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Air and soil's Water Temperature and Entropy Variation in Akungba Akoko

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ABSTRACT

Two similar PIC18F4520 based temperature circuits with two LM34DZ temperature sensor ICs were used to construct soil and air temperature measuring equipment. Temperature data were recorded 2cm in the soil and 2m away in the air every 2 hours from the hours of 9 am to 5pm daily 5pm for 3 days starting from May 11th 2015. The average deviation in temperature of soil 3.6888 is higher than air 1.5728 and the average deviation in air entropy is less than (0.24033) twice that of soil (0.56283) for the first day. The soil temperature has higher average deviation from mean (2.9584) than air (1.2544). and entropy also has higher deviation from its mean (0.45482) than air (0.17642) in the second day. The same trend was repeated in the third day and entropy curve more clearly indicated rainfall event of the first day. Average deviations from the mean of temperature and entropy data for the soil in the 3 days are higher than for troposphere or air showing that temperature varies more in soil.

Keywords: Temperature, Entropy, Soil, Air, Average Deviation, Day
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INTRODUCTION

The digital measurement of soil and air temperature mainly shows the various effect of soil nature on the altitude above it and the effect of varying atmospheric weather on soil and air above it. The temperature data will vary from place due to the type of soil, the vegetation cover, the evapotranspiration and the general weather condition. This temperature variation affects the entropy of water vapour in the soil and air. The rate of change in temperature of a soil body at a given depth is the result of the flux of heat and the thermal capacity or the amount of heat required to change the temperature of a given mass of soil (Batjes and. Bridges, 1992) by:

$dT/dt = kd^2T/(Dcdz^2)$

where: D = soil density,c = specific heat capacity,k = thermal conductivity

k/Dc = thermal diffusivity.

It was stated experimentally that change of Temperature for various levels of the soil water potential affecting the net earth surface radiation flux Rn changes up to 20% of Rn maximum value (.Baranowski et al., 2005). Temperature of soil is hence an important data that should be studied in detail and when generally studied over the years can be related to soil degradation, agricultural productivity, how polluted the environment is tending and underground activities whether large ammunition or nuclear materials are buried in the subsurface. It is not always the case that temperature will decrease with altitude, the fluctuation of temperature with altitude can even show whether the atmosphere is stable or not. The measurement of temperature provides a tool for predicting a number of things about the flying conditions of any given day. The humidity at ground level and the maximum temperature of the day can be used to predict:

- Cloud base at altitudes,
- Trigger temperature (the temperature that air pockets must reach in order to be released as thermals),
- The likelihood of thunderstorms, the amount of cloud cover and the expected day quality in terms of thermal strength.

The temperature as function of altitude (to large altitudes) is physically acquired by releasing balloons (called radiosondes) that sends their measurements (soundings) back to earth by radio transmission (Cimini et al., 2105, www.bergbahnen-werfenweng.com, 2015). The actual computation of coordinate system, with its complex combination of isotherms, saturated and dry adiabats and the mixing ratio (weather parameter functions) are also performable. These possibilities has brought about real time monitoring of variation of temperature and other weather parameters in environmental monitoring (temperature can be monitored with temperature-logging equipment on a specific schedule such as hourly, daily, or monthly (James et al., 2007, Lapham, 1988), decision implementation and prompt hazard prediction. In this analysis, variations of temperature and water entropy are considered.

The state $S_m(V,T)$ of water in soil or air is characterized by the Volume V and Temperature T hence for a non-isochoric process Nernst's theorem states that

$$S_m(V,T) = \int_0^{V,T} \frac{\acute{d}Q}{T} \quad \text{.......1}$$

At volume V_0 and temperature T_0 the water vapour is an ideal gas and equation 1 can be splitted into two forms

$$S_m(V,T) = \int_0^{(V_0,T_0)} \frac{\acute{d}Q}{T} + \int_0^{(V,T)} \frac{\acute{d}Q}{T} \quad \text{.......2}$$

Where $\acute{d}Q$ is the amount of heat received by the system in a reversible process and T is the temperature of the system (Savelyev, 1979).

