SOIL RESISTIVITY SURVEY OF DAMATURU METROPOLIS IN YOBE STATE, NIGERIA.

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Abstract

The electrical properties of soils are the parameters of the natural and artificial field in soil influenced by the distribution of mobile electrical charges mostly inorganic ions in the soil. Identifying low resistivity earth materials and their potentials becomes imperative. The aim of this study is to carry out the soil resistivity survey of the study area. The method used in sample collection is the surface scraping and digging to a depth of about 20 cm at random where each location coordinates is taken using a Global Positioning System (GPS). The samples are stored in plastic containers and taken for laboratory ex-situ measurements. A conductivity meter is used to determine each sample's conductivity where the resistivity of each sample is calculated from the reciprocal of the conductivity. The result is digitized and a contour map of the study area is plotted using Surfer software. The map shows the delineation of the resistivity variation in the study area. The spatial variations of resistivity in the study area are found to be between 5.5 x 10^3 Ω-cm to 1.6 x 10^4 Ω-cm.

***KEYWORDS:** soil, resistivity, survey, conductivity, ex-situ, digitized.*

INTRODUCTION

Soil is the fine earth which covers land surfaces as a result of the in-situ weathering of rock materials or accumulation of mineral matter in addition to organic matter (Nortcliff et al., 2012). The electrical properties of soils are the parameters of the natural and artificial field in soil influenced by the distribution of mobile electrical changes mostly inorganic

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ions in the soil. The soil electrical conductivity is a measurement that correlates with soil properties that affect crop productivity including soil texture, cation exchange capacity, drainage conditions, organic matter level, salinity and subsoil characteristics (Awak et al., 2017). On the other hand, soil electrical resistivity is a measure of the resistance offered by the soil against the passage of electric current through it (Wang et al., 2017). Whereas the presence of water and air pores will increase conductivity reduces resistivity. The aim of this study is to map out the spatial variations of resistivity within Damaturu metropolis.
Several studies have been carried out using electrical conductivity and resistivity among which is a study by Heaney (2003) on electrical conductivity and resistivity on electrical measurement signal processing and displays. Also, Baltopoulos et al. (2013) undertook the sensing strain and damage in polyurethane-MWCNT nano-composite foams using electrical measurements. Among these studies, none has considered the variations of resistivity for soil types using conductivity data for the study area as such this study become necessary.
Electrical resistivity method is widely used for groundwater investigation, groundwater contamination surveys, surface cavity, karst and fault, archeological surveys, characterization of fiber distribution in steel reinforced concrete to study delineation of seepage zones to map out soil layer and their thickness and so forth (Bhoi, 2012). Electrical conductivity is also used to measure soil salinity, to map out spatial variations of soil within a productive soil field in agriculture and for assessing the concentration of solid substances present in any sample of solid waste water (Wiatrak et al., 2009; Aning et al., 2014)

Electrical Conductivity and Resistivity

According to Baltopoulos et al. (2013) for a sample of the material in form of a cube of soil having sides of length one meter is placed between two electrodes, the bulk electrical conductivity is given by

$$\sigma = \frac{L}{RA} = \frac{1}{\rho} \qquad [1]$$

Where A is the cross-sectional area, L is the length of the material, R is the resistance of the material and σ is the electrical conductivity of the material and ρ is the resistivity of the material. The electrical conductivity, σ and the resistivity, ρ are related according to the relation

$$\rho = \frac{1}{\sigma} \qquad [2]$$

Location and Geology of Study Area

The area is located between latitude 11°40'N to 11°48'N and longitudes 11°54'E to 12°01'E (Figure 1). The population of the study area is 87,706 according to 2006 census Dawoud and Raouf (2008) and falls within the Sahel Savannah with sparse grass-cover (Du Preez and Barber, 1965). The area exhibits a tropical dry season condition (Nur et al., 2012). The hottest months are March, April and May with temperatures varying from 39° to 42° (Emeka and Weltime, 2008). Annual

