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Research Paper

Determination of Groundwater Potential Using Vertical Electrical Sounding at Achina and Its Environs

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Abstract— The determination of groundwater potential was carried out in Achina and some neighouring towns in Aguata Local Government Area of Anambra State, Nigeria to investigate the depth of aquifer. A total of eight (8) Vertical Electrical Soundings was carried out in Achina and some neighbouring town with a VES done in each town. The ABEM SAS 1000 resistivity meter was used to acquire data in those areas and the data acquired was interpreted using the Schlumberger automatic INTERPEX analysis software, which generates model curve using initial layer parameters. The results obtained shows that VES 1, 3, 4 and 7 showed AQ type of curve, VES 2 and 5 curve types are KAQ and KQ respectively while VES 6 and 8 curve types are AHQ and HQ respectively as deduced from the resistivity values. The interpreted results were presented as VES 1 – 8 and were presented in terms of resistivity, thickness, depth and lithology. The lithology was inferred to the layers from a standard given by Davis & Annan (1989) and geology of the study area. VES 5 showed four (4) geoelectric layers; VES 1 and 8 showed a total of five (5) layers; VES 3, 4 and 7 showed a total of six (6) geoelectric layers while VES 2 and 6 showed seven (7) and eight (8) geoelectric layers respectively. The geoelectric layers delineated are Top sand, clay, sand, aquiferous sand and sandstone with aquiferous sand being the aquifer bearing unit, the depth of aquifers ranges from 161.3 m to 254.5 m and thickness ranging from 36.1 m to 196.9 m.

Keywords— **Achina, Aquifer, Schlumberger, Borehole, Geoelectric Section, Vertical Electrical Sounding, Ekwulobia**

1. Introduction

Water is one of the essential resources for human lives, yet quality of the water is debatable for human consumption. Population growth, increase in oil and gas explorations, poor environmental stewardship has tremendously destroyed the quality of drinkable water in the area. This effect becomes enunciated in both surface and underground waters in the area.

The investigated area Achina and its environs has the problem of accessing areas with good aquifers and difficulty in digging boreholes as a result of the lithology of the area. However, inspite this borehole drilling is being done by the rich either mainly for business purposes and private consumption because of the high cost in drilling boreholes.

Additionally, groundwater as the only source of potable water supply for domestic, industrial and agricultural uses is under intense pressure of degradation and contamination due to indiscriminate waste disposal, indiscriminate location of landfills to various households. The result is rampantly abandoned low yield water abstraction wells; a situation that yearn urgently for an action plans to improve the efficiency of sitting and mapping out areas for optimal high yield boreholes for groundwater supply becomes very tasking and imperative (WWAP, 2012). This form the main thrust of this investigation using the conventional geophysical method which offers remote and non-destructive evaluation for subsurface delineation of underlying strata. The electrical resistivity method is the most commonly applied geophysical tool for groundwater exploration as it can determine aquifer thickness and depth to bedrock, it is also capable of determining the quality of groundwater i.e. whether the water is saline brackish, fresh or contaminated Idehai and Egai, (2014). The seismic, magnetic, gravity and electrical resistivity methods have been useful in groundwater investigations. In the electrical resistivity method of geophysical survey, an artificial source of direct current (DC) or a low frequency alternating current (AC) is used to inject current into the ground through two current electrodes and then the resulting potential difference developed in the subsurface is measured by means of two potential electrodes. Two methods of electrode configuration are commonly used in Vertical Electrical Sounding namely the Wenner electrode array and Schlumberger electrode array (Olisah and Obiekezie, 2020).

The basic aim of resistivity survey is to delineate vertical and horizontal boundaries with electrical contrast. The Schlumberger array was used in this investigation to delineate water bearing formations (aquifers), because of its better depth interpretation and its usefulness in mapping subsurface aquifers and groundwater exploration this method find more superior compared to other methods Egai, (2013). Other usefulness of this geo-electrical method, particularly, the Schlumberger was chosen for this study, because it is non-invasive and quantitative technique, less expensive and easy to interpret, Fronlch *et al*., (1994), Mbonu *et al*., (1991). This study is an attempt to investigate the subsurface hydro geological conditions so as to improve the efficiency of sitting high yield abstraction boreholes in the area. Sedimentary deposits maintains primary porosity that determines their storage and permeability to a great extent (Ashraf *et. al.* 2018) which tends to make them exhibit good aquifer potential. Igneous rocks tend to have the highest resistivities; however rocks with low resistivities are highly conductive; sedimentary rocks tend to be most conductive, largely due to their high pore fluid content; and metamorphic rocks have intermediate but overlapping resistivities (Reynolds, 1997). The recorded low values for the areas with low groundwater/borehole yield is attributed to the low thickness of both the weathered regolith and fractured bedrock layers which constitute the major aquifers (Hamidu *et. al.* 2014; Ugwu and Ezeh 2012). The significance of this investigation is to delineate the subsurface geo-electric stratigraphy and to access hydro-geological conditions, such as groundwater quality at the sites to select aquiferous zones. Hence, will give the populace idea on the actual depth where good water table can be harnessed.

1.1 Location and Accessibility of Study Area

The areas of study is located at the heart of each town in Aguata Local Government Area of Anambra State. The towns includes Achina, Ekwulobia, Akpo, Igboukwu, Amesi, Umuchu and Aguluezechukwu which lies between longitude 7°1'0"E – 7°7'0"E and latitude 5°50'41"N - 6°7'0"N with an elevation ranging from 190.34 m – 250 m.

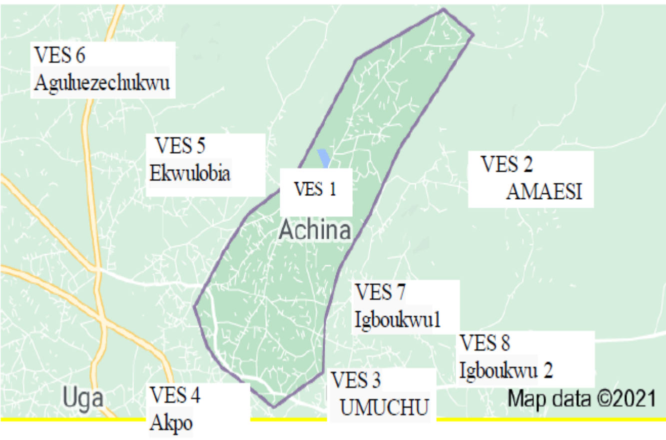

Figure 1: shows the map of the study area with sounding points.

2. Related Work

Surajit Murasingh (2014) analyzed the groundwater potential zones using electrical resistivity method, Remote sensing (RS) and geographical information system (GIS) technique in a typical mine area of Odisha, India observed that the coastal region of the Odisha state are focused to be utilizing groundwater more than interior district of the state. Ashhad and Quamrul (2019) investigated groundwater potential of an area in Delhi and concluded that the groundwater table at the pumping well lies at a depth of about 18.3m and goes to a depth of 47.6m. Mirzaei, *et al*. (2020) explore karst groundwater using electrical resistivity tomography and remote sensing North East Khuzestan concluded after the research that the geological fractures can have a significant effect on storage and flow of groundwater reservoir especially in areas with shallow bedrock fractures, water infiltration.

