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# Geoelezctric Investigation of Aquifer Characteristics and Groundwater Potential in Hawul Local Government Area, Borno State, North Eastern, Nigeria

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**Abstract**

Subsurface geo-electrical survey using the electrical resistivity sounding (VES) method and drillers logs were carried out in Hawul Local Government Area of Borno State in order to investigate the aquifer characteristics and ground, water potential of the subsurface formations. Fifteen (15) vertical electrical soundings were carried out within the area and its environment using the Schlumberger array configuration. The data was interpreted using the conventional curve matching and computer: iteration method. The result shows a four-layer HKH KQK and AKH type curves. The true resistivity of the top soil varies from 110-150Ωm while the thickness varies from 1-2.5m. the second layer has resistivity ranging from 30-40Ωm and thickness ranging from 5-8.0m., this layer is composed of clay to sand. The third layer, which constitutes an aquifer has resistivities an aquifer has resistivity varying from 25-250Ωm and the thickness varies from 20-100m it is composed of fine-grained sand. The fourth geoelectric layers has resistivity values ranging from 10-190Ωm while the thickness varies from 50-180m this layer is composed of fine to medium grain sand with little clay and iron content. The soft layer has resistivity ranging from 30-150Ωm, this layer is composed of medium coarse-grained soil and it constitutes and aquifer of every good quality. of this aquifer of every good quality ground water. The arrange depth of this aquifer is between 30-40m. These results were correlated with lithological logs from boreholes drilled in the study areas and were found to be consistent

**Keywords:** *Resistivity, Groundwater, Subsurface Formation*

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**Background to the Study**

Surface geophysical survey as a veritable tool in groundwater exploration, has the basic advantage of saving cost in borehole construction by locating target aquifer before drilling is embarked upon (Obiora and Onwuka, 2005). Vertical electrical sounding (VES) is a geoelectrical common method to measure vertical alterations of electrical resistivity this method has been recognized to be more suitable for hydrogeological survey of sedimentary basin (Kelly and Stanislav 1993) Schlumberger array is found can be successfully employed for ground water investigations; where a good electrical resistively contrast exists between the water bearing formation and the underlying rocks (Zohdyet, al: 1974).

In general, VES method using Schlumberger array assumes considerable importance in the field of groundwater exploration because of its easy way of operation, low cost and its capability to distinguish between saturated and unsaturated layers. Thus, this technique has been used in case study, this method is regularly use to solve a wide variety of groundwater problems such as determination of depth thickness and boundary of an aquifer (Bello et al, (2007), Omosuyi et, al 2007, Asfahani, 2006; Ismail Mohamaden, 2005; determination of zones with high yield potential in an aquifer (Akaolisa, 2006; Oseji, 2005); estimation of aquifer transmission (Yang and et, al, 2002) and estimation of aquifer specific yield (Onu, 2003).

