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Geophysical Investigation of Groundwater Potential in Akwa Ibom State Polytechnic Campus, Ikot Osurua, Akwa Ibom State, South –South Nigeria Using Electrical Resistivity Method

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ABSTRACT
A geophysical investigation involving the vertical electrical sounding (VES) electrical resistivity method was carried out at Akwa Ibom State Polytechnic Campus ,Ikot Osurua, South-south Nigeria to determine the subsurface layer parameters (resistivities, depth and thicknesses) with a view to determining the aquifer configurations which will assist in sitting high yield boreholes in the community.A total of four (4) 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 lithologic log to produce the geoelectric sections of the subsurface. Three (3) geoelectric layers were delineated and aquifer characterization of the area showed that the aquifer resistivity is in the range of 89.2Ωm to 3287Ωm with corresponding thickness in the range of 40m to 80m although it varies in some locations. The result indicates the presence of fresh groundwater at this depth.
Keywords: *Groundwater, aquifer, vertical electrical sounding (VES), Schlumberger configuration.*

INTRODUCTION
Groundwater is described as the water found beneath the surface of the earth in underground streams and aquifers (Anomohanran, 2011). The availability and accessibility of quality and portable water resource is one of the major concerns in developed, developing and underdeveloped societies all over the world (Omamode and Kennedy, 2014). Groundwater has become more popular as a source of potable water in Nigeria as a result of its quality when compared to other water sources. Lawrence and Ojo, (2012) noted that groundwater is most generally free from odour, colour and has very low dissolved solid. It is also not usually affected by natural factors such as drought. Various researchers have employed different methods in exploring this very essential life sustaining resource.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)*. Other researchers such as Oseji et al., 2006; 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.

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LOCATION AND GEOLOGY OF THE STUDY AREA

The study area is in the Niger Delta, located in the southern part of Nigeria between latitude 5° 09´and 5°40'N and longitude 7° 18´and 7 °20´E. (Figure1). The geology of the Niger Delta has been extensively described by several authors including Etu- Efetobor and Akpokodje (1990), Short and Stauble, (1967).It is underlain by sedimentary formation and it belongs to the area classified as coastal plain sand which is known as the Benin formation. And the Benin formation is composed of loosely consolidates 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 hydrogeological condition favoring the aquifer formation in the area.

