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Full Length Research Paper

Underground water exploration of Oleh, Nigeria using the electrical resistivity method

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A geophysical investigation was carried out in Oleh, Nigeria to determine the groundwater potential and the geological structure of the area. The method employed in this study was the Vertical Electrical Sounding (VES) 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 identified in this study is located along the second layer with resistivity ranging from 347.4 to 1137 Ωm and depth ranging between 2.0 and 3.7 m. Analysis of this layer shows that this aquifer is unconfined and prone to pollution since it underlay's a loose and clayey sand formation that is very thin. The second aquifer is a viable potable water formation with resistivity range of 416.7 to 1459.2 Ωm and a thickness range of 12.0 to 14.9 m. The depth of the aquifer ranges from 21.8 to 29.7 m. Boreholes for potable groundwater are therefore recommended within the forth layer because of its quality and viability.

Key words: Groundwater, electrical resistivity sounding, aquifer, water formation.

INTRODUCTION

Groundwater is water located beneath 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 can yield a usable quantity of water (Alabi et al., 2010). Nearly all the water in the ground comes from precipitation that has infiltrated into the earth. Observations have shown that a good deal of surplus rainfall runs-off over the surface of the ground while the other part of it infiltrates underground and becomes the groundwater responsible for the springs, lakes and wells (Oseji et al., 2006). Groundwater is often withdrawn for agricultural, municipal and industrial use by constructing and operating extraction wells. Groundwater is also widely used as a source for drinking supply and irrigation (UNESCO, 2004). According to Alabi et al. (2010), about 53% of all population relies on groundwater as a source of drinking water. Electrical resistivity method of geophysical exploration happens to be the most preferred method in groundwater exploration. The vertical electrical sounding (VES) is a geoelectrical method for measuring vertical alterations of electrical resistivity. The method has been recognized to be more suitable for hydrogeological survey of sedimentary basin (Alabi et al., 2010 and Iserhien-Emekeme et al., 2004). The reason for its wide use is because the instrument is simple; field logistics are easy and straight forward while the analysis of data is less tedious and economical. This is the reason why many researchers such as Olowofela et al. (2005), Oseji et al. (2005, 2006), Iserhien-Emekeme et al. (2004), Okolie et al. (2005), Omosuyi et al. (2007), Batayneh (2009), Ezeh and Ugwu (2010), Nwankwo (2011), Batayneh et al. (2010) and Tammaneni et al. (2006) have all used this method for the determination of aquifer boundary.

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.

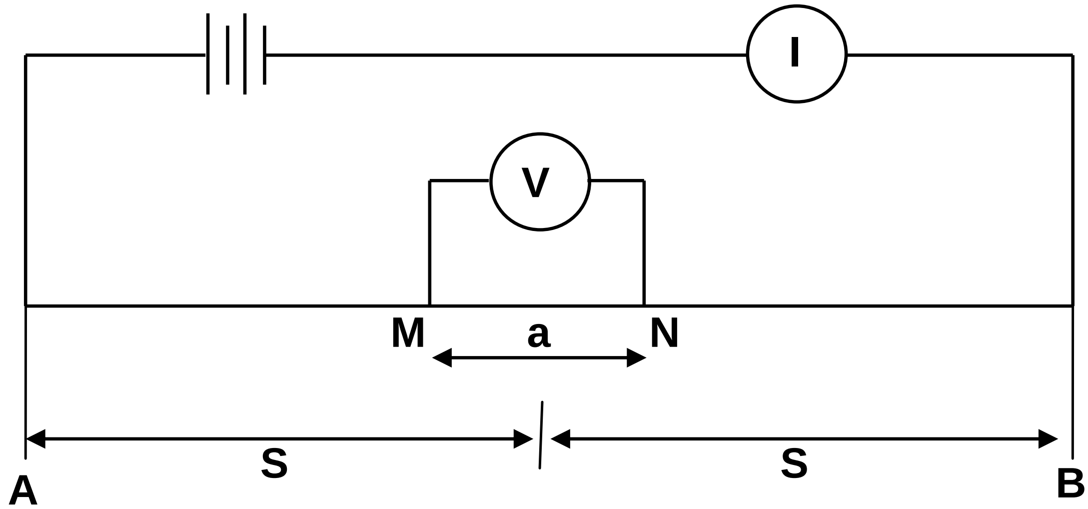

Figure 1. Geometric arrangement of the Schlumberger array configuration.