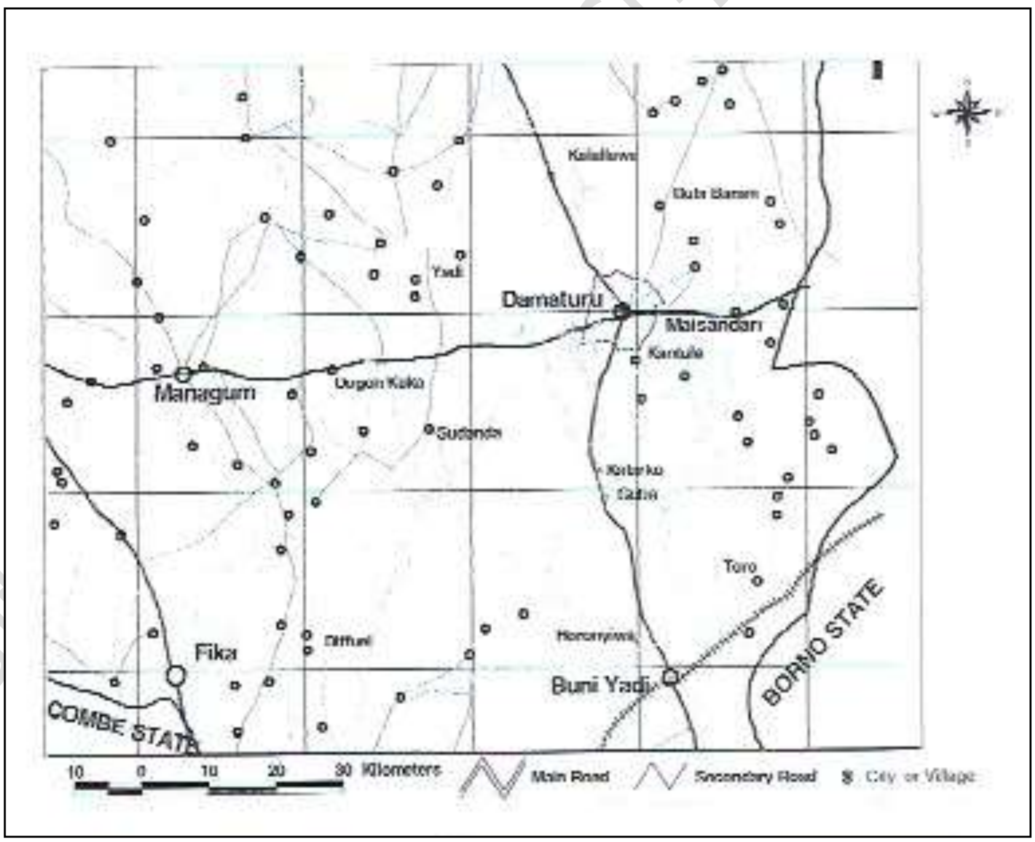

Figure 1 Location map of the study area (Dawoud and Raouf, 2008)

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Rainfall ranges from between 500 mm to 1000 mm and the rainy season starts normally from June to September (Hess et al., 1996). The main source of water supply is groundwater wells within taps in residence (10 – 15%), free public taps (20 – 25%) and private taps requiring payment (60 – 70%) (Dawoud and Raouf, 2008). In most villages of Damaturu there is no public water supply system and water is obtained from private vendors and nearby streams.

The study area is located (Figure 2) in the Northeast sedimentary basin of Nigeria and underlain by the Fika shale, Kerikeri and Chad formations (Nur et al., 2012; Kwaya et al., 2017). The basin contains about 4.65 km of marine and continental sediments, consisting of Bima sandstone, Gongila formation, Fika shale, Kerikeri and Chad formation. The Chad formations overlie the Kerikeri of tertiary deposits and is composed of basal sands and gravels with greenish clays above, the later containing some minor bands of sands (Nur et al, 2012).

