GEOELECTRICAL INVESTIGATION OF GROUNDWATER CONDITION IN OLEH, NIGERIA

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ABSTRACT
A geophysical investigation was carried out in Oleh, Nigeria to assess the groundwater condition of the area. The method employed in this study was the Vertical Electrical Sounding (VES) technique using the Schlumberger configuration. The data obtained were interpreted by computer iteration process and results when compared with lithologic log from existing borehole indicate a four layered formation. The first aquifer layer was identified along the second layer with resistivity values ranging from 347.4 to 1137 Ωm and depth of 2.0 to 3.7 m. Analysis of this layer revealed that this aquifer is unconfined and prone to pollution since it underlay's a loose sand and very thin clayey sand formation. The second aquifer located in the forth layer is a viable portable water formation whose resistivity values ranged between 416.7 and 1459.2 Ωm. The thickness of the aquifer was found to range between 12.0 and 14.9 m while the depth was between 12.8 and 28.7 m. Boreholes for potable groundwater are therefore recommended within the forth layer.

Keywords: Groundwater, Electrical Resistivity Sounding, Aquifer, Water formation

1. INTRODUCTION

Groundwater is explained as water situated below the ground surface in soil pore spaces and in the fractures of lithologic formations. A unit of rock or an unconsolidated deposit is called an aquifer when it is capable of producing a usable quantity of water [1]. It is a known fact that nearly all the water in the ground comes from rain that has infiltrated into the earth. Observations have shown that when rain falls, part of it run-off over the surface of the ground. The other part infiltrates underground and become the groundwater which accounts for the water from springs, lakes and wells [2].

Groundwater is often used for agricultural, municipal and industrial purposes through the construction of extraction wells. Groundwater is also widely used for drinking and irrigation [3]. According to Alabi et al. [1], about 53% of the world population depends on groundwater as a source of drinking water.

Electrical resistivity method of geophysical exploration happens to be the most applied method in groundwater exploration. This is applied through the use of the Vertical Electrical Sounding (VES) technique. The VES is a geoelectrical method for measuring vertical changes of electrical resistivity. The method has been recognized to be more appropriate for hydrogeological study of sedimentary basin [1, 4, 5]. The reason for its wide use is because the instrument is simple to handle. Also, the field logistics are easy and straight forward while the analysis of data is less tedious and economical. This is the reason why many researchers [2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14] have used this method for the determination of aquifer boundaries.

The area under investigation in this study is a fast growing community in terms of population and business activities. This has impacted on the growing demand for portable water. Suffice it to say that the area has no public water supply and depends on personal efforts in getting water for domestic use. This is why it is important to initiate a proper groundwater resource and exploration program. The realization of such a program requires data from geophysical survey which this study is out to address.

2. MATERIALS AND METHODS

2.1 Location and Geological Setting: The study area Oleh is located in Nigeria within longitude 6.13^0 E and latitude 5.42^0 N and covers an area of about 2,720 sqm (figure 1). The area is located within the Niger Delta Basin which is characterised as having undergone different changes right from the tectonic setting through the paleogeographic evolution to the present day. This development of the Delta has been dependent on the balance between the rate of sedimentation and subsidence.

2.2 Field Technique: In carrying out resistivity sounding surveys, electrodes are distributed along a line, centred 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 labelled A and B, and two potential electrodes M and N placed in line with one another and centred on some location. The resistivity survey involves the introduction of current into the ground through the current electrode and the potential electrodes are then used to quantitatively measure the voltage pattern (Alabi et al., 2010). The geometric arrangement for this array is as shown in figure 2.

