International Research Journal of Pure and Applied Physics
Vol.2,No.2,pp.10-19, June 2014
Published by European Centre for Research Training and Development UK (www.ea-journals.org)

THERMAL PROPERTIES OF THREE MAJOR LANDFORMS IN AKWA IBOM STATE, NIGERIA.

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ABSTRACT: *The thermal properties of some selected soil samples collected from three landforms, namely Beach Ride Sand (BRS), Coastal Plane Sand (CPS), Sandstone/Shale Hill Ridges (SHR) from Akwa Ibom State of the Federal Republic of Nigeria were measured, such as; thermal conductivity (K), thermal diffusivity (λ), thermal absorptivity (α) and thermal resistivity (R); the result obtained shows that K falls within the range of 0.272 – 0.501w/mk, $\lambda = 4.9 \times 10^{-6} - 11.4 \times 10^{-8}\ m^2 S^{-1}$, $\alpha = 17.86 - 27.24 m^{-1}$ and R also falls within the range of 1.996 – 3.676mkw^{-1} for all the soil samples, which shows that SHR would make the best soil for building and construction while CPS and BRS are best for planting root crops.*

KEYWORDS: Thermal Conductivity, Thermal Diffusivity, Thermal Absorptivity, Thermal Resistivity, and Soil Samples.

INTRODUCTION

The study of soil properties is very important and useful to measure and compare the thermal properties of soil samples from different locations. This is because different people depend on soil to support plant growth and provide life-sustaining nutrients in food, while others depend on soil for their shelter.Soil thermal properties are required in many areas of engineering, agronomy and soil science. It enables the engineer to determine the proper soil for road construction, water drilling and also help the farmer to determine the best soil suitable for planting of some special crops; it helps in the detection of mineral deposits in the sub-surface.

Similar studies of soil properties in recent time include; comparison of the thermal properties of soil samples for a passively cooled building design (Ekpe and Akpabio, 1994); thermal properties of soil samples in Uyo Local Government Area, (Ekpe et al, 1996) and comparison of the thermal properties of brick samples for a passively cooled building design (Akpabio and Ekpe, 1998).

THEORY

The amount of radiant energy absorbed or reflected depends on the material colouration. The proportion of energy absorbed causes changes in temperature of the material (soil samples).
Thermal conductivity (K): This 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. Thermal conductivity is a property of materials that expresses the heat flux that will flow through the material if a certain temperature gradient exists over the sample.

Thermal conductivity $k = \frac{Mc\,{}^{d\theta}/_{dt}}{\frac{\pi D^2}{4}\left\{\frac{\theta_1-\theta_2}{d}\right\}}$ -- 1.

Where M = mass of the sample (kg); C = specific heat capacity of the sample ($Jkg^{-1}k^{-1}$); $\frac{d\theta}{dt}$ = gradient (the rate of cooling); π = 3.142; θ = temperature (k); d = thickness of the sample (m) and D is the diameter of the soil sample, (Tyler, 1977).

Thermal diffusivity (λ): The ratio of the thermal conductivity to the heat capacity in heat transfer analysis is an important property called the thermal diffusivity. Thermal diffusivity measures the ability of a material to conduct thermal energy. Material with high thermal diffusivity will respond quickly to changes in their diffusivity will take materials with to reach a new equilibrium condition (Incropera and Dewit, 1996).

Thermal diffusivity $\lambda = \frac{k}{\rho c}$ -- 2.

Where k = thermal conductivity (w/mk); ρ = density (kgm^{-3}), c = specific heat capacity ($Jkg^{-1}k^{-1}$)

Thermal absorptivity (∝): Thermal absorptivity of a material is the thermal property associated with insulation of a material. The more heat that a material absorbs, the less it reflects and vice versa.

Thermal absorbtivity $\alpha = [\frac{w}{2\lambda}]^{1/2}$ --- 3.