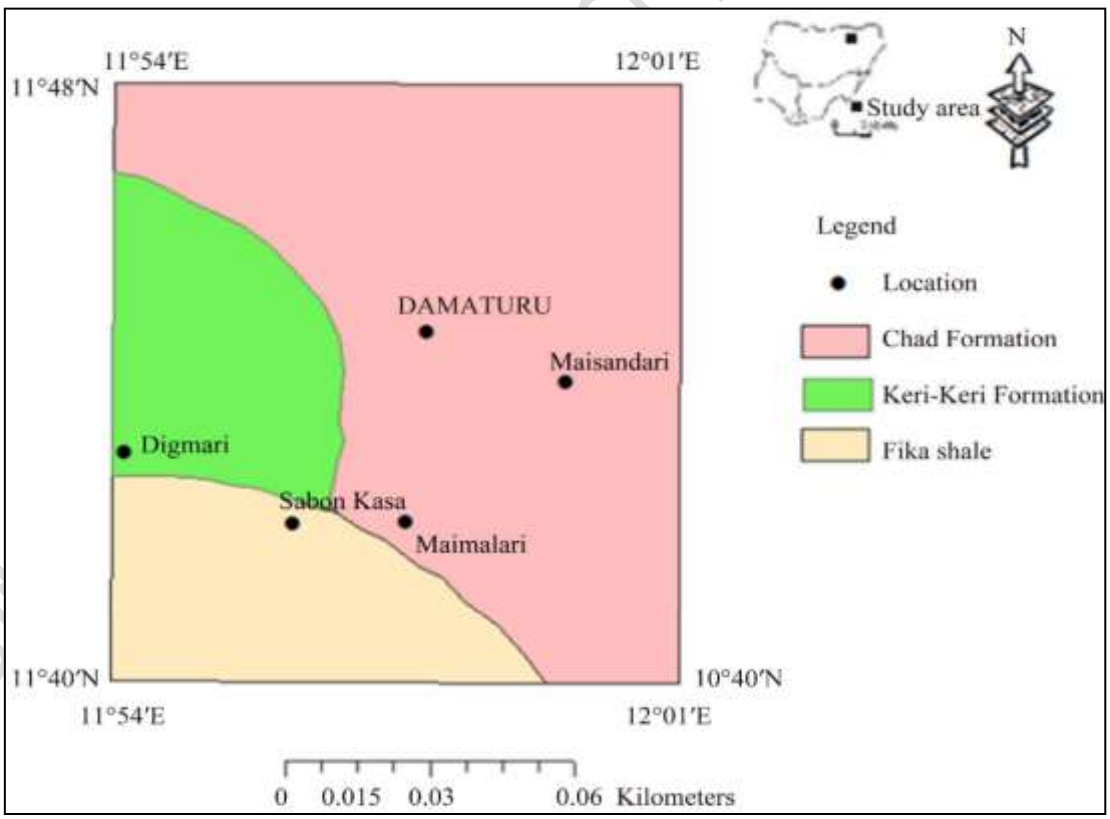

Figure 2 Geology map of the study area (Nur et al., 2012)

MATERIALS AND METHODS

Sample Collection: the surface of the earth was removed using a backhoe and also digging a hole to an average depth of 20 cm with a spade, the sample was collected by scrape-slide vertically and horizontally for each point location. A Global Positioning System (GPS) was used to take the location latitude and longitude for each point location where the soil sample was collected. The samples were then stored in plastic containers with labels DS to mean Damaturu Station for the ten stations as DS1, DS2, DS3, DS4, DS5, DS6, DS7, DS8, DS9 and DS10 of the different stations in preparation for ex-situ laboratory measurements.

Measurement Procedure: each sample of soil was weighed 5 g and transferred into a beaker and 25 ml of distilled water was added. The solution was stirred well for about 5 – 10 minutes and was allowed to settle. The portion of the solution was separated by the use of filter paper after decantation. The filtrate was taken to another beaker where the probes of the conductivity meter were inserted into the filtered solution for each sample and the electrical conductivity was read from the conductivity meter. The inverse of all the electrical conductivities was determined and recorded as the resistivities. The results were digitized using surfer software and their contour maps were plotted.

RESULTS AND INTERPRETATION

The result of resistivity for the survey of the study area is presented as surface contour maps and in 3D surface maps in Figure (3a and 3b) and Figure (4a and 4b) respectively. In the Northeastern part of the study area, two outcrops are manifest. This may be due to Damaturu Stations DS4, DS6 and DS7. Other outcrops appear in the eastern and western parts which may be due to DS8, DS10, DS2 and DS3 respectively. Other stations such as DS1, DS5 and DS9 did not show any outcrop manifestation (Figure 3a). The stations that show outcrops on conductivity

