HEAT FLUX IN SANDY SOIL AND ITS RELATIONS WITH SOIL AND AIR TEMPERATURE

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ABSTRACT

A heat flux plate was installed at 0.05m depth and thermo wires were installed at 0.05 and 0.3m depths in sandy soil with grasses of the surface at Ismailia Agriculture Research Station. Data of soil heat flux (G) (W/m^2) and soil temperatures were recorded every fifteen mints to represent 96 readings/day and air temperatures (^oC) were recorded every one hour. Finally, twenty four values for soil heat flux, soil temperatures were calculated and air temperature were recorded along a year. The objectives must study the soil heat flux at 0.05m depth and its relation to soil and air temperature. Also to calculate heat flux at 0.3m depth and determined the relation between G at 0.05m and G at 0.3m.

The obtained results showed that soil heat flux values (W/m^2) at 0.05 m depth were higher at the day time with their peaks were at the mid day. The values became negative at night and early morning in the months of December, January, February and March, while the values became positive and low at early morning in the other months.

Soil heat flux had been affected by both soil and air temperatures. The temperatures of air were more effective than soil temperatures of all months except for May and June. While, in March both temperatures had more or less similar effect on soil heat flux.

The correlation coefficients and regression equations were significant between soil heat flux and either soil or air temperatures during the tested period.

The values of calculated soil heat flux (G) at 0.30 m depth were less than those of measured soil heat flux (G) at 0.05 m, inspite of the significant values of correlation and regression between each other.

Keyword: Soil heat flux (G) (Wm^2), soil temperature (^oC), Air temperature (^oC).

INTRODUCTION

The amount of thermal energy that moves through an area of soil in a unit of time is the soil heat flux or heat flux density. The ability of a soil to conduct heat determines how fast its temperature changes during a day or between seasons. Soil temperature is a key factor affecting the rate of chemical and biological processes in the soil essential to plant growth. Soil heat flux is important in micrometeorology because it effectively couples energy transfer process at the surface (surface energy balance) with energy transfer processes in the soil (soil thermal regime). This interaction between surface and subsurface energy transfer processes has led to detailed investigations of soil heat flux for a wide variety of agricultural systems **(Sauer and Horton, 2005)**. Also, they mentioned that most recent studies of soil heat flux density have used heat flux plate (also called heat flow meters or heat flow transducers). The concept of a soil heat flux plate was adapted from efforts to measure heat transfer in walls of buildings and bulkheads of ships. **Falckenberg (1930)** is credited as the first to apply this approach specifically for measuring heat transfer in soil. Contributions to the advancements in theory and design of soil heat flux plates have been made by **Dunkle (1940)**, **Deacon (1950)**, **Portman, (1958)**, **Philip (1961)**, **Fuchs and Tanner (1968)**, and **Mogensen (1970)**.

Soil heat flux density is the thermal energy that is utilized to heat the soil. G Is positive when the soil is warming and negative when the soil is cooling. For hourly calculation period, G beneath a dense cover of grass or alfalfa does not correlate well with air temperature, but can be significant **(Allen et al., 2005)**.

Plates should be carefully calibrated and installed. **Fuchs and Hadas (1973**) measured a 27% difference in sensitivity for a flux plate calibrated both in the field and under controlled laboratory conditions.

Soil heat flux plays an important role in surface energy balance at the land–atmosphere interface, and in meteorological modeling. On a well-watered and full-vegetation-covered surface, the soil heat flux is of the same order as the sensible heat flux. The soil heat flux had the same magnitude as the sensible heat flux at this grassland site. (**Kustas and Daughtry, 1990; Clothier et al., 1986**).

The law of heat conduction known as Fourier's law, states that the time rate of heat transfer through a material is proportional to the negative gradient in the temperature and to the area. For many simple applications, Fourier's law is used in its one-dimensional form. Soil heat flux density (G) is estimated for a one-dimension flow in a homogenous mediums and the gradient method is based on **Fourier (1822)** as;

$$G = -K_s \frac{dT}{dz}\left(Wm^{-2}\right) \quad \text{------------}\rightarrow \quad 1$$

where K_s is the thermal conductivity (W m^{-1} $°C^{-1}$) and the dT/dz is gradient representing the change in temperature with depth ($°Cm^{-1}$) called the thermal gradient. It is not possible to directly measure soil heat flux density (*G*) at the surface. If a heat flux plate is placed on the surface, then sunlight striking the plate will cause considerably higher heat flux density than the real conduction through the soil, (**Horton and Wierenga 1983),**.

