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Geoelectric Investigation Of The Subsurface Characterization And Groundwater Status In Ikot Osurua Community, Akwa Ibom State, Nigeria

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ABSTRACT

The study was carried out to investigate the subsurface layer parameters in Ikot Osurua, Akwa Ibom State with a view to determining the aquifer configurations which will assist in sitting high yield boreholes in the community. A total of five (5) vertical electrical sounding (VES) were conducted using the integrated Geo-instrument service (IGIS) resistivity meter to generate the field data. The Schlumberger sounding was carried out with current electrode spacing (AB) ranging from 1-300m. The distance used for the potential electrode spacing (MN) ranging from 0.25-10m. This array was employed in view of it resolution power and its reliability. The field data obtained were subjected to interpretation by partial curve matching and by computer iteration using IP12 WIN software. The interpreted results were constrained by lithological log to produce the geoelectric sections of the subsurface. The geoelectric section showed three (3) to five (5) layered subsurface of top soil, lateritic sand, consolidated sand, clay sand and aquifer layer with different curve types which were Q, KH, and K. Aquifer characterization of the area showed that the aquifer resistivity with depth ranging from 89.2Ωm to 3287Ωm and 40m to 80m although it varies in some locations, this is an indication of the presence of fresh groundwater. Appropriate depths to which portable water can be obtained from the various locations are recommended in this study.

Keywords: Groundwater potentials, subsurface lithology, vertical electrical sounding (VES), Schlumberger configuration.

INTRODUCTION

Groundwater is an important component of the world water resources systems and is widely distributed. It is more preferable as source of water supply than surface water since it has less degree of contamination. There is increased demand for groundwater in Ikot Osurua community in recent times due to inadequate public water supply. The settlers in the study area used the water resources for their domestic, agricultural and social needs. Few boreholes drilled by individuals, government and non-governmental organizations have been the only means of the inhabitants getting water. Inadequate geophysical information affects groundwater exploration in the area, thereby leading to borehole failures as a result of wildcat drilling (Obiora et al., 2016a; Ugwuanyi et al., 2015). To avoid drilling abortive wells, geophysical investigation is imperative because it helps to delineate aquifer Boundaries and properties. Alternatively, assessment of water yielding capacity of aquifers is traditionally determined from parameters obtained from well pump tests and well log data (Singh, 2005), which is time consuming and expensive. Various researchers have employed different methods in exploring this very essential life sustaining resource. Geophysical surveys have been most widely used because of the basic advantage of providing more accurate results than other methods. For instance, Gab et al. (2012) successfully used the seismic refraction method to investigate the groundwater level in the Wadi Al-ain area of United Arab Emirates. The objective was to confirm or not the assumption that groundwater level can primarily be revealed by seismic refraction technique. Lawrence and Ojo, (2012) applied the low frequency electromagnetic and the

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electrical resistivity methods to evaluate the aquifer potential of a typical basement complex terrain of Ado-Ekiti in Nigeria. Other researchers such as Nejad, 2009; Egbai, 2011;Anudu et al., 2011; Sirhen et al., 2011; Ibrahim et al. 2012; Utom et al., 2012; and Anomohanran, 2013 have all used the electrical resistivity method to explore for groundwater in different locations. Electrical resistivity methods are effectively used for groundwater exploration in areas where good electrical resistivity contrast exists between the water bearing formation and the underlying rocks. The method enables the determination of subsurface resistivity by sending an electric current into the ground and measuring the electrical potential produced by the current. A planned geo-electrical investigation is capable of mapping an aquifer system, clay layers, the depth and thickness of aquifers and qualitatively estimating local groundwater flow (Steinich& Marins, 1996, Israil *et al; 2006).* The specific objectives of the study are to determine the depth, thickness, and extent of potential water bearing formations with a view to giving a guide to sitting high yield boreholes in the area.

