length	m	9.0	30.0	16.42
Specific Capacity	l/min/m	0.6	13.1	2.78
Regolith Thickness	m	11.0	30.0	20.32
Saturated Thickness	m	32.0	56.8	44.16

3.3 Comparison of Depth-to-Water Table with Depth-to-Basement Complex

Figure 3 shows a comparison between the plots of depth-to-water table and depth-to-basement with a view to comparing pictorially the relative positions of the water table with respect to the underlying Basement rocks. The figure shows that there is a near-parallel relationship between the water table depth values and the Basement rock surface depths in the study area.

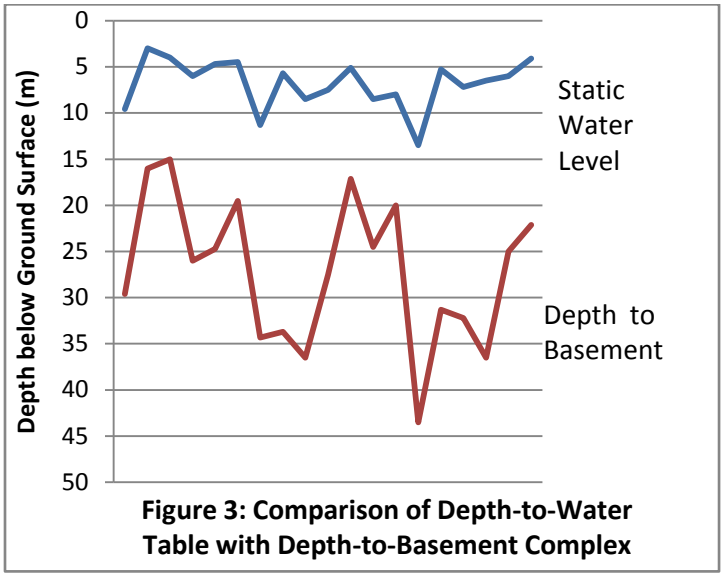

Figure 3: Comparison of Depth-to-Water Table with Depth-to-Basement Complex

3.4 Correlation Analysis of Parameters

The Pearson Product Moment Correlation analysis was used to examine the degree and nature of interrelationship between yield and saturated thickness on one hand, and yield vs regolith thickness on the other hand. The comparisons are shown in Figures 4 and 5.

From figure 4, the plot of yield versus saturated thickness was made to ascertain possible relationship between these two parameters, and the extent of interdependence of one on the other. The regression line of yield on saturated thickness gave a coefficient of 0.385, while the correlation coefficient is 0.148. In figure 5, the regression line of yield on saturated thickness has a coefficient of 0.105 with a correlation coefficient value of 0.011. Both the regression and correlation coefficients showed low and positive values in both cases considered. The low values are indicative of weak relationship while the positivity suggested that as one parameter increases, the other also increases, and vice-versa. It can be deduced from these results that the regolith and saturated thicknesses play minor roles in determining the borehole yield in crystalline areas, although the true relationship between these parameters may require more than such a simplified linear model for more satisfactory results. The influence of porosity, permeability, texture, structure, grain size and other inherent soil properties will definitely have significant influence on the yield of an aquifer.

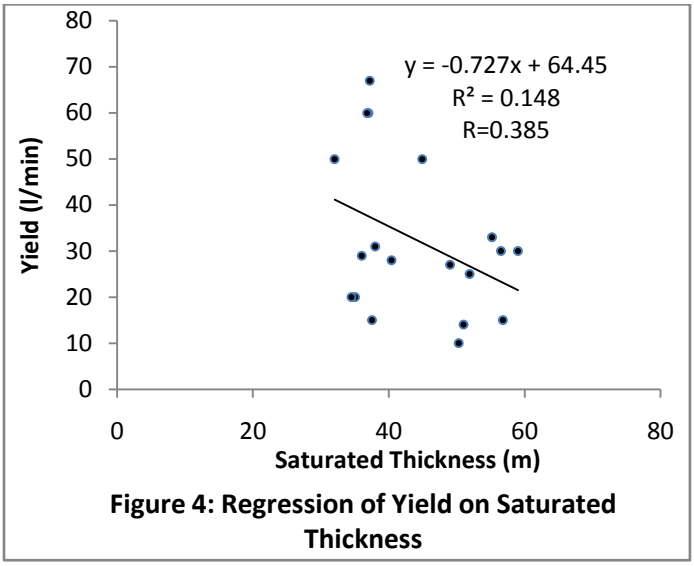

Figure 4: Regression of Yield on Saturated Thickness

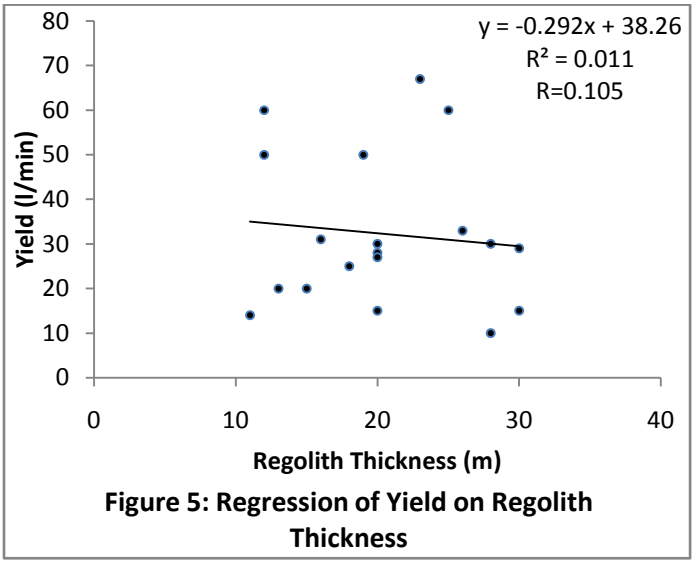

Figure 5: Regression of Yield on Regolith Thickness

4.0 CONCLUSION

Hydraulic characteristics of the groundwater aquifer for Chikun Local Government area of Kaduna State, Nigeria were obtained from 19 completed boreholes in the area, with a view to appraising them with respect to the supply of portable water for semi-urban inhabitants in the area. The data showed that the aquifer has an average yield of 32.32 l/min of water with higher yields occurring mainly in fractured zones. This is typical of Basement complex rocks. The outcome of the correlation analysis agreed with earlier opinion expressed by Uma and Kehinde (1994) that there was a weak correlation between yield and regolith thickness. Also, and there was a weak linear relationship between yield and saturated thickness. The results, therefore, suggested that regolith thickness and saturated thickness do not significantly affect the yield (or productivity) of regolith aquifers. Other factors such as the hydraulic properties of the weathered basement should be considered in selecting drilling points in crystalline basement areas.

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