Kelkar et al., (1980) measured the soil heat flux in Pune black cotton soil in different seasons. Results showed for the period June-February that, the highest daily flux into the soil was in the post-monsoon season (October). In winter, a small amount of heat goes into the soil.

The mean diurnal soil heat flux in winter shows that the maximum is less pronounced than in the pre-monsoon season. For the soil layer 0.05 m means of soil heat flux reached maximum value of 107.12 and 101 W/m^2 around noon in pre-monsoon and winter, respectively **(Roxy et al 2014).** They added that the diurnal variation is characterized by a cross-over from negative to positive values in the early morning occurrence of maximum around noon and return to negative values in the late evening

The objective of this research is to study the seasonal variability of the soil heat flux (G) at 0.05 m soil depth and its relation to soil and air temperature in the sandy soil. Also to calculate heat flux at 0.30 m of soil depth and determine the relation between G at 0.05m and G at 0.3m.

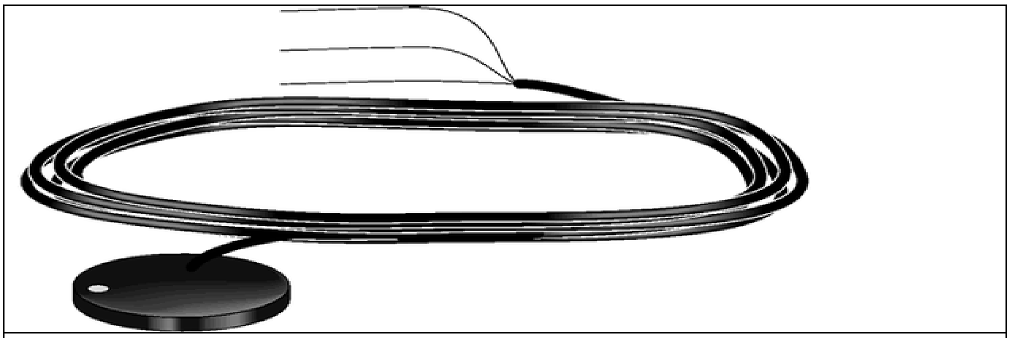
MATERIALS AND METHODS

A Soil heat flux plate was installed at 0.05m depth and thermo-wires were installed at 0.05 and 0.3m depths to measure heat flux and soil temperature in a sandy soils covered with grasses at Ismailia Agricultural Research Station, Egypt. Data of soil heat flux (G) (W/m^2) and soil temperature (^oC) were recorded every 15 minuets along thirteen months (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec, Jan), which represented 96 reading/day and the readings were averaged to represent 24 reading/day, while air temperatures (^oC) were recorded and registered every one hour for Twelve months (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec). Twenty four values for measured soil heat flux, soil temperature and air temperature in every day along one year were recorded. Soil heat flux (G) at 0.30 m depth was calculated according to **Fourier law (1822)** as explained in the introduction. Monthly thermal conductivity values of the same soil at 0.3m were calculated and presented in Table (1) **(El-Raies et al., 2013)**. Soil properties of the initial soil surface samples and soil moisture contents for all collected soil samples were determined after **Piper (1950), Page et al.,**

(1982) and Klute (1986), (Table 2)**.** Soil heat flux plate is illustrated in picture (1) **(El-Raies et al., 2013)**.

Table (1) : Monthly soil thermal conductivity (MJ/M/S/C) at 0.3m.