Back in Nigeria, Olatunji, *et al*. (2016) investigated groundwater potential using electrical resistivity method in parts of Kwara State polytechnic Ilorin Nigeria and concluded that the quality and quantity of the borehole could not be predicted until after drilling have been done and testing pumping carried out. Oseji, *et al*. (2006) determined the groundwater potential in obiaruku and environ, after interpretation of the resistivity curve came to a conclusion that the area has great groundwater potential revealing the lithologic succession as an extensive sandy unit between range of 20m and 136m.

Ekwok, *et al*. (2020) made assessment of ground water potential using a geophysical data in cross river state and concluded that the OM and IME have thin to, moderate sediment thicknesses, while the CF is predominated by thick sedimentation (6217m) .Ezeh and Ugwu (2010) carried out a geoelectrical sounding for estimating groundwater potential in Nsukka L.G.A. Enugu State, Nigeria and concluded that the presence of thick and highly prolific auriferous zone assures the area of adequate water resource.

Abdullahi, *et al*. (2014) carried out geoelectrical method in the evaluation of groundwater potential and aquifer protective capacity of overburden units around Opi area in Nsukka, Southeastern Nigeria and their results delineated three to five geoelectric sections in the study area, namely: the topsoil (which consists of lateritic clay), river sand and gravel and clayey sand. The Vertical Electrical Sounding (VES) results revealed heterogeneous nature of the subsurface geological sequence. Ezeh (2011) carried out a geoelectrical study for estimating aquifer hydraulic properties in Enugu State, Nigeria and concluded that it is possible to obtain quantitative results from VES that are useful for the determination of hydraulic properties of aquifers. In Anambra State, Okafor Desire (2020) investigated ground water potential of the Nanka sands around Nanka - Oko and its environment Anambra state, the result of the interpretation of the geo physical data shows that the area is characterized by a variable sub surface layering ranging from six layer to eight layers. Okeke Florence (2012) investigated groundwater potential using direct geo electric method in a part of old

Aguata and Anaocha local government area Anambra state and concluded that to harness potable water within the aquifer region, it was recommended that the borehole be drilled much beyond the depth range of 24.8m to 130.0m. Onuorah paschal (2017) investigated groundwater occurrence using geo electric method in out-cha and environ Anambra state the result shows that the water saturation is more at the water table mound towards the north than the other areas. Chiwuko, A. I (2015) investigated ground water potential in Awka, Anambra state Nigeria using geo electric method and concluded that the aquifer are capable of yielding enough water that would serve the immediate environs. Delunzu, Chukwu and Okoroji (2018) made assessment of groundwater potential in Anambra state and got to a conclusion that the groundwater potential map could be useful for various purposes such as the development of sustainable scheme for groundwater in the area, the integration of geographical information system and data extracted from satellite images coupled with geophysical data and the geological knowledge of the area under investigation, could provide a powerful tool in groundwater investigation and groundwater potential zones map revealed that the plain areas are prospective zones in the catchment and can be helpful in better planning and management of ground resource.

Onyekwelu, *et al*. (2021) investigated ground water potential of Ogidi and environs, Anambra state south- eastern Nigeria using geo electrical method and concluded that since the aquifer layer was encountered in all sounding location, this shows that the study area have good groundwater potential. Eugene-Obiora, *et al*. (2020) carried out the geoelectrical investigation of groundwater potential and vulnerability at Oraifite, Anambra state concluded that the study revealed that 90% of the study area has poor aquifer protective capacity. Therefore, these areas are vulnerable to contamination from infiltration of surface contamination. Kenechukwu, *et al*. (2020) using geo electric technique for vulnerability and groundwater potential analysis of aquifer in Nnewi Anambra state Nigeria the result shows that the study area has stronger groundwater potential.

The most common water-quality problem in rural water supplies is bacterial contamination from septic tanks, which are often used in rural areas that don't have a sewage-treatment system. Effluent (overflow and leakage) from a septic tank can percolate (seep) down to the aquifer and maybe into *et al*. a homeowner's own well. Just as with urban water supplies, chlorination may be necessary to kill the dangerous bacteria. In these areas, the residents find it very difficult to locate water except for some few rich people who were able to dig borehole for a very excessive price. There are little or no knowledge on the state of environment, depth of water table and level of contaminants in the water table. Therefore, this investigation will not only add to the growing body of environmental knowledge in Achina and its environs, but it will also direct future studies that can fill the remaining gaps. Hence, the aim is to investigate the groundwater potential using Vertical Electrical Sounding at Achina and its Environs, Anambra state and the objectives are to determine the depth to water table, to identify great and resourceful spot for drilling bore hole, to determine the subsurface geoelectric layers, to demonstrate the effectiveness of the use of vertical electrical sounding.

4. Experimental Method/Procedure/Design

The basic equipment used for this geophysical survey is the ABEM SAS 1000 resistivity meter.
The resistivity meter is equipped with a 12 volts battery, two current transmission cables on reels, two potential cables, four metal electrodes and a salt solution. Auxiliary equipment for the survey consisted of a Global Positioning System (G. P. S), to determine the resistivity survey locations and topography, geologic hammers for driving electrodes into the ground, two measuring tapes and cutlasses for clearing traverses.

The study involved the use of electrical resistivity method. The technique adopted was Vertical Electrical Sounding (VES). The sounding was used to characterize the various lithologic units and to determine the depth to water table. A total of ten Vertical Electrical Sounding (VES) using Schlumbeger array (fig 1) was conducted at the heart of Achina and its neighbouring towns.

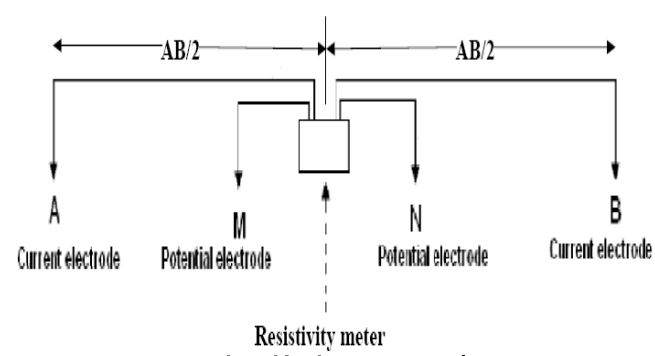

Figure 2: The Schlumberger array configuration

Current is passed between electrodes A and B and monitored by the potential electrodes M and N. As the distance between A and B is increased, deeper horizon have more effect on the potential between M and N. Also when sounding with a Schlumberger array, as distance between the current electrodes are increased, the distance between the current and potential electrodes at the center of the array is also increased. It is this increase between the current and potential electrodes at the center of the array that actually matters in depth probing. The reasonable distance between M and N should be equal or less than one-fifth of the distance between A and B at the beginning. The ratio goes up to one – tenth or one – fifteenth depending on the signal strength. The electrode configuration having a maximum current electrode spread of 800 m was used with a maximum of 400 m on both sides. The current electrode spacing begins with a distance equal to 2 m and extends up to 400 m while the potential electrode spacing begins with a distance of 0.5m and extends up to 20m.The $\frac{AB}{2}$ or half current electrode spacing was increased to a maximum of 400 meters. In most cases $\frac{MN}{2}$ or half potential electrode spacing were overlapping two readings. This means that the potential electrodes were moved only when the potential drops or becomes too small to measure with sufficient accuracy. For the survey, it was not necessary to increase the $\frac{MN}{2}$ distance until the distance $\frac{AB}{2}$ was increased to 9, 75 and 300 meters. At this point, $\frac{\Delta V}{I}$ was measured for both the old and new value of $\frac{MN}{2}$. This procedure permits the detection of near surface inhomogeneities.

