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GEOPHYSICAL PROBE FOR DELINEATING PORTABLE WATER DEPTHS ALONG UDPS, CHOBA, RIVERS STATE

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ABSTRACT

The present study focused on the use of geophysical probe for portable water delineation in 'UDPS', Choba, Rivers State. The objective is to carry out a geophysical survey for resistivity evaluation as the depth of investigation increases, interpret the resistivity curve using geophysical parameters of the subsurface layers, delineate variations in subsurface lithologies and resistivity properties of the layers for geoelectric evaluation and interpret geoelectric section for delineating portable water depths at the subsurface layers. The resistivity data was acquired from the field, processed and interpreted. The result revealed a resistivity curve which shows an increasing resistivity property, AK type curve, five layers, four thicknesses and resistivity trend in the form of $\ell 1<\ell 2<\ell 3>\ell 4<\ell 5$*, a geoelectric section containing five layers of topsoil, fine-medium sand, coarse-gravely sand, silty clay and coarse sand as the prospect zone. The data brought great insight from the rock layers across the area in terms of the resistivity parameters of the layers, the curve type, resistivity trend, the changes in lithologies, the geoelectric section, etc. This, in effect, can be a useful tool for other interested individuals guided by the geophysical investigation concept for groundwater prospecting in the study area.*

INTRODUCTION

Geophysical resistivity techniques are based on the response of the earth to the flow of electrical current. In these methods, an electrical current is passed through the ground and two potential electrodes allow us to record the resultant potential difference between them, giving us a way to measure the electrical impedance of the subsurface material. The apparent resistivity is then a function of the measured impedance (ratio of potential to current) and the geometry of the electrode array (Steve, 1990).

However, DC resistivity measurements are carried out with electrodes. This way, the ratio between measured voltage and injected current is independent of the ground resistance of the electrodes. However, the estimation of the electrode resistance may be important in some situations. If the ground is very resistive, technical issues such as maximum transmitter voltage and signal stability may limit the current that can be injected into the ground. When trying to decrease contact resistance, for example by watering electrodes, the dependence on ground resistivity or geometry is important to find an efficient strategy (Andreas *et al.*, 2013)

Surface methods for probing depth to zones of hydrogeological interest include electromagnetic methods, seismic refraction and resistivity surveys. Selemo, et al., (1995) believe that electrical resistivity method is preferred to other methods of geophysical investigation. In the sedimentary terrain like in the study area, the electrical resistivitymethod for investigation is regarded as appropriate, because of its ability to resolve sedimentary layers with increasing depth.

It also helps to locate aquifers and identify the subsurface layers, their resistivity, and thickness and possibly provide information about the quality of water in the aquifer. In all the geophysical survey methods aforementioned, the electrical resistivity method is the simplest and most reliable technique in a geophysical survey. The main input of an electrical resistivity survey for groundwater as a resource focuses on the location and evaluation of sites for capturing flow and availability of groundwater for human use.

The commonest two arrays are the Wenner and the Schlumberger configurations. In the Wenner array the separation between each electrode (a) is equal. For the Schlumberger array, the distance between the two potential electrodes is small in comparison with that of the current electrodes. For the same current electrode separation, the Wenner array offers marginally improved resolution but a shallower depth of investigation over the Schlumberger array. For both array types, greater depth of investigation is achieved by increasing the separation of the current electrodes (Oseji and Ujuanbi, 2009).

At each electrode separation, a given current is applied via the current electrodes and the voltage across the potential electrodes is measured. Ohm's Law states that the electrical resistance of a circuit component (in Ohms, Ω) is equal to the ratio of the potential drop across the component (Volts), divided by the current passed through it (Amps). The resistance value resulting from this calculation is specific to the spacing of the electrodes; to obtain a unit value of apparent resistivity (ρ) the effects of electrode geometry are a corrected using a standard geometric factor. The resultant resistivity value is an average of all the layer resistivities in the electrified volume of earth, hence it is termed apparent. The true resistivityis a diagnostic physical property and can be used to differentiate between materials.

The refusal to carry out geophysical survey before embarking on borehole drilling in a given location for delineating portable water bearing formation has led to wrong interpretation and investigation of groundwater depths. However, this research seeks to use acquired resistivity data from ‘UDPS’, Choba, Rivers State to understand the various depths to portable water.

Geophysical probe for delineating depths to portable waterdeals with geophysical investigation for groundwater prospecting and to the understanding of various depths to groundwater Formation where portable water are accumulated at the subsurface layers.

However, it is important to know that this is achievable using geophysical data. This in effect, can be useful to other interested individuals who are guided by the concept of geophysical investigation for groundwater prospecting in the study area. The concept is simple in the sense that, the data was used to produce geological model and resistivity curve for subsurface interpretation. So that depths to aquifer units, thickness of medium, lithological types, bed boundaries of layers, etc., can be understood within the area.

