Combined Geoelectrical and Drill Hole Methods for Solving Hydro Geological Problems in the Ninth Mile Corner Area, Near Enugu, Southeastern Nigeria.

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Abstract: ***The Ninth Mile Corner is a centre of industrial activity because of the abundant groundwater resources. Knowledge of geophysical and hydro geological details is vital for designing adequate ground water management programme. Essentially, the area is underlain by the Ajalli sandstone. Schlumberger electrode array was employed in the electrode spacing. Electrode spread AB was more than 1000m. Depth probe results were interpreted by partial-curve matching and computer modeling techniques using two layer master curves. The geoelectrical sounding results were compared with the Drill Hole data and encouraging correlations were obtained to the depth of the water table.***

Keywords: Water table, Schlumberger. Electrical sounding, Hydro geological data

1. Introduction

Ngwo, Akama, Okwe and Umuase villages (Fig 1), come under a popularly name called "The Ninth Mile Corner". The Ninth Mile Corner has become a center of industrial activities in the resent years, particularly those industries that require large amount of water as major raw material. This is in realization that large amount of fresh water abound underground. It is essential to study the ground water resources of the area since the exploration and exploitation cannot continue to be based on guess work.

Available hydrological data are scanty. A lot remains to be done in the collection and interpretation of geophysical and hydro geological data so as to be able to design ground water management programme of the area. This will ensure and preserve this important natural resource. Future location and spacing of bore holes will be better planned if the hydrogeology of the area is well known. With this in view, geoelectrical exploration for hydrogeology was carried out around the ninth mile corner in order to study and understand the subsurface geology of the area, since increase in industrial and manufacturing sectors will obviously necessitate increased water utilization.

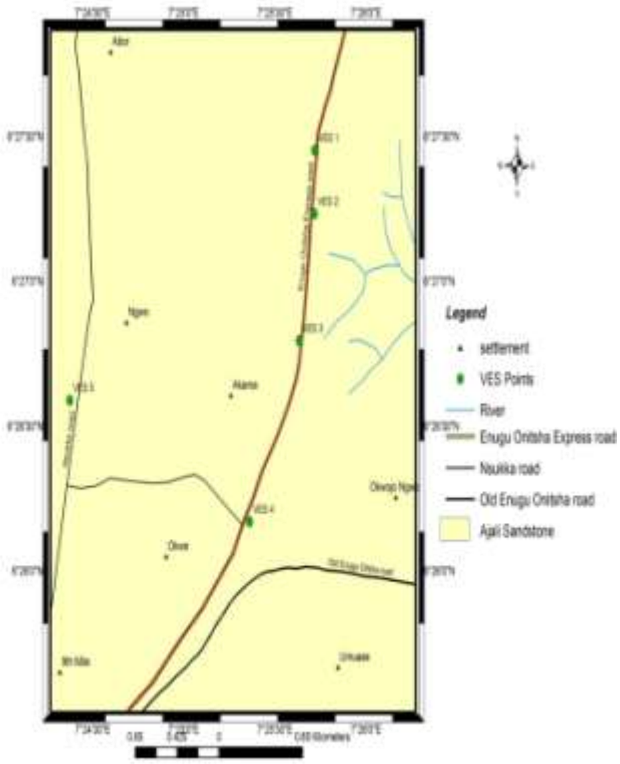

Figure 1: Map, showing the Study Area and VES sounding points.

2. Method of Investigation

The study area situates between latitudes 6^o 25' 30N to 6^0 27' 35N and longitudes 7^0 24'30E to 7^0 26' 10E, part of Udi NE. (Fig.1). Locations of the Vertical Electrical Sounding (VES) points (VES-I, 2, 3, 4 and 5) are also shown in Figure 1. Site localities were recorded using a standard Gamin eTrex HC global positioning system (GPS) instrument. The coordinates of the sounding points are shown in Table 1. In all the depth soundings in this survey, Schlumberger depth probes were employed for the geoelectrical investigations around Ninth Mile Corner where drilling results were available for comparison (Fig 2). This Vertical Electrical Sounding (VES) procedure used for depth investigation was applied because of its better depth of penetration over Wenner array. In this method, the depth of penetration depends on the current electrode separation. The maximum current electrode spread (AB) was 1000m and the anticipated depth of investigation was 125m using the rule of the thumb developed by Roy and Apparao 1971 (0.125L for Schlumberger). The equipment used was ABEM Terrameter SAS 300 and was designed in such a way that accurate readings were obtained for value of L beyond 1000m.The two outer current electrodes and the two inner potential electrodes were arranged along a line and symmetrically about their middle point. In this AMNB arrangement, the current separation AB is usually five or more times the potential separation MN (Roy, 1962). The potential electrode spread MN was usually expanded from 1m to 28m when L was expanded for greater depth penetration. The field results were converted into apparent resistivity by using the relation below