Table 1: Sample of VES data sheet

VES 1 DATA SHEET

LOCATION: Ebele Achina **CO-ORDINATE**
STATION NO: VES 1 **N: 5^0 56.6'**
E: 7^0 7.0'
ELEVATION: 250m

READING NO:	AB/2	MN/2	Ka	R(Ω)	Sa
1	2		11.78	50.42	593.94
2	3	0.5	27.50	21.60	594.00
3	6		112.36	6.937	779.44
4	9		253.79	4.411	1119.44
5	9	2.0	60.50	12.06	729.63
6	15		173.64	6.125	1063.55
7	25		487.93	3.539	1726.78
8	40		1254.00	1.592	1996.37
9	50		1961.14	0.5699	1117.65
10	75		4416.50	0.5421	2394.11
11	75	10.0	868.21	2.403	2086.30
12	100		1555.71	1.825	2839.17
13	150		3520.00	1.176	4139.52
14	200		6270.00	0.6247	3916.86
15	250		9803.04	0.2123	2081.18
16	300		14127.14	0.1232	1740.46
17	300	20.0	7040.00	0.1342	944.76
18	400		12540.00	0.053	643.302
19	500		19611.43		

The VES field results was recorded as shown in fig 3**.**
where
AB/2 is the half current electrode spacing which extends from 2m to 500m on both sides
MN/2 is the half potential electrode spacing which extends from 0.5m to 20m
Ka is the geometric factor (K) calculated using eqn 1 which is

$$K = \pi\left\{\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right\} \quad (1)$$

R (Ω) is the Resistance values collected from the field using ABEM SAS 1000 resistivity meter

S_a is the apparent resistivity values calculated using eqn 2 which is

$$S_a = \pi\left\{\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right\} \times R \quad (2)$$

The VES field data were processed using the Schlumberger automatic INTERPEX analysis software, which generates model curves using initial layer parameters by plotting a graph of apparent resistivity against half current electrode spacing (AB/2). From the graph, the number of layers, depth, VES curve and thickness of each layer was deduced. The lithology was inferred to the layers from a standard given by Davis & Annan (1989) as shown in Table 1 and geology of the study areas.

Table 2: Resistivities of some common rocks and soil (Davis & Annan 1989)

Soil and Rock	Resistivity Range (Ωm)
Clay	0 – 50
Shale	50 – 100
Sand	100 – 3000
Sandstone	3000 – above

5. Results and Discussion

5.1 The Qualitative Interpretation of VES Results

Sounding curve analysis aims to obtain the equivalent subsurface layering of the apparent resistivity curve. The qualitative interpretation of the profiles and depth sounding curve were carried out based on distinctive geoelectric parameters on the number of layers represented by the four types of auxiliary curves (A, H, K and Q). VES 1, 3, 4 and 7 curve type is AQ, VES 2 and 5 curve types are KAQ and KQ respectively while VES 6 and 8 curve type are AHQ and HQ respectively. The summary of qualitative interpretation of VES curves is shown in Table 2.

TABLE 3: SUMMARY OF QUALITATIVE INTERPRETATION OF VES CURVES

VES	CURVE TYPE	RESISTIVITY PROFILE	NUMBER OF LAYERS
1	AQ	$\rho_1<\rho_2<\rho_3>\rho_4>\rho_5$	5
2	KAQ	$\rho_1<\rho_2>\rho_3<\rho_4<\rho_5>\rho_6>\rho_7$	7
3	AQ	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5>\rho_6$	6
4	AQ	$\rho_1<\rho_2<\rho_3>\rho_4>\rho_5>\rho_6$	6
5	KQ	$\rho_1<\rho_2>\rho_3>\rho_4$	4
6	AHQ	$\rho_1<\rho_2<\rho_3>\rho_4<\rho_5>\rho_6>\rho_7>\rho_8$	8
7	AQ	$\rho_1<\rho_2<\rho_3>\rho_4>\rho_5>\rho_6$	6
8	HQ	$\rho_1>\rho_2<\rho_3>\rho_4>\rho_5$	5

VES 1 and 8 showed a total of five (5) layers; VES 5 showed four (4) geoelectric layers; VES 3, 4 and 7 showed a total of six (6) geoelectric layers while VES 2 and 6 showed seven (7) and eight (8) geoelectric layers respectively (fig 3 – 19).

