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A geoelectrical investigation for ground water at Ivorri–Irri in Isoko South Local Government Area of Delta State

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Abstract

The preliminary basis of this investigation is to determine the aquifer layer in the area. The electrical resistivities layers were determined from the results of Schlumberger electrical sound at two VES (Vertical electrical sounding) stations in the study area. The interpretation of the resistivity sounding data indicates a depth of 124m for VES 1 and a depth of 182m for VES 2 to the aquifer. The result of the resistivity survey shows that the aquifer is wet sands and generally indicates the thickness and kind of soil above the aquifer.

***Keywords*:** Vertical Electrical Sounding, Schlumberger Configuration aquifer; Delta State.

1.0 Introduction

The Niger Delta is endowed with numerous rivers and swamps, but unfortunately the water is polluted and not fit for human consumption. In order to provide the community with an underground non–polluted water, I decided to embark on this research to determine the aquifer where non–polluted water are available and there has been no previous geophysical investigation in this area of study.

There are varieties of techniques used in electrical prospecting method; each are based on same electrical properties of materials in the earth. The resistivity method is structured as to give information of bodies having anomalous electrical conductivity.

In the near surface, electric conductivity is basically controlled by porosity, water quality and water content.

For this research the Schlumberger array was chosen; and the earth was assumed to be horizontally homogeneous, Isotropic and stratified media, such change of resistivity is a function of depth.

This paper discusses the results of geophysical survey investigated as ground water exploration in Ivorri–Irri in Isoko south local government area of Delta state. The VES were carried out using Terrameter ABEM SAS 300B with booster SAS 2000.

2.0 Theory

There are numerous types of electrode arrangements for resistivity measurements. For this purpose of the research, the Schlumberger electrode array was used.

Moreover; the earth was approximated to be composed of horizontally stratified, isotropic and homogeneous media in such a way that the change of resistivity is a function of depth. The Schlumberger array is most useful in providing vital information in solving hydrogeological problems. In Schlumberger array, smoothing and interpretation are much more developed than other arrays, and is less sensitivity to the influence of near surface lateral heterogeneities and easy identification of their effects. For resistivity sounding, four electrodes are earth along a straight line AMNB (with MN as potential electrodes and AB as current electrodes). The apparent resistivity is calculated as:

$$la = \frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN} \cdot \frac{\Delta V}{I} = K \frac{\Delta V}{I} \qquad (2.1)$$

Where I and ΔV indicates the current intensity in milliamperes and potential difference in millivolts respectively, k is the geometric factor which depends on the array used.

The technique of data interpretation used involves seeking a solution to the inverse problem mainly by the determination of the subsurface resistivity distribution from surface measurements.

A very good solution to the inverse problem is the kernel function. It is used for interpreting apparent resistivity measurements in terms of lithological variation with depth. The function assumes the earth to be in homogeneous, isotropic layer and locally stratified and unlike apparent resistivity function, it is independent of electrode configuration. It has to be obtained form the configuration of measurement resistivity but cannot be measured in the field.

The kernel function utilized in this research is derived after Ghosh [2,3] . If the observed apparent resistivity is given

$$la(r) = r^2 \int_o^\infty \lambda T(\lambda) J_1(\lambda_r) dr \qquad (2.2)$$

Then the kernel function is given by Ghosh (1971) as:

$$T(\lambda) = \int_o^\infty \left(\tfrac{1}{r}\right) la(r)\, J_1(\lambda_r)\, dr \qquad (2.3)$$

where J_1 is the first – order Bessel function of the first kind and T(λ) is the transformed resistivity data

3.0 Method

Four electrode arrays are commonly used at the surface, one pair for introducing artificially generated direct current into the earth, the other pair for measurement of the potential associated with current.

The potential electrodes remain fixed while the current electrode varies.

Moreso, resistivity generally increases as porosity decreases, the electrical properties are controlled more by water quality than by the resistivities of the rock matrix.

The geophysical instrument used is the ABEM Tarrameter SAS (Signal Averaging system) 300B with booster SAS 2000. The resulting sound curves were interpreted by partial curve matching, using two layer model curves with the corresponding auxiliary curves and computer – iteration technique.