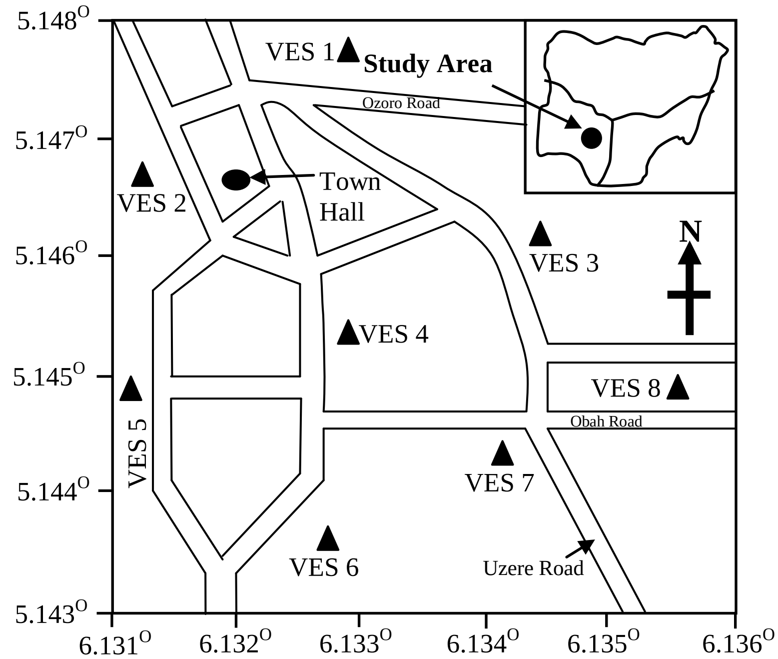

Figure 1: Map of Oleh showing the VES Positions

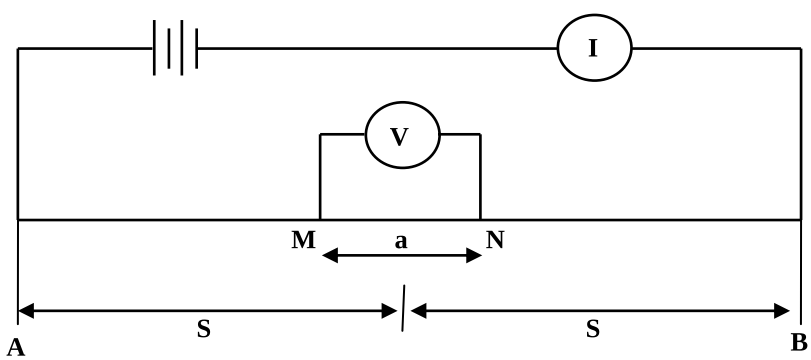

Figure 2: Geometric Arrangement of the Schlumberger Array Configuration.

The apparent resistivity data obtained from the measurements are presented on maps at various levels and they are useful in the first stage of interpretation. More realistic sections of the earth are obtained only after interpretation of the data in terms of true variations of the resistivity distribution. This is a very important step because it allows the estimation of the true position and depth of formations. Moreover, it is possible to estimate the actual electrical resistivity of the region and relate it to its physical state.

2.3 Field Survey: The resistivity soundings in this study were carried out with maximum current electrodes separation ranging between 350 and 600m. Data were collected with an ABEM 300 resistivity meter. The survey lines were located along existing roads and paths avoiding physical obstacles like buildings and fences.

3. RESULTS

The records of the data from the field were interpreted first by using curve matching method and then by computer aided interpretation. The plot of the apparent resistivity against current electrode distance for the eight VES carried out in this study are presented as shown in figure 3. From the nature of the maps in figure 3, the curve types as well as the number of geoelectric layers were determined. The result of this interpretation showing the resistivity of the geoelectric layers as well as their thickness are presented as shown in table 1. Further analysis of the result has revealed a four layered formation.

The resistivity of the first layer ranges from 21 to 297 Ωm while the second layer has a resistivity range of 347.4 to 1137.1 Ωm. The third layer has a resistivity range of 43.7 to 205 Ωm and the fourth layers resistivity ranges from 416.7 to 1459.2 Ωm. The geoelectric section as shown in figure 4 revealed the type of soil in each of the layers and the corresponding resistivity and their depth below the surface.

4. DISCUSSION

The result of this study in comparison to lithologic log from existing borehole has shown a four layered formation. The first layer is mainly clayey sand and loose sand. The resistivity of this layer ranges from 21 to 297 Ωm while the thickness ranges from 0.5 to 0.9 m.

The first aquifer is found in the second layer with resistivity ranging from 347.4 to 1137.1 Ωm. It is composed of fine sand formation with thickness ranging from 2.0 to 3.7 m. This is a very thin unconfined bed and will therefore be prone to contamination. Consequently, this aquifer is unreliable and will not yield potable water for the residents of the area. The third layer is made up of sandy clay with resistivity ranging from 43.7 to 205 Ωm while the thickness ranges from 6.9 to 9.7 m.