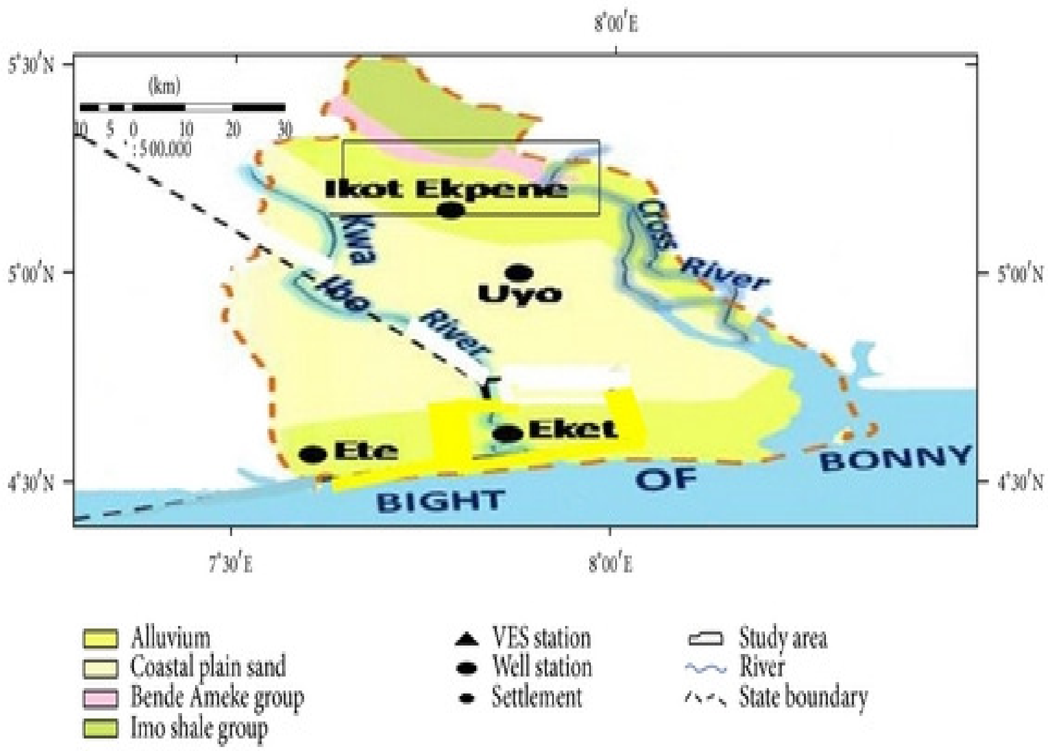

Figure 1: Map of Akwa Ibom State showing the Location and the Geology of the Study Area

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 four (4) points in the school community. 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 resistancegotten 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.

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

Where;

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

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

Where;

ρ_a = Apparent resistivity

AB= Current electrode spacing

MN= Potential electrode spacing

$\pi = 3.142$

The Schlumberger electrode array was employed due to its simplicity, being faster and required fewer number of field workers. The present study aims at integrating the field data from the various sites to give an overview of the groundwater potential of the study area which will not only support the siting of boreholes but will help in future groundwater exploration, exploitation, development and management.

RESULT AND DISCUSSION

The summarized results of the interpretation of the field report is presented as shown in table1 with Q, KH and K curves type dominating (Figures 2-6). Table 2 shows VES location and their coordinates. The measured resistances were converted to apparent resistivity by multiplying with their respective geometrical factors. This apparent resistivity was plotted against half current electrode spacing (AB/2) on a bi-logarithmic graph using Microsoft excels to generate curves from the field data. Unwanted values that failed to follow the dominant curve trend were expunged by the process of curve smothering .The maxima and minima on the smoothened VES curves were taken to depict the vertical variation in resistivity with depth. 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

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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.

Table.1: The summarized result showing resistivity, thickness, depth and lithology of the VES points

VES location	Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithology
Staff quarters road	1 2 3	1181 212 202	2.98 66.30 -	2.98 69.30 -	Top soil fine grain dry sand Lateritic sand Aquifer with saturated coarse grain sand
Football field	1 2 3	3287 433 12	10.90 60.10 -	10.90 71.00 -	Top soil fine grain dry sand Lateritic sand Aquifer with saturated coarse grain sand
Mechanical workshop	1 2 3	2692 478 192	10.30 58.40 -	10.80 68.70 -	Top soil fine grain dry sand Lateritic sand Aquifer with saturated coarse grain sand
Mami market	1 2 3	520 2559 314	6.99 76.00 -	0.99 77.00 -	Top soil fine grain dry sand Lateritic sand Aquifer with saturated coarse grain sand

Table.2: VES Locations and their Coordinates

S/N	LOCATIONS	LATITUDE(E)	LONGITUDE(N)	ELEVATION(m)
1.	Staff quarters road	5°09′42.1″	007°40′81″	57
2.	Football field	5° 9′53.8″	007°40′39.9″	58
3.	Mechanical workshop road	5°08′97.7″	007°40′45.4″	72
4.	Mami market road	5°9′53.8″	007°40′09.0″	49

