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COMPARATIVE STUDY OF ELECTRICITY AND THERMAL CONDUCTIVITY OF THREE LAND FORM IN AKWA IBOM STATE.

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ABSTRACT

The electrical conductivity (Ec) and thermal conductivity (K) of some selected soil samples soil samples from three landforms in Akwa Ibom State, Nigeria namely Coastal Plain Sand (CPS), Beach Ridge Sand (BRS) and Sandstone/Shale Hill Ridges (SHR) were measured, the data obtained were subjected to spearman rank order statistics and the result shows that there were positive correlation of 1.229ds/m between Ec and K. The electrical conductivity of the area under study falls within the range of 0.025 ds/m and 0.095 ds/m while thermal conductivity are between 0.260w/mk and 0.500w/mk; the Ec range of the three landforms is the optimum level for most plants.

Key Words: Electrical Conductivity, Thermal Conductivity, Soil and Samples.

INTRODUCTION

The study of soil properties provides among other advantages and awareness to users; by knowing the electrical and thermal conductivity of their soils. The soil thermal properties are required in many areas of engineering, agronomy and soil science.

The physical mechanism, of conductivity in silicate rock is by semi-conductivity and its electrical conductivity is temperature dependent. It varies with temperature and to a small degree with physical conductions. The conductivities of the ground vary with soil type. Sandy soil is not as good conductor as a black soil. The higher the moisture of the soil, the poorer the conductor the soil is, (Iwena, O. A; 2002).

Similar studies of soil properties in recent times include: measurement of salinity and electrical conductivity of some soil samples of Uruan Local Government area of Akwa Ibom State, (Akpan et al, 2001), thermal properties of soil samples in Uyo Local Government Area, (Ekpe et al, 1996) and comparative study of electrical conductivity and salinity of three land form in Akwa Ibom State, (Akpabio and Agbasi, 2011). All these studies are directed toward effective utilization of our soil for agricultural purposes and other developmental projects such as road construction and bricks making.

Soil electrical conductivity (Ec) is a property of soil that is determine by standardized measures of soil conductance by the distance and cross sectional area through which a current travels (Rhoades, 1996). Thermal conductivity is the coefficient which multiples the temperature gradient to give the rate of heat transfer by conduction expressed in heat energy crossing unit area in unit time (Condon and Ddishaw, 1967). This study is therefore directed towards measuring electrical and thermal conductivity of soil samples in Akwa Ibom State, Nigeria.

EXPERIMENTATION

Sample Collection and Preparation:

Soil samples used for the experiments were collected from three landforms in Akwa Ibom State, Nigeria. The landforms are: Coastal Plane Sand (CPS), Beach Ridge Sand (BRS) and Sandstone/Shale Hill Ridges (SHR) the soil samples were collected using “soil gauge” from different depth (0-45cm).

Six different soil samples were collected; the locations of collection are shown in the table below:

Table 1: Showing Landforms and Location of Collection in Akwa Ibom State.

Landforms	Locations
Beach Ridge Sand (BRS 1)	Ikot Ibok, Eket LGA
Beach Ridge Sand (BRS 2)	Ikot Akpan Mkpe, Onna LGA
Coastal Plane Sand (CPS 1)	Ikot Akan, Nsit Ubium LGA
Coastal Plane Sand (CPS 2)	Ikot Akpan, Nsit Ubium LGA
Sandstone/Shale Hill Ridges (SHR 1)	Ikpe Ikot Nkon, Ini LGA
Sandstone/Shale Hill Ridges (SHR 2)	Ibiaku Ntok Okpo, Ikono LGA

MEASUREMENT OF ELECTRICAL CONDUCTIVITY

The following were used during the experiment: weighing balance, 2.0mm sieve, distilled water, conductometer, shaking cups, mortar and pestle, measuring cylinder, mechanical shaker and the soil samples.

The samples were taken to the physics laboratory in label polythene bags, they were air dried and also dried in an oven to eliminate the water molecules completely. They were then, crushed and passed through a 2.0mm sieve before the analysis.