Soil thermal conductivity (MJ/M/S/C)					
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**
1.506	1.370	1.346	1.498	1.820	1.573
Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1.833	1.934	2.014	1.980	1.814	1.775



Picture (1) : Soil heat flux plate

Table (2): Some soil properties of the studied soil

Soil properties		**Soil properties**	
C.sand (%)	63.80	BD (gm^{-3})	1.69
F.sand (%)	23.20	Porosity (%)	39.52
Silt (%)	5.50	FC (%)	7.90
Clay (%)	7.50	WP (%)	1.42
O.M (%)	0.52	AW (%)	6.48
$CaCO_3$ (%)	2.55	EC (dSm^{-1})	0.25

RESULTS AND DISCUSSION

1-Soil heat flux (G) (W/m^2) at 0.05 m depth of a sandy soil

Data depicted in Figure (1, A, B & C) showed that the soil heat flux values (W/m^2) at 0.05 m depth were higher at the day time and their peaks were at the midday. The values became negative at night and early morning in the months of December, January, February and March (Fig. 1, A), while they became positive and low level at night and early morning in the other months (Fig. 1, B & C). Results were the same as those of **Horton and Wierenga (1983)**. They indicated that surface soil temperatures increased rapidly in the morning hours due to solar heating, thereby producing large positive values of soil heat flux divergence. In the early afternoon hours the soil surface cooled and the divergence become negative. A short period of soil heating resulted, causing a condition of positive divergence.

Fig.(2) show soil heat flux (G) values at depth 0.05m calculated for first 10 days and last 10 days of each month throw thirteen months. Every shart represents the values of last 10 days of a month and fist 10 days of the following month. The figures revealed that the two curves of each shart were similar and represented the own period and different from winter to summer. Some of the parameters used to develop the figures (min and max) are presented in Table (3).