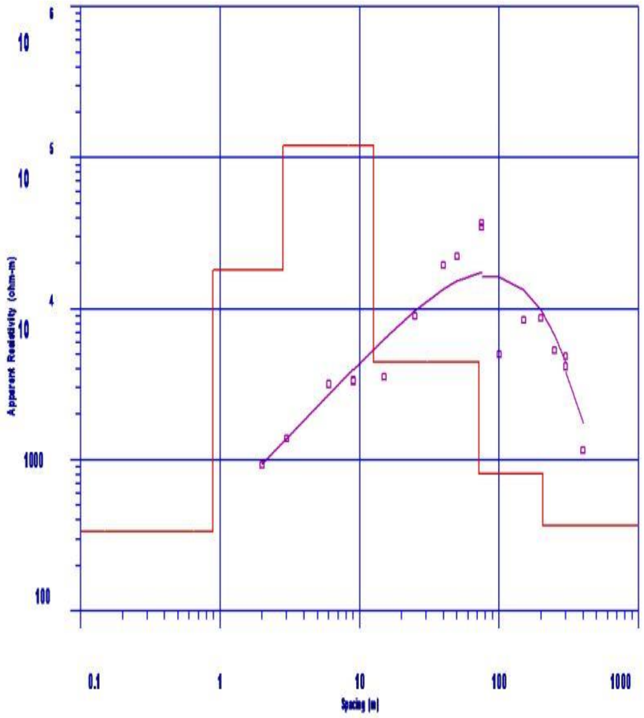

Figure 3: VES curve extracted for VES 1 data

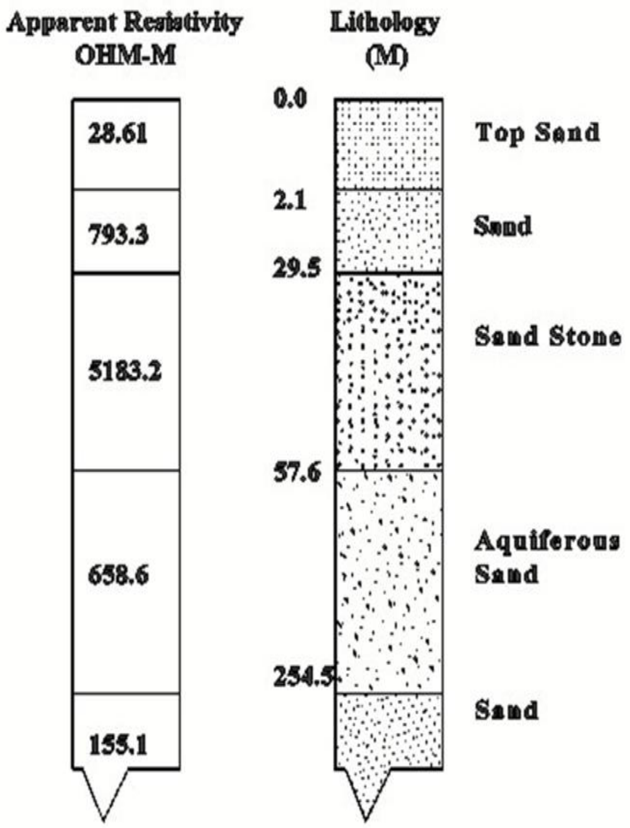

Figure 4: Lithology log for VES 1 as extracted from VES Curve

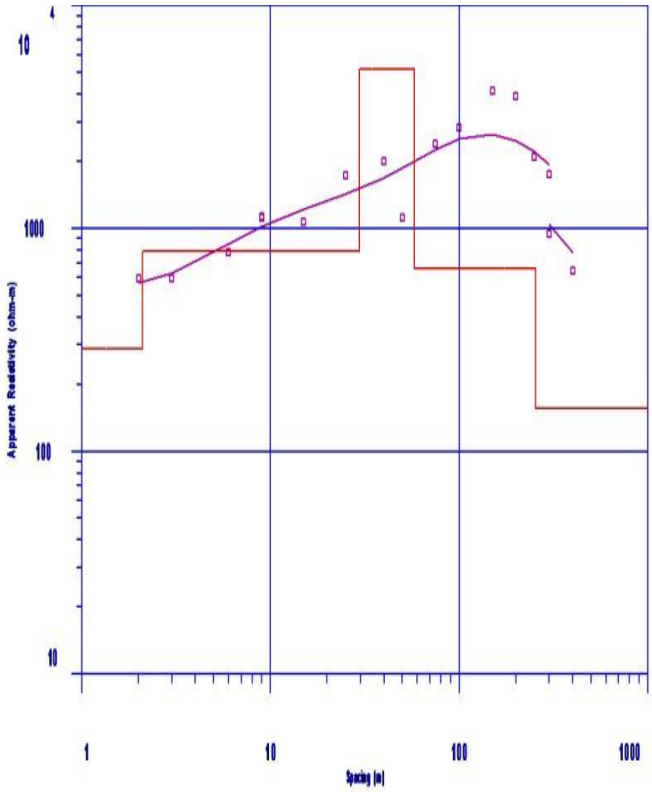

Figure 5: VES curve extracted for VES 2 data

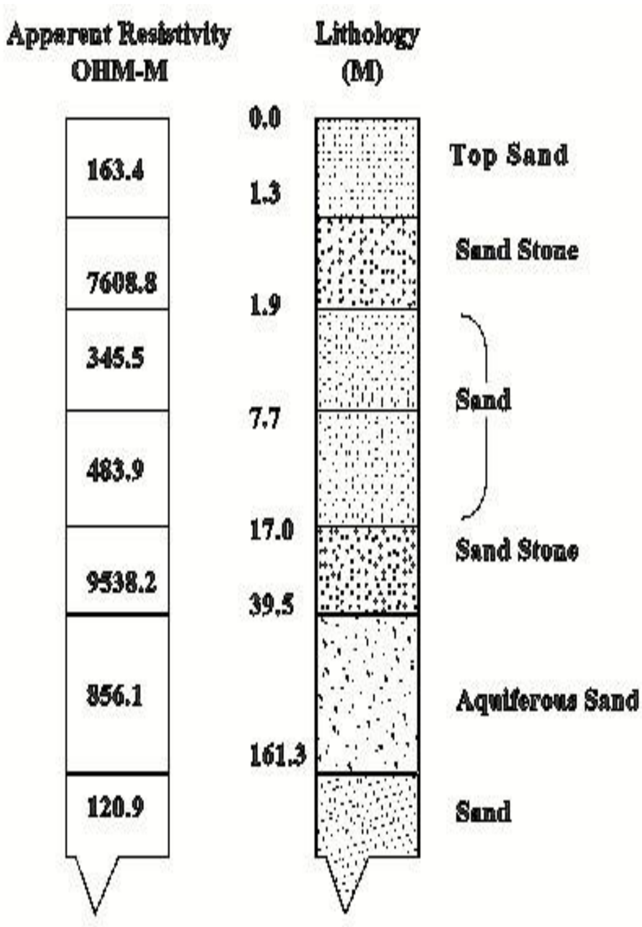

Figure 6: Lithology log for VES 2 as extracted from VES Curve

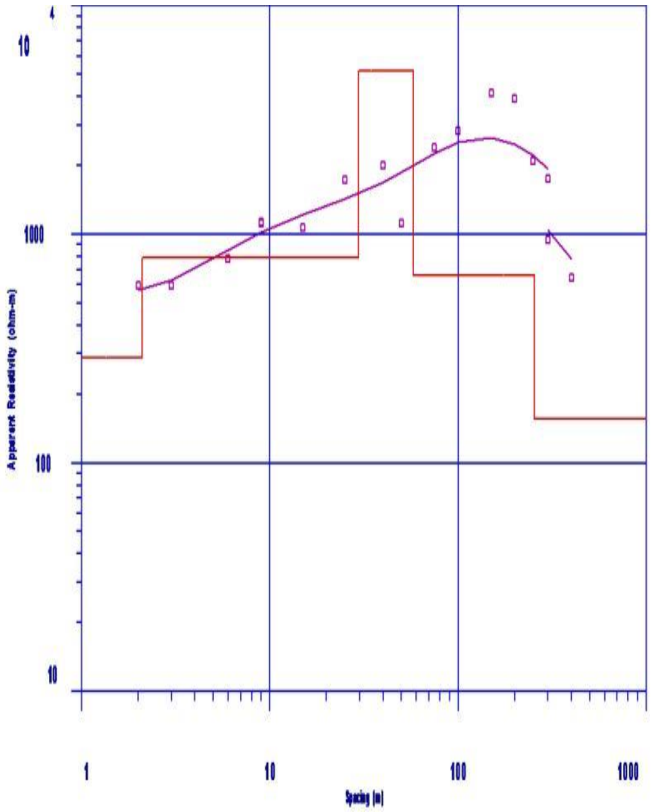

Figure 7: VES curve extracted for VES 3 data

