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Seasonal Variation of Soil Resistivity and Soil Temperature in Bayelsa State

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Abstract: Problem statement: Due to the climatic variation for the year and it's sever harmattan during the month of December to March with the high keraunic level (80-90) in the areas, it was necessary to know the seasonal variation of soil resistivity. The seasonal variation and the nature of soil have considerable influence on electrical characteristics and therefore affect the earthling system performance. **Approach:** Eighteen sites were chosen from three main soil divisions. The soil resistivity was taken in each of the site at depths of 0.5, 0.8 and 1.2 m using the four point test instrument (Wenner Method). From the selected sites in the three soil divisions the temperature was also taken at depths of 0.2, 0.5, 0.8 and 1.0 m. **Results:** The coefficient of seasonal variation at the depth of 0.5 m was high and reduced drastically at a depth of 1.2 m. The soil temperature was higher than the ambient temperature at the depth of 0.2 m during the months of December to March. From 0.8 m depth and below the temperature reduced even during the dry seasons. **Conclusion:** The coefficient of seasonal variation of soil at the depth of 0.8 and 1.2 m was small (1.8-3.0) throughout the year in all soil types. That indicates the high water level and or the permanent moisture table which gives an advantage to low soil resistivity for buried conductors and electrodes in the area.

Key words: Electrical characteristic, permanent moisture level, soil ionization, soil pH and ambient temperature

INTRODUCTION

Bayelsa state is dissected centrally by longitude 6° East and latitude 4.5° north. The land area of Bayelsa is about 12,000 km^2, most of which is in fact wetland. It only definitive boarder is the 185km of coastline through which it's many rivers issue into the Atlantic Ocean (Alagoa, 1999). About 6% of the rivers, creeks and estuaries in the Niger Delta are in Bayelsa State. Some site locations are shown in Fig. 1. This land formation affects soil resistivity values and as such affect the transient behavior of the electrode and subsequent ionization phenomenon (Gupta and Gupta, 1979; Ala *et al*., 2008; Abdullahi *et al*., 2010). All calculations related to the design of grounding system and for the determination of transfer, step and touch potential require information about the soil resistivity at the site. Resistivity of soil depends on the physical composition of the soil, moisture content, dissolved salts, seasonal variation and current magnitude (Poljak and Doric, 2006; Geri *et al*., 1992; Nor *et al*., 2006). Different soil composition gives different average resistivity but moisture has a great influence on resistivity value of soil (Ab Kadir *et al*., 2009; Begamudre, 2009; Razevig, 2003).

Bayelsa State was created due to the neglect of the area by past government of Nigeria. This is an area of rich natural gas and mineral resources and as such is capable of attracting small and medium scale industries. Since the federal government development policies are making impact on the area.

It is necessary therefore to study the seasonal variation of soil to enable telecommunication operators, power system engineers and earth system designers to have available data on earth resistivity.

For the purpose of this study the soil in Bayelsa State was divided into three distinct groups. These are:

- The coastal soil
- The fresh alluvial soil and
- The tidal fresh water swamp soil

The coastal soil like any other coastal soil in the Niger Delta is seasonally water logged soil with high water table at about 100 cm depth in the coastal towns with most swamps submerged during high tide.

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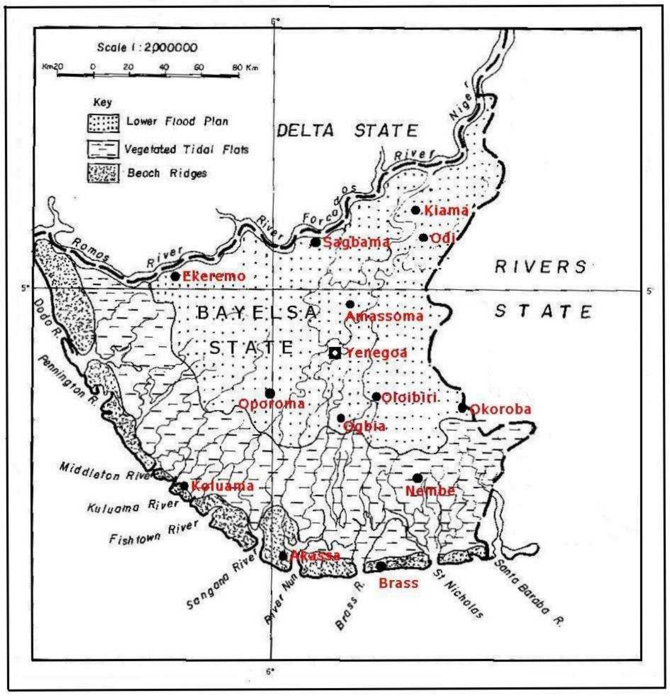

Fig. 1: Geomorphic unit and site location in Bayelsa State

The soil has low PH value (6.1-7.3) but with much salt content due to the salt spray from the ocean and the subsoil water. In Bayelsa State, the coastal soil occupied about 50% of the total land area.

