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GROUNDWATER ASSESSMENT USING GEOELECTRIC APPLICATION IN YENAGOA, BAYELSA STATE, NIGERIA

[1]BUNONYO Y. Tekena and [2]MARERE Omamode

[1] Department of Physics Niger Delta University, Bayelsa State, Nigeria
[2]School of Marine Technology, Burutu, Delta State, Nigeria

Abstract

Subsurface Geoelectrical survey using the electrical resistivity (VES) method was carried out in Yenagoa area of Bayelsa State, in order to investigate the aquifer characteristics and ground water potential of the subsurface formation. Eight (8) vertical electrical soundings were carried out within its environment using the Schlumberger array configuration with SAS 1000 model earth meter. The data was interpreted using the computer iteration method with IPI2WIN software. The results reveal a five layer A, K, H and HA type curves and true resistivity of the top soil varies from 3.01 – 314 Ωm, while the thickness varies from 0.53 – 8 m. The second layer has resistivity ranging from 0.9 - 2039 Ωm and thickness ranging from 0.39 – 89.6m composed of clay to sand, which is the first confined aquifer layer. The third layer has resistivity varying from 0.111 - 19850 Ωm while the thickness is 13.7 m composed of sand. The fourth geoelectric layer has resistivity values of 1060Ωm while the thickness is 16.2 m to continuity composed of sand, medium coarse grained soil and it constitutes an aquifer of very good quality groundwater. The average depth of this aquifer is between 30-40m.These results were correlated with lithological logs from boreholes drilled in the study areas and were found to be consistent.

***Keywords*:** Geoelectrical, Resistivity, Aquifer, Groundwater.

INTRODUCTION

In the past, residence of Yenagoa depended on the slow-running rivers for their domestic water needs, but with the increased activities from companies, population and advent of technology has increase the demand of good quality water, which has made the quest for water drift from ordinary search for surface water to prospecting for steady and reliable subsurface or ground water from boreholes. However, with recent technological development, groundwater is the choice for domestic and industrial use. In Nigeria, presently, boreholes have rescued the citizenry from acute shortage of potable water. For this research work, the application of electrical resistivity survey method was used. Electrical resistivity method in geophysical exploration for groundwater in a sedimentary environment has proven reliable [1]. Records show that the depths of aquifers differ from place to place because of variation in geo-thermal and geo-structural occurrence [2]. Electrical resistivity method is one of the most useful techniques in underground water geophysical exploration because; the resistivity of rock is very sensitive to its water content. In turn, the resistivity of water is very sensitive to its ionic content. The vertical electrical method was chosen for this study because; the instrumentation is simple, field logistics are easy and straight forward while the analysis of data is less tedious and economical [3,4]. The theory of resistivity and its application to ground water studies have been much discussed [5]. The study area has a flat topography, It is thickly populated and of high economic importance. Some parts get flooded during rainy season and then remain dry during the dry season, the vegetation is typical rainforest.

The study area is located in the Niger Delta, consists of three main tertiary stratigraphic unites (Akata, Agbada and Benin formation) overlain by quatemary deposite. The geology of the study area reveals that the entire area is underlain by sedimentary rocks that age between Paleocene to recent consist of mainly sandstone and shale intercalation which constitutes the Benin formation that has a prolific aquifer, comprising fluviatile sand, gravels, sandy clay, clay intercalation and sand [6]. The study is aim at characterizing aquifer occurrence beneath the surface lithology.

METHODOLOGY

Eight (8) vertical electrical sounding by adopting the electrical resistivity method was carried out at preferred points in the study area (Table.1). The Schlumberger electrode separation configuration with a maximum current electrode spread of 200 m with an ABEM SAS

Corresponding Author**:** Bunonyo Y.T., Email: tbunonyo@gmail.com, Tel: +2348030874256

1000 Terrameter was carried out. True resistivity and thickness of the subsurface layers were interpreted from the resistivity model curve using the IPI2Win software. The results obtained from the computer modeling are presented in Figure 2.0 – 2.8. The geometric factors used to calculate the apparent resistivity 'ρ 'was derived from Ohm's law of electrical theory.

In a four-electrode survey over homogeneous ground in fig 1.0, the expression for' K 'is given as Geometric factors, that is not affected by interchanging current and voltage electrodes and voltage electrode spacing are normally kept small to minimize the effects of natural potentials [7].