MATERIALS AND METHOD

Materials used in the resistivity survey

The following materials were used in the resistivity survey include:

a) Hammer
b) Resistivity Terrameter
c) Current and Potential Electrodes
d) Measuring Tapes
e) Data sheet and Pen

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Method of the study

The Schlumberger array, which is often preferred for speed and convenience, was adopted for this study. Prior to the commencement of fieldwork in the study area, permission was obtained from the inhabitants and security personnel around the study areas to allay fears that the work is purely a research work for academic purpose, which will not pose any environmental treat. Having chosen a suitable site for the sounding, the necessary electrical connections were made. One vertical electrical sounding (VES) was probed into the ground. The maximum current electrode separation was 740 meters i.e. 370 meters each way and the maximum potential separation was 55 meters.

The methodology employed for this project involves vertical electrical sounding (VES) utilizing the Schlumberger Electrode configuration. A direct current (D.C) from a charged car battery of 12 volts was connected to ABEM - Terrameter (signal Averaging system) SAS 1000 which regulated the voltage and used 20A. The current was injected into the ground through a pair of current electrodes which were connected to current cables and the potential electrode was also connected to potential cables. The potential difference was measured between a pair of potential electrodes. The current and potential electrodes were generally arranged in a linear array, with the potential electrodes inside, while the current electrode was outside the array. The potential electrodes were kept fixed until the measured voltage decreased to low values as the potential gradient in the ground fell with increasing current electrode separation. The ABEM-Terrameter (signal Averaging System) SAS 1000 was positioned at the centre of the linear array.

Schlumberger Array Configuration

This is the most widely used electrode configuration in electrical resistivity prospecting. The electrodes are arranged in a linear array such that AB is the current electrodes and MN is the potential electrodes. This measures the potential gradient between two closely spaced potential electrodes M and placed mid-way between current electrodes A and B. in the field survey, the spacing between current electrodes arc progressively increased, while the potential electrodes are adjusted when it is needed because of decreasing sensitivity of measurements.

The procedure involves the use of an ABEM 1000 series Terrameter and its accessories. The Schlumberger electrode arrangement was used with the number of sounding stations varying from one location to another depending on the geology and accessibility of the area. The half-current electrode separation (AB/2) varied from 1m to 150m. On getting to each location, equipment were set up according to the Schlumberger arrangement.

Firstly, four electrodes were driven into the ground with the use of a hammer. The two electrodes at the middle are potential electrodes while the two other electrodes at both ends are called current electrodes. Installed cables were connected to both the current and potential electrodes to the terminals (positive and negative) of the tetrameter which was positioned adjacent to the centre of the arrangement of the electrodes. When the circuit was properly setup and the electrode configuration was found to be all right, the tetrameter was then switched on to obtain readings which is referred to as the resistance value for each sounding station. The values obtained from the tetrameter were then seen and read from it. The mid-point of the array (potential electrodes) was kept fixed in each case while the current electrodes were progressively increased. This is because current lines penetrate increasingly at greater depths just as the current electrode separation is increased.

The Schlumberger array has a geometric factor given by: (equation I)

However, for most purposes

$L^2 >> a^2$, hence (equation II)

Geometric factor K(equation III)

thus, ρa = KR where v/I = R

L = current electrode separation

a= potential electrode separation "a" is constant as "L" is increasing during measurement. For accurate results "a" should be equal to or less than 1/5 of L. the geometric factor can only be applicable when the difference between current and potential are great.

Instrumentation

The following were the set of instruments used while carrying out this fieldwork.

(a) ABEM-Terrameter (Signal Averaging System) SAS 1000
(b) Current and Potential Cable sets
(c) A pair of current Electrodes
(d) A pair of potential Electrodes
(e) Measuring Tapes
(f) Two Geologic Hammers
(g) A (12 Volts) charged Car Battery
(h) Two pairs of Crocodile clips

Data Acquisition

The Schlumberger electrode configuration was such that the separation between the potential electrodes MN was smaller than the current electrodes AB. The current AB was passed through the two outer electrodes at a fixed distance apart.The resulting potential difference was measured between the potential electrodes.A record of the current (1) and voltage (v) as well as MN/2 and AB/2 was made, the measurements were repeated with a fixed MN and AB was increased symmetrically until the response from the meter becomes too small, then MN was increased and the readings repeated with the previous AB/2 so that the reading overlaps.The Terrameter resolves and records the resistivity value of each point on the linear array. The apparent resistivity data is acquired by the multiplication of the geometric constant (K) and the resistance recorded from the Terrameter.