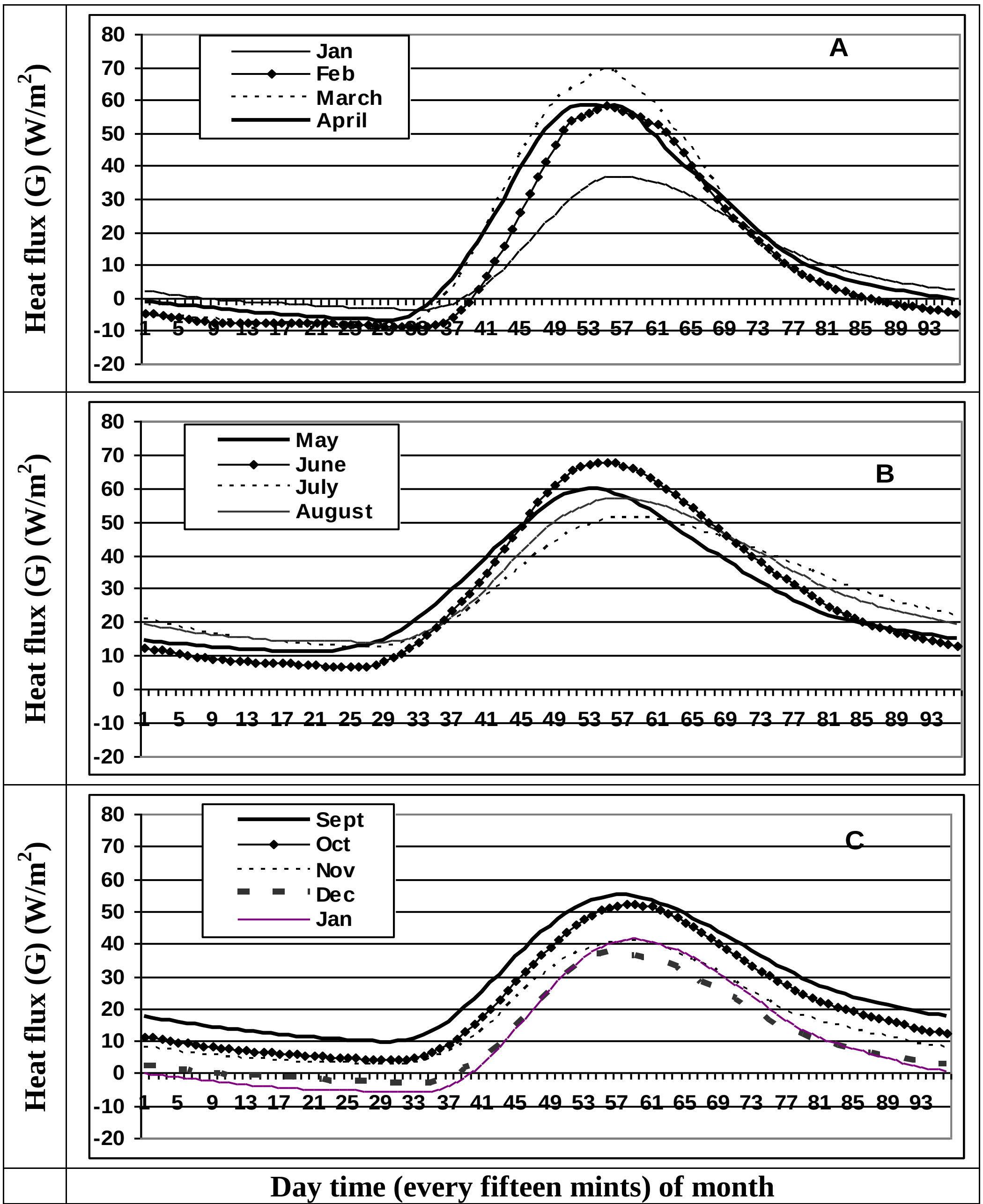
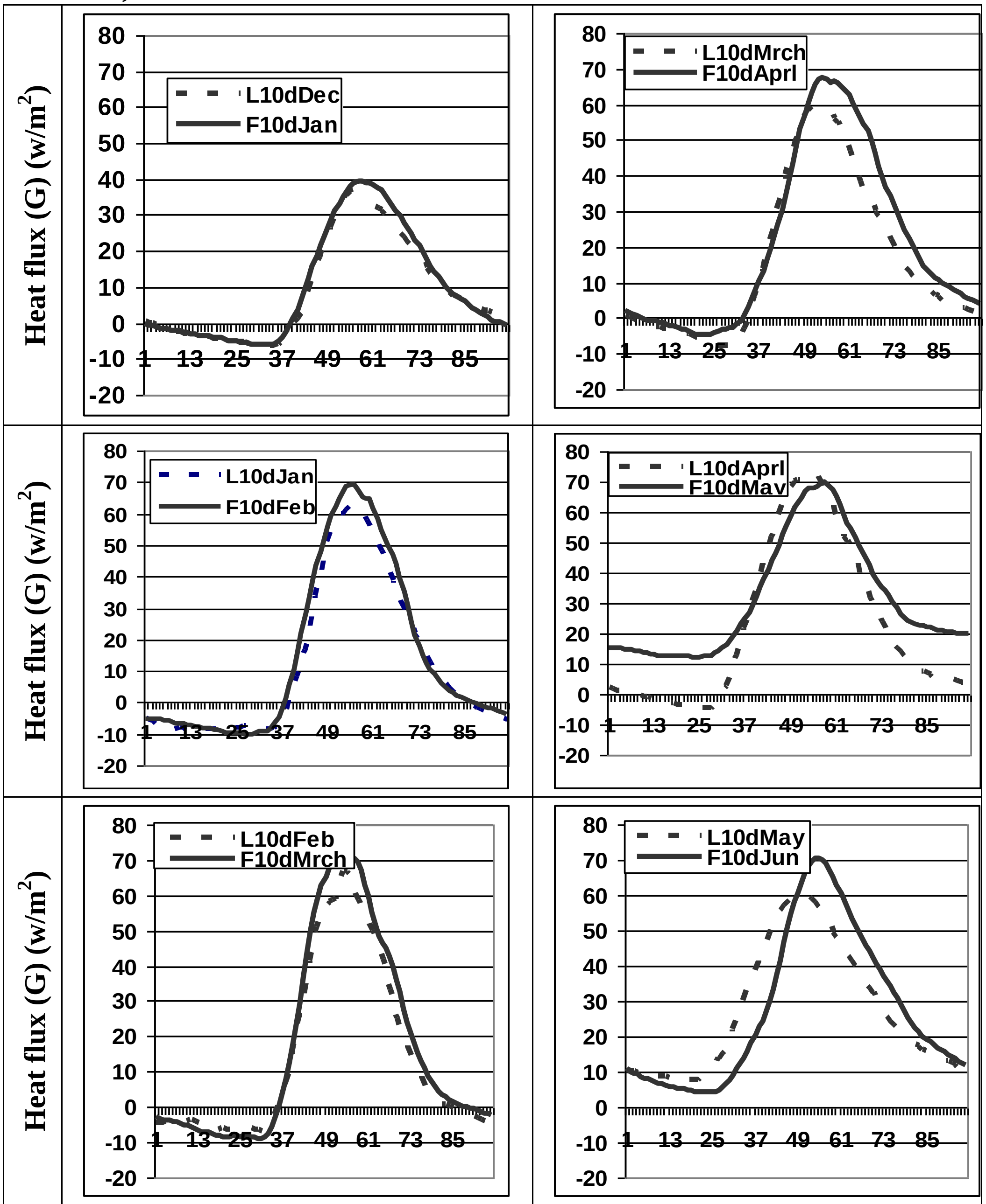