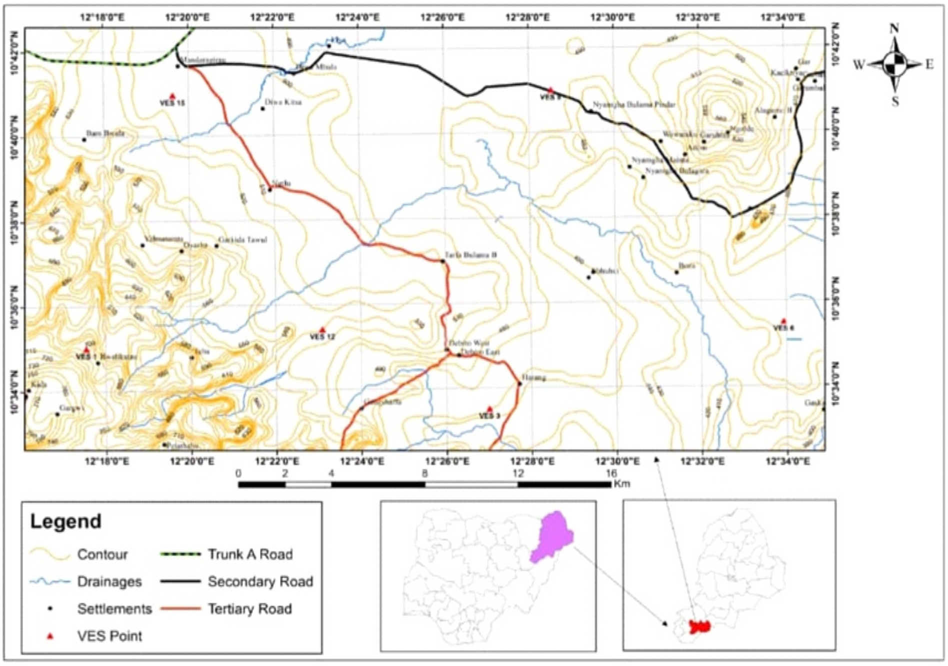
The electrical resistivity technique enables the determination of subsurface resistivity by sending an electric current into the ground and measuring the potential field generated by the current the depth of penetration is proportional to the Schlumberger array which uses closely spaced potential electrodes and widely space current electrodes. The Schlumberger method have a greater penetration than the wenner in the resistivity sounding method, the wenner configuration discriminates between resistivity's of different geometric lateral layers while the Schlumberger configuration is used for the depth sounding (Olowofelaet, al. 2005). Separation between the electrodes in homogeneous ground and varying the electrodes separation provides information about the stratigraphic of the ground (Dahlin, 2001). However, in general, the depth of infiltration is small in this method and only shallow subsurface layers have been surveyed (Danielsen et, al. 2007).

The study area covers some parts of the Biu Plateau lying between longitude $12^{o}00^{1}$ E and $12^{o}$ $24^{1}$ E and latitude $10^{o}$ $19^{1}$ N and $10^{o}$ $30^{1}$N the towns bordering the area include Damaturu to the North, Gombi to the South, Damboa to the East and Gombe to the West, the area is fairly accessible and has relatively good network of roads and foot paths. The vegetation of the study area could be best described as Sudan type. Biu Plateau falls within the Guinea savannah climatic zones of Nigeria. The purpose of the study is to assess the groundwater potential to determining the aquifer characteristics using geo-electrical method. The study will act as a starting point in the development of a database for assessing groundwater potential and also develop strategies to protect the aquifers.

**Geology and Hydrogeology of the Study Area**

The study area is part of the North-Eastern (NE) basement terrain underlain by basement rocks of Precambrian age. They are mainly basaltic rock. Biu Plateau is situated on the structural and topographic divide is a broad E-W ridge or swell of basement, which extends to the western edge of the Biu Plateau. They are mostly accruing as "flood basalts" in a number of flows and in fact cover nearly the area with its center around Biu. According to Turner (1973), the basalt at some places has built up large number of flows.

**Fig 1:** Topographic map of the Study Area




The Precambrian rocks in the area are mainly granitic and migmatitic rocks, on which rest non-conformably the sedimentary and volcanic rocks swing in age from cretaceous to quaternary (carter et 1963). The basement complex rocks are grouper into two the magmatite-gnesis coupler and the older granites.

Geologically, the area is underlain by a series of metamorphic and igneous rocks believed to be of Pre-Cambrian age. Most published works have shown this area as being underlain by undifferentiated basement complex rocks. Islamand Baba (1990) tried to differentiate the rock units broadly, and showed that the area has been underlain by older Granites intruded into a migmalites-gnesis quartzite complex considered as country rock. The country rock outcrops along the margins, and as xenoliths within the granite bodies. the study area is composed of low-lying gneisses, quartzite minor amphibolites and grantes, (Mohammed, 2010). The migmatities- gneisses out crop more often at the margins of the hilly granites where sharp contact relationship is more common than gradational the surface water of this area occurs in the form of stream and lakes. They serve as water supply sources for both drinking and domestic uses. Most of the streams are seasonal. The streams and lakes are recharged by direct precipitation during the rainy.