Where w = angular frequency and λ = thermal diffusivity

***Thermal resistivity* (R):** The resistance of the passage of heat through a material is known as the thermal resistivity of the material and it is a reciprocal of the thermal conductivity of that material.

Thermal resistivity $R = \frac{1}{k}$ -- 4.

Where k = thermal conductivity.

EXPERIMENTATION

Samples Collection and Preparation

Soil samples used for the experiments were collected from three landforms in Akwa Ibom State, Nigeria.

The Landforms are:

Beach Ridge Sand: BRS_I, BRS_2, BRS_3; Coastal Plain Sand: CPS_1, CPS_2, CPS_3; Sandston / Shale Hill Ridges: SHR_1, SHR_2, SHR_3; the soil samples were collected at different depth (0 – 30cm) using soil gauge. Nine different soil samples were collected; locations and sources of collection are as shown in the table below;

Table 1: Showing Landforms and Sources of Soil Samples

LOCATION	SOURCES
Beach Ridge Sand BRS 1	Ikot Ibok, Eket LGA
Beach Ridge Sand BRS 2	Ikot Akpan Mkpe, Onna LGA
Beach Ridge Sand BRS 3	Ikot Akpan Mkpe, Onna LGA
Coastal Plain Sand CPS 1	Ikot Akan, Nsit Ubium LGA
Coastal Plain Sand CPS 2	Ikot Akan, Nsit Ubium LGA
Coastal Plain Sand CPS 3	Uniuyo Annex, Uyo LGA
Sandstone/Shale Hill Ridges SHR 1	Ikpe Ikor Nkon, Ini LGA
Sandstone/Shale Hill Ridges SHR 2	Ibiaku Ntok Okpo, Ikono LGA
Sandstone/Shale Hill Ridges SHR 3	Ntak Inyang, Itu LGA

In order to prepare these samples for use, they were stored in a dry place for one week to solidified; it was then exposed to sun light to dry the sample. To ensure that the water molecules has been removed completely it was placed in an oven for about five minutes. Dry samples were used to avoid the problem of redistribution of water under the influence of temperature gradient. The soil samples were specifically used to determine the thermal properties. Thermal conductivities were determined for each of the samples using the steady state method. Lee disc apparatus for s bad conductor was modified and adapted for use. At the steady state the heat conducted across the soil sample is equal to the rate at which it is emitted from the exposed surface.

The specific heat capacity was determine by cooling correction method (Nelkon and Parker, 1978). Measurement of the bulk density of each of the sample was made by using the weighing and displacement method (Okeke and Anyakoha, 1995).

RESULT AND DISCUSSION

The results obtained during the analysis are showing in table 2 and 3 respectively.

Table 2: Showing the specific heat capacity and density of different Landform

Landforms	**C($Jkg^{-1}k^{-1}$)**	**ρ($Jkg^{-1}k^{-1}$)**
BRS 1	1964.54	1964.35
BRS 2	1431.32	2212.00
BRS 3	1813.63	2430.43
CPS 1	2323.42	2245.22
CPS 2	1428.01	2432.38
CPS 3	2380.21	2412.00
SHR 1	2197.36	2348.42
SHR 2	2228.15	2263.08
SHR 3	3313.24	2485.26

Table 3: The thermal properties of all the landforms under study

Landforms	**k (w/mk)**	**λ(m^2s^{-1})**	**α (m^{-1})**	**R (mkw^{-1})**
BRS 1	0.333	$8.60x10^{-8}$	20.56	3.003
BRS 2	0.363	$11.40x10^{-8}$	17.86	2.755
BRS 3	0.451	$10.20x10^{-8}$	18.88	2.217
CPS 1	0.272	$5.20x10^{-8}$	26.44	3.676
CPS 2	0.302	$8.60X10^{-8}$	20.58	3.311
CPS 3	0.331	$5.70X10^{-8}$	25.26	3.021
SHR 1	0.409	$7.90x10^{-8}$	21.45	2.445
SHR 2	0.501	$9.90x10^{-8}$	19.16	1.996
SHR 3	0.404	$4.90x10^{-8}$	27.24	2.475

Analysis of the results for the experimental determination of thermal conductivity, k; thermal diffusivity, λ; thermal absorbtivity, α; and thermal resistivity, R was done by using Spearman Ranking Correlation Coefficient.