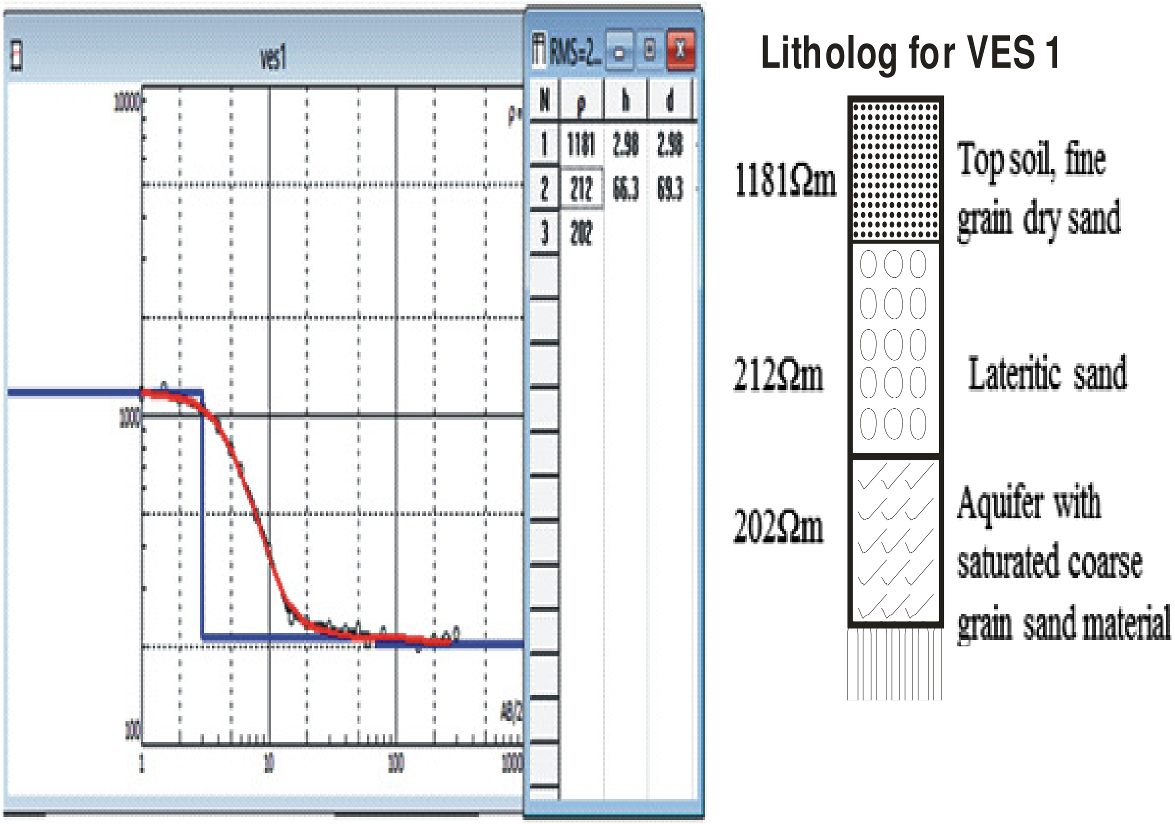

Figure: 2: Model layer curve for VES 1

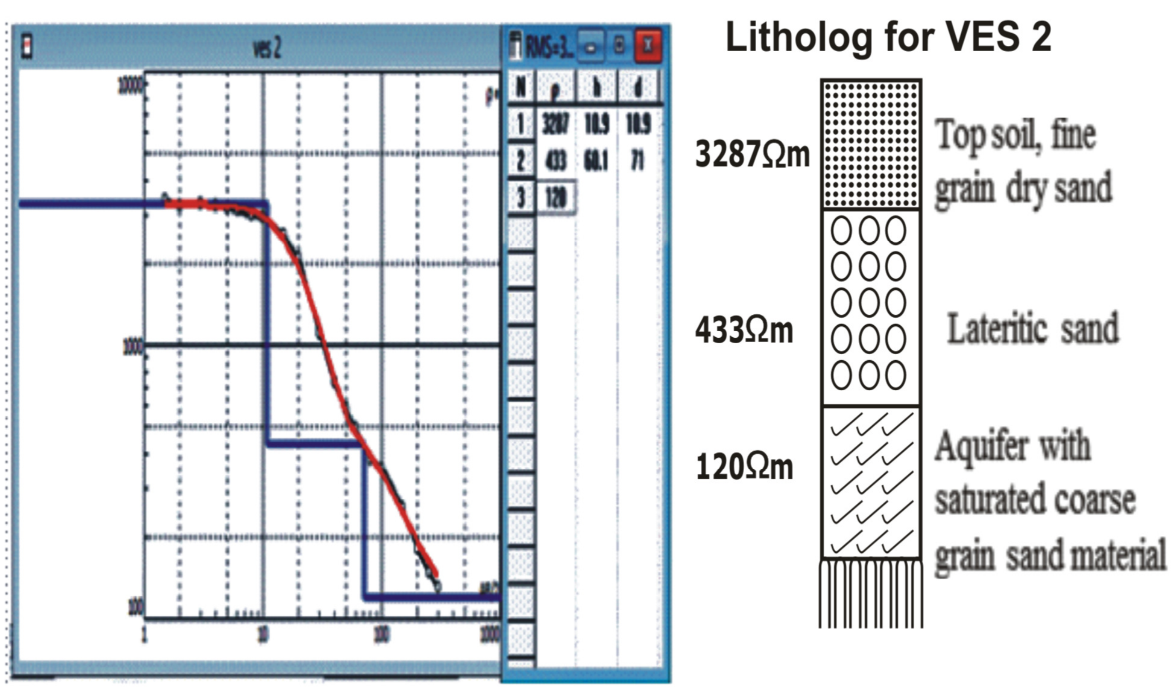