$$\acute{d}Q = C_v dT + pdV \quad \text{.......3}$$

Since pdV=RdT, Equation 2 can be solved after integration and dividing by T as

$$\int_{(V_0,T_0)}^{(V,T)} \frac{\acute{d}Q}{T} = \int_{T_0}^{T} \frac{C_v dT}{T} + \int_{V}^{V} \frac{RdV}{V} = C_v \ln\frac{T}{T_0} + R\ln\frac{V}{V_0} \quad \text{.......4}$$

The Entropy of water at constant volume changes with temperature from 0 to 100^{0}C. Equations 2 and 4 become

$$S(T) - S(T_0) = \int_{T_0}^{T} \frac{C_v dT}{T} = C_v \ln\frac{T}{T_0} \quad \text{.......5}$$

T=273, hence $S(T) - S(273) = C_v \ln T - C_v \ln 273$

$$S(T) = C_v \ln T + \text{Constant} \quad \text{.......6}$$

The entropy of water can be computed with specific heat capacity of water taken as 4.2kJ/(kg.K).

GEOLOGY OF RESEARCH LOCATION

The site for the measurement is located in Akungba Akoko with the longitude N7 28 197 and latitude E005 44 125 and the elevation ranging from 328.2m to 335.7m. . It is 753m perpendicular away from middle of an East west massive spanning granite gneiss outcrop of total length 2.3 km. The regolith surface is sandy clay while the interior is lateritic, followed by thin weathered layer of soft granite gneiss next to the hardened granite gneiss. The depth of this measurement is 3cm within the sandy clay layer.

MATERIAL AND METHODS

Two similar PIC18F4520 based temperature circuits were modified from embedded lab PIC16f887 temperature circuit design guide, programmed in C and constructed. Each temperature was compared with ambient air temperature reading of mercury in glass thermometer and the readings were comparably similar. The LM34DZ integrated circuit sensor was placed 2cm into the soil and 2m away in the air and values of LCD displayed temperatures were recorded every 2 hours from the hours of 9 am to 5pm daily.

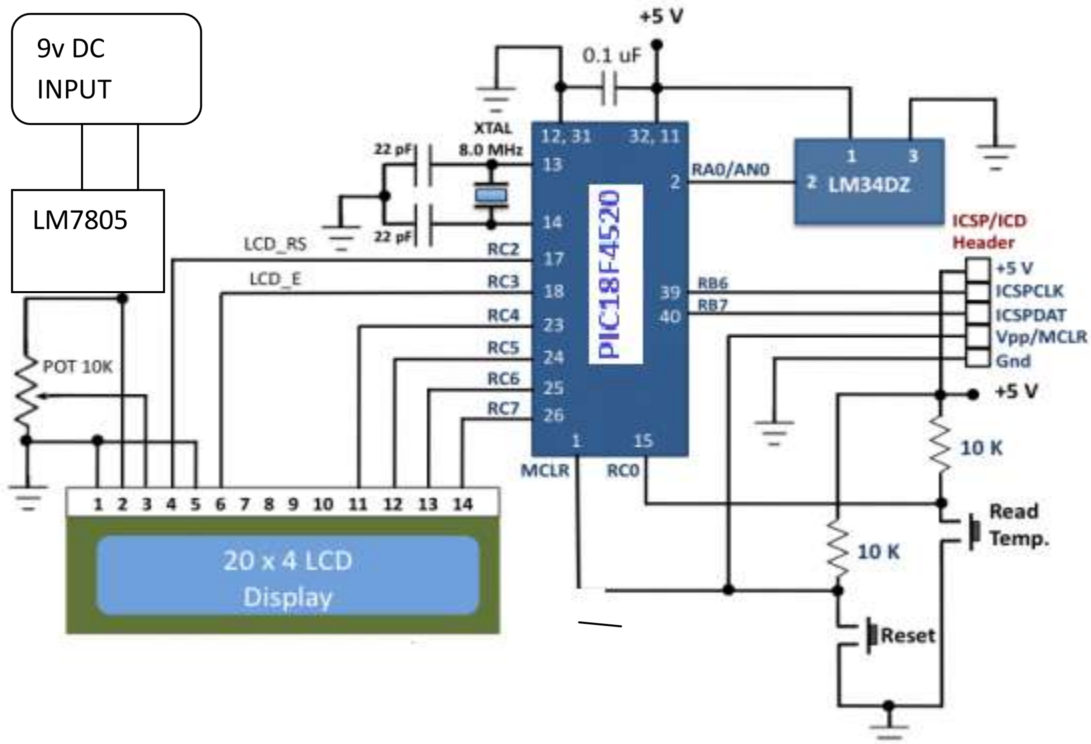

Fig.1 PIC18F4520 temperature circuit modified from http://embedded-lab.com, 2015.