Let, $(x_1\ y_1)$, $(x_2\ y_2) - - - (x_n\ y_n)$ 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 each are

Equal $\frac{\sum n}{n} = \frac{1}{n}\ \frac{n(n+1)}{2} = \frac{n+1}{2}$.

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

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

Where X and Y are deviations from the mean.

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

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

Clearly, $\sum X = \sum Y$ and $\sum X^2 = \sum Y^2$

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

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

$\therefore \sum XY = \frac{1}{2}\left\{\frac{n(n^2-1)}{6} - \sum d^2\right\} = \frac{1}{12}\, n\,(n^2-1) - \frac{1}{2}\sum d^2$ --------------------- (*).

The computation of the coefficient is based on ranks of the sample used for the Pearson's γ, between two variables X and Y is defined by the relations.

$$\gamma = \frac{\sum XY}{\sqrt{(\sum X^2)(\sum Y^2)}} = \frac{\rho}{6\ x\ 6y} = \frac{covariance}{\sqrt{variance\ x}}\frac{(x,y)}{\sqrt{variance\ y}} \quad \text{----------------------------------- 5.}$$

by putting (*) into (5) we have;

$$\gamma = \frac{\frac{1}{2}n(n^2-1) - \frac{1}{2}\sum d^2}{\frac{n(n^2-1)}{12}} = 1 - \frac{6\sum d^2}{n(n^2-1)} \quad \text{-- 6.}$$

(DASS, H. K; 1998); By using equation (6), the results obtained during the analysis for all the thermal properties are shown in table below, with 9 degree of freedom $\boldsymbol{\gamma}_{\text{table at}}\ \boldsymbol{\gamma} = 0.05$, 95%; ANOVA was used for test of hypothesis.

Table 4: Showing result of (K and λ) calculating K_R, λ_R, d= K_R - λ_R and d^2

Landforms	***K*(w/mk)**	**λ (m^2s^{-1})**	***K_R***	**λ_R**	**d=K_R - λ_R**	**d^2**
BRS 1	0.333	8.60×10^{-8}	4.000	5.000	-1.000	1.000
BRS 2	0.363	11.40×10^{-8}	5.000	9.000	-4.000	16.000
BRS 3	0.451	10.20×10^{-8}	8.000	8.000	0.000	0.000
CPS1	0.272	5.20×10^{-8}	1.000	2.000	-1.000	1.000
CPS 2	0.302	8.60×10^{-8}	2.000	6.000	-4.000	16.000
CPS 3	0.331	5.70×10^{-8}	3.000	3.000	0.000	0.000
SHR 1	0.409	7.90×10^{-8}	7.000	4.000	3.000	9.000
SHR 2	0.501	9.9×10^{-8}	9.000	7.000	2.000	4.000
SHR 3	0.404	4.90×10^{-8}	6.000	1.000	5.000	25.000

$\sum d^2 = 72.000$

Using the value of K and λ in the table and spearman rank correlation coefficient

$$\boldsymbol{\gamma} = 1 - \frac{6\sum d^2}{n(n^2-1)} \quad \text{--- 7.}$$

Where n = 9, (number of soil samples) d = K_R,- λ_R, $d^2 = (K_R, - \lambda_R)^2$, K_R, and λ_R are correlation coefficient of thermal conductivity and thermal diffusivity read from correlation table respectively.