Figure: 3: Model layer curve for VES 2

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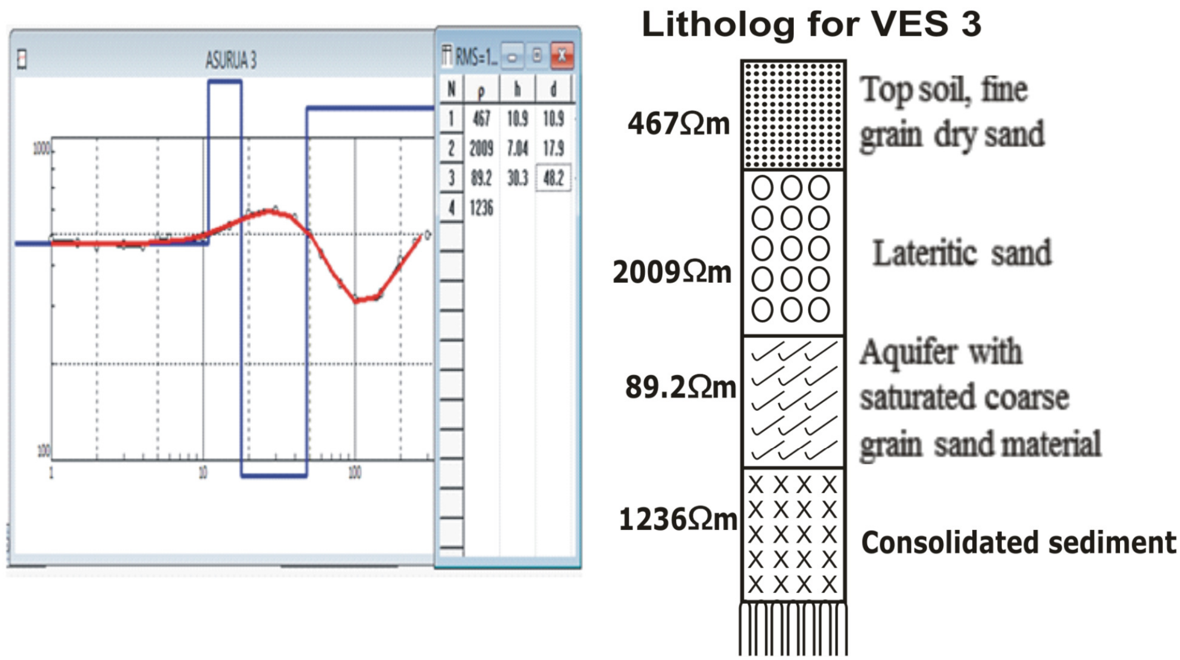