Table 1. Air and Soil Temperatures (in ^{0}C) of Days 1 to 3

TIME	AIR	SOIL	AIR	SOIL	AIR	SOIL
9.00 AM	27.64	26.27	28.34	22.34	25.37	21.81
11.00 AM	24.33	22.10	28.60	27.34	27.66	28.64
1.00 PM	26.36	30.52	30.64	32.87	28.32	35.15
3.00 PM	26.69	32.22	31.64	30.87	27.60	25.06
5.00 PM	30.50	32.87	28.64	29.27	26.36	27.66
Average Deviation	1.5728	3.6888	1.2544	2.9584	0.9576	3.3848

Table 2. Air and Soil's Water Entropy of Days 1 to 3

TIME	AIR	SOIL	AIR	SOIL	AIR	SOIL
9.00 AM	13.9409	13.7274	14.046	13.0468	13.581	12.9459
11.00 AM	13.4052	13.0014	14.0843	13.8951	13.9439	14.0902
1.00PM	13.7418	14.3572	14.3737	14.6688	14.043	14.9504
3.00 PM	13.79401	14.5849	14.5086	14.4051	13.9348	13.5293
5.00 PM	14.3545	14.6688	14.0902	14.1816	13.7418	13.9439
Average Deviation	0.24033	0.56283	0.17642	0.45482	0.15	0.52347