But $\sum d^2 = 72.000$ and n = 9

Then, from equation (6) we have: $\gamma = 1 - \frac{6\sum d^2}{n(n^2-1)}$

$\gamma = 1 - \frac{6x72}{9(9^2-1)} = 1 - \frac{432}{720}$

$\gamma = 1 - 0.6$

$\gamma = 0.4000$

By using ANOVA for the analysis of variances,

Null hypothesis (H_O): K = λ, if $\gamma_{cal} > \gamma_{table}$

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

Where γ_{cal} = calculated value of γ and γ_{table} = value from correlation table.

From the correlation table with 9 degree of freedom γ_{table} at γ = 0.05, 95% is 0.683; γ_{table} = 0.683; γ_{cal} = 0.400.

Hence, $\gamma_{table} > \gamma_{cal}$ and the alternative hypothesis is upheld that K ≠ λ, as showing in above table.

The same procedure is repeated for the results in table 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15.

Table 5: Showing result of (K *and* ∝) calculating K_R, $\propto_R$, d = $K_R - \propto_R$ and d^2

Landforms	***K*(w/mk)**	**∝(m^{-1})**	K_R	$\propto_R$	**d=k_R-$\propto_R$**	**d^2**
BRS 1	0.333	20.56	4.000	4.00	0.00	0.00
BRS 2	0.363	17.86	5.000	1.00	4.00	16.00
BRS 3	0.451	18.88	8.000	2.00	6.00	36.00
CPS 1	0.272	26.44	1.000	8.00	-7.00	49.00
CPS 2	0.302	20.58	2.000	5.00	-3.00	9.00
CPS 3	0.331	25.26	3.000	7.00	-4.00	16.00
SHR 1	0.409	21.45	7.000	6.00	1.00	1.00
SHR 2	0.501	19.16	9.000	3.00	6.00	36.00
SHR 3	0.404	27.24	6.000	9.00	-3.00	9.00

$\sum d^2 = 172.00$

Table 6: Showing result of (K and R) calculating K_R R_R, d = $K_R - R_R$ and d^2

Landforms	***K*(w/mk)**	**R(mkw^{-1})**	K_R	**R_R**	**d=K_R-R_R**	**d^2**
BRS 1	0.333	3.003	4.00	6.00	-2.00	4.00
BRS 2	0.363	2.755	5.00	5.00	0.00	0.00
BRS 3	0.451	2.217	8.00	2.00	6.00	36.00
CPS 1	0.272	3.676	1.00	9.00	-8.00	64.00
CPS 2	0.302	3.311	2.00	8.00	-6.00	36.00
CPS 3	0.331	3.021	3.00	7.00	-4.00	16.00
SHR 1	0.409	2.445	7.00	3.00	4.00	16.00
SHR 2	0.501	1.996	9.00	1.00	8.00	64.00
SHR 3	0.404	2.475	6.00	4.00	2.00	4.00

$\sum d^2 = 240.00$

Table 7: Showing result of (λ and K) calculating λ_R K_R, d= λ_R – K_R and d^2

Landforms	**λ (m^2s^{-1})**	***K*(w/mk)**	**λ_R**	**K_R**	**d=λ_R–K_R**	**d^2**
BRS 1	$8.60x10^{-8}$	0.333	5.000	4.000	1.000	1.000
BRS 2	$11.40x10^{-8}$	0.363	9.000	5.000	4.000	16.000
BRS 3	$10.20x10^{-8}$	0.451	8.000	8.000	0.000	0.000
CPS1	$5.20x10^{-8}$	0.272	2.000	1.000	1.000	1.000
CPS 2	$8.60x10^{-8}$	0.302	6.000	2.000	4.000	16.000
CPS 3	$5.70x10^{-8}$	0.331	3.000	3.000	0.000	0.000
SHR 1	$7.90x10^{-8}$	0.409	4.000	7.000	-3.000	9.000
SHR 2	$9.90x10^{-8}$	0.501	7.000	9.000	-2.000	4.000
SHR 3	$4.90x10^{-8}$	0.404	1.000	6.000	-5.000	25.000