The fresh alluvial plain soil is the next predominant soil that extends to the northern parts of the neighboring state (Rivers State). The fresh alluvial plain soil is silt sandy clayey soil and powdery white when dry and caked under intensified prolonged sun. With much water content the soil easily crumbles. Due to this nature, it is easily affected by flood and erosion. The soil is acidic with pH of about 4.3-5.0. The tidal fresh water swamp soil is not always submerged during flood except at the bank of the creeks and the smaller creeks that runs into the land mass. It is a sandy clay soil with 80% clay at 2 m depth.

MATERIALS AND METHODS

This study was carried out from November 2008 to March 2009 in Bayelsa State of Nigeria. The instrument used was the conventional four electrode method (the Wenner method). Measurements were done on at least 5 sites from every soil division and the depths of electrode were taken as a 0.5, 0.8 and 1.2 m for the selected months. As shown in Fig. 2 the Wenner technique uses four equally spaced electrodes connected in a single line.

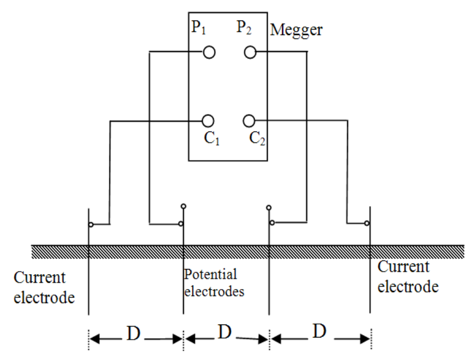

Fig. 2: Four method test instrument (Wenner Method)

Current is passed between the outer two electrodes (C_1 C_2 and the voltage between the inner electrode (P_1, P_2). From the experiment, the electrode distance maintained was 3 m for all measures depth.

The ratio of this measured potential to the calculated current for the given spacing is known as the apparent resistivity. From the experimental value:

$$p = 2\pi DR \text{ (When } b << D)$$

Where:

p = Soil resistivity in ohm-m
D = Distance between two successive electrodes
R = The value of V/I in ohms

The temperature was measured at one selected site from each soil division at depths of 20, 50, 80 and 100 cm.

RESULTS

From the result, a site from the different soil division was taken for analysis. The values are shown in Table 1-3.

With the values of Table 1-3 the graphs of Fig. 3 and 4, (resistivity values for the months) were drawn.

The graph of soil temperatures with depths were drawn for each selected site for the three soil divisions and are shown in Fig. 3 and 4a-c.

An average was found from the experimental values for the eighteen sites for each soil division. Seasonal variations, the ambient temperature and relative humidity are shown in Table 5.

Table 1: Soil resistivity temperature (Ambient), humidity measurement

	Coasted soil, selected site-Brass					
Depth of electrode	Feb.	May	August	Oct.	Dec.	Coefficient of soil variation
0.5	120.0	25.0	23.0	28.0	110.0	4.8-5.7
0.8	32.0	22.0	21.0	20.0	30.0	1.6-1.8
1.2	22.0	20.0	18.0	21.0	20.0	1.1-1.2
Air Temp. (°C)	35.5	30.8	29.1	29.5	33.6	-
Humidity mm H_g	71.0	81.0	85.0	78.0	76.0	-

Table 2: Soil resistivity, temperature (ambient), humidity measurement

	Tidal fresh water swamp soil, selected site-Ogbia town					
Depth of electrode	Feb.	May	August	Oct.	Dec.	Coefficient of soil variation
0.5	280.0	80	62.0	95.0	230.0	4.5-5.6
0.8	120.0	48	35.0	42.0	87.0	2.9-3.4
1.2	55.0	31	20.0	22.0	38.0	2.5-2.7
Air Temp. (°C)	3.6	30	29.2	29.7	34.3	-
Humidity mm H_g	70.0	78	80.1	75.0	71.0	-

Table 3: Soil resistivity, temperature (ambient), humidity measure

	Fresh water Alluvial plain soil, selected site-Amassoma					
Depth of electrode	Feb.	May	August	Oct.	Dec.	Coefficient of Soil variation
0.5	321	85	52.0	55	202.0	5.8-6.2
0.8	102	45	34.0	36	86.0	2.9-3.0
1.2	47	29	23.0	27	30.0	1.7-2.0
Air Temp. (°C)	37	32	27.0	30	33.7	-
Humidity mm H_g	77	80	82.3	78	74.0	-