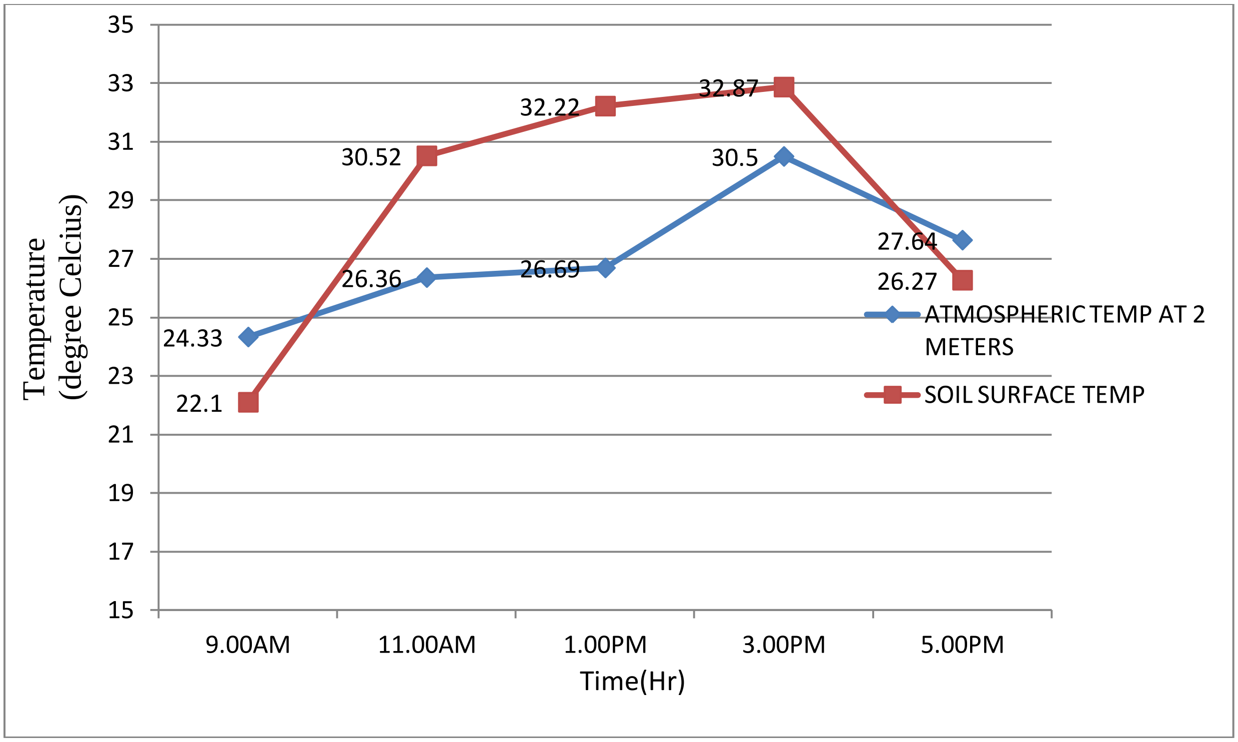

Figure 2. Temperature Variations in Air and Soil on day

Table 1 and figure 2 both show atmospheric temperature initially higher than soil temperature at 9am. The soil temperature increased after 10 am more than air temperature until after 4 pm, this can be due to soil storing heat more than air. The average deviation in temperature of soil 3.6888 is higher than air 1.5728, showing that temperature varies more in soil for about 1 hour of rainfall occurring around 11 am.

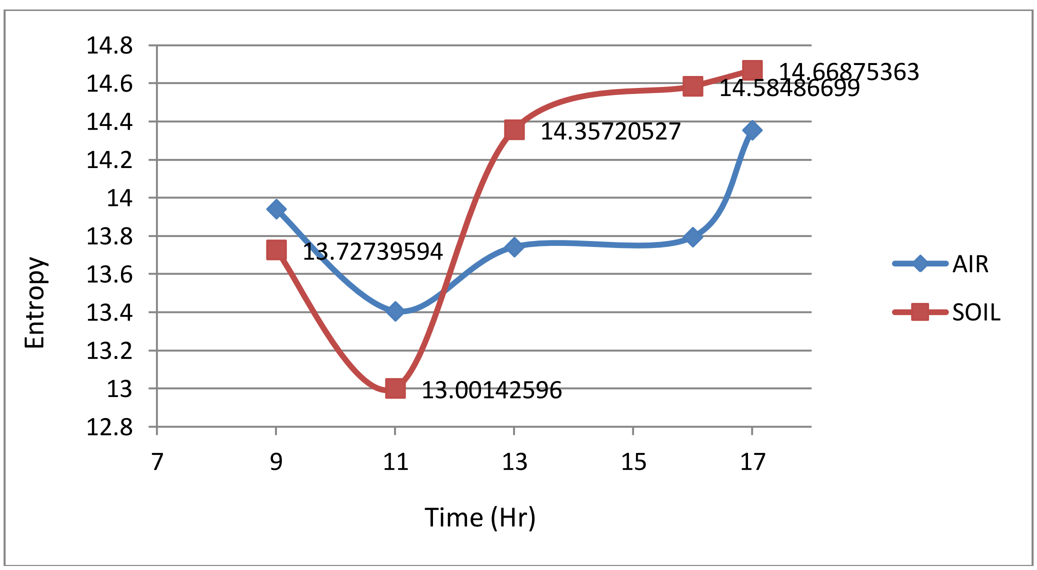

Figure 3. Entropy Variation in Soil and Air on day 1

Table 2 and figure 3 indicate the air entropy with higher values than soil entropy until 12 noon when soil entropy temperature became greater until after 5pm. The entropy of soil was the lowest at 11 am and also highest at 5 pm and the entropy trends are different from those of soil and atmospheric temperature. The entropy showed more vividly the period around 11 am when rain fell on the first day but the temperature indicated heat regime better in that soil was absorbing heat more rapidly than the troposphere. The average deviation in air entropy is less than (0.24033) twice that of soil (0.56283) for the first day when there was about 1 hour of rain.

