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Geophysical Analysis of Soil Properties and Their Effect on Intensive Maize Farming in Jalingo, Taraba State

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ABSTRACT
This study investigated the geophysical properties of selected soil samples and their effects on intensive maize farming in Jalingo, Taraba State. Loamy, sandy and clay soils were analyzed in the laboratory to determine their physical and thermal characteristics, including mass, density, emissivity, thermal conductivity and thermal resistivity. The study applied the steady-state and cooling-curve methods to evaluate heat transfer through the soil samples. Results showed that clay soil had the highest thermal conductivity (1.0675×10^{-3} W/mK) and the lowest thermal resistivity (936.77 mK/W), indicating faster heat transfer. Sandy soil recorded moderate conductivity (8.0985×10^{-4} W/mK) and resistivity (1234.79 mK/W), while loamy soil had the lowest conductivity (2.45×10^{-4} W/mK) and highest resistivity (4000.00 mK/W). The findings indicate that loamy soil provides the most favorable thermal condition for maize cultivation because it supports stable root-zone temperature, better moisture retention and improved root development. Sandy and clay soils can also support maize production, but they require improved management practices such as mulching, organic matter addition, drainage control and proper irrigation. The study concludes that soil thermal behavior is an important factor in intensive maize farming and should be considered when selecting and managing farmland in Jalingo.

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INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops worldwide and serves as a major source of food, livestock feed, and industrial raw materials (Ranum et al 2014 and Shiferaw et al 2011).. According to the Food and Agriculture Organization (FAO), global maize production exceeds one billion tons annually, making it the most widely produced cereal crop (Kaul et al 2019 and Erenstein et al 2022). In sub-Saharan Africa, maize occupies a strategic position in ensuring household food security and supporting rural livelihoods, where millions of smallholder farmers depend on its cultivation as a primary source of income (Santpoort, R. 2020 and Amaza et al 2021). In Nigeria, maize is cultivated across virtually all the zones and represents one of the country's most economically valuable cereal crops. (Chege et al 2024). Despite continuous improvements in crop breeding and fertilizer management, maize productivity in many parts of Nigeria remains below its attainable yield potential (Ojeniyi et al 2024 and Shehu et al 2018). This yield gap has been attributed to several interacting factors, including declining soil fertility, erratic rainfall patterns, poor soil management practices, land degradation, and inadequate understanding of soil physical properties that regulate crop growth. Among these factors, the thermal behavior of agricultural soils has received comparatively less attention despite its fundamental influence on seed germination, root establishment, soil microbial activity, nutrient cycling, and water dynamics (Sharma et al 2023 and Pregitzer, & King, 2025). Soil temperature controls numerous biological and physicochemical processes occurring within the root zone, thereby directly influencing crop development throughout the growing season (Mondal et al 2016)

Consequently, understanding the mechanisms governing soil heat transfer is essential for developing sustainable agricultural management strategies capable of improving maize productivity under changing climatic conditions (Ahmad et al 2024 & Tang et al 2025).The transfer of heat within soils is primarily governed by thermal conductivity, a physical property that quantifies the ability of a material to conduct thermal energy under a temperature gradient (Mitchell et al 2025, Viera et al 2017 & Zhang et al 2020). The thermal conductivity of soil is controlled by a complex interaction of several physical characteristics, including soil texture, bulk density, porosity, moisture content, mineralogical composition, organic matter content, and particle arrangement (Zhang et al 2017).

Among these factors, soil moisture exerts one of the strongest influences because water conducts heat far more efficiently than air occupying pore spaces. As soil moisture increases, air-filled pores are progressively replaced by water, thereby creating continuous pathways for conductive heat transfer (Wen et al 2026).

Clay, sandy, and loamy soils possess contrasting thermal characteristics because of their differences in particle size distribution, pore geometry, water-holding capacity, and mineral composition (Regrassa et al., 2023). Clay soils generally contain abundant fine particles and microspores that retain relatively large quantities of water, thereby increasing their thermal conductivity under moist conditions (Kumar and Tripathi., 2023). However, excessive clay content may also restrict aeration and root penetration when compaction occurs. Sandy soils, in contrast, are characterized by coarse particles, large pore spaces, rapid drainage, and limited moisture retention (Umair et al., 2025).

These characteristics often result in lower thermal conductivity under dry conditions and greater fluctuations in soil temperature due to rapid heating and cooling (He et al., 2021).