Table 4: Temperature for various depths of Soil

	Temperature (°C)					
	BRASS site		OGBIA site		Amassoma site	
Depth cm	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.
20	48.0	28.0	45.0	27.0	46.0	29.0
50	36.0	26.0	34.0	25.5	30.0	26.8
80	28.0	24.0	29.0	21.9	28.9	25.0
100	24.0	23.0	26.0	22.0	25.0	23.0
Ambient temp. (°C)	35.2	28.9	34.5	29.4	34.2	28.3

Table 5: Average season variation of soil for the three soil divisions

Serial number	SD	Depth (m)	Seasonal variation range	Ambient Temp. (°C)	Humidity relative (%)
1.	Coastal soil	0.5	3.0-4.8		
		0.8	1.7-2.0	32.8	78
		1.2	1.1-1.2		
2.	Tidal fresh water swamp soil	0.5	4.5-6.0		
		0.8	3.0-5.0	32.5	70
		1.2	2.0-2.7		
3.	Fresh Alluvial and soil plain	0.5	5.6-6.5		
		0.8	2.1-3.7	32.7	72
		1.2	1.9-2.6		

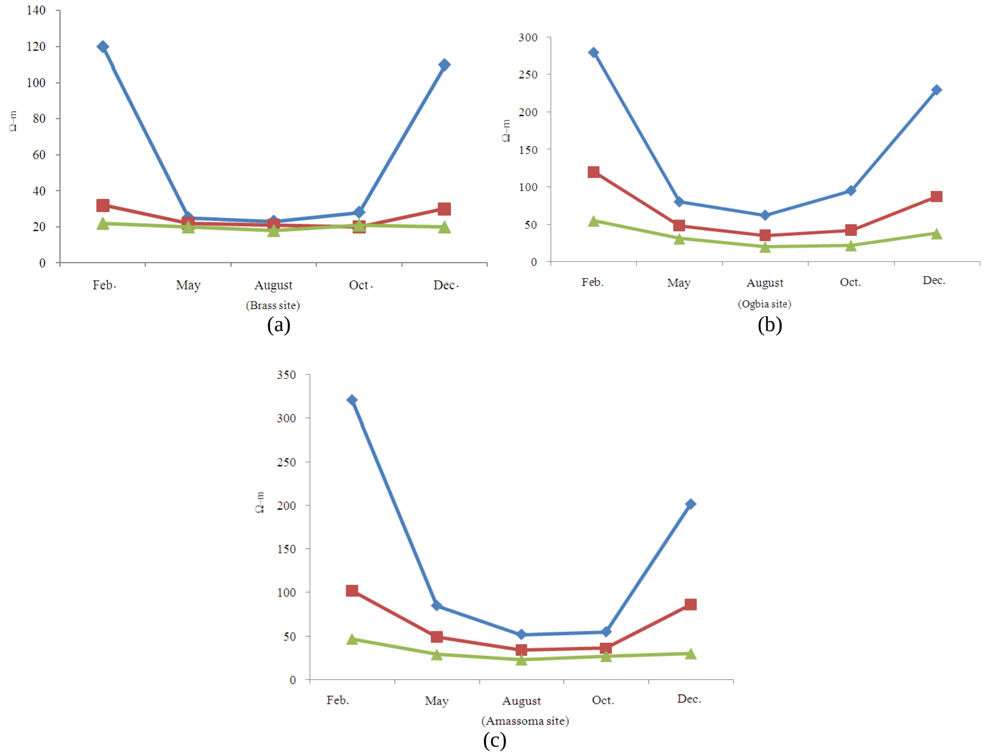

Fig. 3: (a) Soil resistivity variation for the year at different depth in Brass; (b) Soil resistivity variation for the year at different depth in Ogbia; (c) Soil resistivity variation for the year at different depth in Amassoma site