The forth layer is composed of medium grain sand with resistivity of 416.7 to 1459.2 Ωm. This result is an indication that potable groundwater exist in the form of confined aquifer with depth range of 21.8 to 27.9 m. The thickness of this aquifer ranges from 12.0 to 14.9 m.

The analysis of the results indicate that groundwater exist in the second and forth layers. While the second layer aquifer is unconfined and prone to pollution, the second aquifer in the forth layer is confined and therefore of good quality. Viable boreholes for potable water are therefore recommended to be sank to the forth layer with a depth range of 21.8 m to 27.9 m.

5. CONCLUSION

This study has revealed the groundwater potential of the area. The output of this work will no doubt be of benefit to the people of the area as it will aid them in the sinking of boreholes to depth which will provide clean and healthy water. This investigation has once again confirmed the fact that the vertical electrical sounding is a reliable tool for underground water exploration in a sedimentary basin [15].

Table 1: Layer resistivity and their corresponding thickness

VES	Curve Types	ρ_1 (Ωm)	ρ_2 (Ωm)	ρ_3 (Ωm)	ρ_4 (Ωm)	ρ_5 (Ωm)	h_1 (m)	h_2 (m)	h_3 (m)	h_4 (m)	RMS (%)
1	KHK	243.8	751.9	115.7	1151.1	319.6	0.8	3.3	7.4	12.0	3.8
2	KHK	228.9	1131.4	174.6	1459.2	245.9	0.6	2.8	8.6	13.6	2.4
3	KHK	297.1	1137.1	111.7	1303.0	273.0	0.5	3.7	8.4	13.6	2.5
4	KHK	214.5	321.9	105.2	1052.4	172.7	0.5	3.4	9.5	14.5	2.8
5	KHQ	21.0	747.1	158.2	961.2	205.0	0.5	3.1	7.1	12.1	2.4
6	KHK	144.5	945.0	43.7	836.6	141.2	0.5	2.0	9.5	14.5	2.4
7	KHK	51.9	347.4	95.2	416.7	136.7	0.7	2.7	9.7	13.7	2.6
8	KHK	115.1	489.0	205.0	611.1	148.9	0.9	2.8	6.9	14.9	2.4