LOCATION OF THE SURVEY AREA

Ikot Osurua is one of the Village in Ikot Ekpene L.G.A in Akwa Ibom State. The Village is located in the southern part of Nigeria between latitude 5° 09′ and 5° 40′N and longitude 7° 18′ and 7 °20′E. The town has an undulating nature and it is among the thick forest area but the town is not flooded because of it relatively high elevation with respect to nearby Villages, towns and flowing streams of permeable topsoil. The town is accessible through a network of roads and bordered in the North by Atan Ikot Okoro, south by Abiakpo NtakInyang, West by Uwa and East by Ikot Akpan Abia. (Figure 1)

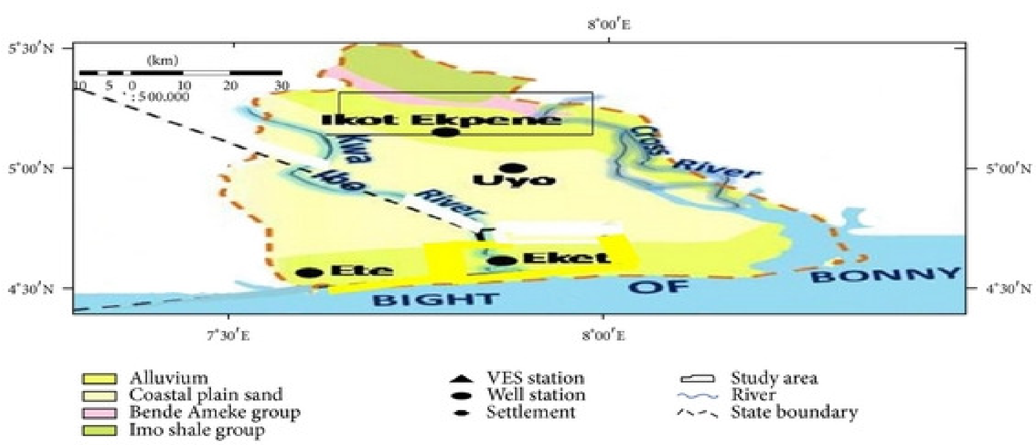

Figure 1: Map of Akwa Ibom State showing the location and the geology of the study area

GEOLOGY OF THE STUDY AREA

The study area is underlain by sedimentary formation and it belongs to the area classified as coastal plain sand which is known as the Benin formation. The Benin formation is composed of loosely consolidated sand and gravel with intercalation of shales. During dry season, the water level in rivers and streams decreases suggesting that part of the river is recharging the aquifer beside precipitation. On the north-west and north-east, the area is bounded by cretaceous to tertiary sediments. The temperature is uniform throughout the year. On the other hand, the high permeability of Benin formation, the overlying lateritic earth and weathered top of this formation as well as the underlying clay shale provide the hydro-geological condition favoring the aquifer formation in the area.

MATERIALS AND METHOD

The survey procedure adopted for field acquisition is the vertical electrical sounding (VES) technique. The VES technique measures vertical variation in ground resistivity with depth. In this method, series of resistances were acquired at successively larger electrode spacing while maintaining a fixed central reference point. For this study, the Schlumberger configuration was used to acquire VES data at five (5) points in the community. The current electrode separation (AB/2) varied from 1m to 300m at some stations. Current electrodes were passed into the ground through the current electrodes planted on the ground while the resulting potential was picked by the potential electrodes. Measurements were taken along profiles. The potential electrode separation ranged from 0.25m to 10m, while current electrode separation ranged from 1m which was progressively expanded along a straight line of profile up to 300m on both sides at some point. The apparent resistivity values were ascertained by multiplying the resistance gotten from the resistivity meter with an appropriate geometric factor which depends on the current and potential electrode spacing (Teldford et al, (1990) as shown in equation 1 below.

$$\rho_a = K\frac{\Delta V}{I} \quad \ldots\ldots (1)$$

Where;

K represents the geometric factor of the Schlumberger electrode array which is given by the equation:

$$K = \pi\left(\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2\right) \quad \ldots\ldots (2)$$

Where;

ρ_a = Apparent resistivity

AB= Current electrode spacing

MN= Potential electrode spacing

π = 3.142

The Schlumberger electrode array was employed due to its simplicity, being faster and required fewer number of field workers.