Table.1: Electrical Sounding Location

VES POINTS	DESCRIPTION	LATITUDE	LONGITUDE
VES 1	**Opolo- Elebele (T-Junction)**	**N4^0 53' 03.19"**	**E6^o 21' 32.24"**
VES 2	**Ekine Street Along Opolo Rd**	**N4^0 54' 48.84"**	**E6^o 20' 22.20"**
VES 3	**Opposite NNPC Fuel Station**	**N4^0 56' 52.96"**	**E6^o 20' 00.53"**
VES 4	**Opposite Unless God Fuel Station street, Yenagoa**	**N4^0 56' 48.05"**	**E6^o 19' 52.61"**
VES 5	**Akio Road Yenagoa**	**N4^0 56' 31.59"**	**E6^o 19' 16.10"**
VES 6	**Akenfa 1 Yenagoa**	**N5^0 00' 23.99"**	**E6^o 23' 13.13"**
VES 7	**Akenfa 3 Yenagoa**	**N5^0 00' 18.56"**	**E6^o 23' 05.74"**
VES 8	**Akenfa 2 Yenagoa**	**N4^0 59' 37.88"**	**E6^o 22' 45.77"**

ELECTRICAL THEORY

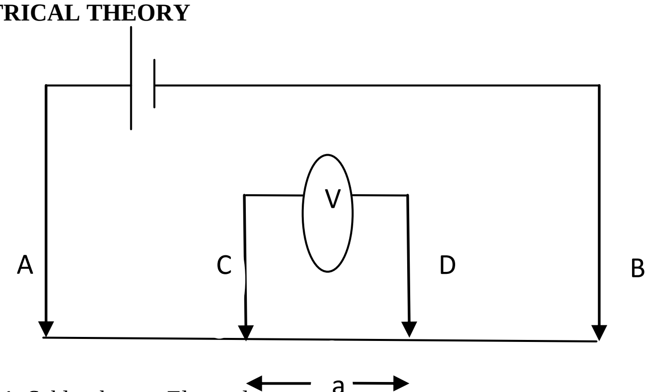

Figure .1: Schlumberger Electrode array

$J = I/A$ (1)

$E = \rho J$ (2)

$E = -\delta u/\delta r$ (3)

$E = \rho I/2\pi r^2$ (4)

$U = \rho I/2\pi r$ (5)

Considering an arrangement of a pair of current and potential electrodes. The Current electrodes A and B at a source and sink respectively.

For $A = \rho I/2\pi r_{AB}$ while for $B = -\rho I/2\pi r_{CB}$

The combine potential at C

$U_C = \rho I/2\pi(\frac{1}{r_{AB}} - \frac{1}{r_{CB}})$ (6)

While the resultant potential at D is

$U_D = \rho I/2\pi(\frac{1}{r_{AD}} - \frac{1}{r_{DB}})$ (7)

The potential difference measured by a voltmeter connected between C and D is

$V = U_C - U_D$ (8)

$V = \frac{\rho I}{2\pi}[(\frac{1}{r_{AC}} - \frac{1}{r_{CB}}) - (\frac{1}{r_{AD}} - \frac{1}{r_{DB}})]$ (9)

All quantities in equation (9) can be measured at the ground surface with exception of the resistivity, which is given by;

$\rho = \frac{V}{I} 2\pi \frac{1}{[(\frac{1}{r_{AC}} - \frac{1}{r_{CB}}) - (\frac{1}{r_{AD}} - \frac{1}{r_{DB}})}$ (10)

For Schlumberger array

$r_{AC} = \frac{(1-a)}{2}$

$r_{CB} = \frac{(1+a)}{2}$

$r_{AD} = r_{CB}$

$r_{DB} = r_{AC}$

Apparent Resistivity is geometric factor K multiplied by the Resistance

$\rho_a = KR$

From Ohm's law R= V/I

$\rho_a = KV/I$

Schlumberger $K = 2\pi a$

$\rho_a = 2\pi aV/I$

$$\rho = \frac{V\pi}{I4a}(L^2 - a^2) \quad (11)$$

Therefore

$$K = \frac{\pi}{4a}(L^2 - a^2) \quad (12)$$

Apparent resistivity is given as

$$\rho_a = \frac{V\pi}{I4a}(L^2 - a^2) \quad (13)$$

RESULT AND DISCUSSION

The interpretation of the field data revealed the presence of 3-5 geoelectric layers in the subsurface, reflected that the plain was characterized by horizontal variations. The geoelectric layers are topsoil and alluvial formations which could be clay, silt, sand and sand mixed with clay. The top layer was found to have resistivity varying from 6 – 240 Ohm- m. Its thickness was found to be around 2 m. The second and third layers had thicknesses ranging from 2 – 22 m and 5 m – 176 m respectively while the fourth layer had thickness ranging from 136 - 191 m and fifth layer thickness that extended beyond the probing depth in most of the cases.