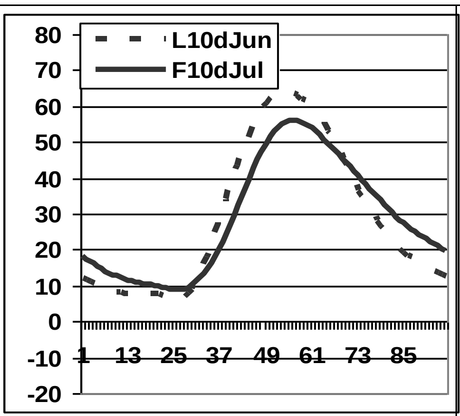
Fig (1, A,B,C) : Soil heat flux (G) (W/m^2) of the thirteen months in sandy soil at 0.05m depth

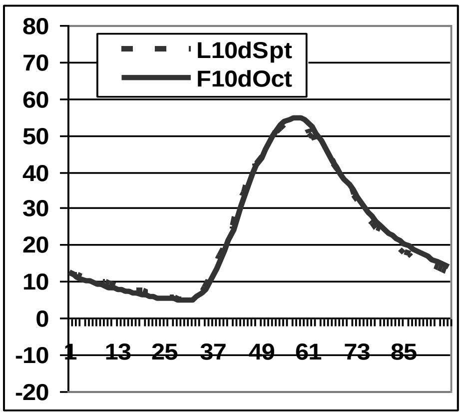


Day time (every fifteen mints) of 10 days | **Day time (every fifteen mints) of 10 days**

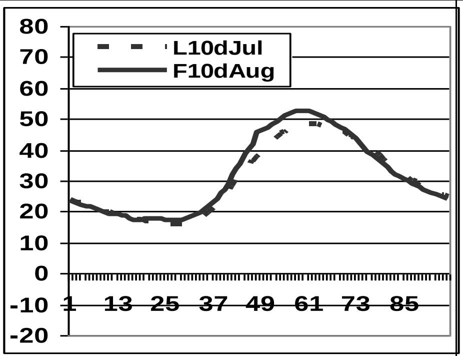
Fig (2): Soil heat flux values at 0.05m depth for the first and last 10 days of December to June .

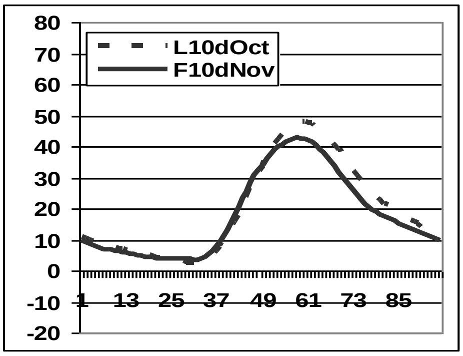
Heat flux (G) (w/m^2)



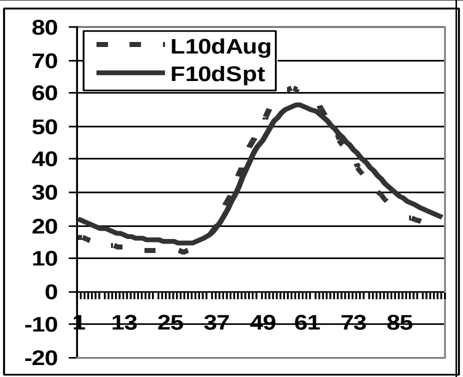


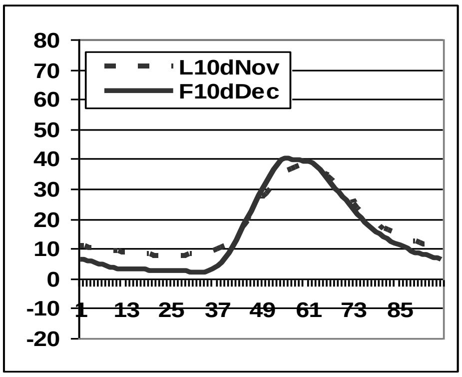
Heat flux (G) (w/m^2)