Loamy soils, consisting of balanced proportions of sand, silt, and clay, frequently provide intermediate thermal conductivity together with favorable moisture retention, aeration, and nutrient availability. Consequently, loamy soils are generally regarded as highly suitable for intensive crop production because they provide a stable thermal and hydrological environment for root development Gozubuyuk et al., 2014) During maize establishment, rapid and uniform seed germination requires an optimal thermal environment that supports enzymatic activation and vigorous seedling emergence (Waqas et al., 2021). Therefore, characterization of soil thermal conductivity provides valuable insight into the capacity of agricultural soils to maintain favorable root-zone temperatures throughout the crop growth cycle.

Recent advances in agricultural geophysics have demonstrated the growing importance of non-destructive techniques for characterizing subsurface soil properties (Romero-Ruiz et al., 2025) Geophysical methods enable rapid assessment of soil structure, moisture distribution, compaction, porosity, and thermal behavior over relatively large areas with minimal disturbance to the soil profile (Adão et al., 2025).

Integrating soil thermal conductivity data with laboratory analysis allows farmers to maximize crop yields and minimize environmental damages through precision in agriculture.

Previous investigations conducted in different regions have primarily focused on soil fertility, nutrient management, erosion, and moisture availability, while comparatively limited attention has been devoted to evaluating soil thermal properties under tropical agricultural conditions (Kussiy et al., 2025). This lack of site-specific information limits the ability of farmers, agricultural extension officers, and land-use planners to develop effective soil management strategies tailored to local environmental conditions. Reliable thermal conductivity data are therefore needed to improve predictions of soil heat transfer, optimize irrigation practices, guide conservation measures, and support sustainable crop production in the region.

Against this background, the present study investigates the thermal conductivity of representative clay, sandy, and loamy soils within Jalingo Local Government Area using laboratory-based geophysical measurements.

MATERIALS AND METHODS

Study Area and Sampling

The research was conducted in Jalingo with the map in Figure 1. Taraba State lies between Latitude 6º and 8º N of the Equator and longitude 9º and 14º E Meridian. The State is bounded to the North by Gombe and Adamawa States, to the West and Southwest by Plateau and Benue States and to the South by the Republic of Cameroon

The area has two distinct seasons, dry and wet season with temperature and humidity varying with the seasons. The wet season begins in May and ends in September 70% of the total rainfall in the area falls within June to August. The mean annual rainfall for the area is 982mm, while the temperature ranged from 27 ºc to 40 ºc. The vegetation is the savannah type (Sudan Savanah).

Figure 1: Map of Taraba State

To evaluate the thermal conductivity of agricultural soils used for maize cultivation, a field assessment was initially conducted across representative maize-growing areas of Jalingo to identify locations with contrasting soil characteristics. Based on field observations and the predominance of maize cultivation, three representative soil groups, sandy, loamy and clayey soils were selected for comparative analysis. The geographical coordinates of the sampling locations were recorded using a handheld Global Positioning System (GPS) receiver. Soil sampling was conducted within the 0–20 cm depth, corresponding to the principal cultivated surface layer and an important portion of the maize root zone. At each representative location, five subsamples were collected within a 10 m radius after removal of surface litter and other debris. A clean stainless steel auger was used for sampling. The five subsamples from each location were thoroughly homogenized to obtain a composite sample representative of the sampling location. The composite samples were placed in labelled polyethylene bags, sealed to minimize changes in moisture condition during transportation, and transferred to the laboratory for analysis.

Soil Sample Preparation

The collected soil samples were air-dried under laboratory conditions and gently disaggregated. Visible roots, stones and other coarse materials were removed before the samples were passed through a 2-mm sieve. The physical properties of the soils were determined prior to the thermal conductivity experiment. Particle size distribution was determined using a standard hydrometer method, and the proportions of sand, silt and clay were used to establish the textural class of each sample. The resulting laboratory classifications were used to confirm the sandy, loamy and clayey soil categories identified during field assessment

Laboratory Measurement

Thermal conductivity was measured using the steady-state Lee's Disc apparatus. Each prepared soil was compacted into a circular specimen of known diameter and thickness.

The following materials were used in measuring the thermal conductivity of the ceiling sample.

i. Three copper discs A, B and C with a hole drilled in them.

ii. Three thermometers T_A, T_B and T_C which are to be inserted in the holes.
iii. The roofing ceiling sample prepared in the form of disc having the same diameter as the copper disc.
iv. A heat disc (heating element).
v. A wooden frame for clamping the disc together.
vi. A voltmeter, an ammeter, a rheostat, a plug key and a 12-volt battery.
vii. A stop watch.
viii. Groundnut oil.