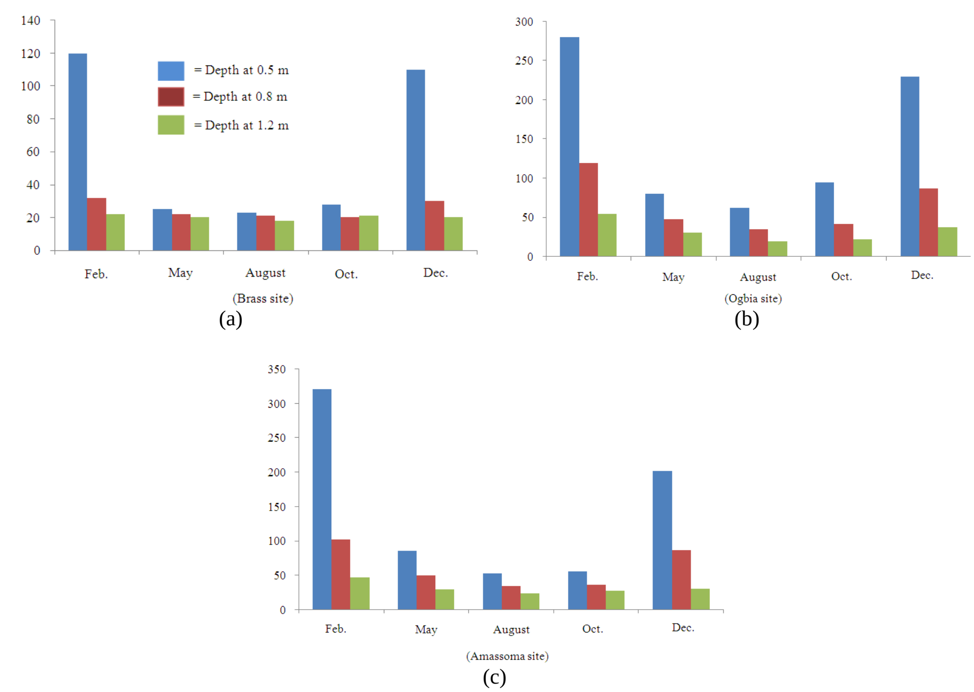

Fig. 4: (a) Soil resistivity for selected months (Brass); (b) Soil Resistivity for selected months (Ogbia); (c) Soil Resistivity for selected months (Amassoma)

DISCUSSION

From the seasonal variation result the value of resistivity for the topsoil (depth = 0.5 m) was fairly high especially for the tidal fresh water swamp soil and the fresh alluvial plain soil.

From all measurement the soil resistivity of the coastal soil at all seasons was almost the same both at topsoil 0.5 m and at 1.2 m depth. The variation was more on the topsoil and can be attributed to the topography and temperature variation. The soil resistivity is generally very low because the landmass is less than 1 m above the sea level; therefore the land is saturated with the surrounding water and subsoil water to a level of less than 100 cm. The inland areas of the coastal soil like Nembe site has a high seasonal variation at topsoil because the salt wind drift which affected the landmass of the coastal soil close to the sea and ocean is of small effect.

At 1.2 m depth there is a moderate variation for the apparent resistivity for all the three soil division.

The main reason is that at that depth the soil is at its permanent moisture level and therefore has very low apparent resistivity. The ground water level, the rivers and creeks and the flooding seasons contributed to a more saturated soil.

At Yenagoa site 1 and 2 there was a marked difference of resistivity value, this is as a result of the topography and the local surface drainage streams. Site 2 is not well drained and it ponds after the rainy seasons followed by the seasonal flooding. Since the soil dries up after a long period, the soil resistivity is affected.

During the dry seasons and the hamattan periods, the temperature variation is high especially at the top soil (20 cm). The temperature reduces from 50cm below the ground. From the study carried out (Gupta and Gupta 1979; Dawalibi *et al*., 1995; Ala *et al*., 2009), it was concluded that temperature variation of surface layer (≤20 cm) contributes largely to the diurnal variation of the soil resistivity.

CONCLUSION

From Table 6 the average season variation is small; this is due to the soil formation and surrounding water level.

Since at the depth of 0.8 and 1.2 m the soil resistivity is low at all seasons of the year, earthling of electrical apparatus or system is not the problem in this part of the country. Earth electrode designer can work with the field measurement at any particular place in the area where the work is to be carried out.

Table 6: Average season variation of soil for the three soil divisions

Soil division	Depth (m)	Seasonal variation range	Ambient Temp. (°C)	Humidity relative (%)
Coastal soil	0.5	3.0-4.8		
	0.8	1.7-2.0	32.8	78
	1.2	1.1-1.2		
Tidal fresh water	0.5	4.5-6.0		
swamp soil	0.8	3.0-5.0	32.5	70
	1.2	2.0-2.7		
Fresh alluvial	0.5	5.6-6.5		
and soil plain	0.8	2.1-3.7	32.7	72
	1.2	1.9-2.6		

From the test of soil resistivity and the pH value known (not recorded), the only problem with the soil in Bayelsa State of Nigeria is soil corrosion.

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