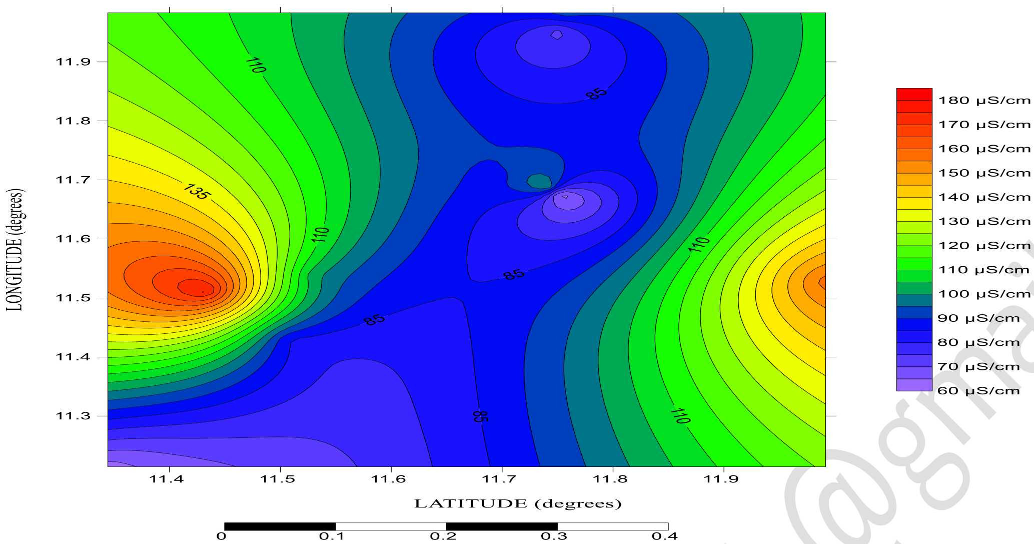

Figure 3 (a) 2D Surface Contour Map for Conductivity

contour map could be as a result of the concentration of high conductivity materials such as salts, contaminants, minerals etc. And as such the resistivity contour map (Figure 3b) show valleys where it is outcrop for conductivity.

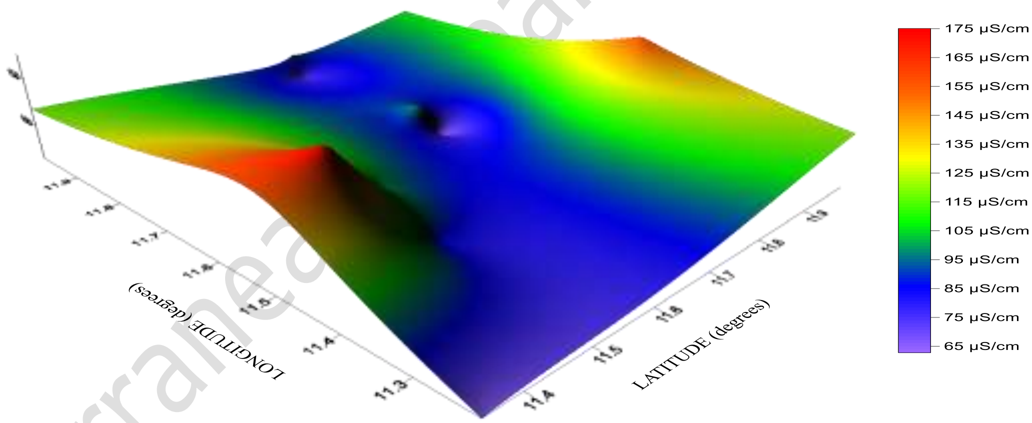

Figure 3 (b) 3D Surface Contour Map for Conductivity

This is in conformity with equation 2. Other areas that did not show any manifestation of outcrop signatures in the conductivity contour map is signifying low conductivity materials and high resistivity. This could be due to earth materials such as pure water-bearing zones, rocky materials and other geologic high resistivity material bearing zones. This could be weathered materials from rocks, underground erosion of salt-bearing materials such as leaching. The 3D surface map of the study area for conductivity (Figure 4a) shows how an outcrop in the concentration of dissolved earth