RESULT AND DISCUSSION

The electrical resistivity survey involves electrical sounding using Schlumberger configuration with ABEM WADI (SAS 300B) Terameter. The potential electrodes remain fixed and the current electrodes are expanded simultaneously about the centre of the spread. The Schumberger array used, with maximum current electrode separation of 100m-300m electrodes are normally arranged along a straight line, with the potential electrode placed

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in between the current electrodes. This configuration is mostly used as it would provide subsurface information considering the depth of penetration which ranges between 1/3 and ¼ of the total current electrode separation (David and Ofrey, 1989; Osemeikhian and Asokhia, 1994; Mallam and Ajayi, 2000).The resistivity sounding curves were interpreted quantitatively; this is done by partial curve matching technique and computer iteration of the interpreted resistivity curves. These resistivity values were further subjected to computer modeling using the inversion technique. This was made possible by geographical software called IP12WIN which involves a forward or inverse modeling approach to generate a computer modeled curve which shows the measured apparent resistivity pseudo section, calculated apparent resistivity pseudo section and inverse model resistivity section. Due to the geological nature of the study area being sedimentary area, there are resistivity values that shows the structure of the study area which are in layers. The layer parameters: resistivity, depth and thickness for each (VES) point were obtained after a series of iteration to match the field curve with theoretical curves. From the modeled VES data, it was observed that out of the seven (7) VES points, four have five layers; two have four layers and one have three layers (Figures 2-8). The figures depict the fact that the curve types for Ikot Osurua Community are mainly Q, KH, K, KHK and QHK respectively. These curves represent a good curve types for the existence of a viable groundwater aquifer. Table1 shows VES location and their coordinates while table2 shows the summarized results of the interpretation of the field report.

Table1: VES locations and their coordinates

S/N	LOCATIONS	LONGITUDE (E)	LATITUDE (N)	ELEVATION
1.	A (Abiakpo Road)	5°10′50.39″	007°40′28.5″	71m
2.	B (Abuja street)	5°09′44.8″	007°40′28.7″	75m
3.	C (First bank road)	5°09′57.1″	007°40′08.7″	70m
4.	D (Aba road)	5°08′45.6″	007°40′32.5″	68m
5.	E (Hostel road)	5°09′48.6″	007°40′30.3″	76m
6	F (Osurua Path)	5°08′75.2″	007°40′12.9″	73m
7.	G(ICT Center road)	5°08′65.7″	007°40′35.9″	81m

TABLE 2.0: Summarized results of data interpretation

VES Location	Layer	Resistivity	Thickness(m)	Depth(m)	Layer Characteristics
A	1	675	0.5	0.5	Topsoil/fine grain dry sand
	2	3882	0.922	1.42	Laterite
	3	289	12.0	13.4	Aquifer with Saturated coarse grain sand
	4	6489	58.7	72.1	Lower aquifer
	5	386	-	-	Consolidated sand
B	1	562	1.68	1.68	Topsoil/fine grain dry sand
	2	1377	2.81	4.49	Laterite
	3	245	14.7	19.2	Shallow aquifer with Saturated coarsegrain sand
	4	3638	54.	73.4	Aquifer with Saturated coarse grain sand
	5	274	-	-	Consolidated sand
C	1	68.8	1.34	1.34	Clay sand
	2	771	1.36	2.7	Lateritic sand
	3	30.6	69.4	72.1	Aquifer with saturated coarse grain sand
	4	1773	-	-	Consolidated sand
D	1	78.9	0.5	0.5	Clay sand
	2	624	1.66	2.16	Lateritic sand
	3	23.7	3.96	6.12	Clay sand
	4	198	66.6	72.7	Aquifer with saturated coarse grain sand
	5	68.2	-	-	Consolidated sand
E	1	1217	2.66	2.66	Clay sand
	2	124	4.55	7.21	Lateritic sand
	3	2376	61.8	71.0	Aquifer with saturated sand
	4	206	-	-	Consolidated sand
F	1	220	1.37	1.37	Clay sand
	2	1609	73.8	75.1	Aquifer with saturated grain sand
	3	218	-	-	Consolidated sand
G	1	80	0.51	0.51	Clay sand
	2	4368	0.42	0.93	Lower aquifer
	3	60.9	17.8	18.8	Shallow aquifer
	4	222.5	57	75.7	Consolidated sand as a protective layer
	5	55.4	-	-	Consolidated sand