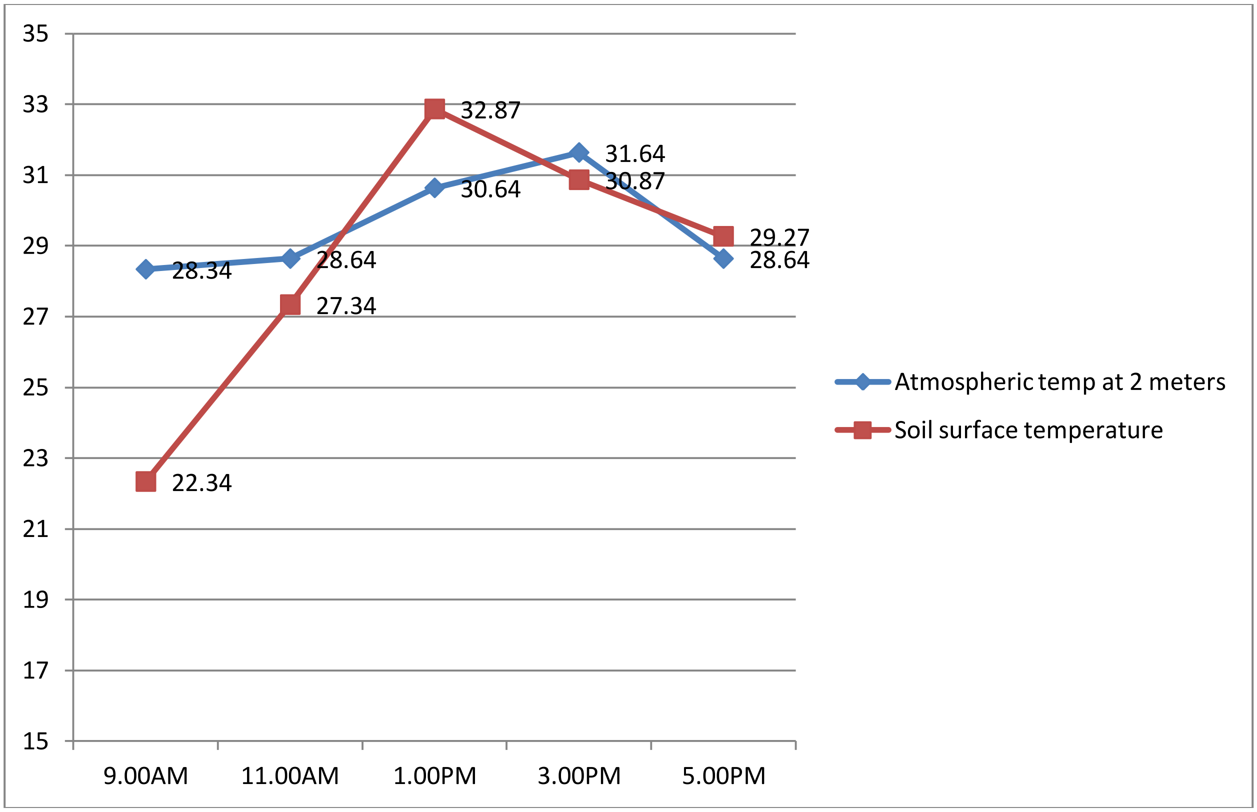

Figure 4. Temperature Variations in Air and Soil on day 2

Table 1 and figure 4 both show atmospheric temperature initially higher than soil temperature until after 11am. The soil temperature thereafter increased more than air temperature until after 1 pm, the soil emitted temperature more than the first day. The entropy on the same day in figure 5 for air was higher than soil's until after 11 am. Soil entropy increased thereafter reaching maximum at 1pm until after 3 pm when air temperature increased a little more and both continued to decrease. The temperature trend was the same for entropy of day 2 shown in figure 5 with soil temperature having higher average deviation from mean (2.9584) than air (1.2544). The soil entropy also has higher deviation from its mean (0.45482) than air (0.17642).