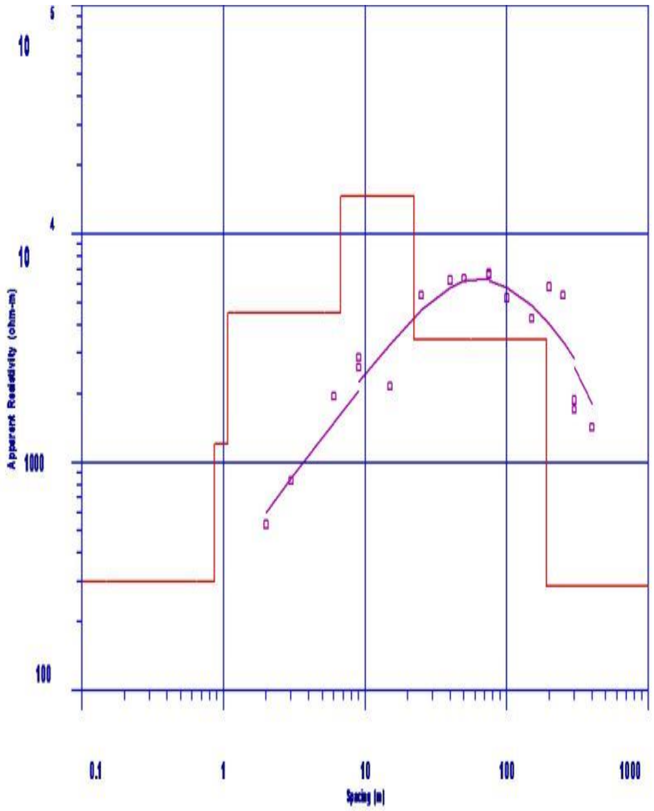

Figure 9: VES curve extracted for VES 4 data

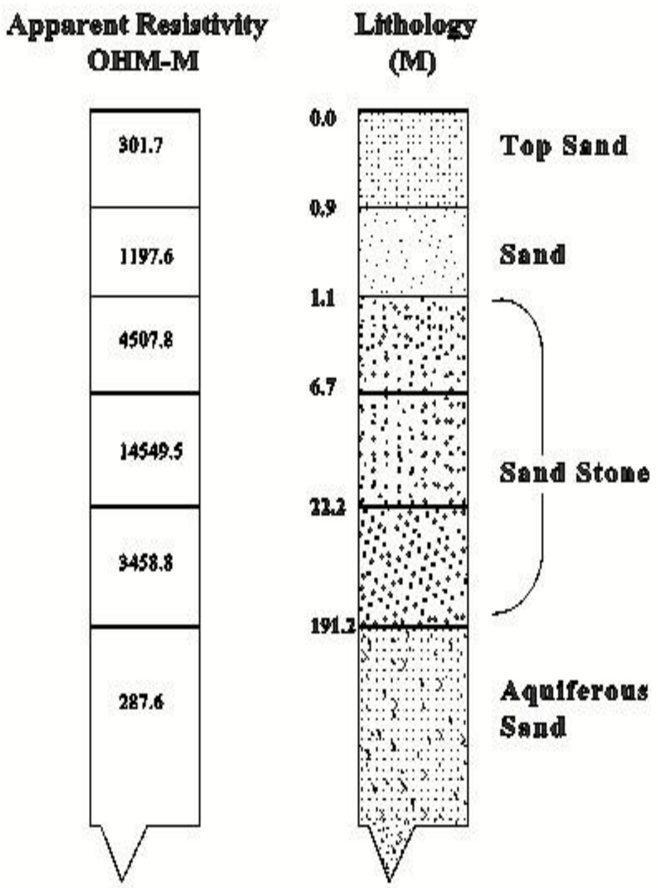

Figure 8: Lithology log for VES 3 as extracted from VES Curve

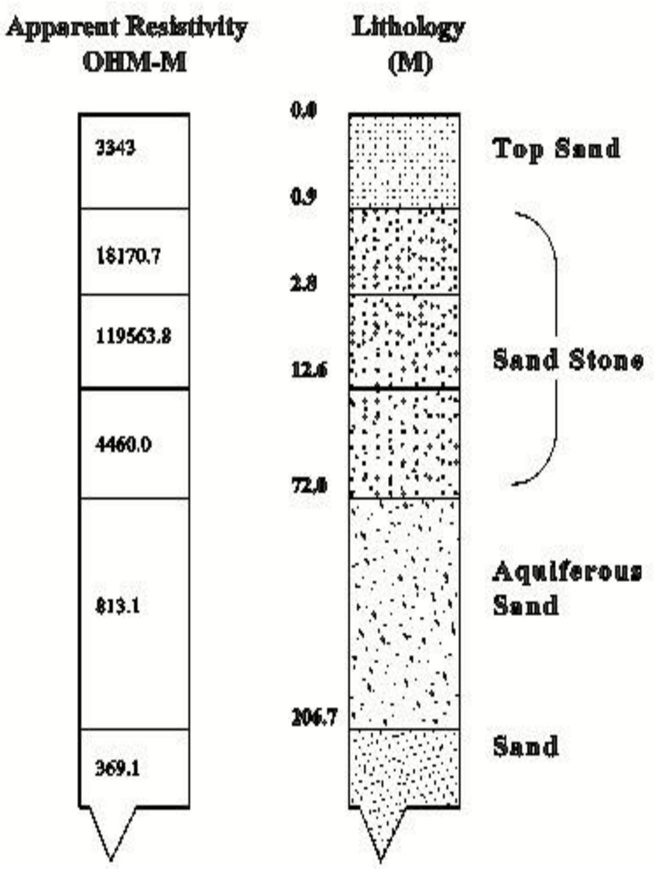

Figure 10: Lithology log for VES 4 as extracted from VES Curve

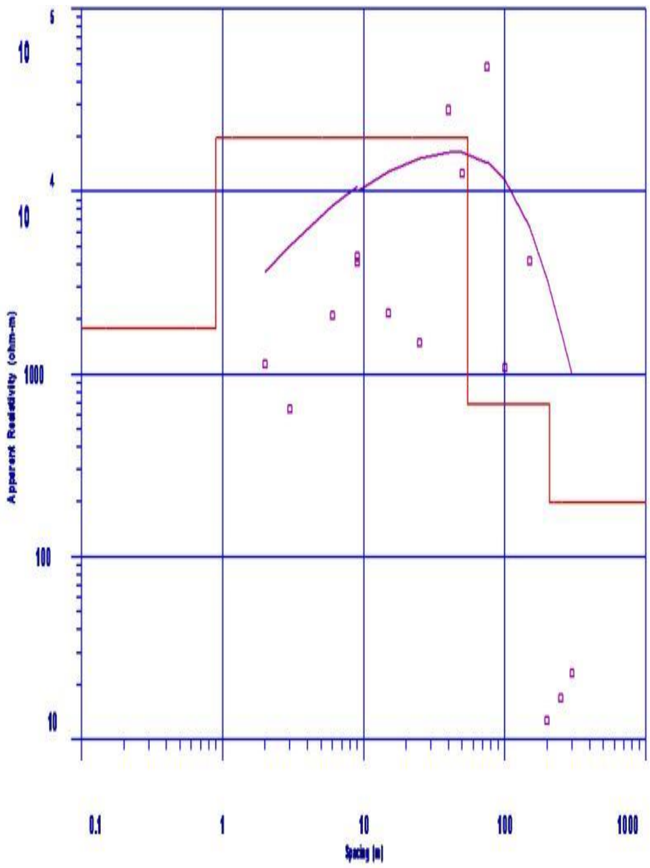

Figure 11: VES curve extracted for VES 5 data

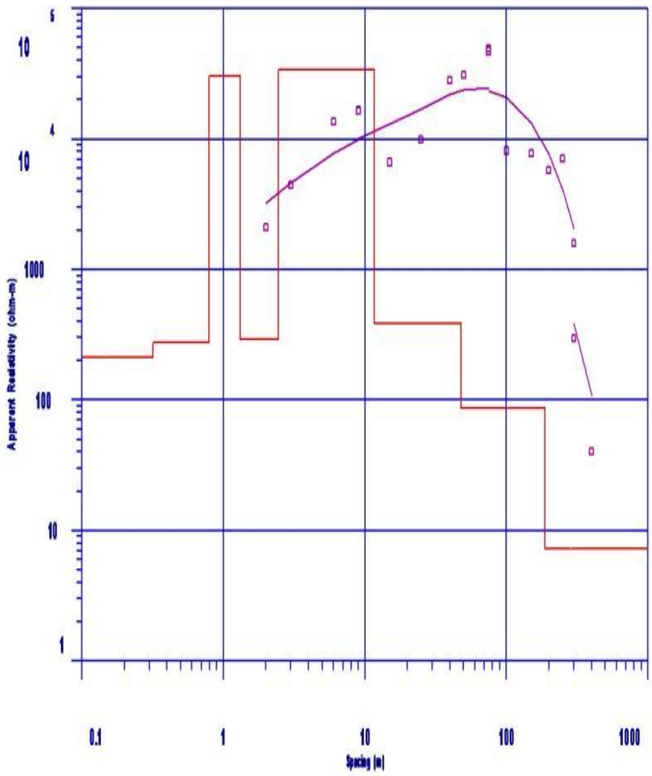

