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Determination of groundwater potential and strata formation in Isiokolo Nigeria using surface geoelectric sounding

Adrian Ohwofosirai[1*], Abaja Jahswill[1], Omovo Lilian[1], Akpotihwe Philip[2]
[1]Department of Physics, Delta State University Abraka, (NIGERIA)
[2]Department of Geology, Delta State University Abraka, (NIGERIA)
E-mail : adrian4ist2007@gmail.com

ABSTRACT

A geophysical investigation was carried out in Isiokolo, 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 obtained data were interpreted by computer iteration process and results when compared with lithologic log from existing borehole indicate a four layered formation. The interpretation of the resistivity data indicates that there are four to nine layers in the area under study (Table 2). The top layer shows diversity of resistivity values ranging from 50Ωm to 1600Ωm and can be classified as loose soil. The thickness of this layer differs from one location to the other ranging from 2m to 4m. The resistivity of the second layer ranges from 179Ωm to 3733Ωm and is interpreted as clayey sand to sandy clay. Kokori has nine layers as the highest number of layers and Isiokolo 2 station having the least number of layers. Boreholes for potable groundwater are therefore recommended within the forth layer because of its quality and viability.

INTRODUCTION

Water is important to all human communities and a key factor in determining human settlement. Man has always attempted to settle close to places where natural features of water such as continuous distribution of rainfall, lake etc. Though there are other sources of water; streams, rivers ponds, etc., none is as hygienic as groundwater because groundwater has an excellent natural microbiological quality and generally adequate chemical quality for most uses (Macdonald et al., 2002).

To reveal the mystery of groundwater, a detailed geophysical and hydro-geological study of understanding of the aquifer types and their spatial location are necessary in order to characterize the hydric zones in an area.

The study area Isiokolo is the headquarters of Ethiope East Local Government Area of Delta State Nigeria. This area is bounded by longitude $06^o01^1028^{11}$E and $06^o01^1883^{11}$E and latitude $05^o39^1009^{11}$ and $05^o40^1023^{11}$ of the Greenwich Time meridian with an average elevation of 15m physiographically, the area is mainly flat and gently undulating terrain. Groundwater usually occurs in unconfined to confined condition at depth.

The electrical resistivity of a rock formation limits the amount of current passing through the formation when an electric potential is applied. Todd[12] stated that the resistivity of a rock material whose resistance is R and having a cross sectional area A and length l is expressed as:

$$\rho = \frac{RA}{l} \quad 1$$

Electrical resistivity method of geophysical survey 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[1,4]. The simplicity of instrument is a reason for its wide use in the area; 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 Iserhien-Emekeme et al.[4], Olowofela et al.[8], Oseji et al.[9,10], Okolie et al.[7], Tammaneni et al.[11] Omosuyi et al. (2007), Batayneh (2009), Ezeh and Ugwu[3], Batayneh et al.[1] and Nwankwo[6] have all used this method for the determination of aquifer boundary.

This research paper tends to estimate the thickness, depth below sea level of aquifer as sources of groundwater using geophysical survey method of electrical resistivity with the intention of setting up a good bore hole drilling system in the Isiokolo and its suburbs. This area under investigation is a fast growing community in terms of population and business activities, and this has a great effect on the demand of water uses. 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 is the reason of such investigation.

EXPERIMENTAL DETAILS

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 configuration 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.

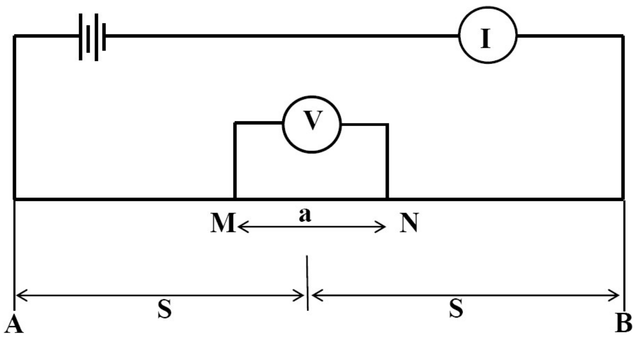

Figure 1: Geometric arrangement of the Schlumberger array configuration.