MATERIALS AND METHODS

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. 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 1. 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.

Location and geological setting

The study area Oleh is located in Nigeria within longitude 6° 8^{l} E and latitude 5° 25 ^{l}N and covers an area of about 2,720 sqm (Figure 2). 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.

Field survey

The resistivity soundings in this study were carried out with maximum current electrodes separation ranging between 350 and 600 m. 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.

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 eight VES carried out in this study is shown in Figure 3. From the nature of the maps in Figure 3, the curve type as well as the number of layers that exist in the area was determined. The result of this interpretation showing the resistivity of the soil layers as well as their thickness is presented in Table 1. Further analysis of the result has revealed a four layered structure which is also shown in Table 1. The resistivity of the first layer ranges from 21 to 297 Ωm while the second layer showed 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 of Figure 4 shows the type of soil in each of the layers and the corresponding resistivity and their depth below the surface.

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 and loose sand. The resistivity of this layer ranges from 21 to 297 Ωm. The thickness of this layer ranges from 0.5 to 0.9 m. The areas which show high resistivity in this layer are observed to be swampy. The first aquifer is found in the second layer with resistivity ranging from 347.4 to 1137.1

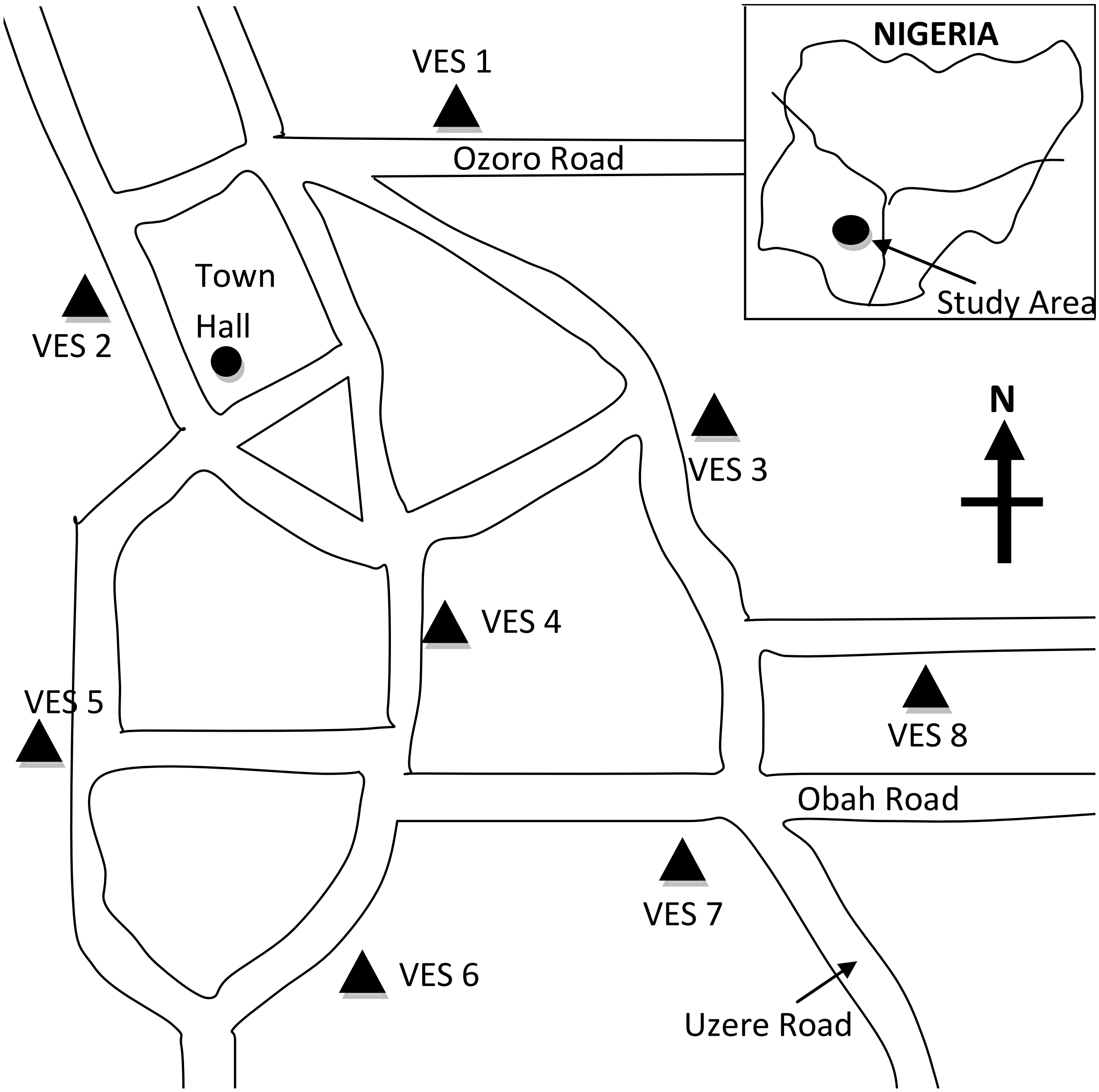

Figure 2. Map of Oleh showing the VES positions.

Ωm. It is composed of fine sand formation with thickness range of 2 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. Analysis indicates 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 is from 12.0 to 14.9 m. The analysis of the results indicate that ground water 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 to 27.9 m.

Conclusion

This study has revealed the groundwater potential and the hydroelectrical properties of the area. The output of this work will no doubt be of benefit to the people of the