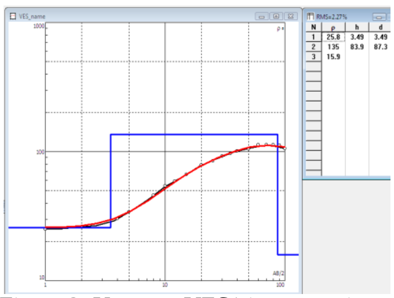

Figure.2: Yenagoa VES1 interpretation curve

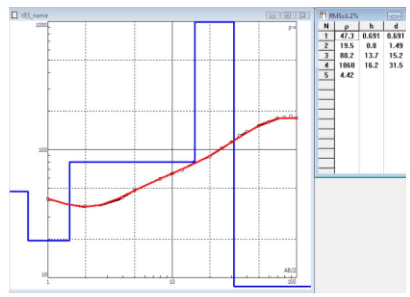

Figure.3: Yenagoa VES2 interpretation curve

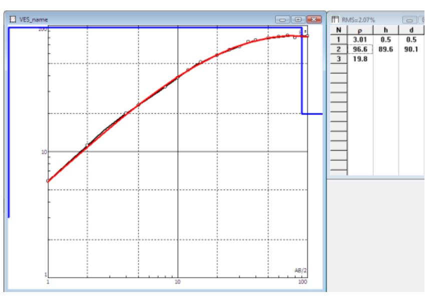

Figure.4: Yenagoa VES3 interpretation curve

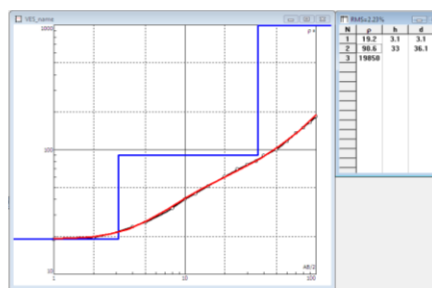

Figure.5: Yenagoa VES4 interpretation curve

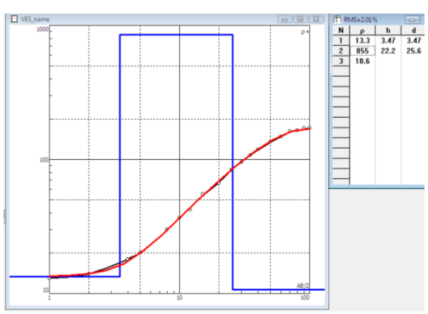

Figure.6: Yenagoa VES5 interpretation curve

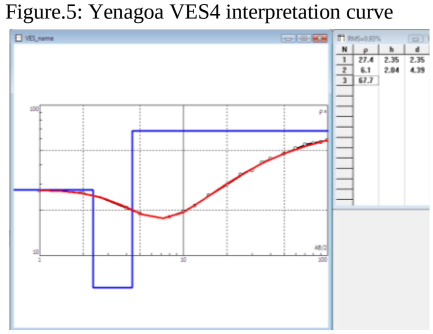

Figure.7: Yenagoa VES6 interpretation curve

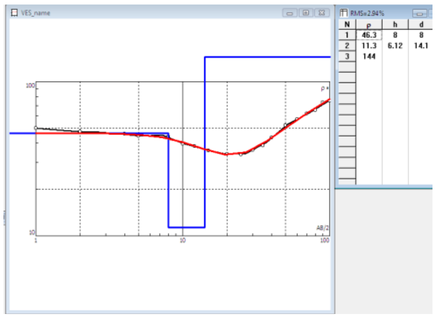

Figure.8: Yenagoa VES7 interpretation curve

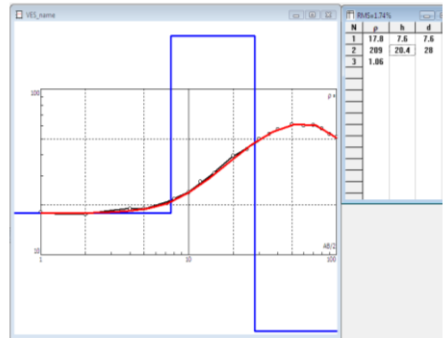

Figure.9: Yenagoa VES 8 interpretation curve

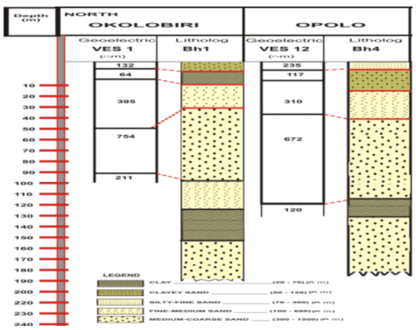

Figure.10: Geological drill log for correlation (Bayelsa Water board, 2006)

CONCLUSION

Surface electrical resistivity surveys were conducted in Yenagoa locations with the aim of providing valuable information on the hydrogeologic system of the aquifer and delineate the subsurface configuration of the area. Range of Resistivity values for different formations has been established using the interpreted VES results and resistivity standard values or borehole lithologs which can help to understand the subsurface litological variation prevailing in the area. The groundwater occurs basically under confined condition at depths of about 1.9 m to about 31.5 m. The near surface part of the aquifer may be vulnerable to contamination as a result of the thin overlying geoelectric layer and clay layer of VES 9 inclusive; however the presence of clay lenses at different depths may play the role of forming confining layers. The thickness of the clay layer could not be completely resolved as the electrodes terminated within this layer. From the study, it is recommended that boreholes are drilled to 30 - 40m to amass potable water within the fourth aquifer. This therefore calls for further investigation using wider current electrode separation. It is recommended that aquifer vulnerability studies should be carried out while groundwater monitoring should be conducted regularly in the area. This study has provided an insight into the subsurface disposition of the shallow aquifer systems and delineated areas for groundwater development programme in the area.

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