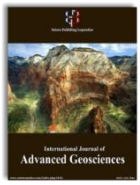
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Research paper



Evaluation of Ground Water Potential in Ekpri-Ikang, Bakassi Local Government Area, Cross River State, Nigeria. "A Case Study of Open Bible Standard Church Premises."

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Abstract

Electrical resistivity survey using Schlumberger Vertical Electrical Sounding (VES) field technique was carried out at Ekpri Ikang in Bakassi local government area of Cross River State. The survey is aimed at determining the water bearing formation of the area. Data acquired were interpreted using WinRes Program into a curve showing true resistivity and thickness of the subsurface layers. Result indicates that there are four distinct layers in the study area. Analyses of the data and interpretation of the sounding curve reveals that the water bearing layer exist in the layer two (2) and three (3) with resistivity values of 347.6Ω and 375.5Ω, also with thickness of 14.5m and 21.3m, depth of 39.6m and 61.0m. It is therefore recommended that boreholes for good drinking water be drilled to the layer two (2) and three (3) of the investigated area.

Keywords: *Aquiferous Unit; Borehole; Groundwater; Resistivity; Vertical Electrical Sounding (VES).*

1. Introduction

Groundwater is described as water which exists below the earth surface within saturated layers of sand, gravel and pore spaces in sedimentary as well as crystalline rocks (Oseji and Ofomola, 2010). According to Todd (2004) "groundwater is the water occupying all the empty spaces within a geologic stratum". It is among the natural resources of prime importance to man throughout the world. Oseji and Adegoke-Anthony (2005) noted that groundwater occurs in many types of geologic formations. Those known as aquifer are the most important permeable material to yield significant quantities of water to wells and spring (Abiola et al., 2009).
The vertical electrical sounding method was chosen for this study because the instrumentation is simple and easily available; also interpretation and analysis of data is economical and less tedious.
Groundwater, through the various dissolved salts it contains, is ionically conductive and enables electric currents to flow into the ground (Bernard, 2003). Tyson (1993) also noted that all groundwater contain natural occurring minerals such as iron and manganese in varied concentration. Consequently, measuring the ground resistivity gives the possibility to identify the presence of water, taking into consideration the following properties:

- A hard rock without pores or fracture and dry sand without water are very resistive: several thousand ohm.m.
- A porous or fractured rock bearing free water has a resistivity that depends on the resistivity of the water and on the porosity of the rock; several hundred to several thousand ohm.m.
- An impermeable clay layer, which has bound water, has a low resistivity: several units to several tens ohm.m.
- Mineral ore bodies (iron, sulphides) have very low resistivity due to their electronic conduction: usually lower or much lower than 1 ohm.m.

Olorunfemi and Oluruniwo (1987) used the electrical resistivity method for groundwater investigation of geo- electrical and hydrogeologic characteristics of areas in South West Nigeria. They investigated groundwater prospect in the basement complex of rocks of Southern Western Nigeria. They concluded that local geological condition play an important role in the yield of boreholes located in the basement complex area in South Western Nigeria.
Gnanasunder and Elango (1999) carried out groundwater quality assessment of a coastal aquifer lying South of Chennai City, Madias India using electric techniques. This study was able to delineate a fresh water ridge of good groundwater quality in the central portion of the coastal aquifer while the Eastern and Western margins of the aquifer however contained groundwater of poor quality.
Ajayi and Adegoke-Anthony (1987) investigated groundwater prospect in the basement of complex rocks of southwestern Nigeria. They concluded that local geological condition play an important role in the yield of boreholes located in the basement complex area of southwestern Nigeria.
Olorunfemi and Fasuyi (1993) used the electrical resistivity method in investigation of geo-electric and hydro-geologic characteristic of areas in southern west Nigeria.
Agbasi and Etuk (2016) carried out geoelectric survey employing Vertical Electrical sounding (VES) in parts of Ikot Abasi Local Government Area, Akwa Ibom state, Nigeria to be a guide for the suitable position of borehole in order to avoid wild cat drilling and also to avoid salt intrusions using the VES geophysical techniques and also shows that most parts of the study area have aquifer with poor protecting capacity (<0.1 mhos) resulting in high salt intrusion.

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Ako and Osundu (1986) carried out groundwater investigation at Darazo on the kerri-kerri formation; they concluded that Dar-Zarouk parameters are related to borehole characteristics. The conclusion holds that the highest traverse resistance (T) corresponds to the zone with the highest borehole yield.