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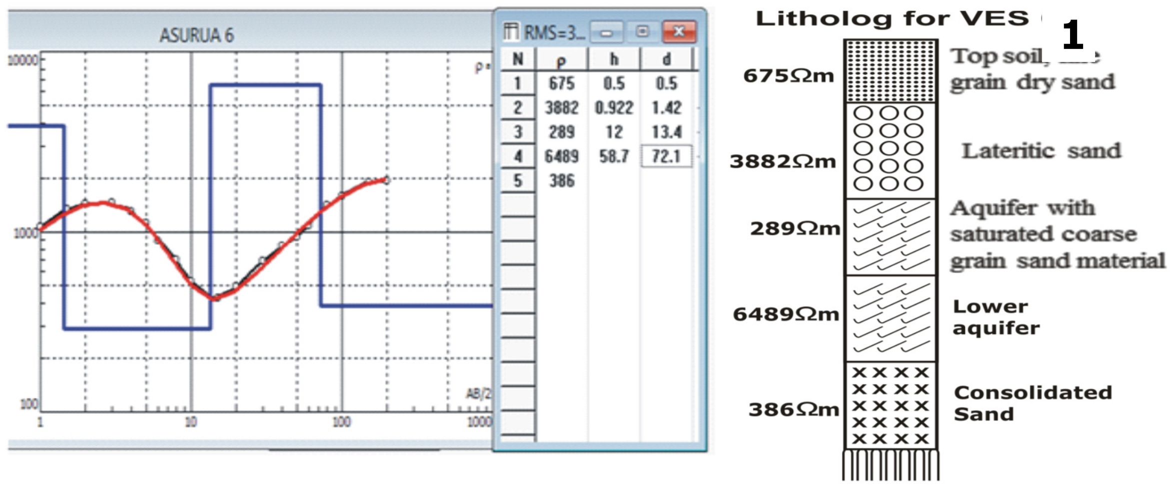