When steady state has been reached, let $\frac{de}{dt}$ represent the rate of emission of heat from the exposed surfaces measured in $Jm^{-1}S^{-1}$ per ^0C excess temperatures. If it is assumed that the temperature of the specimen S is the mean of the temperatures of A and B, the total heat emitted per second is giver, by

$$\frac{Q}{t} = \frac{de}{dt}a_A\theta_A + \frac{de}{dt}a_S\left(\frac{\theta_A+\theta_B}{2}\right)\frac{de}{dt}a_B\theta_B + \frac{de}{dt}a_C\theta_C \quad \ldots \ (1)$$

Where a_A, a_B, a_C and a_S are the exposed surface areas of A, B, C and S respectively. Now the heat emitted per second is all supplied by the heating element. This is given by

$$\frac{Q}{t} = \text{IV } (JS^{-1}) \ldots \quad (1)$$

Where I is the current measured in amperes end V is the potential drop in volts across the heating element.
Equations (1.0) and (1.1) are equal. Hence,

$$IV = \frac{de}{dt}a_A\theta_A + \frac{de}{dt}a_S\left(\frac{\theta_A+\theta_B}{2}\right)\frac{de}{dt}a_B\theta_B + \frac{de}{dt}a_C\theta_C \quad (2)$$

Hence $$\frac{de}{dt} = \frac{IV,}{a_A\theta_A + a_S\left(\frac{\theta_A+\theta_B}{2}\right)a_B\theta_B + a_C\theta_C} \ldots\ldots\ldots\ldots (1.3)$$

The heat conducted through S per second is given by

$$q = kA\frac{\theta_B - \theta_A}{d} \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where A is the cross sectional area of S, d and K are the thickness and thermal conductivity of S respectively.
Now all the heat entering S from B does not pass into A since some of it is emitted from the curved surface of S. the heat flowing through S is therefore taken as the mean of the heat entering S from B and that leaving S for A. The heat entering s from B is that which is emitted by S and A together. It is given by

$$\frac{de_{AS}}{dt} = \frac{de}{dt}a_A\theta_A + \frac{de}{dt}a_S\left(\frac{\theta_A+\theta_B}{2}\right) \ldots \quad (5)$$

The heat leaving S for A is that which is emitted by A alone. It is given by $ea_A\theta_A$. The mean of these is

$$\frac{1}{2}\left[ea_A\theta_A + ea_S\left(\frac{\theta_A+\theta_B}{2}\right)\right] = ea_A\theta_A + \frac{1}{4}ea_S(\theta_A+\theta_B) \ldots \ (6)$$

At steady state, (3.2) and (3.3) are equal, hence

$$kA\frac{\theta_A+\theta_B}{d} = \frac{de}{dt}a_A\theta_A + \frac{1}{4}\frac{de}{dt}a_S(\theta_A+\theta_B) \ldots \quad (7)$$

Therefore $$k = \frac{de}{a(\theta_A+\theta_B)}\frac{de}{dt}a_A\theta_A + \frac{1}{4}\frac{de}{dt}a_S(\theta_A+\theta_B) \quad (8)$$