$\sum d^2 = 72.000$

Table 8: Showing result of (λ *and* ∝) calculating λ_R, $\propto_R$, d = λ_R – $\propto_R$ and d^2

Landforms	**λ(m^2 s^{-1})**	**∝(m^{-1})**	**λ_R**	**$\propto_R$**	**d=λ_R-$\propto_R$**	**d^2**
BRS 1	$8.60x10^{-8}$	20.56	5.00	4.00	1.00	1.00
BRS 2	$11.40x10^{-8}$	17.86	9.00	1.00	8.00	64.00
BRS 3	$10.20x10^{-8}$	18.88	8.00	2.00	6.00	36.00
CPS 1	$5.20x10^{-8}$	26.44	2.00	8.00	-6.00	36.00
CPS 2	$8.60X10^{-8}$	20.58	6.00	5.00	1.00	1.00
CPS 3	$5.70X10^{-8}$	25.26	3.00	7.00	-4.00	16.00
SHR 1	$7.90x10^{-8}$	21.45	4.00	6.00	-2.00	4.00
SHR 2	$9.9x10^{-8}$	19.16	7.00	3.00	4.00	16.00
SHR 3	$4.90x10^{-8}$	27.24	1.00	9.00	-8.00	64.00

$\sum d^2 = 238.00$

Table 9: Showing result of (λ and R) calculating λ_R R_R, d = λ_R – R_R and d^2

Landforms	**λ(m^2s^{-1})**	**R(mkw^{-1})**	**λ_R**	**R_R**	**d=λ_R-R_R**	**d^2**
BRS 1	$8.60x10^{-8}$	3.003	5.000	6.000	1.000	1.000
BRS 2	$11.40x10^{-8}$	2.755	9.000	5.000	4.000	16.000
BRS 3	$10.20x10^{-8}$	2.217	8.000	2.000	6.000	36.000
CPS 1	$5.20x10^{-8}$	3.676	2.000	9.000	-7.000	49.000
CPS 2	$8.60X10^{-8}$	3.311	6.000	8.000	-2.000	4.000
CPS 3	$5.70X10^{-8}$	3.021	3.000	7.000	-4.000	16.000
SHR 1	$7.90x10^{-8}$	2.445	4.000	3.000	1.000	1.000
SHR 2	$9.9x10^{-8}$	1.996	7.000	1.000	6.000	36.000
SHR 3	$4.90x10^{-8}$	2.475	1.000	4.000	-3.000	9.000

$\sum d^2 = 168.000$

Table 10: Showing result of (∝ and K), calculating $\propto_R$, K_R, d = K_R, - K_R and d^2

Landforms	$\propto(m^{-1})$	*K*(w/mk)	$\propto_R$	K_R	d= $\propto_R$ - k_R	d^2
BRS 1	20.56	0.333	4.000	4.000	0.000	0.000
BRS 2	17.86	0.363	1.000	5.000	-4.000	16.000
BRS 3	18.88	0.451	2.000	8.000	-6.000	36.000
CPS 1	26.44	0.272	8.000	1.000	7.000	49.000
CPS 2	20.58	0.302	5.000	2.000	3.000	9.000
CPS 3	25.26	0.331	7.000	3.000	4.000	16.000
SHR 1	21.45	0.409	6.000	7.000	-1.000	1.000
SHR 2	19.16	0.501	3.00	9.000	-6.000	36.000
SHR 3	27.24	0.404	9.00	6.000	3.000	9.000

$\sum d^2 = 172.000$

Table 11: Showing result of (∝ *and* λ) calculating $\propto_R$, λ_R, d = $\propto_R - \lambda_R$ and d^2