Figure: 4 Model layer curve for VES 3

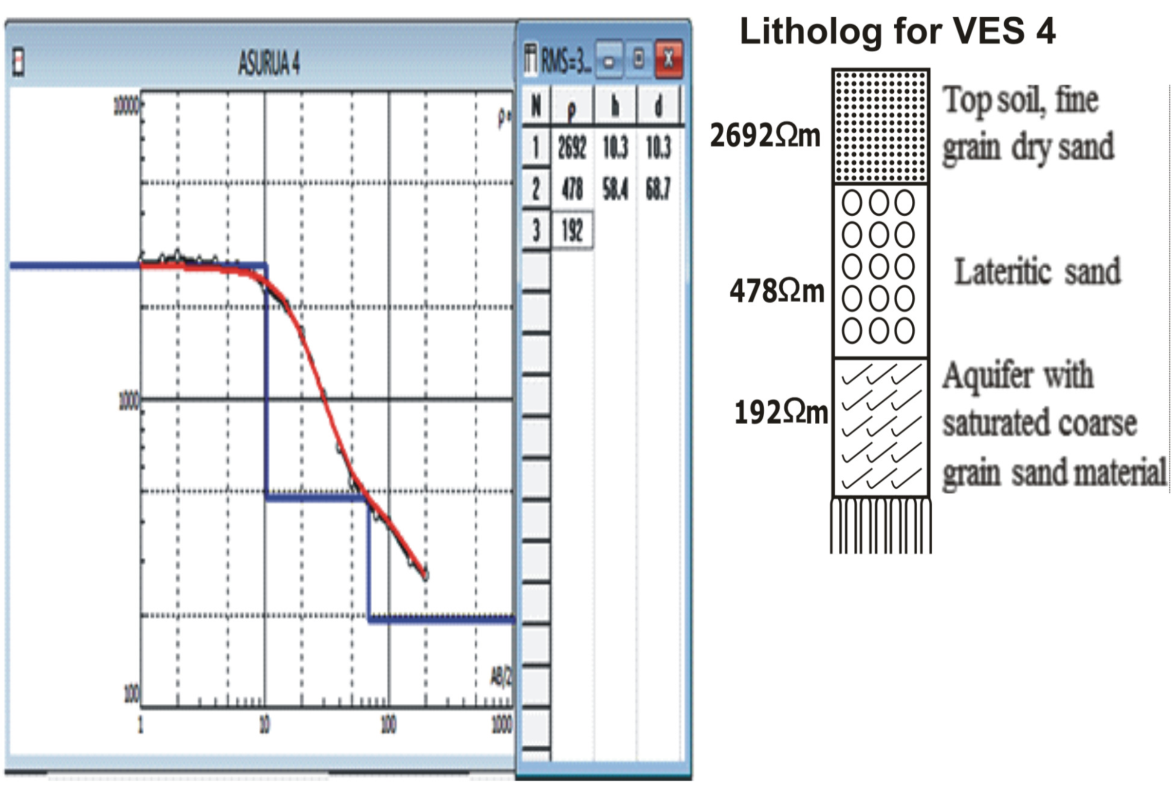

Figure: 5: Model layer curve for VES 4

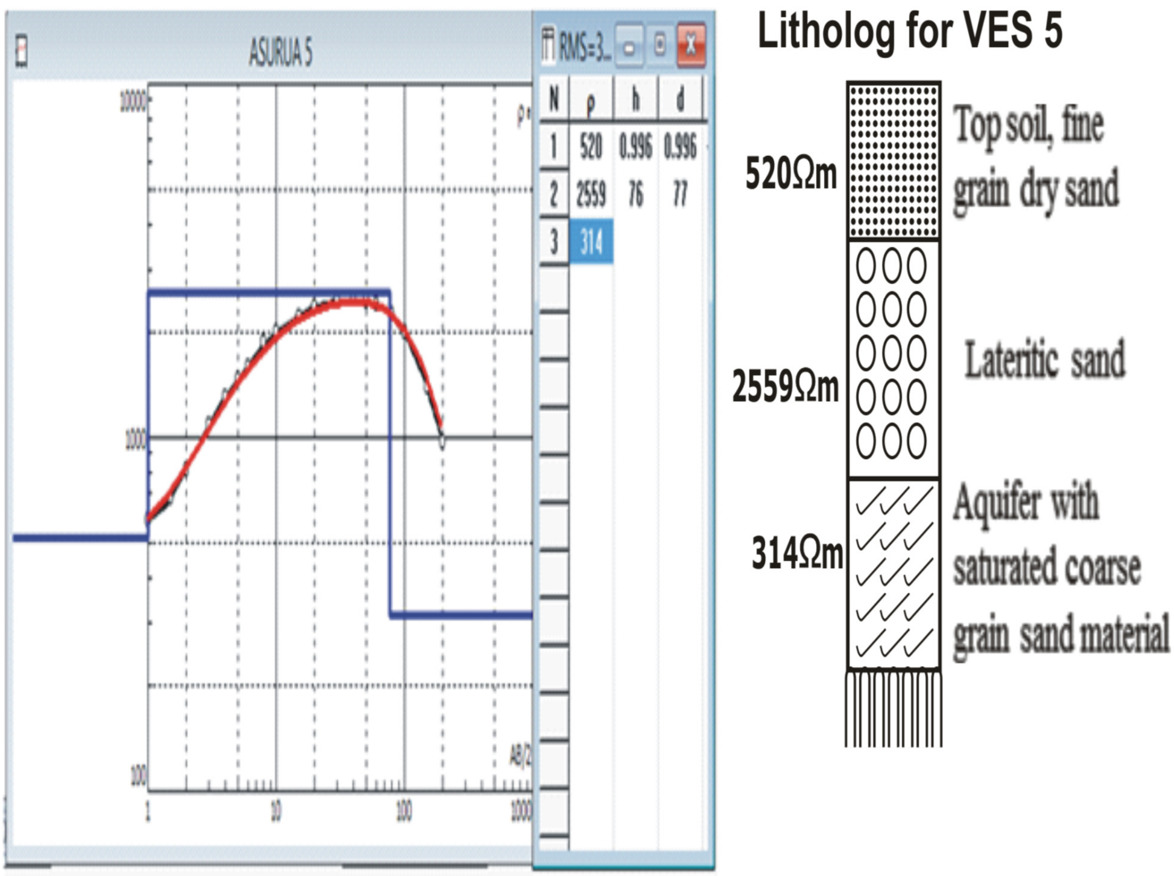

Figure: 6: Model layer curve for VES 5

The plot of the apparent resistivity against current electrodes separation is presented as shown in figures 2-6. Table 1 has revealed the existence of three geoeletric layers. The first geoelectric layer has a resistivity range of 467Ω mand 3287Ωm and comprise of fine grain dry sand in all the locations. The depth ranged between 0.99m and 11.9m. The resistivity of the second geoelectric layer ranged between 212Ωm and 2559Ωm while the depth ranged between 11.0m and 68.7m. The formation composed of lateritic sand in all the locations. The third geoelectric layer has a resistivity range of 89.2Ωm and 1236Ωm. It is an aquifer layer in all the locations. The distance to the top of these layers are 63.3m in Staff quarters road, 11.0m in School football field,11.9m in Mechanical workshop road and 68.1m along Mami market road. The result of geoelectric interpretation compares favourably with records of existing wells in the study area. In general table1 above revealed the existence of three geoelectric layers in the study area. Hence since the resistivity of a rock material is a function of soil moisture and generally decreases with increasing water content, it follows that the degree of water content, and its salinity, interconnectivity of the pores in rocks which defines it's permeability, degree of compaction and orientation during deposition, texture, temperature at any depth and porosity affect the resistivity of rock.

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CONCLUSION

The study was carried out in Akwa Ibom State Polytechnic, Ikot Osurua, Ikot Ekpene, South – South, Nigeria, and employing Schlumberger electrode configuration. The survey involved a total of four vertical electrical sounding (VES) and the interpretation of the field data gives a set of geologic models where three geoelectric layers were delineated.

The result showed that the resistivity values in the study area ranged from 89.2Ώm to 3287Ώm while the aquifer depth range from 40m to 80m although it varies in some location; thus for sustainable water supply in Akwa Ibom State Polytechnic Campus, it is recommended that groundwater can be sourced at a depth of about 40m to 80m in these locations.

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