4.0 Results and discussion

The results of the geophysical survey are presented as field curves in figure 4.2 and figure 4.2, the geoelectric sections showing the number of layers, thickness of layers, depth to the layers and the lithologies are as shown in Table 4.2 and Table 4.4. Also Table 4.1 and Table 4.3 present the computer - interpreted VES results. Tables 4.1 and 4.3 show the results of the vertical electrical soundings obtained from the field as shown in the table, with the first column showing $\frac{AB}{2}$ in meters (*m*); the second column, observed values in ohm – meters and the third column, the computed values in ohm-meters.

Tables 4.2 and 4.4 show various lithologies encountered in VES 1 and VES 2.

Figures 4.1 show the arrangement of Schlumberger electrode array pattern used in the field.

Figure 4.1 and Figure 4.2, the ascending curves shows a more resistive layer while the descending curves show a less resistive layer.

On the basis of the VES results, the geologic layers were identified within the depth transverse.

(i) The top soil consists of sands stone with shale; it is coarse grained, grandly and locally grained and are formed from the Niger Delta formation.

(ii) The aquifer (Ivorri – Irri) is made up of sands from the Benin formation, but is made up of wet sands.

Based on the results of the interpreted VES curves, the aquifer was found to be mainly wet sands.

The aquifer was encountered in VES 1 with a depth of 124.43m and in VES 2 with a probale depth of 182.40m.

Table 4.1: Observed (Field) and computer (Theoretical) data for VES 1

$AB/2$ Value(meters)	Observed values (ohm –*m*)	Computed values (ohm – *m*)
1.00	927	861.281
1.47	1175	1095.118
2.15	1382	1291.071
3.16	1418	1407.301
4.64	1462	1437.691
6.81	1387	1397.031
10.00	1172	1107.816
14.70	1156	1098.113
21.50	1307	1281.301
31.60	1547	1594.551
46.40	1809	1798.092
68.10	2113	2016.706
100.00	2110	2107.601
147.00	2098	2007.761
215.00	2232	2199.981
316.00	2272	2208.310
464.00	2503	2489.312

Root – Mean –Square percent [R.M.S %) = 7.60%

Table 4.2: Various lithologies encountered in VES 1

Layer	Apparent resistivity (Ohm-*m*)	Thickness *h* (*m*)	Lithology
1	700.00	0.60	Sands
2	2800.00	0.60	Sands
3	1186.36	18.70	Aquifer (sands)
4	3600.00	26.40	Aquifer (sands)
5	1759.09	78.13	Water bearing sands

Table 4.3: Observed (field) and computed (theoretical) data for VES 2

$\frac{AB}{2}$ Value(meters)	Observed values (ohm –m)	Computed values (ohm – m)
1.00	883	709.331
1.47	903	831.201
2.15	945	961.113
3.16	861	907.201
4.64	857	861.130
6.81	725	781.913
10.00	811	803.031
14.70	905	891.014
21.50	911	908.311
31.60	801	813.972

46.40	722	763.871
68.10	788	799.015
100.00	838	821.981
147.00	851	862.141
215.00	745	769.039
316.00	575	589.861
464.00	422	531.761

Root-mean-square percent (R.M.S %) = 6.733%

Table 4.4: Various lithologies encountered in VES 2

Layer	**Apparent resistivity (Ohm-*m*)**	**Thickness *h* (*m*)**	**Lithology**
1	850.00	0.80	Sands
2	1038.89	0.84	Sands
3	511.54	1.88	Sandy clay
4	1012.50	12.88	Aquifer (Sands)
5	511.54	9.00	Water bearing sands
6	855.56	156.00	Aquifer (sands)
7	150.00	∞	Sandy Clay

Furthermore; on comparison with some previous work undertaken by geophysicists in the Niger Delta region; the depth of some aquifer are listed in Table 4.5.