## Materials and Methods

The electrical resistivity method was used for the investigation. A total of (15) Vertical Electrical Sounding with maximum current electrodes spacing of AB/2 = 100m were carried out using the Schlumberger array (Zhody et. al, 1974). Layout of electrodes was done with non-conducting measuring tapes since tape of conducting material can easily deface. The resistivities of the layers were measured using the ABEM SAS 300 terra meter and SAS 2000 Booster.

The Schlumberger electrode configuration having a maximum current electrode spread of 100m was used. The apparent resistivity values obtained from the measurement were plotted against half the current electrode spacing on a log-log graph in order to determine the apparent resistivity thickness of the layers. The curves interpreted quantitatively by matching small segments of the field curves using two layers' model curves and the corresponding auxiliary curves. The resistivity and thickness obtained from the partial curve matching results were used for computer iteration using the resist software, (1988).

**Table 1:** Resistivities, Layer Thickness and Curve Types of Selected VES Stations.

| VES Station | Layer | Resistivities Ωm | Thickness (m) | Curve Type |
|---|---|---|---|---|
| 1 | 1 | 110 | 1 | HKH |
| | 2 | 40 | 5 | |
| | 3 | 100 | 25 | |
| | 4 | 70 | 205 | |
| 3 | 1 | 15 | 1 | HKH |
| | 2 | 180 | 4 | |
| | 3 | 19 | 60 | |
| | 4 | 30 | 120 | |
| 6 | 1 | 80 | 1 | HKH |
| | 2 | 30 | 5 | |
| | 3 | 100 | 60 | |
| | 4 | 200 | 120 | |
| 9 | 1 | 25 | 1 | HKH |
| | 2 | 20 | 7 | |
| | 3 | 105 | 75 | |
| | 4 | 205 | 150 | |
| 12 | 1 | 105 | 1 | HKH |
| | 2 | 15 | 3 | |
| | 3 | 200 | 90 | |
| 15 | 1 | 100 | 1 | HKH |
| | 2 | 90 | 5 | |
| | 3 | 150 | 20 | |
| | 4 | 90 | 100 | |

**Table 2:** Summary of Results

| VES Locations Layers And Curve types | Resistivity Ωm | | Thickness M | Depth | Lithology |
|---|---|---|---|---|---|
| 1 | 1 | 110 | 1 | 1 | Top soil |
| H | 2 | 40 | 4 | 5 | Weather basement |
| | 3 | 100 | 20 | 25 | Fractured basement |
| | 4 | 70 | 180 | 205 | Fresh basement |
| 3 | 1 | 15 | 1 | 1 | Top soil |
| H | 2 | 180 | 4 | 5 | Weathered basement |
| | 3 | 19 | 60 | 65 | Highly weathered basement |
| | 4 | 30 | 120 | 185 | Fresh basement |
| 6 | 1 | 80 | 1 | 1 | Top soil |
| H | 2 | 30 | 5 | 6 | Weathered basement |
| | 3 | 100 | 60 | 66 | Highly weathered basement |
| | 4 | 200 | 120 | 246 | Fresh basement |
| 9 | 1 | 25 | 1 | 1 | Top soil |
| H | 2 | 20 | 7 | 8 | Weathered basement |
| | 3 | 105 | 75 | 83 | Highly weathered basement |
| | 4 | 205 | 150 | 248 | Fresh basement |
| 12 | 1 | 150 | 1 | 1 | Top soil |
| H | 2 | 15 | 3 | 4 | Weathered basement |
| | 3 | 200 | 90 | 94 | Fresh basement |
| 15 | 1 | 100 | 1 | 1 | Top soil |
| HK | 2 | 90 | 5 | 6 | Weathered basement |
| | 3 | 150 | 20 | 26 | Weathered basement |
| | 4 | 90 | 100 | 120 | Fresh basement |

**Result and Discussions**

From the table 1, VES 1, 3 and 6 are four layers HKH types of curves while VES 9, and 15 are four-layer HKH types curves, VES 12 is a three layers H type of curve, the interpreted curves are presented at geo-electrical Section (Fig. 1).