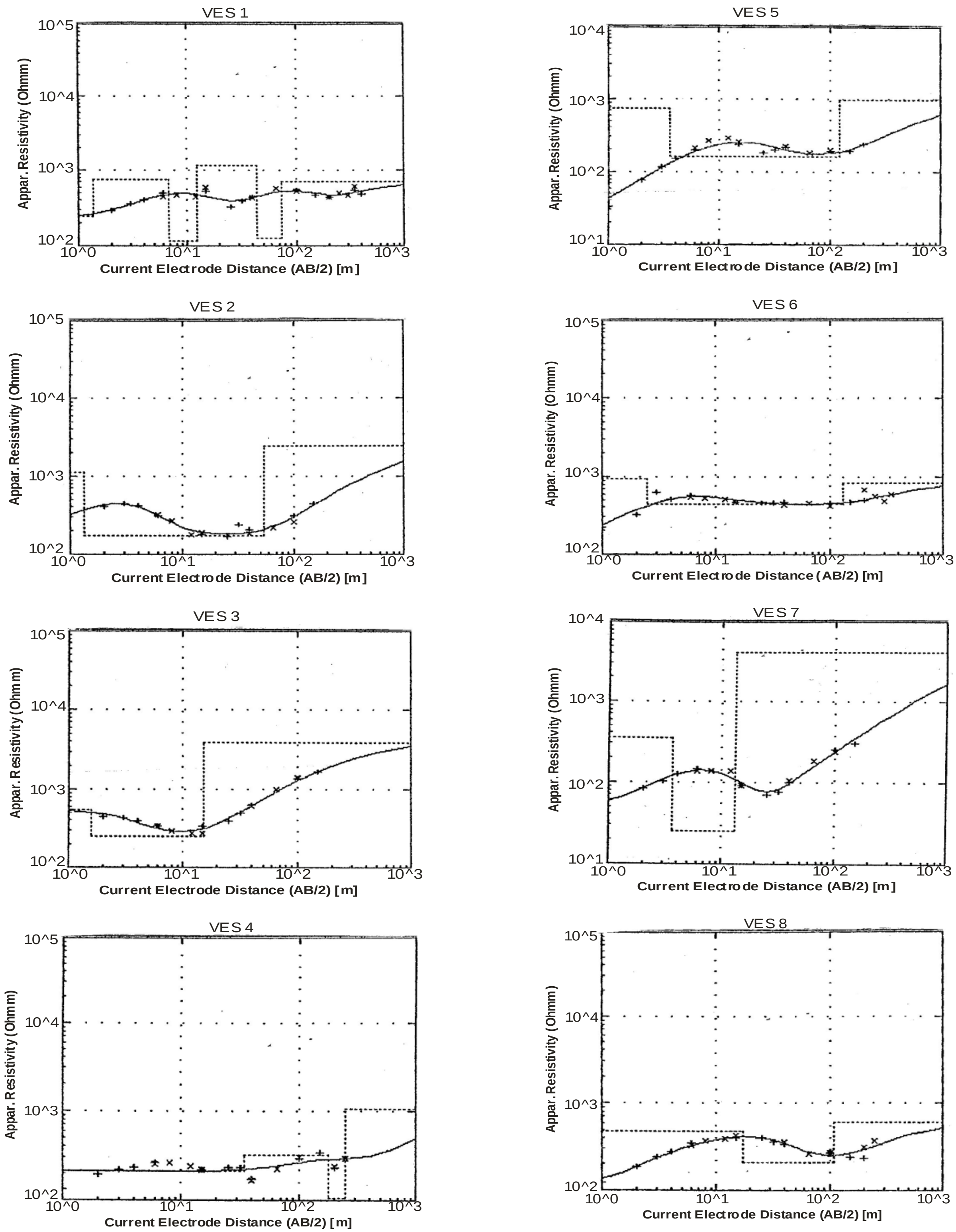

Fig. 3: Apparent resistivity versus half current electrode spacing curve for VES 1 to VES 8

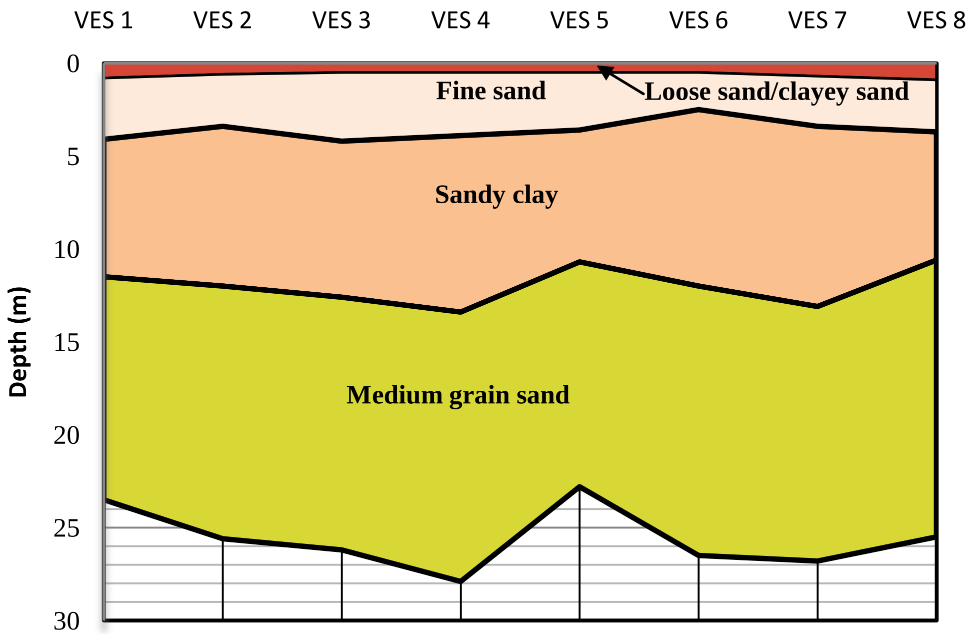

Figure 4: Geoelectric section of study area.

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