Table 4.5: Summary of some various aquifer depths In Niger Delta area.[9]

S/N	**Locations**	**Depth to the deep fresh water aquifer (*m*)**
1	Burutu	107.8
2	Okunti	198.5
3	Koko	217.6
4	Ogaghoro	141.7
5	Ebokiti	101.7

Table 4.5, shows the variation in the depth of the aquifer in the locations indicated. The variation in depth may be due to geological structural and stratigraphy factors which affect the flow of ground water. Drainage and water balance were assumed to be controlled entirely by local topography [10]

Furthermore, many investigators have found deep bed rock aquifers to be heterogeneous in nature, reflecting strongly the influence of fracture permeability in the age and chemistry in the water, as well as response to withdrawals [11].

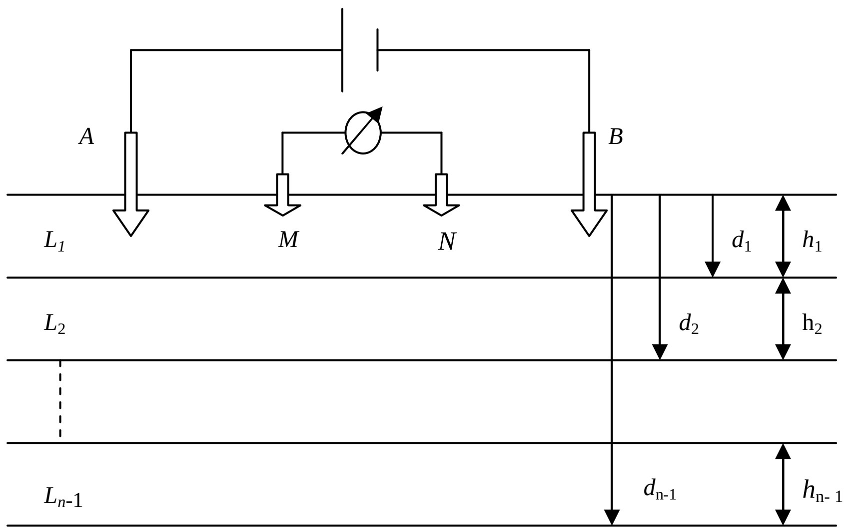

Figure 4.1: Schlumberger electrode array pattern

A,B = Current Electrodes: M,N = Potential Electrode
Li = the resistivity of the i^{th} layer
*d*i = the depth to the interface between the
*h*i = the thickness of the i^{th} layer

Topography features such as cliffs, road, cuts, hills etc. affect the current flow lines and current density between current electrodes. The quantitative effect of these features is very difficult to calculate, when the current density is increased the apparent resistivity will also show an increase, the above listed factors account for the variations in the aquifer in the different geological zones. They also affect the depth of the aquifer in VES 1 which indicates a depth of 124 meters and VES 2 indicates a depth of 182m to the aquifer layer.