2. Location and geology of survey area

The survey area Ekpri-Ikang in Bakassi L.G.A. lies in the southern senatorial district of Cross River State and it is about 45 minutes' drive from Calabar, the capital city of the state. It is located within latitude 04° 49' 35.8"N and longitude 008° 30'23.1"E at about 36m above sea level.

Geologically, the soil is composed of materials similar to those of the Mkporo shale which is dark and carbonaceous. The marl is yellowish and in bands up to 30m thick. It is bioturbated and highly fossil ferrous.

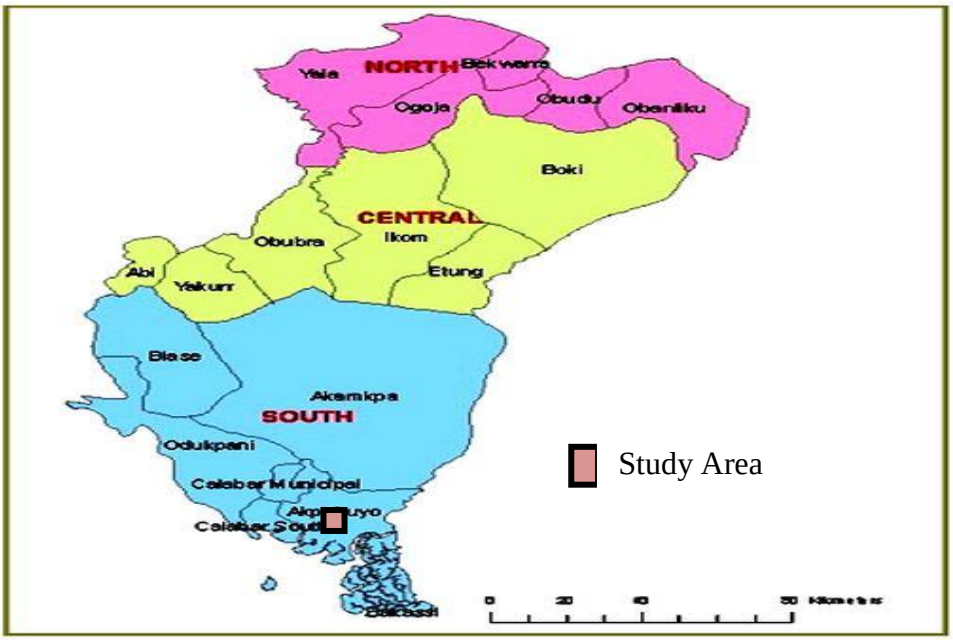


Fig. 1: Map of Cross River State Showing the Study Area (Www.Crossriverwatch.Com, 2013).

3. Methodology

Electrical geophysical prospecting methods detect the surface effects produced by electric current flow in the ground. Using electrical methods, one may measure potentials, currents and electromagnetic fields which occur naturally or are introduced artificially in the ground. In addition, the measurements can be made in a variety of ways to determine a variety of results. There is a much greater variety of electrical and electromagnetic techniques available than in the other prospecting methods, where only a single field or force or anomalous property is used.

Basically, it is the enormous variation in electrical resistivity found in different rocks and minerals which makes these techniques possible (Telford et al, 1976). Furthermore, this method is employed in characterizing vertical and. lateral discontinuities. In subsurface electrical properties, vertical changes are measured using the vertical electrical sounding (VES) techniques while lateral changes are measured using the horizontal resistivity profiling (HRP) technique (Oseji et al., 2005).

Of all surface geophysical methods, the electrical resistivity method has been applied most widely for ground water investigations out of the entire surface geophysical methods. Examples are the use of electrical resistivity profiling and vertical electrical sounding methods in delineation of various aquiferous units of southwestern Nigeria crystalline basement complex by Olorunfemi and Olorunniwo (1985), Olorunfemi and Opadokun (1986).The electrical resistivity method can be best employed to estimate the thickness of overburden and the thickness of weathered/fractured zones with reasonable accuracy. Though both Wenner and Schlumberger electrode configuration methods are popularly employed, the Schlumberger electrode configuration method is more suited to the study area, ensuring better results. The method has practical, operational and interpretational advantages over other methods such as the Wenner method of electrode arrangement (Zohdy et al., 1974).

Most of the electrical resistivity techniques require injection of electrical currents into the subsurface via a pair of electrodes planted on the ground. By measuring the resulting variations in electrical potential at other pairs of planted electrodes, it is possible to determine the variations in resistivity (Dobrin, 1988; Ozcep et al., 2009; Alile et al., 2011). A conventional vertical electrical sounding (VES) survey was used for quantitative interpretation where the center point of the array remains fixed and the electrode spacing is increased for deeper penetration (Loke,1999).