Figure 14: VES curve extracted for VES 6 data

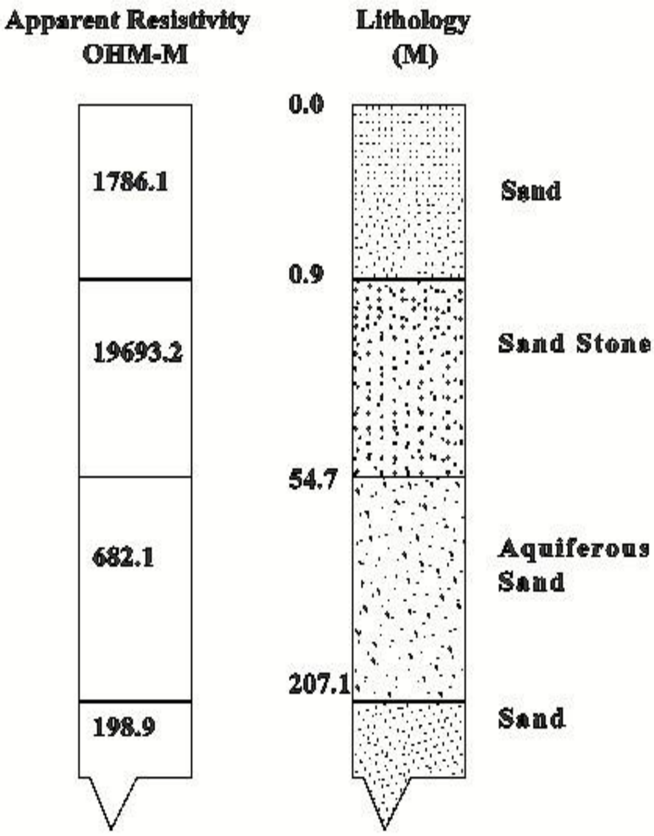

Figure 13: Lithology log for VES 5 as extracted from VES Curve

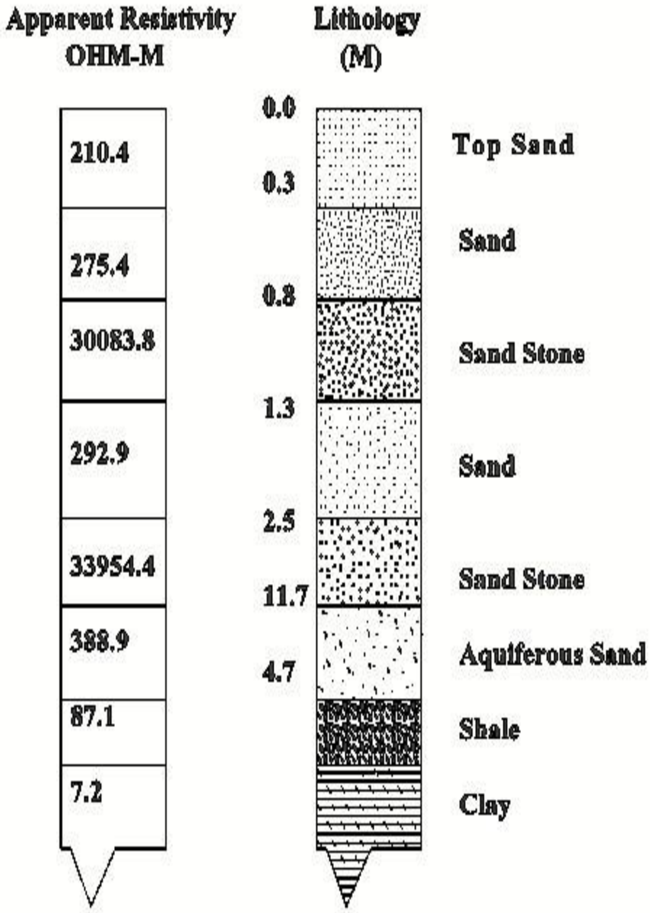

Figure 15: Lithology log for VES 6 as extracted from VES Curve

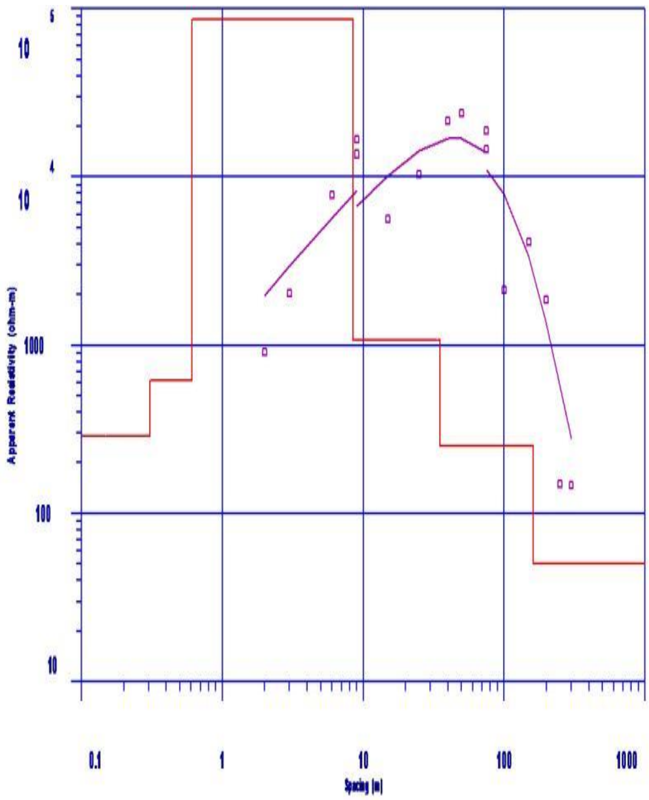

Figure 16: VES curve extracted for VES 7 data

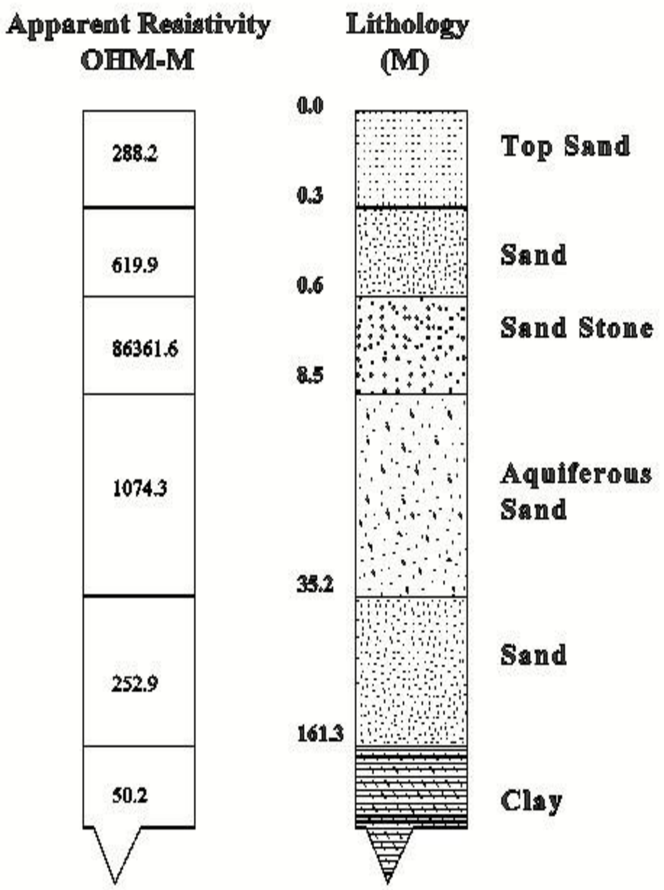

Figure 17: Lithology log for VES 7 as extracted from VES Curve