Figure: 2: Model layer curve for VES 1

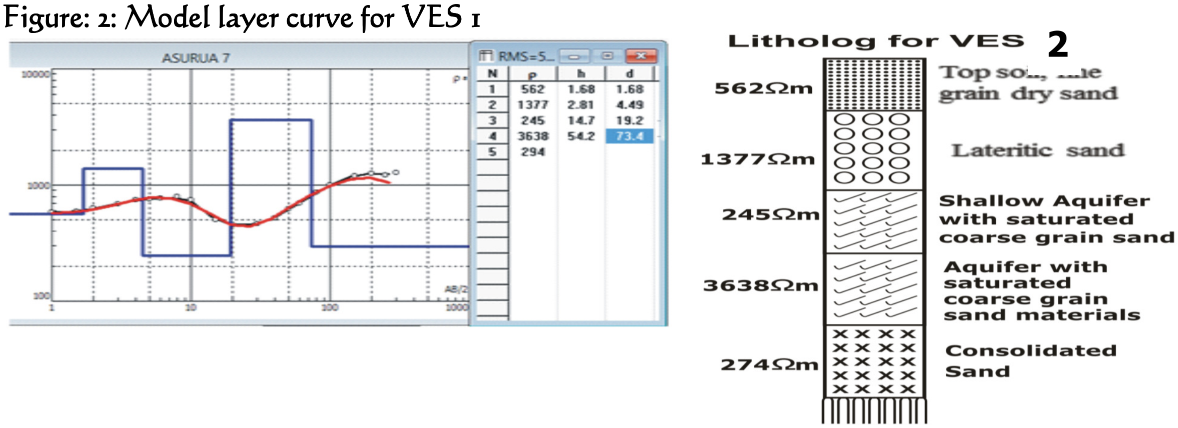

Figure 3: Model layer curve for VES 2

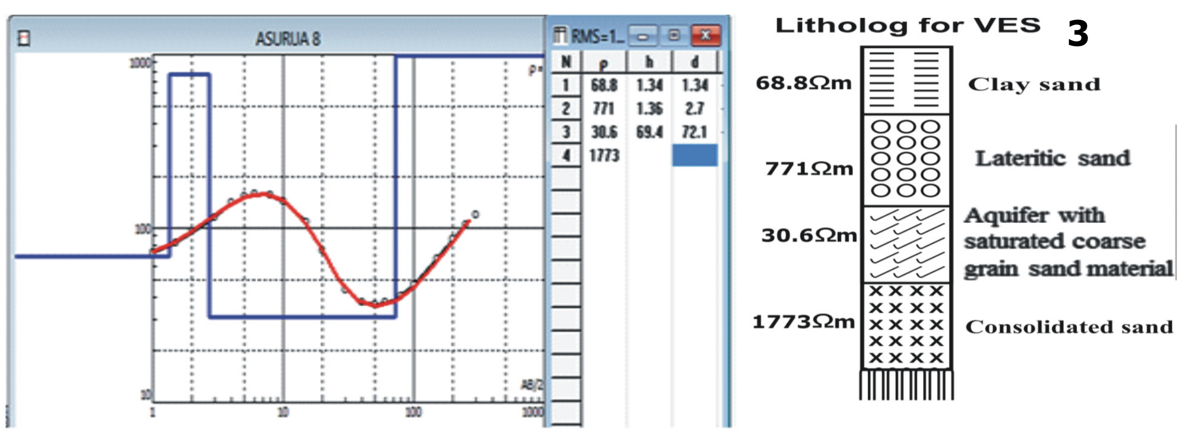

Figure 4: Model layer curve for VES 3

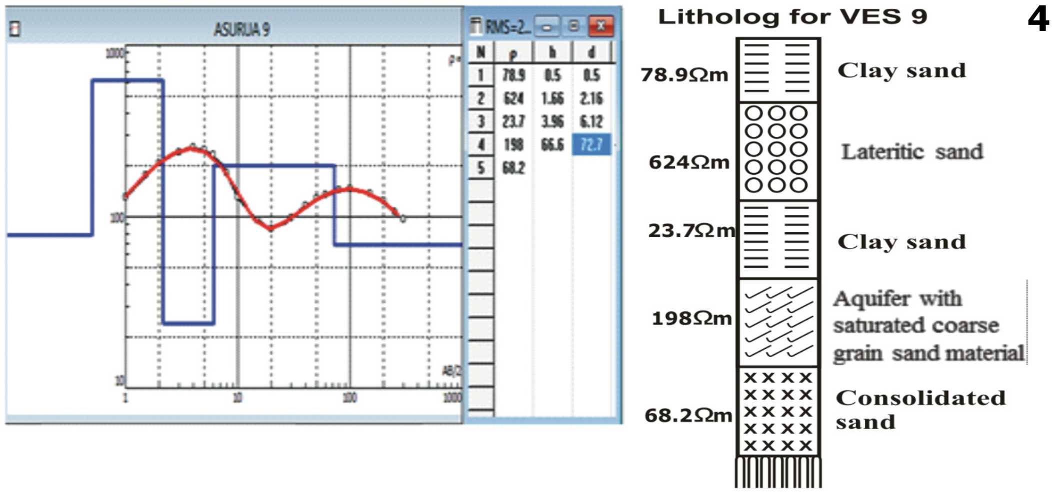

Figure: 5: Model layer curve for VES 4

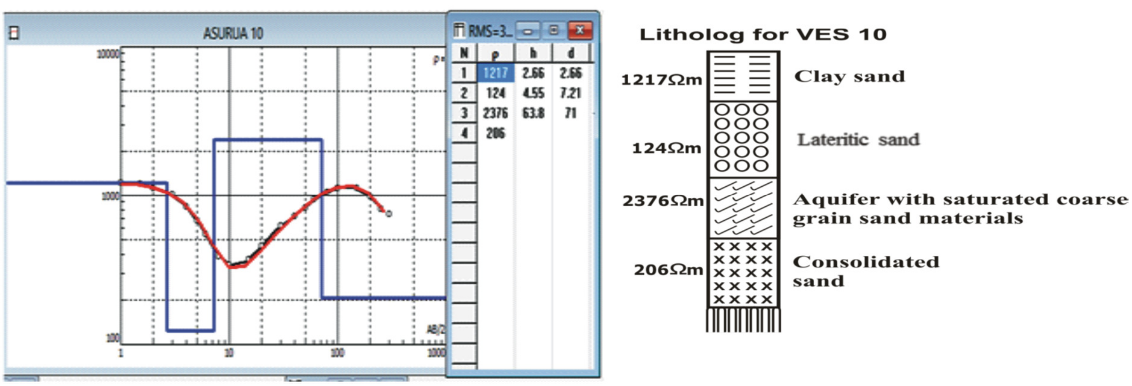

Figure 6: Model layer curve for VES 5

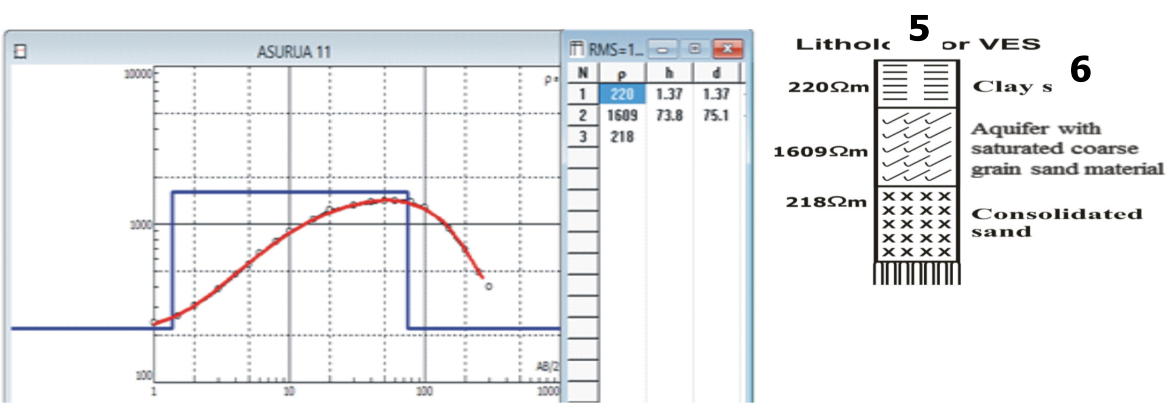

Figure: 7: Model layer curve for VES 6

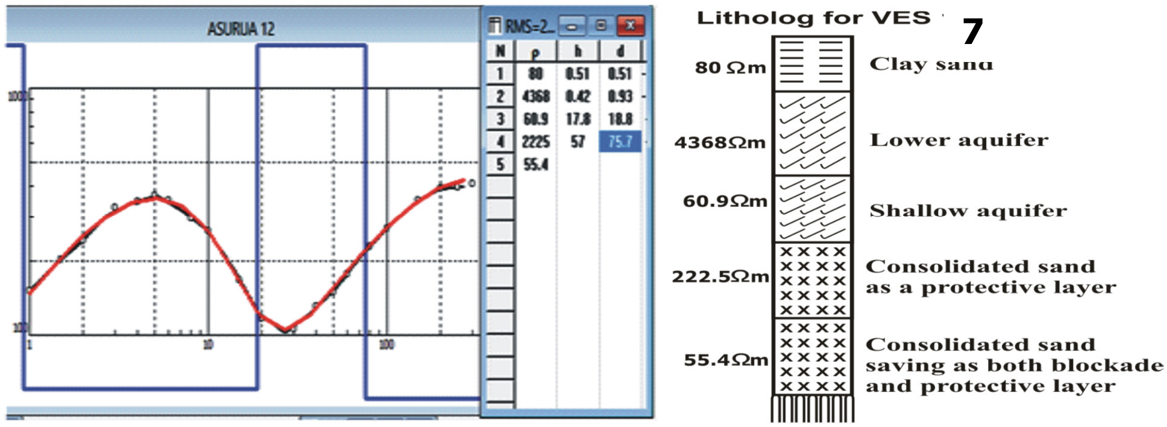

Figure: 8: Model layer curve for VES 7

For the three layer curve, the first geoelectric layer has a resistivity of 220Ωm and a depth of 1.37m. The resistivity of the second geoelectric layer is 1609Ωm, with a depth of 75.1m. The third geoelectric layer has a resistivity of 218Ωm. The formation is composed of clay to sandy clay. The second layer is mainly dominated by the aquifer with saturated coarse grain sand materials while the third layer is consolidated material which serves as blockade for the aquifer. For the four layer curves, the first geoelectric layer has a resistivity range of 68.8Ωm and 2376Ωm while the depth ranged between 1.34m to 72.1m.The resistivity of the second geoelectric