15g of each of the soil samples were weighed into 100ml polyethylene tube and 25ml of distilled water was added to each of the 100ml polyethylene tube. They were agitated on a mechanical shaker for 2 minutes, and then allowed to stand for one hour. They were returned to the mechanical shaker for two hours. Centrifuged (filtered) and carefully decant the supernatant solution. The electrical conductivity of each of the soil samples were measured using electrical conductivity meter (conductometer) by taking reading directly from the meter.

MEASUREMENT OF THERMAL CONDUCTIVITY

The following were used during the experiment: lee's disc apparatus, thermometer, steam can, vernier caliper, strings, retort stand with clamp, heat source (kerosene stove) and rubber tubings.

The cylindrical metal slab C was suspended with three inextensible strings from the retort stand. Kept at different positions with the flat surface of the slab kept horizontal. The disc shape moulded soil sample B was placed one at a time for all the soil samples and the cylinder A rested on the sample. Water was poured into the steam can to a level that once slightly titled, would reveal the water meniscus through the glass tube on the side of the steam can.

As heat from the heat source (stove) heated the steam can and the water reach it boiling point, steam passed through the rubber tubing to the cylinder, heat are transferred to the sample and the metal slab C. at steady state, the temperature θ_1 and θ_2 indicated by the two thermometers T_1 and T_2 were read and recorded. The thermometer T_1 and T_2 were interchanged, at steady state θ_1 and θ_2 were taken again. The mean temperature for θ_1 and θ_2 were determined;(Nelkon, M and Parker, P 1989).

The cylinder A was removed and help under slab C to heat its bottom until T_2 recorded a temperature reading of about 10^0c higher than this temperature the heat source were removed, by observing the thermometer, temperature readings were taken at 30 seconds intervals until the temperature decreased to about 10^0c below the mean/steady state temperature θ_2; (Tyler, F; 1977).

The diameter of the material under investigation was measured and the thickness no result.

RESULT AND DISCUSSION

Table 2: Results showing values of Electrical and Thermal Conductivity of the Soil Samples

Landform	Electrical Conductivity (ds/m)	Thermal Conductivity (w/mk)
BRS 1	0.078	0.333
BRS 2	0.054	0.363
CPS 1	0.055	0.272
CPS 2	0.062	0.302
SHR 1	0.127	0.409
SHR 2	0.037	0.404

Using spearman's rank correlation let Ec = x and K = y respectively. Hence, $(x_1\ y_1)$, $(\ x_2\ \ y_2) - - - (x_n\ y_n)$ be the ranks of n individuals corresponding to two characteristics. Assuming two soil samples are equal in either classification, each sample takes the values 1, 2, 3, . . ., n and their arithmetic means are, each = $\Sigma\, \frac{\boldsymbol{n}}{\boldsymbol{n}} = \frac{\mathbf{1}}{\boldsymbol{n}} \quad \frac{\boldsymbol{n}(\boldsymbol{n}+\mathbf{1})}{\mathbf{2}} = \frac{\boldsymbol{n}+\mathbf{1}}{\mathbf{2}}$.

Let x_1, x_2, x_3 - - -x_n be the values of samples Ec and y_1, y_2, y_3 - - - y_n those of K.

Then, d = $x - y$ = $\left\{\boldsymbol{x} - \frac{\boldsymbol{n}+\mathbf{1}}{\mathbf{2}}\right\} - \left\{\boldsymbol{y} - \frac{\boldsymbol{n}+\mathbf{1}}{\mathbf{2}}\right\} = \boldsymbol{x} - \boldsymbol{y}$

Where x and y are deviations from the mean.

$$\sum x^2 = \sum\left\{\boldsymbol{x}-\frac{\boldsymbol{n+1}}{\boldsymbol{2}}\right\}^2 = \sum x^2 - (\boldsymbol{n}+\boldsymbol{1})\sum\boldsymbol{x} + \sum\left(\frac{\boldsymbol{n+1}}{\boldsymbol{2}}\right)^2$$

$$= \frac{\boldsymbol{n(n+1)(2n+1)}}{\boldsymbol{6}} - = \frac{\boldsymbol{(n+1)\,n(n+1)}}{\boldsymbol{2}} + \text{n}\,\frac{\boldsymbol{(n+1)^2}}{\boldsymbol{2}} = \frac{\boldsymbol{n(n^2-1)}}{\boldsymbol{12}}$$