1. The first geo-electric layers correspond to the top soil with resistivity ranging from 110-150Ωm reflecting the various compositions and moisture content of the soil. It is composed of clay, fine sand and decomposed organic materials. The thickness varies from 1.0m-2.5m.
2. The second geo-electric layer of VES 1, 3, 6 and 15 has resistivity ranging from 30-40Ωm and thickness varies from5.0m-8.om. The resistivity is diagnostic of clayed layer. This may act as a confining layer, however because of the small clay thickness it may be susceptible to pollution.
3. The resistivity of the second layer of VES 12, ranging from 15-20Ωm and the thickness varies from 3.017.0m, this layer is composed of fine-grained sand. This layer constitutes the first aquifers. The fourth geo-electric layer has resistivity value ranging from 10-190Ωm with thickness varies from 5.0m-18.0m, this layer is composed of fine medium grain sand with little clay and iron content. The fifth geo-electric layer has resistivity ranging from 25-250Ωm and the thickness varies from 2.0-10.0m, it is composed of fine sand and does not act as a confining layer.
4. The average depth of this aquifer is between 30-40m. the VES interpretations correlated well with information from boreholes lithological logs obtained on the study area.

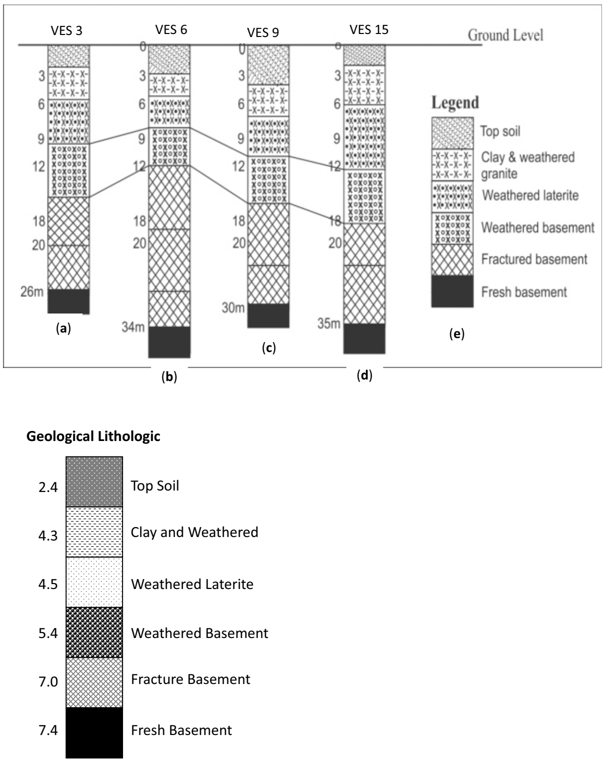



**Fig 3 a-d:** Borehole Log Describing Lithology of Hawul (after Hill water Nigeria Limited) (2017) and e-Geological lithology obtained from L and T Hydro-Eng. Co. Nig. Ltd (2017). From the VES correlation with borehole logs (fig 3). It shows that results of the electrical resistivity survey conducted for ground water development in the area is correct despite the apparent (not true) nature of the subsurface and its homogeneity or inhomogeneity.

## Conclusion

The result geometric of the interpreted data and the lithological logs from borehole indicate four geometric layers, which are not confined with the second layer, which may act as a confining bed, is not thick enough so in the event of pollution the ground water may occur from the study, it is recommended that borehole are drilled to 30 – 40m to harness potable water within the 2$^{nd}$ aquifer.

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