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# Subsurface Characterization using Electrical Resistivity(Dipole-Dipole) method at Lagos State University (LASU) Foundation School, Badagry

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# ABSTRACT

2-D resistivity inversion survey technique of electrical resistivity method was undertaken at Lagos State University (LASU) Foundation School, along Topo-Ascon road in Badagry Local Government Area of Lagos State with a view to mapping the subsurface characterization for borehole development. Dipole-dipole configuration covering the entire area was conducted using the ABEM Terrameter SAS 1000 and inter-electrode spacing of 10m, 20m, 30m and 40m were used in the traverse. The data were processed by creating a pseudo-section of the apparent resistivity values using DIIPRO software. Computer iterations were then carried out and two-dimensional (2-D) resistivity contour maps were created. Four different types of soil formations were observed from the beginning to the end of the traverse but to a depth of about 2.3m while a uniform layer of clayey sand is shown on the traverse from a depth of about 2.3m to 5.0m.The areas that have favourable resistivity with appreciable thickness are sand formations.

Keywords: traverse, borehole, resistivity soundings, geoelectric layers, aquifer.

# INTRODUCTION

Resistivity measurements are associated with varying depths depending on the separation of the current and potential electrodes in the survey, and can be interpreted in terms of a litho logic and/or geo-hydrologic model of the subsurface [5,6]. Measurement of resistivity (inverse of conductivity) is, in general, a measure of water saturation and connectivity of pore space. Air, with naturally high resistivity, results in the opposite response compared to water when filling voids. Whereas the presence of water will reduce resistivity, the presence of air in voids will increase subsurface resistivity [7, 11]

The reason for the wide use of electrical method is due to the fact that it is inexpensive, fast and it is a non-invasive technique that yields useful information about subsurface conditions [5].

The use of dipole-dipole array in electrical prospecting has become common. In terms of logistics on the field, it is the most convenient especially for large spacing. This is because other arrays require significant lengths of wire to connect the power supply and voltmeter to their respective electrodes and this wire must be moved for every change in spacing as the array is either expanded for a sounding or moved along a line [12].

The convention for dipole-dipole array is that current and potential electrode spacing is the same, a, and the spacing between them is an integral multiple of a, na. The apparent resistivity is thus given by

 $\rho_a = V/I \pi an (n+1)(n+2)$ 

The dipole-dipole array is used to measure the curvature of the potential field and is most sensitive to resistivity changes between the electrodes in each electrode pair.

#### Location and Geology of the study area

Lagos State University Foundation School is located along Topo-Ascon Road in Badagry Local Government area. It falls within the Lagos metropolis located in the Western Nigeria coastal zone; a zone of coastal creeks and lagoons [10] developed by barrier beaches associated with sand deposits [1,3]. The area is bounded by longitude  $3.22^{0}$ E and  $3.27^{0}$ E and latitude  $6.24^{0}$ N and  $6.28^{0}$ N. The metropolis is the area of land around the only inlet of the sea into extensive lagoon system. The study area falls entirely in the extensive Dahomey Basin. The entire area is underlain by sedimentary rocks with no basement outcrops. These underlie about 6500 square kilometers of the area. It has a flat topographic surface and is sparsely vegetated with grasses and shrubs. The costal belt varies in width from about 8km near the Republic of Benin border to 24km towards the eastern end of the Lagos lagoon [9, 2]

#### MATERIALS AND METHODS

#### METHODOLOGY

Resistivity soundings and mappings are geophysical methods used to provide an image of the underground resistivity by non-destructive means [7].

Electrical profiling, known as constant separation traversing (CST), uses collinear arrays to determine lateral resistivity variations in the shallow subsurface at a more or less fixed depth of investigation. The current and potential electrodes are moved along a profile with constant spacing between electrodes. The two most common array types used for CST are the dipole-dipole and pole-dipole arrays, where a dipole is a pair of current or potential electrodes.

Many electrode configurations are used in geophysics to measure subsurface resistivity. A common factor in these configurations is a set of current input electrodes usually labeled A and B and a set of voltage measurement electrodes usually labeled M and N. The dipole-dipole method places the A and B electrodes to one side with a spacing between them denoted as "a".

The M and N electrode pair with equal a-spacing are placed collinearly a distance "na" away from A and B. A distance equal to an integer multiple of "a" is denoted "na".

As measurements are taken at various n's, that is, the pairs of electrodes are moved apart, a sounding is obtained. If the electrodes are moved across the surface, a profile of comparative values is generated. Thus the dipole-dipole method produces a combination sounding-profiling set of data if measurements are taken at various values of n along a profile. Figure 1 depicts dipole-dipole configuration including electric field lines and resultant equipotential surfaces.



Figure 1: Dipole-dipole configuration, including electric field lines (solid) and resultant equipotential surfaces (dashed)

#### Theory of electrical resistivity method

The resistance of a resistive object determines the amount of current through the object for a given potential difference across the object, in accordance with ohm's law [8.11].

The resistance R, of a conductor of uniform cross-section can be computed as

Where,

L is the length f the conductor, measured in metres (m)

A is the cross-sectional area, measured in square metres  $(m^2)$ 

 $\rho$  is the electric resistivity ( also called specific electrical resistance) of the material, measured in Ohm meter ( $\Omega$ m). Resistivity is a measure of the material's ability to oppose electric current.