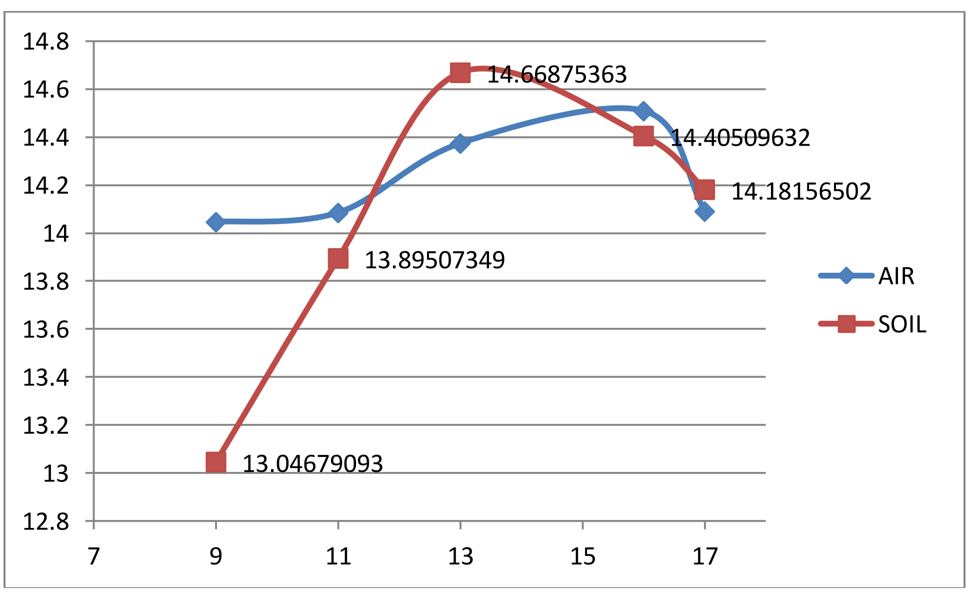

Figure 5. Entropy Variation in Soil and Air on day 2

Table 1 and figure 6 show the air temperature values increasing more than soil temperature until 11 am where soil temperature became higher reaching maximum value of 35.15^{0}C at1 pm and reduced more rapidly than air temperature. It became lower than air temperature at 3pm but changed after few minutes and eventually became higher than air temperature. The entropy shown in figure 7 has similar trend as soil temperature have higher average deviation (3.3848) than air (0.9576). The entropy of soil fluctuates more about its mean (0.5247) than air (0.15). Both second and third day temperatures and entropy showed similar trends and soil emitted more heat for the two days when there was no rainfall and the weather was similar. The first day has highest magnitudes of average deviation of temperature and entropy than the remaining second and third days.