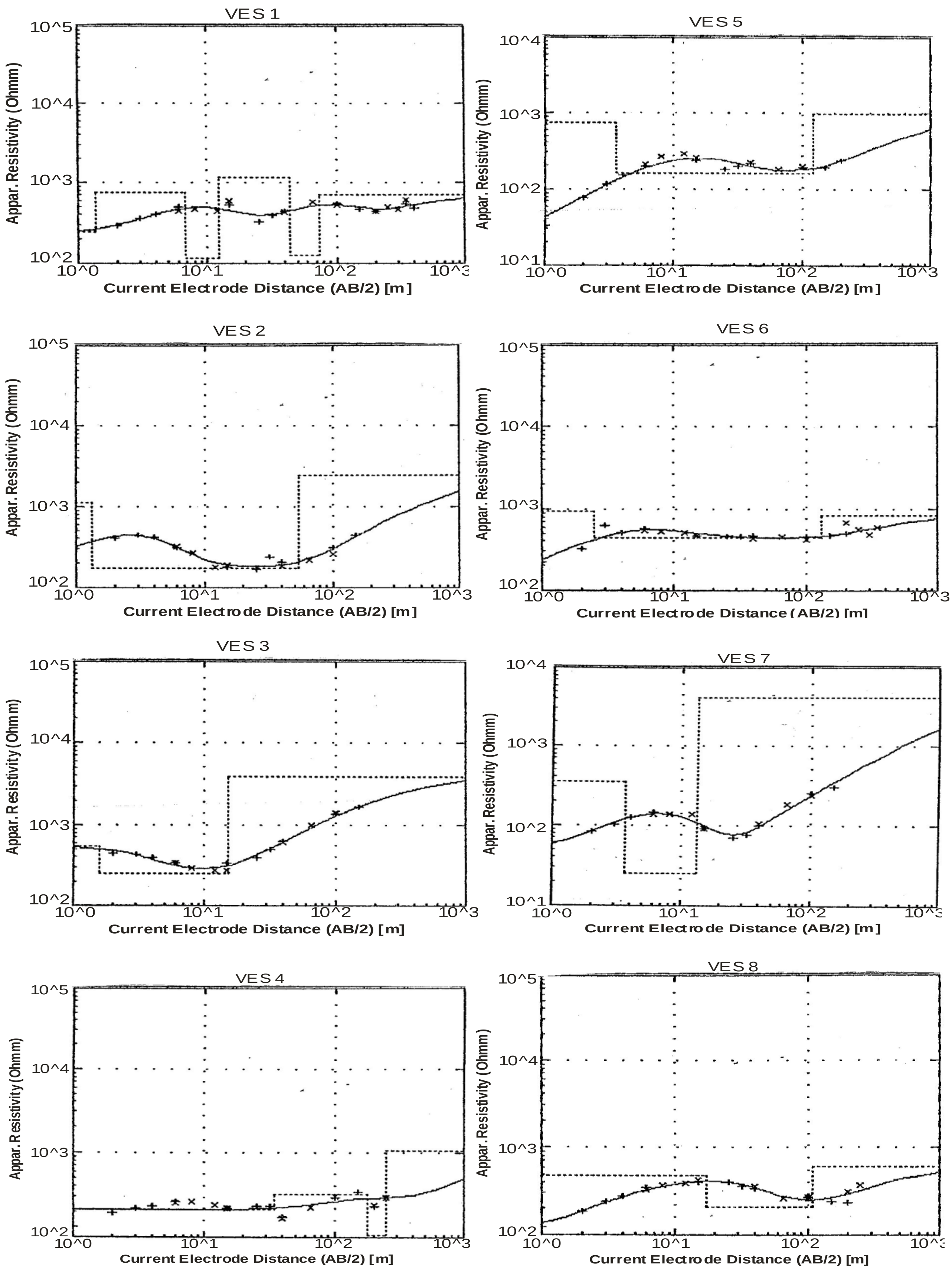

Figure 3. Apparent resistivity versus half current electrode spacing curve for VES 1 to 8.

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