$$S_a = \pi \left(\frac{a2}{b} - \frac{b}{4} \right) R$$

Where Sa = apparent resistivity

a = half the current electrode spread ($\frac{AB}{2}$)

b = potential electrode separation MN

R = resistance of the ground

Table 1: Vertical Electrical Sounding (VES) Point Locations

Vertical Electrical Sounding Points	Latitudes N (degrees)	Longitudes E (degrees)
VES-1	06 27 307	07 25 730
VES-2	06 27 051	07 25 702
VES-3	06 26 596	07 25 604
VES-4	06 26 063	07 25 322
VES-5	06 25 439	07 24 388

Method of Interpretation

The form of VES curve indicates the number of layers being probed at the position of sounding. Depending on the nature of the curve, three methods have been used to interpret the VES data. These are: (a) the general curve matching technique (b) the graphical interpretation method for A and H type curves and (c) partial curve matching and computer iteration (Ghosh, 1971). With these techniques, the results of interpretation yield information on overburden thicknesses in Tables 2–6 below.

The interpretation of the depth probe results was based on the assumption of horizontal layers of the stratified underground. The resistance values were converted into apparent resistivity and plotted on the logarithmic graphs (Fig.3) The interpretation starts with short electrode spacing at the left –hand corner of the field graph so that the resistivity of the upper two layers and thickness of the first layer were interpreted by the partial - curve marching techniques. When both layers were combined into a fictions single layer, the third layer resistivity and thickness of the second layer were obtained. This method was applied to interpret the field data by using the two layer- master curves and corresponding auxiliary curves.

3. Interptreted Field Results of the Geoelectrical Sounding Data Hydrogeology

The studied area is underlain by Ajalli Formation. It has maximum thickness of about 370 meters and tending to thin out to the south-east (Offodile, 2002) It comprises of alternating beds of well sorted massive sandstones, broken by occasional thin beds of sandy shales and clay-stones .The thick beds of the porous sandstone of the Ajalli sandstone are the most important aquifers in this area (Fig-2, BH-1 and BH-2). A large number of springs issue from the base of the Ajalli sandstone on the Enugu Escarpment and result from the low permeability of the underlying formations. Such springs maintain river flow to the east during the dry season (Fig-1)

West of Enugu, the water table occurs at considerable depth and wells are generally over 50m, although perched aquifers can be tapped locally in the beds of shales. Comparative litho logs of boreholes (BH-1 and BH-2), Fig 2 shows Surface to Water Level (SWL) in the Ninth Mile Corner confirms water table in the studied area ranges between 50 and 50.5m.