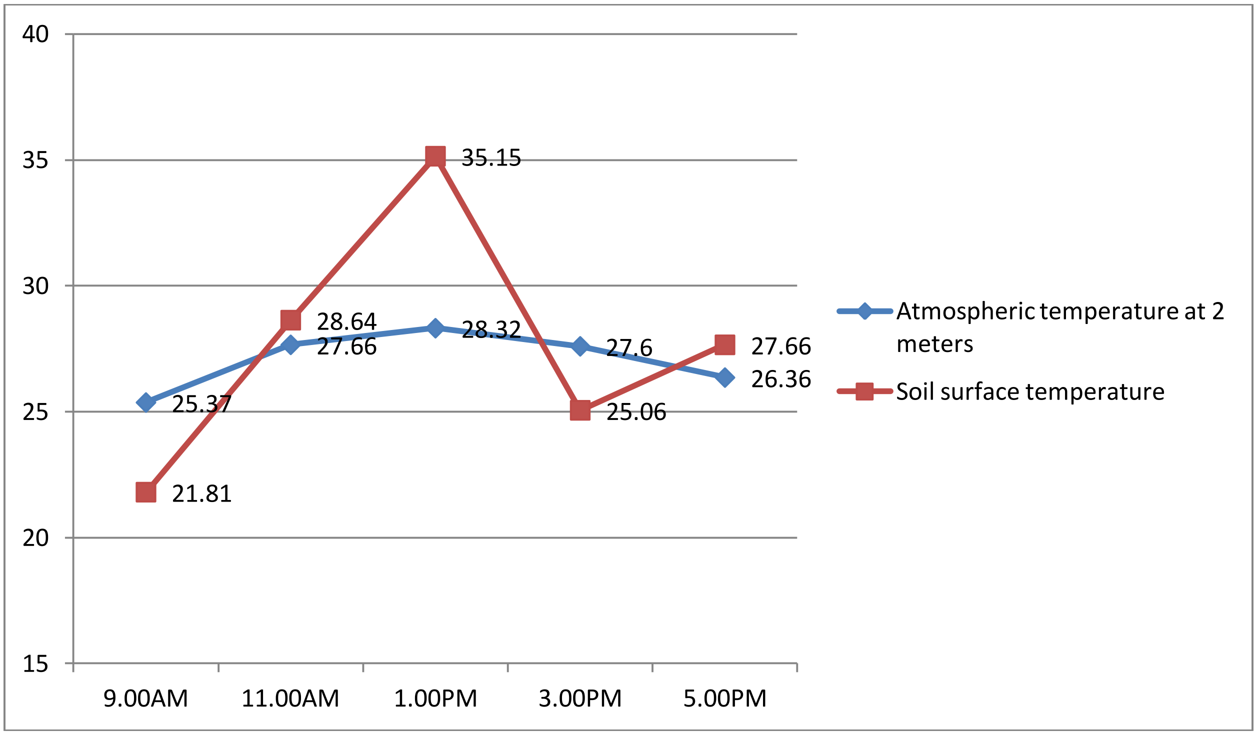

Figure: 6. Temperature Variations in Air and Soil on day 3

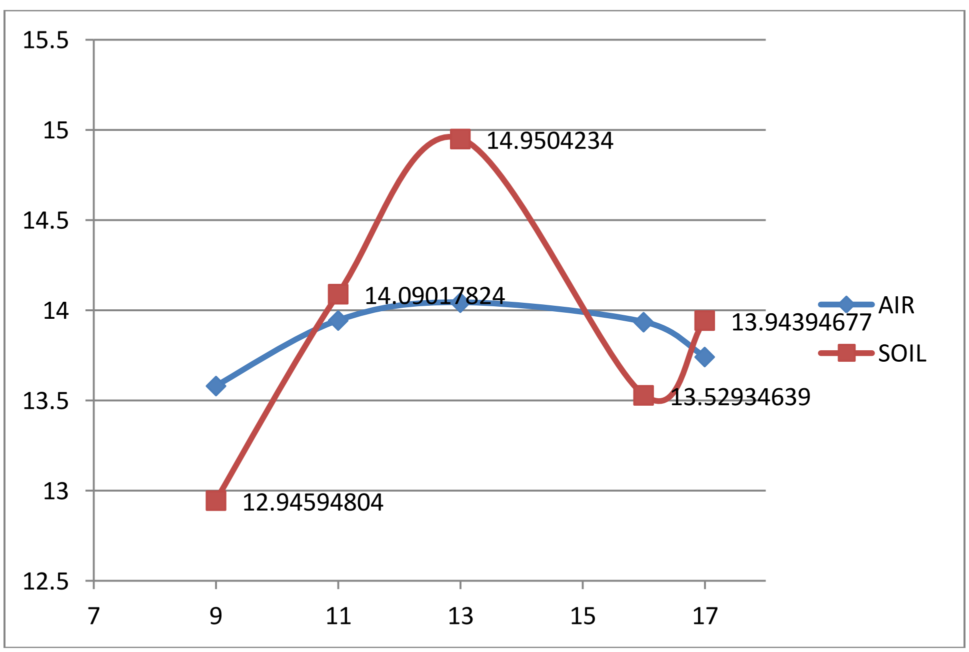

Figure 7. Entropy Variation in Soil and Air on day 3

CONCLUSION

The measurement of temperature and computation of entropy provided data used for the interpretation of soil and air or troposphere conditions. The trend of increase in soil temperature that is more than air showed that soil absorbed more heat. The rainfall event was corroborated by the curve of entropy falling to the lowest value and rising around the rainfall period on the first day. The average deviations from the mean in temperature and entropy for the soil in the 3 days are higher than for troposphere or air. Further works suggested are to study and interpret the variation of temperature, soil moisture, entropy and rainfall data over longer hours. The present circuit capability should then be increased to monitor and store the relevant parameters by adding more sensors, larger EEPROM and reprogramming.

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