Clearly, $\sum x = \sum y$ and $\sum x^2 = \sum y^2$

$$\therefore \sum y^2 = \frac{\boldsymbol{n(n^2-1)}}{\boldsymbol{12}}$$

Hence, $\sum d^2 = \sum(x-y)^2 = \sum x^2 + \sum y^2 - 2\sum xy$

$$\therefore \sum xy = \frac{1}{2}\left\{\frac{\boldsymbol{n(n^2-1)}}{\boldsymbol{6}} - \sum\boldsymbol{d^2}\right\} = \frac{\boldsymbol{1}}{\boldsymbol{12}}\,\boldsymbol{n}\,(\boldsymbol{n^2}-\boldsymbol{1}) - \frac{\boldsymbol{1}}{\boldsymbol{2}}\sum\boldsymbol{d^2}\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_}(*)$$

The computation of the coefficient is based on ranks of the sample used for the Pearson's γ, between two variables x = Ec and $y = k$ is defined by the relations.

$$\gamma = \frac{\sum \boldsymbol{XY}}{\sqrt{(\sum \boldsymbol{X^2})(\sum \boldsymbol{Y^2})}} = \frac{\boldsymbol{\rho}}{\boldsymbol{6\,x\,6y}} = \frac{\boldsymbol{covariance}}{\sqrt{\boldsymbol{variance\ x}}}\frac{\boldsymbol{(x,y)}}{\sqrt{\boldsymbol{variance\ y}}}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

by putting (*) into (1) we have;

$$\gamma = \frac{\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{n}\left(\boldsymbol{n^2-1}\right) - \frac{\boldsymbol{1}}{\boldsymbol{2}}\sum\boldsymbol{d^2}}{\frac{\boldsymbol{n(n^2-1)}}{\boldsymbol{12}}} = 1 - \frac{\boldsymbol{6\sum d^2}}{\boldsymbol{n(n^2-1)}}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

(DASS, H. K; 1998)

Table 3: Showing result of Calculating Ec_R - K_R

Landform	Ec (ds/m)	K (w/mk)	EC_R	K_R	$d=EC_R-K_R$	d^2
BRS 1	0.078	0.333	5.00	3.00	2.00	4.00
BRS 2	0.054	0.363	2.00	4.00	-2.00	4.00
CPS 1	0.055	0.272	3.00	1.00	2.00	4.00
CPS 2	0.062	0.302	4.00	2.00	2.00	4.00
SHR 1	0.127	0.409	6.00	6.00	0.00	0.00
SHR 2	0.037	0.404	1.00	5.00	-4.00	16.00

But $\sum \boldsymbol{d^2}$ = 32

From equation (2) $\boldsymbol{\gamma} = 1- \frac{6\sum d^2}{n(n^2-1)}$

Where n = 6 (number of soil samples, d = EC_R-K_R, d^2 = -8. But EC_R-K_R are correlation coefficient of electrical conductivity and thermal conductivity read from correlation table respectively.

$$\boldsymbol{\gamma} = 1- \frac{6\sum d^2}{n(n^2-1)}$$

$$= 1- \frac{6x(32)^2}{6(6^2-1)}$$

$$= 1- \frac{(192)}{6(35)}$$

$= 1- \frac{(192)}{210}$

= 1-0.91428

= 0.08572 ≏ 0.0857

ANALYSIS OF RESULT

Using analysis of variance to determine whether the Ec values for the landforms where the soil samples were collected are the same.

Null hypothesis (H_N): Ec = K if $\gamma_{cal} > \gamma_{table}$

Alternative hypothesis (H_A): Ec ≠ K if $\gamma_{cal} < \gamma_{table}$

Where γ_{cal} calculated value of γ and γ_{table} = value of γ from correlation table with degree of freedom γ_{table} at $\propto = \mathbf{0.05}$. (Gerald, K and Brian, W; 2003).

γ_{table} = 0.886

γ_{cal} = 0.0857 < γ_{table} = 0.886, we upheld the alternative hypothesis and conclude that there is no significant difference in the two values of the different landform observed in Akwa Ibom State.