Experiment Setup

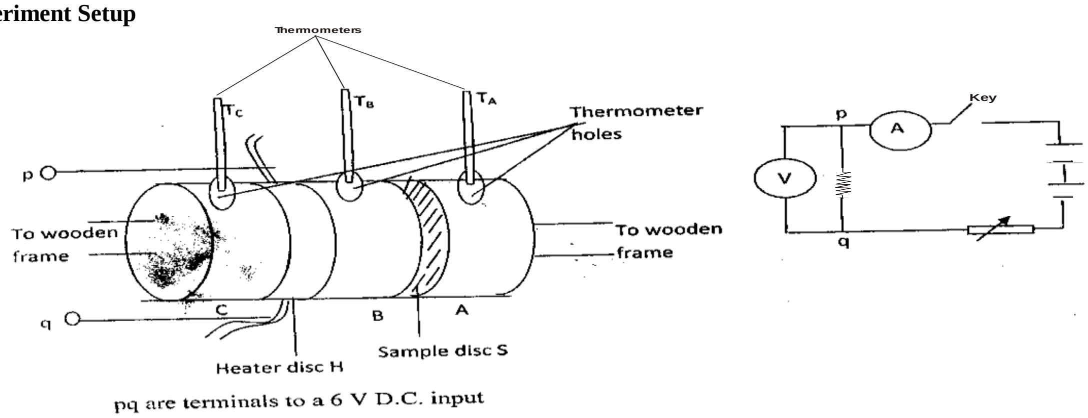

Figure 2: Pq are Terminals to a 6 V D.C Input

Procedure for Soil Sample Measurement

Various soil samples sandy loam (Sample A), loam (Sample B), clay loam (Sample C), and sandy clay loam (Sample D) the thermal conductivity to be determined the copper disc the soil sample and heating element were placed together in the following order Disc A, sample S, Disc B, heating element and the Disc C with assurance that the holes in the discs were directed upwards. The thermometers T_A and T_B were inserted into the metal discs A and B place on either side of the sample Disc S and the space around the thermometer bulbs filled with oil to maximize thermal contact.

The heater disc was connected to a low voltage power supply and a steady state was reached where the temperature lies between (70^o - 90^o). This is the temperature at which heat loss through sample to Disc B is equal to the heat gained by the sample from Disc A. the temperature reading were recorded and the rate of heat loss from the Disc A was found which was achieved by removing Disc B, C and S and heating the Disc A directly to about 10^oC above the steady state temperature earlier recorded.

The heater Disc was removed and samples were placed, the rise in temperature at intervals of one minute was measured. The above procedure was repeated for each soil sample. The diameter for Disc B was determined using Venier caliper, the thicknesses of the samples were also determined using micrometer screw gauge and the beam balance was used to measure the mass of the Disc B. A cooling curve was plotted for each sample and the slope was also determined, then the thermal conductivity (K) of each sample was determine using

$$\frac{de}{dt} = kA\frac{\theta_B-\theta_A}{d} \quad \ldots\ldots\ldots \quad (9)$$

Where K is the thermal conductivity to be determined
A is the cross-sectional area of the soil samples and is given as

$$A = \frac{\pi D^2}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

$\frac{d\theta}{dt}$ Is the rate of heat loss and $(\theta_B - \theta_A)$ is the temperature difference

RESULTS AND DISCUSSION

This chapter presents the laboratory results obtained from the geophysical analysis of selected soil samples in Jalingo, Taraba State. The objective addressed in this chapter is to determine the thermal properties of loamy, sandy and clay soils and explain how these properties can affect intensive maize farming. The measured and calculated parameters include thickness, cross-sectional area, mass, emissivity, density, thermal conductivity and thermal resistivity.

The analysis was based on the steady-state method and the cooling-curve method. Thermal conductivity was used to determine the ability of each soil sample to transmit heat, while thermal resistivity was used to determine the resistance of each soil sample to heat flow. These properties are important in maize production because soil temperature influences germination, root development, moisture retention and nutrient uptake

Sample Specification

The three samples in table 1 have the same thickness, cross-sectional area and diameter. The mass values differed among the samples, indicating differences in compactness and soil structure. Sandy soil had the highest mass, followed by clay soil, while loamy soil had the lowest mass. This difference is important because soil density affects pore spaces, aeration, water movement and root penetration.

Table 1 presents the physical specifications of the selected soil samples used for the laboratory analysis

Table 1: Specification of the Soil Samples

Specimen	Thickness (m)	Area (m^2)	Diameter (cm)	Mass (kg)
Loamy soil	7.47×10^{-3}	1.32×10^{-3}	4.2	7.49×10^{-3}
Sandy soil	7.47×10^{-3}	1.32×10^{-3}	4.2	11.58×10^{-3}
Clay soil	7.47×10^{-3}	1.32×10^{-3}	4.2	9.64×10^{-3}

Thermal Conductivity Calculation

The thermal conductivity of the soil samples was obtained from the cooling curve using the relationship:

$$K = \frac{M_C \left(\frac{\Delta T}{\Delta t} \right) x}{A(\theta_B - \theta_A)} \quad (1)$$

where K is thermal conductivity, M_c is the mass of the copper disc, $\Delta T/\Delta t$ is the slope of the cooling curve, x is the thickness of the sample, A is the cross-sectional area and $(\theta_B - \theta_A)$ is the temperature difference across the sample. Thermal resistivity was calculated as:

$$R_t = \frac{1}{K} \quad (2)$$

where R_t is thermal resistivity. Density was determined from the ratio of mass to volume.