layer ranged between 124Ωm and 771Ωm while the depth ranged between 2.7m to 7.21m. The third geoelectric layer has a resistivity ranged between 30.6Ωm and 2376Ωm while the depth ranged between 71.0m to72.1m. The formation is composed of fine grain dry sand, coarse lateritic sand materials, aquifer with saturated coarse grain sand material and consolidated sediment which acts as a confining bed to the aquifer layer. The geoelectric interpretation also shows that for the five layer curve, the resistivity of the first layer ranged between 78.9Ωm and 675Ωm while the depth layer ranged between 0.5m and 1.68m. The resistivity of the second geoelectric layer ranged between 624Ωm and 4368Ωm while the depth ranged between 0.93m to 4.49m. The third geoelectric layer has a resistivity ranged between 23.7Ωm and 609Ωm while the depth ranged between 6.2m to19.2m. The geoelectric interpretation also shows that the fourth layer resistivity ranged between 198Ωm and 6489Ωm. The low specific resistivity of the fourth layer is an indication of water bearing clayey deposits. The depth of this layer ranged between 72.1m and 75.7m. Also the fifth geoelectric layer has a resistivity ranged between 55.4Ωm and 386Ωm. This layer serves as blockade for the aquifer. The formation is composed of clay sand, coarse lateritic sand materials, aquifer with saturated coarse grain sand material and consolidated sediment which acts as a confining bed to the aquifer layer.

CONCLUSION

The study meant to investigate the groundwater condition of Abiakpo road, Abuja Street, First Bank road, Aba road, Hostel road, Osurua path and ICT. Road, all in Ikot Osurua Community in Ikot Ekpene L. G. Area of Akwa Ibom State .The result shows that Vertical electrical sounding technique of the electrical resistivity method has proven to be successful and highly effective in the identification and delineation of subsurface structures that are favorable for groundwater accumulation in a crystalline basement complex area. The resistivity of the aquifer ranged from 30.6'Ωm to 6489'Ωm while the aquifer depth ranged between 50m to 80m. From the result, it is recommended that boreholes for sustainable water supply in Ikot Osurua community should be drilled to about 50m to 80m; this is an indication of the presence of fresh groundwater.

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