Landforms	$\propto(m^{-1})$	$\lambda(m^2\,s^{-1})$	$\propto_R$	λ_R	d=λ_R-$\propto_R$	d^2
BRS 1	20.56	$8.60x10^{-8}$	4.00	5.00	-1.00	1.00
BRS 2	17.86	$11.40x10^{-8}$	1.00	9.00	-8.00	64.00
BRS 3	18.88	$10.20x10^{-8}$	2.00	8.00	-6.00	36.00
CPS 1	26.44	$5.20x10^{-8}$	8.00	2.00	6.00	36.00
CPS 2	20.58	$8.60X10^{-8}$	5.00	6.00	-1.00	1.00
CPS 3	25.26	$5.70X10^{-8}$	7.00	3.00	4.00	16.00
SHR 1	21.45	$7.90x10^{-8}$	6.00	4.00	2.00	4.00
SHR 2	19.16	$9.9x10^{-8}$	3.00	7.00	-4.00	16.00
SHR 3	27.24	$4.90x10^{-8}$	9.00	1.00	8.00	64.00

$\sum d^2 = 238.00$

Table 12: Showing result of (∝ *and* R) calculating $\propto_R$, R_R, d = $\propto_R - R_R$ and d^2

Landforms	$\propto(m^{-1})$	$R(mkw^{-1})$	$\propto_R$	R_R	d=$\propto_R$-R_R	d^2
BRS 1	20.56	3.003	4.000	6.000	-2.000	4.000
BRS 2	17.86	2.755	1.000	5.000	-4.000	16.000
BRS 3	18.88	2.217	2.000	2.000	0.000	0.000
CPS 1	26.44	3.676	8.000	9.000	-1.000	1.000
CPS 2	20.58	3.311	5.000	8.000	-3.000	9.000
CPS 3	25.26	3.021	7.000	7.000	0.000	0.000
SHR 1	21.45	2.445	6.000	3.000	3.000	9.000
SHR 2	19.16	1.996	3.000	1.000	2.000	4.000
SHR 3	27.24	2.475	9.000	4.000	5.000	25.000

$\sum d^2 = 68.000$

Table 13: Showing result of (R and K), calculating R_R, K_R, d = R_R – K_R and d^2

Landforms	**R (mkw^{-1})**	***K*(w/mk)**	**R_R**	**K_R**	**d=R_R–K_R**	**d^2**
BRS 1	3.003	0.333	6.000	4.000	2.000	4.000
BRS 2	2.755	0.363	5.000	5.000	0.000	0.000
BRS 3	2.217	0.451	2.000	8.000	-6.000	36.000
CPS1	3.676	0.272	9.000	1.000	8.000	64.000
CPS 2	3.311	0.302	8.000	2.000	6.000	36.000
CPS 3	3.021	0.331	7.000	3.000	4.000	16.000
SHR 1	2445	0.409	3.000	7.000	-4.000	16.000
SHR 2	1.996	0.501	1.000	9.000	-8.000	64.000
SHR 3	2.475	0.404	4.000	6.000	-2.000	4.000

$\sum d^2 = 240.000$

Table 14: Showing result of (R and λ) calculating R_R λ_R, d = R_R – λ_R and d^2

Landforms	**R(mkw^{-1})**	**$\lambda(m^2s^{-1})$**	**R_R**	**λ_R**	**d=R_R-λ_R**	**d^2**
BRS 1	3.003	$8.60x10^{-8}$	6.00	5.00	1.00	1.00
BRS 2	2.755	$11.40x10^{-8}$	5.00	9.00	-4.00	16.00
BRS 3	2.217	$10.20x10^{-8}$	2.00	8.00	-6.00	36.00
CPS 1	3.676	$5.20x10^{-8}$	9.00	2.00	7.00	49.00
CPS 2	3.311	$8.60X10^{-8}$	8.00	6.00	2.00	4.00
CPS 3	3.021	$5.70X10^{-8}$	7.00	3.00	4.00	16.00
SHR 1	2.445	$7.90x10^{-8}$	3.00	4.00	-1.00	1.00
SHR 2	1.996	$9.90x10^{-8}$	1.00	7.00	-6.00	36.00
SHR 3	2.475	$4.90x10^{-8}$	4.00	1.00	5.00	25.00