Table 2 shows the cooling-curve values used in determining the thermal conductivity of the soil samples

Table 2: Cooling-curve Summary for the Soil Samples

Specimen	Initial temp. (°C)	Final temp. (°C)	Time (min)	Slope (°C/s)	Temp. diff. (°C)
Loamy soil	57.0	34.0	77	6.58×10^{-3}	36
Sandy soil	61.0	44.0	38	9.65×10^{-3}	16
Clay soil	58.0	35.0	36	9.54×10^{-3}	12

Table 3 presents the calculated thermal properties of the Soil Samples The results showed that clay soil had the highest thermal conductivity with a value of 1.0675×10^{-3} W/mK, followed by sandy soil with 8.0985×10^{-4} W/mK, while loamy soil had the lowest value of $2.45 \times 10^{-}$ W/mK. This means that clay soil transferred heat more readily than the other samples, while loamy soil resisted heat movement more effectively

The thermal resistivity values presented in table 3 showed the opposite trend. Loamy soil had the highest thermal resistivity of 4000.00 mK/W, sandy soil had 1234.79 mK/W, and clay soil had the lowest value of 936.77 mK/W. A high thermal resistivity means that the soil can reduce rapid heat flow and maintain a more stable temperature condition around the maize root zone (Zuo et al., 2023)

The density values also varied among the samples. Sandy soil recorded the highest density of 320.86 kg/m3, followed by clay soil with 267.11 kg/m3, while loamy soil had the lowest density of 207.54 kg/m3. The lower density of loamy soil suggests better pore spaces, which can improve aeration, water movement and root penetration when compared with more compact soil conditions (Yu et al., 2024)

Table 3 presents the calculated thermal conductivity, thermal resistivity, density and emissivity of the three soil samples.

Table 3: Calculated Thermal Properties of the Selected Soil Samples

Specimen	Conductivity (W/mK)	Resistivity (mK/W)	Density (kg/m^3)	Emissivity (W/m^2s)
Loamy soil	2.45×10^{-4}	4000.00	207.54	12.53
Sandy soil	8.0985×10^{-4}	1234.79	320.86	13.80
Clay soil	1.0675×10^{-3}	936.77	267.11	18.277

Table 4 provides the agronomical implications of the different soil components. The result indicates that loamy soil is the most favorable of the three samples for intensive maize farming in the study area. Its low thermal conductivity and high thermal resistivity imply that it does not transfer heat too quickly. This helps to maintain moderate soil temperature, reduce heat stress and support better germination and early root development. Loamy soil also provides a good balance between water retention and drainage, which is important for maize growth.

Sandy soil showed moderate thermal conductivity and resistivity. This means it can warm up faster than loamy soil and may lose moisture more quickly. Although sandy soil allows good drainage and aeration, it may require frequent irrigation, mulching and organic matter addition for intensive maize production. Without proper management, maize grown on sandy soil may suffer from moisture stress and nutrient leaching.

Clay soil recorded the highest thermal conductivity and lowest thermal resistivity. This shows that clay soil allows heat to move more easily through it. Clay soil can retain water, but it may also become compacted or waterlogged if drainage is poor. For maize farming, clay soil requires good tillage, ridging and drainage management to prevent poor aeration and root restriction.

Based on the thermal properties obtained, the order of suitability for intensive maize farming is loamy soil, followed by sandy soil, and then clay soil. However, all the soil types can support maize production if appropriate soil management practices are applied. The density results suggest that soil structure and compaction differ among the samples, which can affect aeration, water infiltration and maize root growth. The results show that soil thermal behavior is an important factor to consider in intensive maize farming in Jalingo, Taraba State

Table 4: Agronomic Implications

Property	Loamy	Sandy	Clay	Effect on maize
Temperature stability	Excellent	Moderate	Good	Uniform germination
Moisture conservation	Excellent	Poor	Very good	Controls drought stress
Root development	Excellent	Good	Moderate	Influences nutrient uptake
Overall suitability	Highest	Moderate	High with management	Yield potential

The study establishes that loamy soil exhibits the lowest thermal conductivity and highest thermal resistivity among the tested types, providing a stable root-zone environment for maize cultivation in Jalingo, Taraba State, which aligns with previous literature on balanced hydrological conditions (Adnan 2026 & Al-Shammary et al., 2025). While loamy soil naturally offers optimal thermal stability and moisture retention for maize production, sandy and clay soils can also support intensive farming when paired with targeted management practices such as mulching, organic amendments, and irrigation control