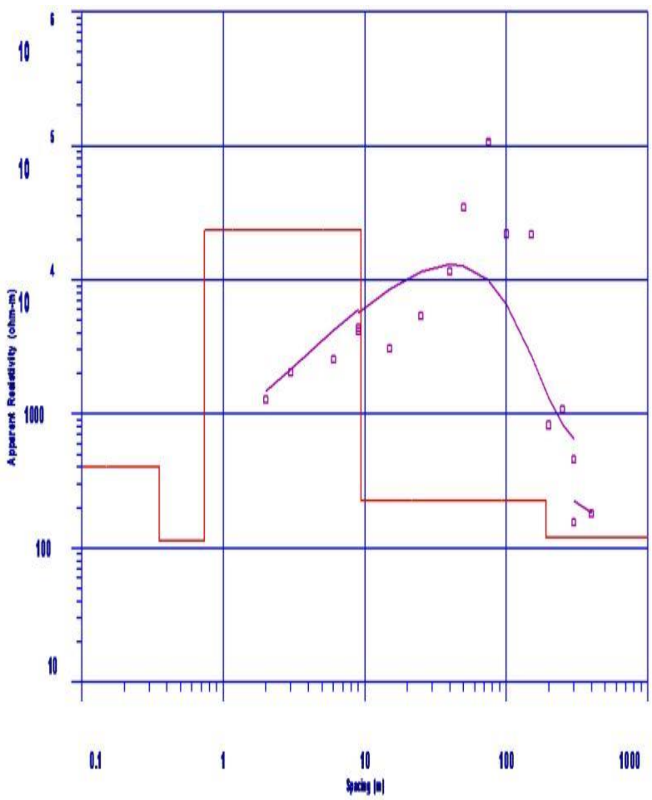

Figure 18: VES curve extracted for VES 8 data

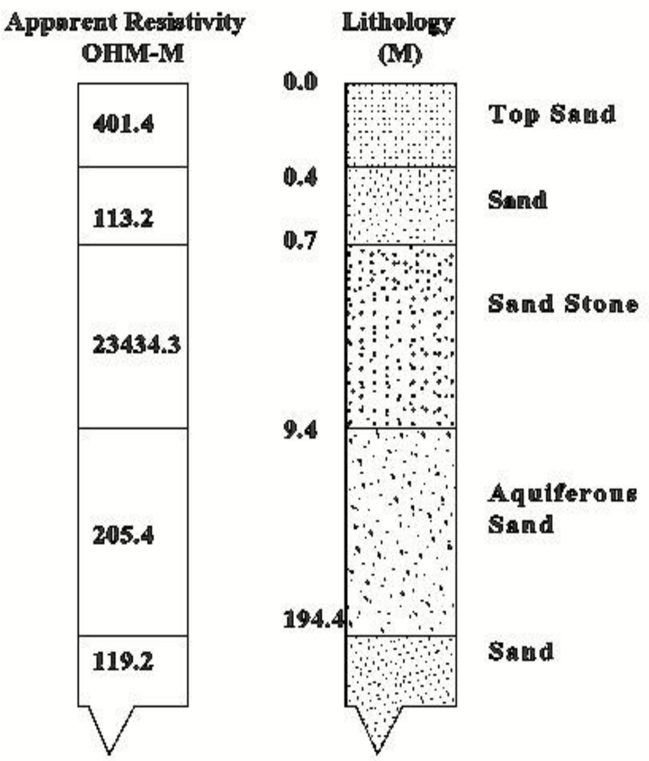

Figure 19: Lithology log for VES 8 as extracted from VES Curve

5.2 Quantitative Interpretation

Eight geoelectric soundings were carried out with one sounding in each town and two soundings in Igboukwu because of its large land mass. The stations were represented and interpreted as VES 1 to 8 as shown in Table 3.