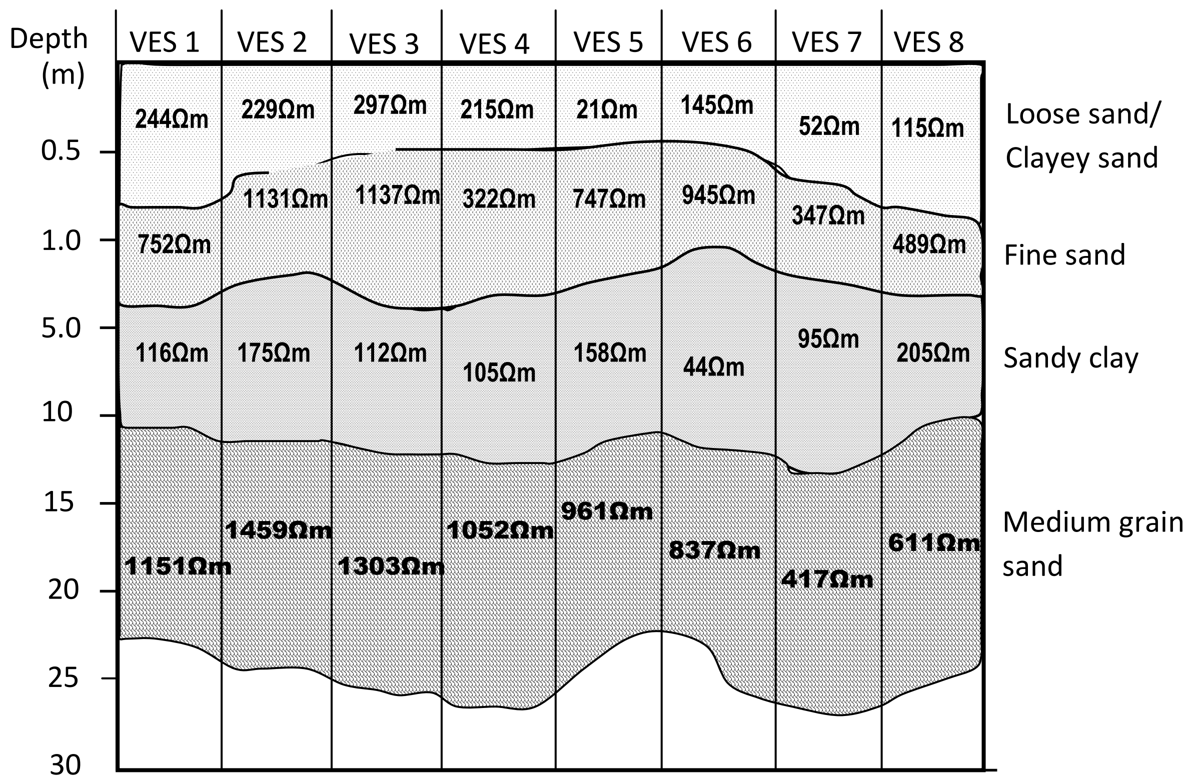

Figure 4. Geoelectric section of study area.

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 (Alile et al., 2008).

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