CONCLUSION

This study examined the thermal properties of loamy, sandy and clay soils and their effects on intensive maize farming in Jalingo, Taraba State. The results revealed clear differences in the thermal conductivity, thermal resistivity, density and emissivity of the soil samples. Loamy soil was found to be the most suitable soil for intensive maize farming because it had the lowest thermal conductivity and highest thermal resistivity. These properties help the soil to maintain a more stable temperature, reduce rapid heat transfer and support favorable conditions for maize germination and root development, thus farmers in Jalingo should prioritize loamy soils for intensive maize farming due to their superior thermal stability and favorable root conditions. For sandy and clay soils, farmers should apply organic manure and practice mulching to improve soil structure, conserve moisture, and prevent excessive surface heating.

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Appendix

Loamy Soil

Emissivity (e)

e = $\frac{IV}{a_A\theta_A + a_s\frac{(\theta_A+\theta_B)}{2}a_B\,\theta_B + a_c\,\theta_c}$

Parameters I = 0.5amp

V= 10vol

a_A, a_B, a_C a_S=exposed surface areas of A, B, C and S respectively

a_A = 1.56 × $10^{-3}m^3$ (for brass disc as calculated earlier)

θ_A = 48.0°C

a_S = $2\pi rx$ = 9.62 × $10^{-4}m^2$ (same size and thickness as the metal)

$(\frac{\theta_A+\theta_B}{2})$ = $(\frac{48.0+84}{2})$ = 66. 0°C

a_A = same with a_B (brass disc same size) =1.56 × 10^{-3} m^3

θ_B = 84.°C

a_A = 1. 56 × $10^{-3}m^3$

e = $\frac{IV}{a_A\;\theta_A + as\left(\frac{\theta_A+\theta_B}{2}\right)+\theta_B\,a_B + a_C\,\theta_C}$

e = $\frac{10\times0.5}{(1.56\times10^{-3}\times48)+(9.62\times10^{-4}\times66)+(1.56\times10^{-3}\times84)+(1.56\times10^{-3}\times83)}$

e=$\frac{5.0}{0.07488+0.063492+0.13104+0.12948} = \frac{5.0}{0.398892}$= 12.53

e = 12.53 W/km^2s

Determine of K Arithmetically

K= $\frac{x\times e}{A(\theta_B-\theta_A)}\times a_A\;\theta_A + \frac{1}{4}\,a_s\,(\theta_A+\theta_B)$

e = 12.53w/m^2s

x = thickness of loamy soil = 7.47 × 10^{-3}m

a_A = 1.56×$10^{-3}m^2$

θ_A= 48.0^0C

a_s = 9.62 × $10^{-4}m^2$

$(\theta_A+\theta_B)$ = (48 +84) =132^0c

A =cross section area of disc = πr^2 = 1.32 ×$10^{-3}m^2$

$(\theta_A-\theta_B)$ = (84 -48) =36.0°C

K = $\frac{7.47\times10^{-3}\times12.53}{(1.32\times10^{-3}\times36)}$ ×1.56× $10^{-3}\times48$ + $\frac{1}{4}[9.62\times10^{-4}\times(132)]$