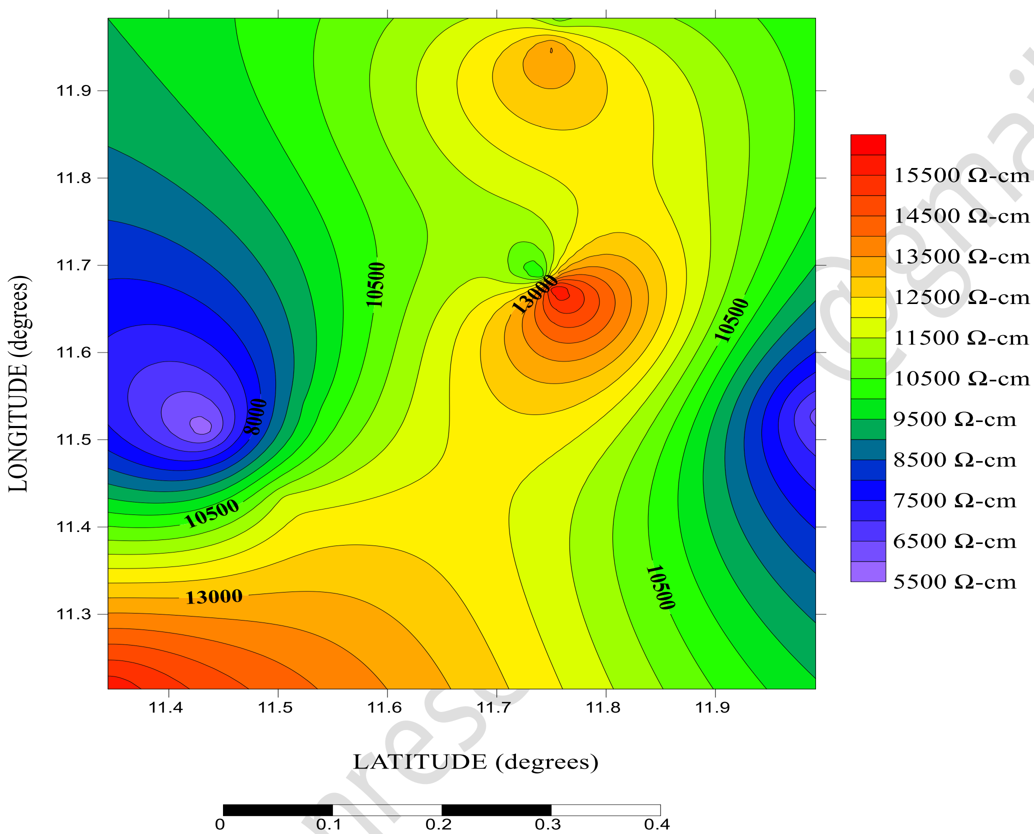

Figure 4(a) 2D Surface Contour Map For Resistivity

materials translates into a valley in the 3D surface map for resistivity (Figure 4b) showing clearly the relationship between conductivity and resistivity is in conformity with equation 2. The spatial variations of resistivity in the study area are found to be between 5.7×10^3 Ω-cm to 1.3×10^4 Ω-cm and when we compared this with standard values for soils it corresponds to that of Clay, gumbo, loam, or shale in average and maximum values. This also intersects with the minimum and average values for Clay, gumbo, loam, or shale with varying portions of sand and gravel. This result is in agreement with the geological work of Nur et al. (2012) who found that Damaturu is composed of shale with minor deposits of sand and gravels.

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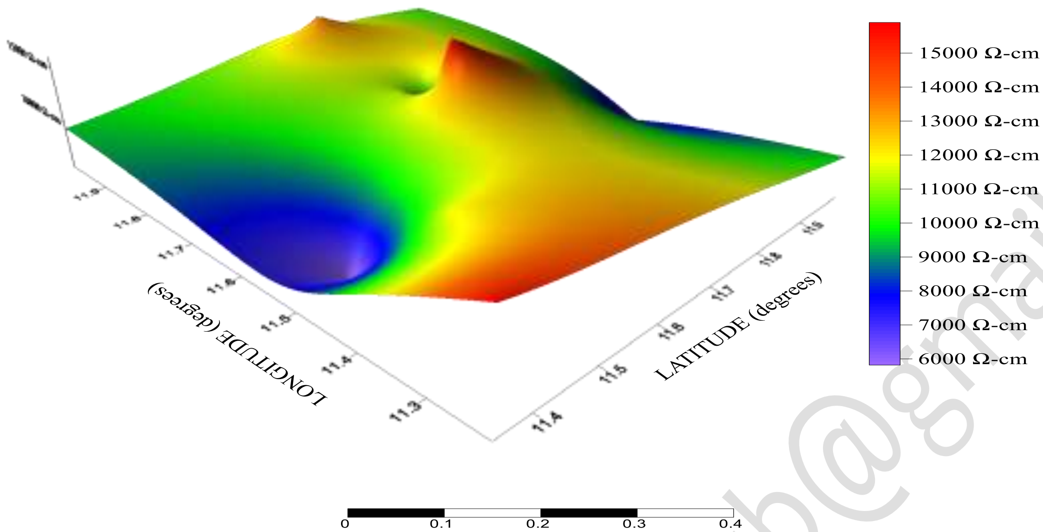

Figure 4(b) 3D Surface Contour Map for Resistivity

CONCLUSION

The spatial variation of resistivity for Damaturu has been determined from conductivity data. The study area has been found to have some outcrops of conducting earth materials which translate to valleys for resistivity and vice versa. These outcrops could either be a result of salt solution or minerals or a result of leaching where water has carried away these salt solutions. The variation of resistivity is between 5.7×10^3 Ω-cm to 1.3×10^4 Ω-cm. This shows that the study area is composed of clay, shale with minor sand and gravel deposits.

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