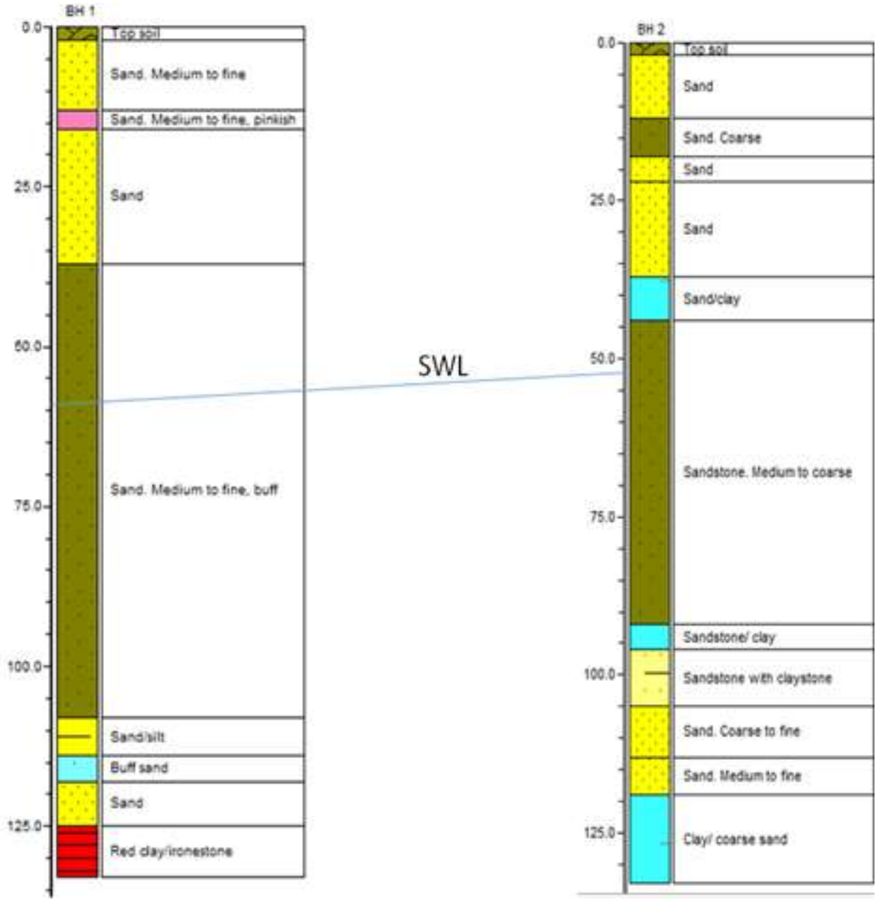

Figure 2: Lithologic Logs of Available Boreholes at Ninth Mile Corner.

Table 2: Vertical Electrical Sounding (VES) -1

Geoelectric Section	Apparent Resistivity ohm-m	Thickness (m)
Layer 1	5900.0	1.5
Layer 2	2528.6	3.0
Layer 3	4696.0	12.0
Layer 4	2661.7	38.4
Layer 5	1400.6	

Depth to Water Table 54.9m

Table 3: Vertical Electrical Sounding (VES) – 2

Geoelectric Section	Apparent Resistivity ohm-m	Thickness (m)
Layer 1	17000.0	1.5
Layer 2	68000.0	1.5
Layer 3	7555.5	6.3
Layer 4	2666.7	50.4
Layer 5	1193.0	59.7

Depth to Water Table 59.7m

Table 4: Vertical Electrical Sounding (VES) -3

Geoelectric Section	Apparent Resistivity ohm-m	Thickness (m)
Layer 1	4900.0	1.5
Layer 2	257.9	2.0
Layer 3	138.9	8.4
Layer 4	1250.1	42.0
Layer 5	220.6	

Depth to Water Table 53.9m

Table 5: Vertical Electrical Sounding (VES) - 4

Geoelectric Section	Apparent Resistivity ohm-m	Thickness (m)
Layer 1	2700.0	1.5
Layer 2	1157.1	4.2
Layer 3	2148.0	6.3
Layer 4	113.2	15.1
Layer 5	1017.9	15.1
Layer 6	548.1	

Depth to Water Table 42.3m

Table 6: Vertical Electrical Sounding (VES) – 5

Geoelectric Section	Apparent Resistivity ohm-m	Thickness (m)
Layer 1	1000.0	1.5
Layer 2	3000.0	1.8
Layer 3	26000.0	54.0
Layer 4	4764.7	

Depth to Water Table 57.5m

Table 7: Depth to the Water Table from Boreholes at Ninth Mile Corner

Borehole	*Static Water Level (meters)*
A	57.6
B	45.1
C	61.9
D	54.9
E	47.3
F	53.4
G	54.3
H	59.9