TABLE 3: SUMMARY OF VES INTERPRETATION RESULTS

VES	Layers	Resistivity(Ωm)	Thickness (m)	Depth (m)	Lithology
1	1	286.8	2.1	2.1	Top sand
	2	793.3	27.4	29.5	Sand
	3	5183.2	28.1	57.6	Sandstone
	4	658.6	196.9	254.5	Aquiferous sand
	5	155.1	-	-	Aquiferous sand
2	1	163.4	1.3	1.3	Top sand
	2	7608.8	0.6	1.9	Sandstone
	3	345.5	5.8	7.7	Sand
	4	483.9	9.3	17.0	Sand
	5	9538.2	22.5	39.5	Sandstone
	6	856.1	121.8	161.3	Aquiferous sand
	7	120.9	-	-	Aquiferous sand
3	1	301.7	0.9	0.9	Top sand
	2	1199.6	0.2	1.1	Sand
	3	4507.8	5.6	6.7	Sandstone
	4	14549.5	15.5	22.2	Sandstone
	5	3458.8	168.9	191.2	Sandstone
	6	287.6	-	-	Aquiferous sand
4	1	334.3	0.9	0.9	Top sand
	2	18170.7	1.9	2.8	Sandstone
	3	119563.8	9.8	12.6	Sandstone
	4	4460.0	59.4	72.0	Sandstone
	5	813.1	134.7	206.7	Aquiferous sand
	6	369.1	-	-	Aquiferous sand
5	1	1786.1	0.9	0.9	Sand
	2	19693.2	53.8	54.7	Sandstone
	3	682.1	152.4	207.1	Aquiferous sand
	4	198.9	-	-	Aquiferous sand
6	1	210.4	0.3	0.3	Top sand
	2	275.4	0.5	0.8	Sand
	3	30083.8	0.5	1.3	Sandstone
	4	292.9	1.1	2.5	Sand
	5	33954.4	9.2	11.7	Sandstone
	6	388.9	36.1	47.8	Aquiferous sand
	7	87.1	138.6	186.5	Shale
	8	7.2	-	-	Clay
7	1	288.2	0.3	0.3	Top sand
	2	619.9	0.3	0.6	Sand
	3	86361.6	7.9	8.5	Sandstone
	4	1074.3	26.7	35.2	Aquiferous sand
	5	252.9	126.1	161.3	Aquiferous sand
	6	50.2	-	-	Clay
8	1	401.4	0.4	0.4	Top sand
	2	113.2	0.4	0.7	Sand
	3	23434.3	8.7	9.4	Sandstone
	4	225.4	182.0	191.4	Aquiferous sand
	5	119.2	-	-	Aquiferous sand

5.3 Discussion of VES results

VES 1 and 8 carried out at Achina and Igboukwu 2 showed a total of five (5) layers namely top sand, sand, sandstone and aquiferous sand with aquiferous sand being the aquifer bearing unit as shown in figs 4 and 11 respectively. The aquifer resistivity values ranges from 119.2 Ωm – 658.6 Ωm. Its thickness ranges from 182 m - 196.9 m and located at depth which varies from 191.4 m to 254.5 m.

VES 3, 4 and 7 carried out at Umuchu, Akpo and Igboukwu 1 respectively showed a total of six (6) geoelectric layers as shown in figs 6, 7 and 10 respectively. The geoelectric layers are as follows: namely top sand, sand, sandstone, aquiferous sand and clay with the aquifer unit inferred to be aquiferous sand with resistivity values ranging from 252.9 Ωm – 1074.3 Ωm. Its thickness ranges from 26.7 m – 126.1 m and located at depth which varies from 161.3 m – 206.7 m.

VES 2, 5 and 6 carried out at Amaesi, Ekwulobia and Aguluezechukwu respectively showed four (4), seven (7) and eight (8) geoelectric layers as shown in figs 5, 8 and 9 respectively, their lithologies are as follows: top sand, sand, sandstone, clay, shale and aquiferous sand the aquifer units was inferred to be aquiferous sand with resistivity values ranging from 388.9 Ωm – 856.1 Ωm. Its thickness ranges from 36.1 m – 152.4 m and located at depth which varies from 161.3 m – 207.1 m. All the VES points carried out in these areas showed a very good groundwater potential because of sedimentary deposits which show primary porosity that determines the storage and permeability of aquifers to a great extent in agreement with (Reynolds, 1997). The aquifer units of the study areas showed low resistivity values (< 1074.3 Ωm) which implies a high conductivity suggesting an aquiferous zones. VES 1 - 8 showed good productive and sustainable aquifer yield because of their high aquifer thicknesses (> 100 m) except for VES 6 carried out at Aguluezechukwu that has an aquifer thickness of 36.1 m in agreement with (Hamidu *et. al.* 2014;Ugwu and Ezeh 2012).

6. Conclusion and Recommendation

The results of groundwater potential determination using vertical electrical sounding in Achina and its environs, Anambra state, Nigeria has enabled us establish and identify great resourceful spot for drilling borehole and also the depth of aquifer. The interpreted result of VES data were presented as geoelectric section. The results were presented as VES 1 – 8. A total of four (4) to eight (8) geoelectric layers were delineated with Top sand, clay, sand, aquiferous sand and sandstone as the lithology seen with aquiferous sand being the aquifer bearing unit, the depth of aquifers ranges from 161.3 m to 254.5 m and thickness ranging from 36.1 m to 196.9 m. The VES points carried out in these areas showed a very good groundwater potential because of sedimentary deposits which show primary porosity that determines the storage and permeability of aquifers to a great extent also the aquifer units of the study areas showed low resistivity values (< 1074.3 Ωm) which implies a high conductivity suggesting an aquiferous zones. The study areas also showed good productive and sustainable aquifer yield because of their high aquifer thicknesses (> 100 m) except for VES 6 carried out at Aguluezechukwu that has an aquifer thickness of 36.1 m in agreement with (Hamidu *et. al.* 2014;Ugwu and Ezeh 2012)

The results of this study have provided additional baseline data for an elaborate groundwater development and siting of borehole, for residential and commercial facilities within Achina and its environs. For effective groundwater development programmes in the study areas, it is recommended that pre-drilling geophysical investigations such as to assess groundwater potential, to estimate the possible depth of aquifer at Aguluezechukwu be conducted for economic and environmental purposes.

Authors' Contributions

Olisah Nzemeka C. is a geophysicist who has carried out various research work especially on groundwater potential and vulnerability in Enugu and Anambra State. I contributed to the analysis by collecting data at these towns and creating the map and figures depiciting terrain, surface water and groundwater.

Onyekaozuru Chinonso D. is a student of geophysics who carried out all the interpretation and analyzing existing water resources data.

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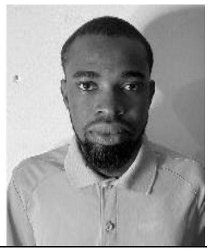

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