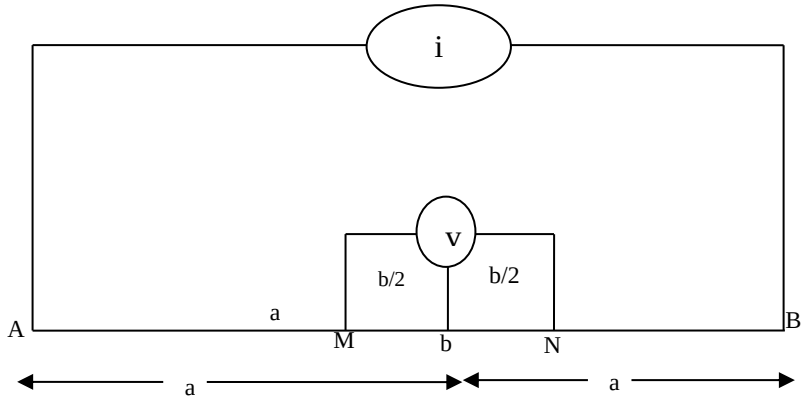


Fig. 2: Schlumberger Array Configuration (Loke 1999).

In carrying out resistivity sounding survey, electrodes are distributed along a line centered about a midpoint that is considered the location of the sounding. The electrode arrangement used in data acquisition is the Schlumberger array of electrodes. The Schlumberger survey involves the use of two current electrodes labeled A and B, and two potential electrodes M and N placed in line with one another and centered on some location. It is worthy to state that the potential and current electrodes are not placed equidistant from one another. To acquire the resistivity data in the field, current is introduced into the ground through the current electrodes and the potential electrodes are then used to quantitatively measure the voltage pattern (Alabi et al., 2010). The geometric arrangement for this array is shown in Figure 2.

Instruments used during the survey include ABEM terrameter (SAS 300), measuring tapes, current cables, potential cables, electrodes, hammers, GPs, crocodile chips, 12-volt battery.

With the help of a measuring tape, the initial potential electrode spacing was at 0.25m and the current electrode spacing was at 1m from both ends. After marking out these points, the first reading was taken after which the spacing of the potential electrodes and current electrodes were moved as designated using the Schlumberger Array. Reading was taken by switching on terrameter after which the measure key was pressed so as to have the value displayed on the screen. The maximum current electrode spread was 300m.

Before the resistivity data was obtained, current was introduced into the ground through the current electrode and their respective potential differences were measured between the protected electrodes after which the sub-surface apparent resistivity was calculated. Electrical resistivity surveys have been employed for many years in geophysical investigation aimed at ground water research. These surveys have successfully delineated aquifers in situations where significant resistivity differences exist between them and their surroundings formations.

The resistivity data obtained using these different electrode spacing at fixed location were then evaluated to yield a sounding curve for each occupied site and corresponding geological model which represents the variation of layer resistivity with depth. A total of 4 soundings were carried out with a maximum spread of 300m covering about 2 stations per station.

The Schlumberger array was adopted with a maximum half current electrode spacing $\left(\frac{AB}{2}\right)$ of 300m.

∴ Therefore a total of 8 stations covering distance of 300m horizontal resistivity profiling were covered.

Table 1: Ves Data Acquired at Open Bible Standard Church, Ekpri Ikang. Schlumberger Array. Northing: 44935°8, Easting: 83023°1 Elevation: 36m

S/N	AB/2(m)	MN/2(m)	Geometrical Factor (K)	R	ρ(Ω-m)
1	1	0.25	5.89	439.511	2588.71
2	1.5	0.25	13.75	202.073	2778.50
3	2	0.25	24.74	117.722	2912.44
4	3	0.25	56.16	55.2367	3101.7
5	3	0.5	27.49	------	------
6	4	0.5	49.49	61.4240	3039.87
7	4	0.25	100.15	30.8119	3085.6
8	5	0.5	77.76	37.7859	2937.7
9	6	0.5	112.33	25.2342	2829.92
10	8	0.5	200.30	14.3670	2876.3
11	8	1	98.97	------	------
12	10	1	155.53	18.2201	2830.1
13	10	0.5	313.41	9.03231	2820.6
14	15	1	351.90	7.38654	2568.8
15	20	1	626.83	4.61406	2883.2
16	30	1	1412.33	1.83654	2542
17	30	2.5	561.63	------	------
18	40	2.5	1001.51	1.98117	1981.9
19	40	1	2512.03	0.82456	2059
20	50	2.5	1567.07	1.00907	1567
21	60	2.5	2258.31	0.54573	1219.3
22	80	2.5	4017.83	0.22253	883.9
23	80	10	989.73	------	------
24	100	10	1555.29	0.45767	699.75
25	100	2.5	6280.07	0.11202	690.80
26	150	10	3519.04	0.18326	633.42
27	125	10	2438.98	------	------
28	200	10	6268.29	0.12494	752.16
29	250	10	9803.04	0.7785	754
30	300	10	14123.29	0.04874	564.9