Where the Geometric constant K is;

$$K \equiv \left[\frac{\left(AB/2\right)^2 - \left(MN/2\right)^2}{2\left(MN/2\right)} \right] * \pi \text{ (equation IV)}$$

Where:

π=3.142

AB/2=Half-Current Electrode Spacing

MN/2=Half-Potential Electrode Spacing

Data Processing

The data processing began by the multiplication of the values the geometric constant (K) and the resistivity values recorded from the ABEM-Terrameter to get the apparent resistivity; this is shown in Table 3. Example (6.28) x (19.426) ohms 122.00 (ohm-m).

The data analysis began with a master curve plotting, which depicted the relative thickness of the different layers when interpreted and their relative resistivity which varied systematically over the ranges of thickness and resistivity for each layer that was expected lobe of practical interest. Where (AB/2 is the Half-current electrode separation).

The graph paper was then superimposed on the sheet containing the set of curves chosen for comparison, and its position is shifted horizontally and vertically to obtain the best possible fit. Another form of data processing was the computer iteration method, which is consists of both forward modelling and inverse modelling. The process began when data acquired is keyed in to the Schlumberger Automatic Analysis Version 0.92 Computer Software which processed the data and finally produced results which were further used for interpretations.

However, after the interpretation, it was expected that the Root Mean Square (RMS) error should not be greater than 10%, if this occurred then the field curve representing the data should be re- iterated to reduce the error.

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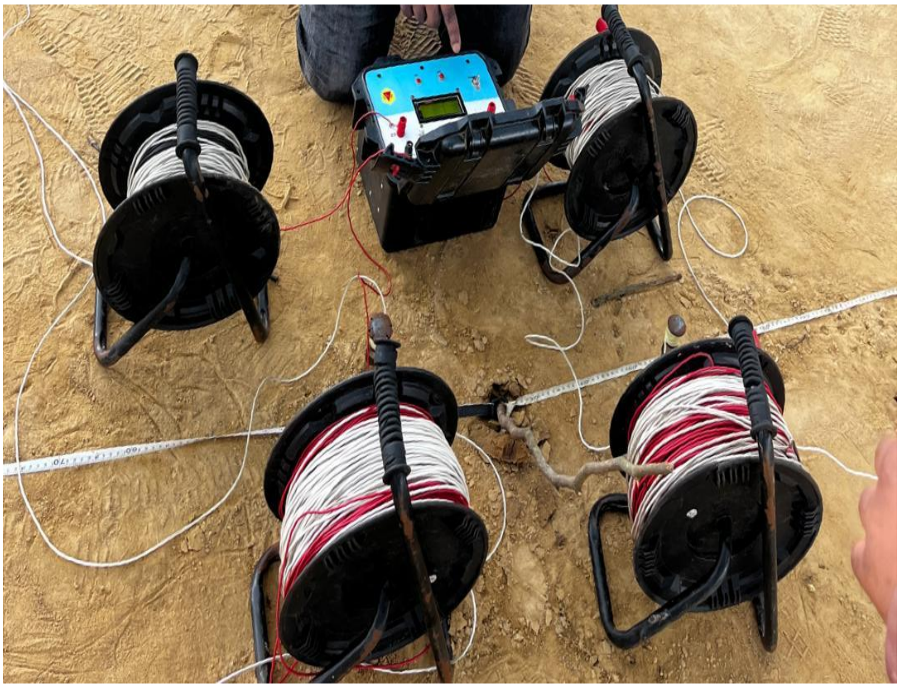

Figure 1: Geophysical Survey Equipment (Terrameter) showing the setup.