Location and geological setting

The study area which are Isiokolo and environs are popularly known as the Agbon clan is bounded by longitude $06^{o}01^{1}028^{11}$E and $06^{o}01^{1}883^{11}$E and latitude $05^{o}39^{1}009^{11}$ and $05^{o}40^{1}023^{11}$ of the Greenwich Time meridian. The area is fed by South – West rainfall which starts in the last week of June and extends until the end of September.

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 AND DISCUSSION

The data obtained from the geophysical survey were initially interpreted using the conventional partial curve matching techniques. From this, the estimation of the layer resistivity and thickness were obtained, which serve as a starting point for computer assisted interpretation (computer iteration).

TABLE 1 and 2 show the summary of the curve matching and the iterated VES results respectively which reveals the No. of layers, thickness of layers, curve type, and the resistivity of the various VES stations The curve types for the various locations are prominently AH, Q,

TABLE 1 : summary of curve matching results

Location	VES Station	No. of layers	Resistivity (Ωm)	Thickness (m)	Curve type
			550	4	
			10450	37.5	
Isiokolo	1	5	7367	42	AH
			3967	78	
			9200	75	
			1200	2	
Isiokolo	2	3	400	1506	Q
			818	200	
			1600	2	
			3733	4	
Kokori	3	5	3266.6	18	AH
			3000	277.2	
			2261	2170	
			200	2.1	
			164	9.6	
			1140	30	
Okpara	4	7	5490	20	AKH
			4000	150	
			2600	588	
			1	22	

TABLE 2 : Summary of iterated VES results

VES Station	No. of layers	Resistivity (Ωm)	Thickness (m)	Depth (m)	Curve type
		50.0	4.0	4.0	
		950.0	10.0	14.0	
		5384.0	12.0	26.0	
1	8	12561.0	14.4	40.4	AA
		50244.0	10.8	51.2	
		41109.0	8.0	59.2	
		2164.0	6.5	65.7	
		6491.0			
		1200	2.0	2.0	
2	4	400.0	2.4	4.4	H
		327.0	12.0	16.4	
		400.0			
		1600.0	2.0	2.0	
		3733.0	2.0	4.0	
3	6	8711.0	2.4	6.4	KH
		17422.0	6.7	13.1	
		21294.0	47.0	60.1	
		4238.0			
		1600.0	2.0	2.0	
		3733.0	2.0	4.0	
3	6	8711.0	2.4	6.4	KH
		17422.0	6.7	13.1	
		21294.0	47.0	60.1	
		4238.0			
		210.0	2.3	2.3	
		179.0	2.7	5.0	
		515.0	5.0	10.0	
		4639.0	3.0	13.0	
4	9	18556.0	2.7	15.7	KQ
		37112.0	7.0	23.3	
		37.1	5.7	29.0	
		15.9	2.0	31.0	
		63			

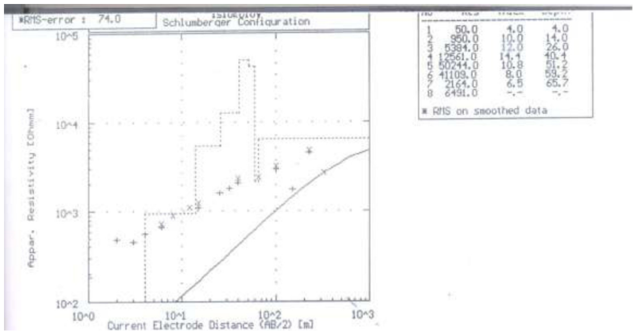

Figure 1 : Apparent resistivity versus half current electrode spacing curve for VES 1 (ISIOKOLO 1)

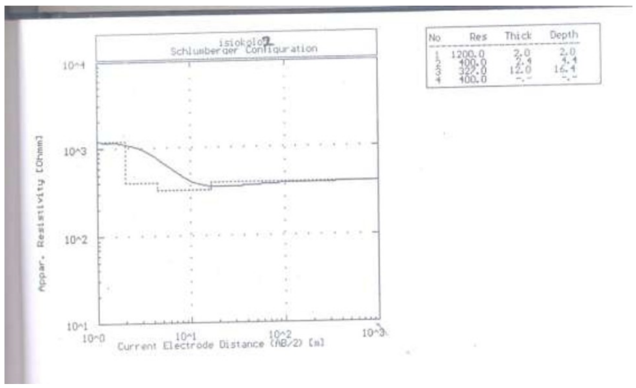

Figure 2 : Apparent resistivity versus half current electrode spacing curve for VES 2 (ISIOKOLO 2)