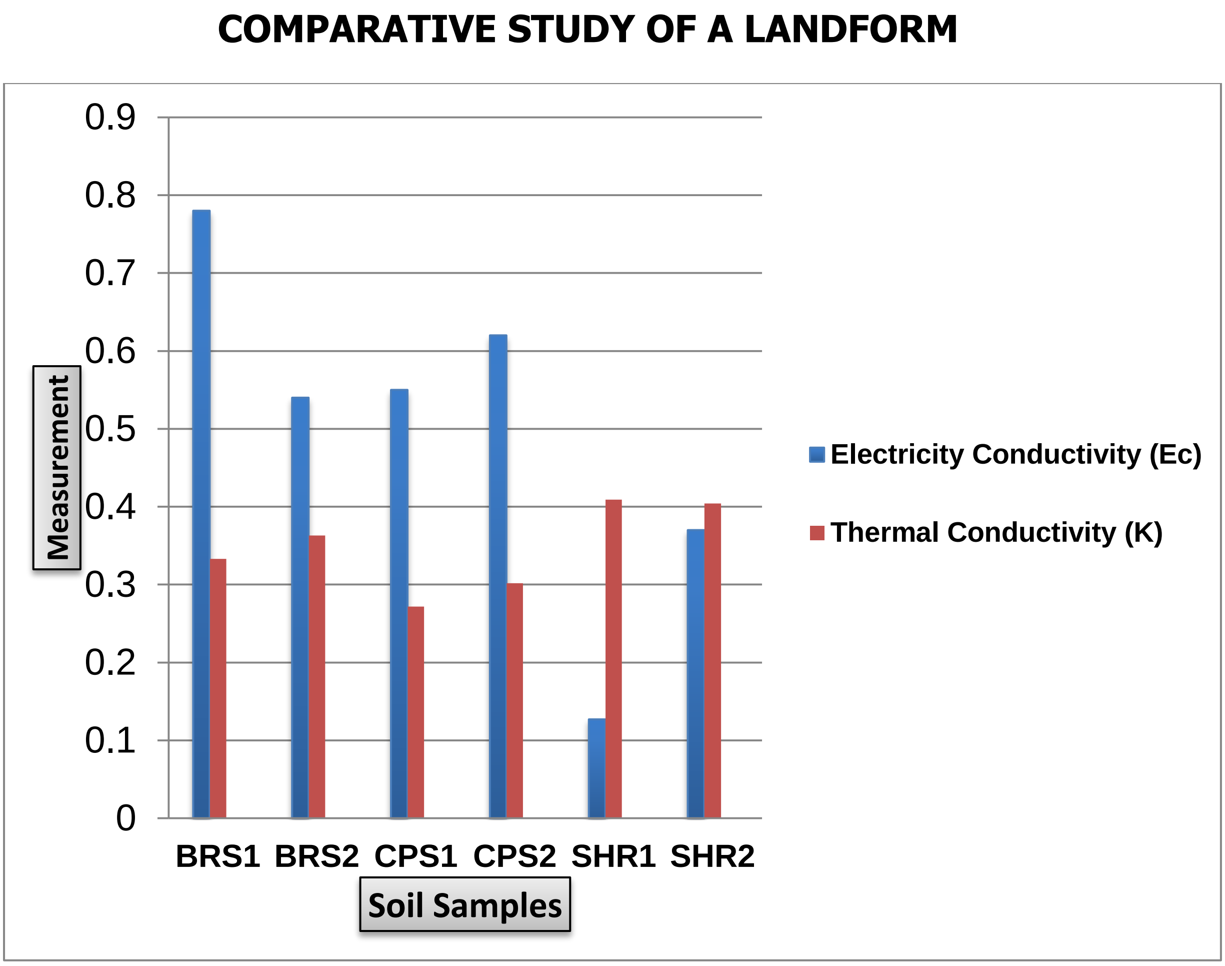

Figure 1: Electrical and Thermal Conductivities of Different Landforms.

CONCLUSION

From the result of measurement of electrical and thermal conductivities of some soil samples from different landforms in Akwa Ibom State, the electrical conductivity is between 0.037ds/m and 0.127ds/m. It is a fact that, electrical conductivity data were less than 1.5ds/m which indicates that those lands where the soil samples were collected are suitable for cultivation and the strength of the soil thermal conductivity measurement decreases while the soil electrical conductivity is directly proportional.

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