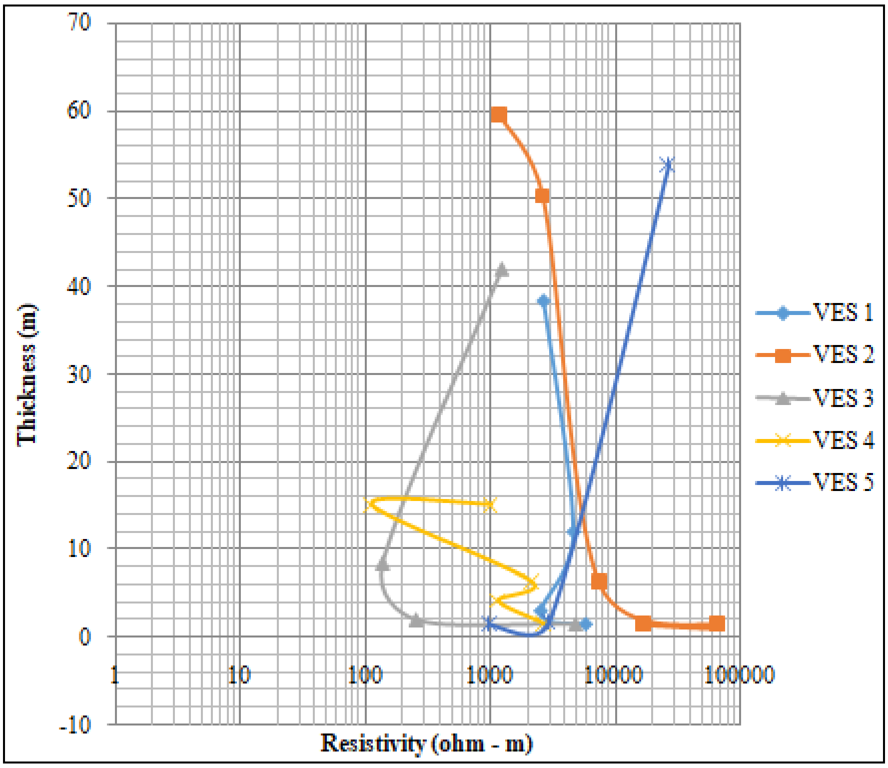

Figure 3: Geoelectric Layers of VES-1, 2, 3, 4 and 5

Further interpretation of geophysical measurements is usually done in two steps. (1) From surface measurement, the physical properties of the underground can be derived by a mathematical-physical interpretation. (2) The interpretation is correlated to the geological (hydro geological) structure. In this investigation, the interpreted field data were compared with the available Drill Hole results Fig-2. Drill Hole results (BH-1 and BH-2, Fig2) are usually quite reliable. The drill hole litho log are shown in Fig-2 while the geoelectrical sounding graphs are shown in Fig.-3. The sounding graphs on the whole show medium to high resistivity that may indicate sands, sandstone substrata. The overburden resistivity in the range of 1700 ohm-m to 5900 ohm-m indicates dry sandy overburden. The next three layers have rock resistivity between 100 ohm-m and 26000 ohm-m which indicate dry sandstone substrata. The resistivity of the aquifer was evaluated in the range of 220 ohm-m to 1400 ohm-m and mainly confirmed to the fifth geolectrical layer. This is well exhibited in the geoelectric section in Fig-3.The medium to high resistivity for the aquifer may indicate the ground water is a poor electrolyte and the absence of clayey materials in the section. The problem of equivalence is narrowed down by the Drill Hole data available (Fig-2). This is well illustrated by comparing figures 2 and 3. The two results show much encouraging correlation. The available borehole aquifer depths (Table 7) of 57.6m, Borehole A); 53.34m, Borehole F), and 54.31m, Borehole G) are quite comparable to the geolectrical sounding results of 54,9m (VES-1, Table 2), 59,7m (VES-2, Table 3) and 53.9m (VES-4, Table 5) as the interpreted depths for the water table.

4. Conclusion

The results described in the proceeding section clearly indicate that geoelectriical techniques can be a good qualitative exploratory tool, when coupled with the Drill Hole results for any ground water development programme. The geoelectrical results can be quite reliable when meticulous interpretations are done and it can tremendously reduce exploratory costs.

We have also shown from surface geophysical measurements coupled with the Drill Hole data, the subsurface conditions that exist at the Ninth Mile Corner area. It is hoped that this work can be of immense benefit to all those who may wish to carry out ground water development and management. Pre-drilling geoelectrical explorations would tremendously save exploration costs and waste. The most probable area for erecting successful boreholes will be known before actual drilling. Deep boreholes are the only satisfactory solution to water problems in this area.

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