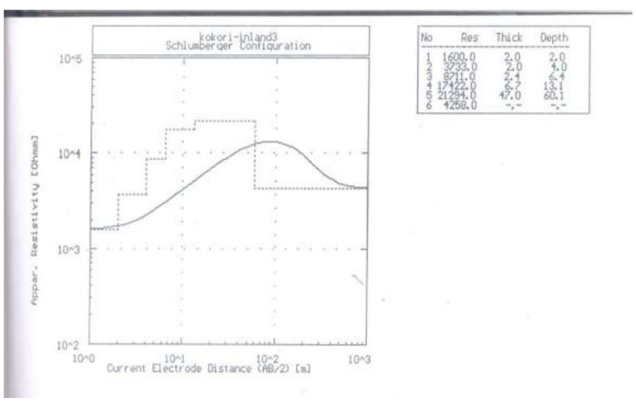

Figure 3 : Apparent resistivity versus half current electrode spacing curve for VES (Kokori inland)

AH and AKH as shown in TABLE 1. AA, H, KQ and KH as shown in TABLE 2.

The interpretation of the resistivity data indicates that there are four to nine layers in the area under study (TABLE 2). The top layer shows diversity of resistivity values ranging from 50Ωm to 1600Ωm and can be classified as loose soil. The thickness of this layer differs from one location to the other ranging from 2m to 4m. The resistivity of the second layer ranges from 179Ωm to 3733Ωm and is interpreted as clayey sand to sandy clay. The thickness of this layer varies from 2m to 10m.

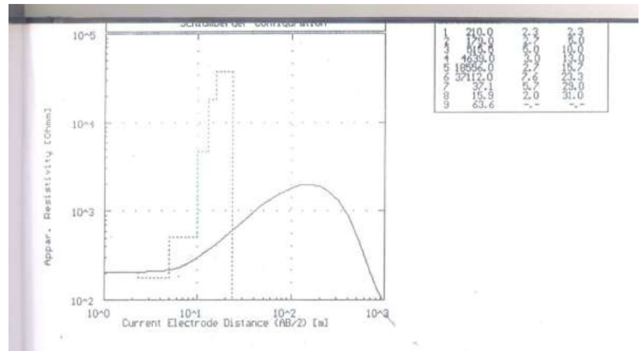

Figure 4 : Apparent resistivity versus half current electrode spacing curve for VES 4 (Okpara inland)

The third layer has a resistivity range of 327Ωm to 8711Ωm and is an indication of alluvial deposits (fine sand, coarse grain and gravel). There is evidence of groundwater accumulation in this layer. Further comparison with close borehole indicates that groundwater exist at a depth of 35.5m downward. The thickness of this aquifer ranges from 2.4m to 12m. This is an indication of the presence of thick and highly prolific aquifer zone. The fourth layer resistivity ranges between 400Ωm and 17422Ωm which is typical of sandy clay to sandy formation. Kokori has nine layers as the highest number of layers and Isiokolo 2 station having the least number of layers. Boreholes for potable groundwater are therefore recommended within the forth layer because of its quality and viability.

CONCLUSION

The application of vertical electric sounding (VES) technique has provided detailed information on the thickness and hydroelectrical characteristics of the aquifer in the study area. Analysis of the data indicate that water bearing formation exist in the third layer within the area under study with thickness ranging from 2.4m to 12m. Boreholes for good drinking water and water scheme are recommended to be drilled to the third layer of the different locations. The presence of thick and highly prolific aquiferous zone assures the area of adequate water resource. This study will no doubt guide the borehole program of the state capital and provide additional database for groundwater development and utilization in the area. Boreholes for potable groundwater are therefore recommended within the forth layer because of its quality and viability.

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