$\sum d^2 = 184.00$

Table 15: Showing result of (R and ∝) calculating R_R, $\propto_R$, d = R_R –$\propto_R$ and d^2

Landforms	**R(mkw^{-1})**	**∝(m^{-1})**	**R_R**	**$\propto_R$**	**d=R_R-$\propto_R$**	**d^2**
BRS 1	3.003	20.56	6.000	4.000	2.000	4.000
BRS 2	2.755	17.86	5.000	1.000	4.000	16.000
BRS 3	2.217	18.88	2.000	2.000	0.000	0.000
CPS 1	3.676	26.44	9.000	8.000	1.000	9.000
CPS 2	3.311	20.58	8.000	5.000	3.000	9.000
CPS 3	3.021	25.26	7.000	7.000	0.000	0.000
SHR 1	2.445	21.45	3.000	6.000	-3.000	9.000
SHR 2	1.996	19.16	1.000	3.000	-2.000	4.000
SHR 3	2.475	27.24	4.000	9.000	-5.000	25.000

$\sum d^2 = 68.000$

Table 16: showing different thermal properties with corresponding correlation coefficient: k – Thermal conductivity, λ – thermal diffusivity, α – thermal absorptivity and R – thermal resistivity, Null hypothesis (H_O), Alternative hypothesis (H_A), γ_{cal}, γ_{tab}, and $\mathbf{d^2}$

Thermal Properties	γ_{cal}	$\gamma_{tab\ at\ 0.05}$	$\mathbf{d^2}$	Null Hypothesis(H_O)	Alternative Hypothesis (H_A)
K and λ	0.400	0.683	72.000	K=λ if $\gamma_{cal} > \gamma_{tab}$	K≠λ if $\gamma_{cal} < \gamma_{tab}$
K *and* α	-0.433	0.683	172.000	K= α if $\gamma_{cal} > \gamma_{tab}$	K ≠ α if $\gamma_{cal} < \gamma_{tab}$
K and R	-1.000	0.683	240.000	K=R if $\gamma_{cal} > \gamma_{tab}$	K ≠ R if $\gamma_{cal} < \gamma_{table}$
λ and k	0.400	0.683	72.000	λ =k if $\gamma_{cal} > \gamma_{tab}$	λ ≠ k if $\gamma_{cal} < \gamma_{tab}$
λ *and* α	-0.983	0.683	238.000	λ=α if $\gamma_{cal} > \gamma_{tab}$	λ ≠ α if $\gamma_{cal} < \gamma_{tab}$
λ and R	-0.400	0.683	238.000	λ=R if $\gamma_{cal} > \gamma_{tab}$	λ≠ R if $\gamma_{cal} < \gamma_{tab}$
α and k	-0.433	0.683	172.000	α=k if $\gamma_{cal} > \gamma_{tab}$	α ≠ k if $\gamma_{cal} < \gamma_{tab}$
α *and* λ	-0.983	0.683	238.000	α=λ if $\gamma_{cal} > \gamma_{tab}$	α ≠ λ if $\gamma_{cal} < \gamma_{tab}$
α and R	0.433	0.683	68.000	α = R if $\gamma_{cal} > \gamma_{tab}$	α ≠ R if $\gamma_{cal} < \gamma_{tab}$
R and K	-1.000	0.683	240.000	R=K if $\gamma_{cal} > \gamma_{tab}$	R ≠ K if $\gamma_{cal} < \gamma_{tab}$
R and λ	-0.533	0.683	184.000	R=λ if $\gamma_{cal} > \gamma_{tab}$	R ≠ λ if $\gamma_{cal} < \gamma_{tab}$
R *and* α	0.433	0.683	68.000	R= α if $\gamma_{cal} > \gamma_{tab}$	R ≠ α if $\gamma_{cal} < \gamma_{tab}$