Comparing equations (2) and (3), we have

Equation (4) can be used to determine the resistivity of any homogenous and isotropic medium provided the geometry is simple. For semi – infinite medium, however, the resistivity at every point must be defined. If we allow parameters (A) and (L) to infinitesimal size then:

Where E = Electric field and J = Current density.

$$\therefore J = \underline{E} = \sigma E \dots (6)$$

But E is the gradient of a scalar potential

i.e  $E = -\nabla V$  $j = -\sigma \nabla V$ 

Current crossing the spherical body of surface area A is

$$I = 4\pi r^2 P \frac{\partial V}{\partial r}$$
$$\therefore \partial v = \frac{\partial}{\partial r}$$

$$\therefore v = -\int \frac{IP}{4\pi r^2} \partial r$$
$$v = \frac{IP}{4\pi r^2} \partial r$$

In practice, the earth structure is an approximate of hemisphere than current density  $J = \frac{I}{A} = \frac{I}{2 - 2}$ 

A 
$$2\pi$$

$$E = \frac{IP}{2\pi r^2}$$
$$\partial v = \frac{IP}{2\pi r^2} \partial r$$
$$V = -\int \frac{IP}{2\pi r^2} dr$$

$$V = IP / 2\pi r$$

This is the potential of P due to a current at C, the surface of the earth.

#### **Data Acquisition and Presentation**

For the geophysical investigation of subsurface characterization carried out in this area, an ABEM Terrameter SAS 1000, electrodes, reels of wire, cell, were used to carry out the field procedure. Dipole-dipole array was used in the procedure on the field to obtain horizontal soundings within the location on two traverses. Inter- electrode spacing of 10m, 20m, 30m and 40m were used in all the traverses.

The data acquired from the survey were processed by creating a pseudo-section of the apparent resistivity values using DIIPRO software. Computer iterations were then carried out and two-dimensional (2-D) resistivity contour maps were then created.

#### **RESULTS AND DISCUSSION**

The Dipole- dipole data acquired were done in such a way to have a proper distribution and fair coverage in order to enhance data correlation and interpretation.

From the 2-D resistivity structure, it is shown that there is a concentration of four types of soil formations along the traverse but to a depth of about 2.3m. While a uniform layer of clayey sand was observed on the traverse from a depth of 2.3m to 5.0m

A large formation of sandy clay was observed from 3m to 18m with resistivity value ranging from  $234\Omega m$  to  $531\Omega m$ . At 3m to 4m to a depth of 1.6m from the surface, a formation of sand with resistivity value ranging from  $120\Omega m$  to  $155\Omega m$  was observed, while a clay settlement with resistivity value above  $50\Omega m$  is confined within the sand from a depth of about 0.2m to 1.1m.

On the traverse at 6m to 8m to a depth of 0.2m from the surface is an intrusion of clayey sand with resistivity value of  $800\Omega m$ . At 6.5m to 9m from a depth of 0.8m to 1.3m is a formation of sand with resistivity value ranging from  $120\Omega m$  to  $155\Omega m$ , while a clay settlement from a depth of 0.8m to 1.1m is confined within the sand.

At 10.5m to 13m and from a depth of 0.8m to 1.8m, a formation of sand with resistivity value ranging from  $120\Omega m$  to  $155\Omega m$ ; confined within the sand formation is a clay settlement with resistivity value ranging from  $30\Omega m$  to  $103\Omega m$ .

From 13.3m to the end of the traverse, down to the depth of 2.4m from the surface, a large formation of sand with resistivity value of  $155\Omega m$  was observed. Confined within the sand formation, is a clay settlement 2.0m deep from the surface with resistivity value ranging from  $45\Omega m$  to  $105\Omega m$ .

The areas that have favourable resistivity with appreciable thickness are areas with sand formation along the traverse.

It was observed that the total range in resistivity of the subsurface contents is from  $45\Omega m$  to  $800\Omega m$ . Clay was observed to have the lowest resistivity ranging from  $45\Omega m$  to  $103\Omega m$ , while clayey sand was observed to have the highest resistivity of  $800 \Omega m$ . Sand was observed to have resistivity range of  $120\Omega m$  to  $155\Omega m$ , while sandy clay was observed to have resistivity ranging from  $234 \Omega m$  to  $531 \Omega m$ . The varying resistivities could be as a result of their closeness to the surface as the formations of the contents were observed to be concentrated at the depth of 2.3m from the surface, and human and natural activities from the surface can also be responsible for the varying resistivities and structural pattern of the subsurface. There is tendency, therefore for the layers to be polluted because of the closeness to the surface.

On this survey line or traverse the competent areas for groundwater development are from  $318\Omega m$ -800 $\Omega m$ , although there appear to be a large extent of horizontally weathered fractured bed that constitute the aquifer units. The 2-D structure suggests possible communication between the aquifer units along this traverse.





# CONCLUSION

The electrical resistivity (dipole-dipole) data gave reasonable results that can be used to understand the subsurface layers and groundwater potential. Four different types of soil namely; sandy clay, clayey sand, sand and clay were observed from the 2-D resistivity data representation along the traverse. The four different types of soil formations were observed from the beginning to the end of the traverse but to a depth of about 2.3m, while a uniform layer of clayey sand is shown on the traverse from the depth of about 2.3m to 5.0m.

Sandy clay was observed with resistivity ranging from 234  $\Omega$ m to 531  $\Omega$ m to a depth of about 2.3m from the surface. Clayey sand was observed with resistivity value of 800 $\Omega$ m from a depth of about 2.3m to 5.0m. A small formation of clayey sand was also observed at 6m to 8m along the traverse and at the depth of 2.0m from the surface, while sand was observed with resistivity value of 155 $\Omega$ m at a depth of 2.3m from the surface. The sand formation was observed at four points along the traverse. Clay was observed with resistivity value ranging from 45 $\Omega$ m to 105 $\Omega$ m to a depth of about 2.0m from the surface. The clay was also observed at four points along the traverse and it is confined within the sand formations.

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