RESULTS AND DISCUSSION

Interpretation of Resistivity Curve

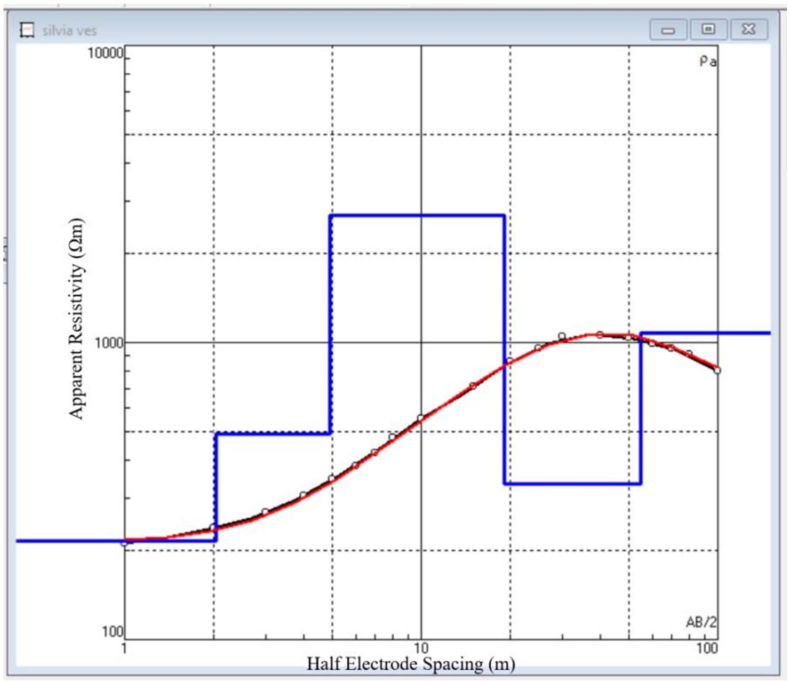

Figure 2: Resistivity curve of the subsurface layers showing the AK type curve.

Table 1: Resistivity parameter of the subsurface layers

S/N	Resistivity, ℓ (Ωm)	Depth (m)	Thickness (m)
1	215	2.0	2.0
2	492	4.9	2.8
3	2679	19.1	14.1
4	334	55	35.9
5	1076		

Lithological Characterization of the subsurface layers

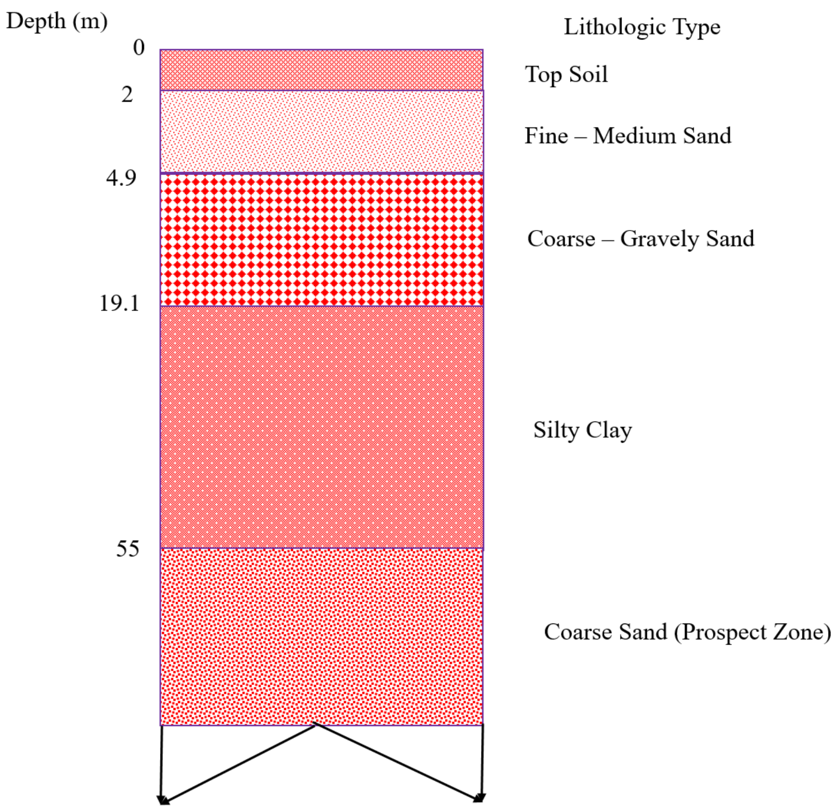

Figure 3: A geoelectric section of the subsurface layers showing the lithology.

DISCUSSIONS

The use of geophysical probe/investigation for delineating portable water Formation in the study area has proven successful. The concept revealed five stratigraphic layers of Top soil, Fine-Medium Sand, Coarse-Gravely sand, Silty clay and Coarse sand as the prospect zone respectively. The resistivity curve shows an increasing resistivity property, AK type curve, five layers, four thicknesses and resistivity trend in the form of ℓ1<ℓ2<ℓ3 >ℓ4<ℓ5. The resistivity data was used to produce geological model and resistivity curve for subsurface interpretation. So that depths to aquifer units, thickness of medium, lithological types, bed boundaries of layers, etc., can be understood and utilized for subsurface geological evaluation within the area.

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CONCLUSION

The electrical resistivity method used in this study is profound to the understanding of geological Formation in the study area. The method is a low-cost effect compared to other geophysical methods and has brought great insight to the rock layers across the area in terms of resistivity parameters of the layers, the curve type, resistivity trend, the changes in lithologies, the geoelectric section, etc. This in effect, can be useful to other interested individuals who are guided by the concept of geophysical investigation for groundwater prospecting in the study area.

I would sincerely recommend the following for a successful groundwater prospecting in the area:

a) This work should serve as a guide for borehole drillers for citing a borehole within the study area.

b.) A detail geophysical survey should be done as a quick look mechanism before drilling

c.) to any given depth for aquifer delineation in this area.

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