K =1.969678 × 1.56 ×$10^{-3}\times$48

K = 0.1474894 + 0.031746 = 0.179 w/mk

Density (ρ) = mass/ volume

Mass of loamy soil = 7.49 ×$10^{-3}kg$

Volume = $\frac{4}{3}\pi r^3$ =3.609 ×$10^{-5}M^3$

ρ = 7.49 × 10^{-3}/3.609 ×10^{-5}

ρ = 207. 54 kg/m^3

Thermal resistivity $\rho = \frac{1}{K}$

$\rho = \frac{1}{0.0179} = 55.865$

(ρ) = 55.805 W^{-1}/mK

Table 2: The Rate of Cooling of Sample A Loamy Soil

Time (t) min	Temp (T) °C	Time (t) min	Temp (T) °C	Time (t) min	Temp (T) °C
1.0	57.00	27.0	43.00	62.0	35.30
2.0	56.00	28.0	42.20	630	35.20
3.0	55.00	29.0	42.00	64.0	35.10
4.0	54.80	30.0	41.70	65.0	35.00
5.0	53.80	31.0	41.50	66.0	35.00
6.0	53.00	32.0	40.90	67.0	34.90
7.0	52.80	33.0	40.80	68.0	34.80
8.0	52.00	34.0	40.30	69.0	34.80
9.0	51.00	35.0	40.00	70.0	34.80
10.0	50.50	36.0	39.80	71.0	34.50
11.0	49.80	37.0	39.20	72.0	34.30
12.0	49.50	38.0	39.00	73.0	34.20
13.0	49.00	39.0	38.80	74.0	34.20
14.0	48.20	40.0	38.20	75.0	34.20
15.0	47.90	41.0	38.00	76.0	34.00
16.0	47.20	42.0	38.00	77.0	34.00
17.0	47.00	43.0	38.00	62.0	35.30
18.0	46.20	44.0	37.90	63.0	35.20
19.0	46.00	45.0	37.80	64.0	35.10
20.0	45.50	46.0	37.80	65.0	35.00
21.0	45.10	47.0	37.80	66.0	35.00
22.0	44.80	48.0	37.70	67.0	34.90
23.0	44.20	49.0	37.20	68.0	34.80

Time (t) min	Temp (T) °C	Time (t) min	Temp (T) °C	Time (t) min	Temp (T) °C
24.0	44.00	50.0	37.00	69.0	34.80
25.0	43.80	51.0	36.90	70.0	34.80
26.0	43.20	52.0	36.80	71.0	34.50

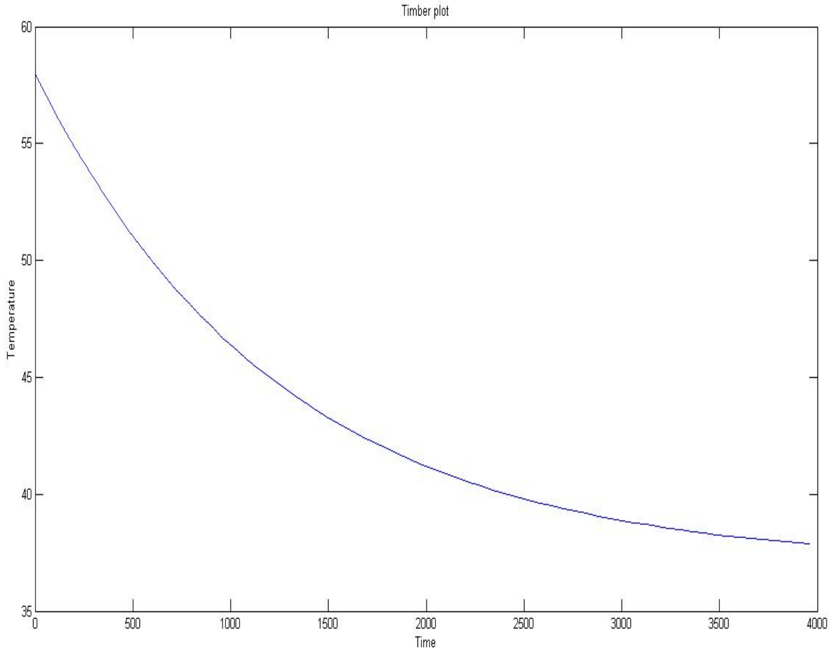

Figure 1: Temperature vs. Time for Loamy Soil

Determination of thermal conductivity (K) from the cooling curve i.e. using the value of $\frac{\Delta T}{\Delta t}$ (slope) of the curve.

From equation 1.6 $K = \frac{M_c \frac{\Delta T}{\Delta t} x}{A(\theta_B - \theta_A)}$

Where $M_C = 146 \ X \ 10^{-3}$kg

$\frac{\Delta T}{\Delta t}$ (Slope) = 6.58 X 10^{-4} $°C/s$

$A = 1.32 \ X \ 10^{-3} \ m^2$

$x = 12.14X \ 10^{-3} \ m$

$\theta_B - \theta_A = 36°C$

$k = \frac{146 \ X10^{-3} X \ 6.58 \ X10^{-3} X \ 12.14 \ X \ 10^{-3}}{1.32 \ X \ 10^{-3} (36)} = \frac{1.1663 \ X10^{-5}}{0.04752} = 0.000245 \ W/mk$

Resistivity (ρ) = $\frac{1}{K} = \frac{1}{0.000245} = 4000 \ W^{-1}/mk$