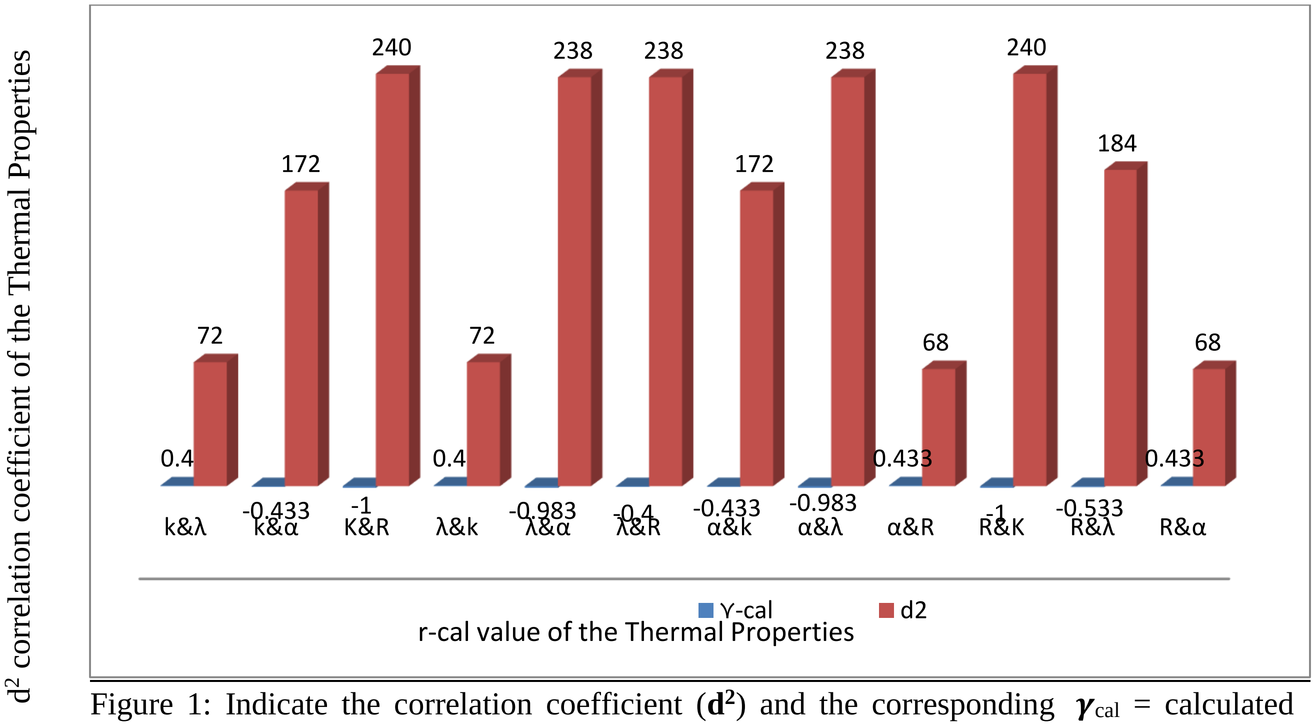

Figure 1: Indicate the correlation coefficient ($\mathbf{d^2}$) and the corresponding γ_{cal} = calculated value of the thermal properties.

SUMMARY AND CONCLUSION

The experiment was conducted using different soil samples (landforms), BRS 1, 2, 3, CPS 1, 2, 3; and SHR 1, 2, 3. The thermal properties of each sample were determined, the result show that the thermal properties of all the landforms are closely related to one another. Also, comparing the result in table 3 with that of the correlation coefficient in table 4 to 15 as summarizes in table 16 and figure 1, indicate that there is no significant different in the thermal properties of the major landforms in Akwa Ibom State, Nigeria. This research is important to civil engineers soil scientists and the farmers; this would help them to know the quality of soil and the type of crops to be cultivated in such soil for a better harvest.

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