Table 2: VES Data Acquired at Open Bible Standard Church, EKPRI IKANG. Schlumberger Array. Northing: 44935°8, Easting: 83023°1 Elevation: 36m

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4. Results and discussion

Measured resistivity values of the study area are presented by the VES data in Table 2. Computer iteration using WinRes Program yielded the sounding curve shown in Figure 3.

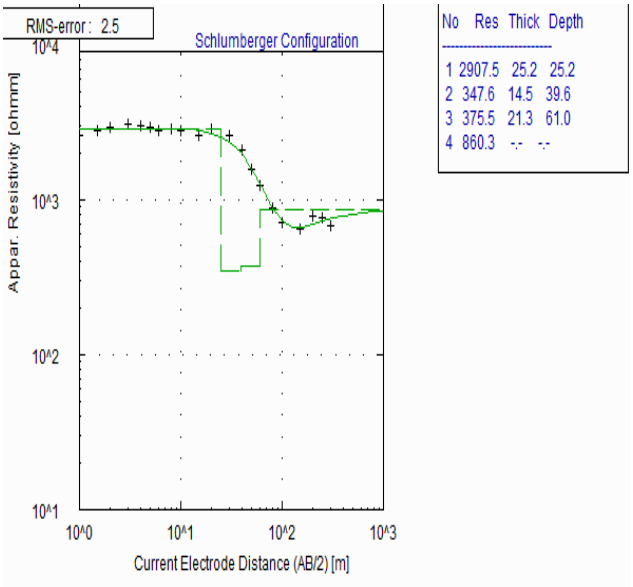


Fig. 3: Four Layer VES Curve.

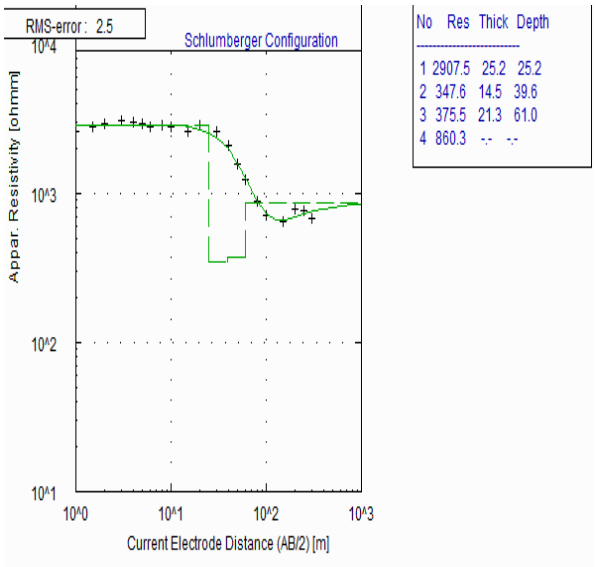


Fig. 4: Four Layer VES Curve.

Based on the VES curve for the four layers investigated in Figure 4 and their corresponding resistivity values;

Layer 1 which has the highest resistivity value of 2907.5**Ω**m is interpreted to be a dry sandy formation. This is true for a tight formation.

Layer 2 and 3 with low resistivity values of 347.6 **Ω** m and 375.5**Ω**m respectively are interpreted to be the water being formation (acquifer). This is true as resistivity values decreases in Figure 4 indicating a wet porous and permeable formation.

In layer 4, the resistivity values increases again, indicating that it is a tight and dry sandy formation which contains no water. In conclusion, layer 2 and 3 are the aquiferous unit.

The application of vertical electrical sounding (VES) technique has provided detailed information on the thickness and hydroelectrical characteristics of the aquifer in the study area.

The result of the interpreted data reveals Layer 2 and 3 as the promising layer for any drilling operations. Drilling at this point is

expected to reach at least a depth of 60m to enable the entire thickness of the aquiferous layer to be penetrated.

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