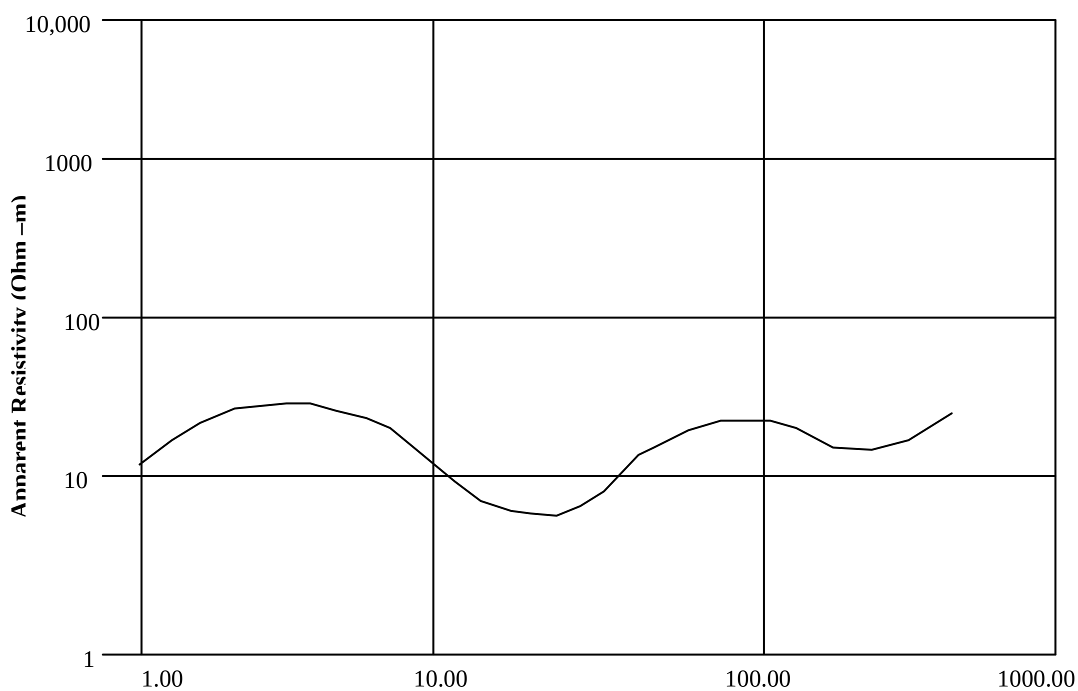

Figure 4.2: Typical VES 1 curve in Ivori-Irri

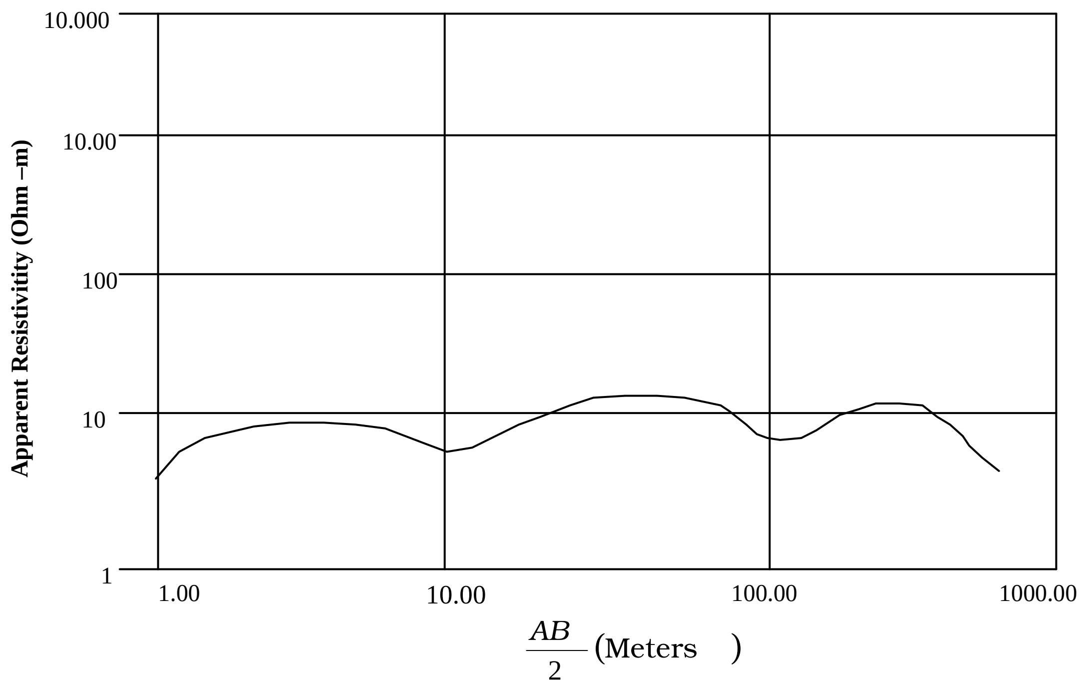

Figure 4.3: Typical VES 2 curve in Ivorri-Irri

5.0 Conclusion

The results of the interpreted VES data, assert that there are variations in the apparent resistivity values at different layers down to the earth.

It is recommended that a bore hole has to be drilled to depth of 124.43m for VES 1 and 182.40m for VES 2 to the aquifer to acquire a source of potable water that are naturally protected from pollution which has been a great problem in most of the communities in Delta State.

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