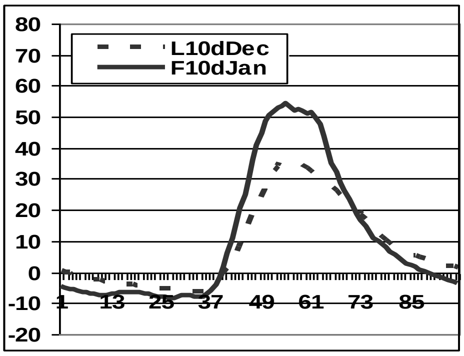
Heat flux (G) (w/m^2)





Day time (every fifteen mints) of 10 days

Fig (2): Cont. for the 10 days average of July to December and last January, (F10d mean average of fist 10 days, L10d mean average of last 10 days)



Day time (every fifteen mints) of 10days

Table (3): Average maximum and minimum soil heat flux values(G).

Period	Soil heat flux (G)		Period	Soil heat flux (G)	
	Max	**Min**		**Max**	**Min**
L10dDec.	36.96	6.53	F10dJul.	56.09	8.88
F10dJan.	54.38	8.24	L10dJul.	48.24	15.67
L10dJan.	62.69	9.08	F10dAug.	52.53	17.13
F10dFeb.	69.35	10.23	L10dAug.	60.85	11.70
L10dFeb.	66.75	7.07	F10dSpt.	56.07	14.44
F10dMar.	70.53	8.95	L10dSpt.	53.31	4.69
L10dMar.	59.53	8.15	F10dOct.	54.76	4.78
F10dApr.	67.60	4.76	L10dOct.	47.75	2.22
L10dApr.	72.77	4.95	F10dNov.	42.73	3.58
F10dMay	69.95	12.14	L10dNov.	37.53	7.25
L10May	60.85	7.50	F10dDec.	40.11	1.78
F10dJun.	70.54	4.07	L10dDec.	36.96	6.53
L10dJun.	64.09	6.32	F10dJan.	39.29	6.07

Notes: L10d = last 10 days of a month, F10d = first 10 days of the following month

2-The effect of soil and air temperatures on soil heat flux (G) (W/m^2)

Fig. (3) reveled that soil heat flux values were affected by soil and air temperatures. The peak of flux was more pronounced at the midday which reflects the role of soil and air temperatures. Air temperature was more effective than soil temperature except for those of May and June, while that of March had more or less similar effect on soil heat flux. Similar results were obtained by **Roxy et al, (2014)**. The diurnal variation is characterized by a cross-over from negative to positive values in the early morning occurrence of maximum around noon and return to negative values in the late evening.

Results in Table (4) represent the maximum, minimum and average values of soil heat flux (G) (W/m^2), soil temperature (^{o}C) and air temperature (^{o}C). The values ranged for soil heat flux (W/m^2) from 36.80 to 69.01, from -0.39 to 14.23 and from 10.60 to 30.48, as for soil temperature, from 16.97 to 36.56, from 9.89 to 29.07 and from 12.84 to 30.93 ^{o}C, also for air temperature, from 19.78 to 36.44, from 9.11 to 23.29 and from 14.12 to 29.10 ^{o}C for maximum, minimum and average, respectively.

Correlation relations were developed between soil heat flux and soil and air temperatures. Results in Table (5) showed that the correlation coefficients describing the relation between soil heat flux and either soil or air temperatures were between moderate and high values. Multiple regression analysis between soil heat flux and soil and air temperatures was developed and the obtained equations including the coefficient of determination (r) and significance level are presented in Table (6,A). Regression equations were highly significant. Soil and air temperatures affected on soil heat flux, while each of them individually had different behavior. The analysis in Table (6, B) show the standard deviation of soil and air temperatures. The values for soil temperature ranged from 0.89 to 3.69, and for air temperatures were from 3.36 to 5.02 along the twelve months.

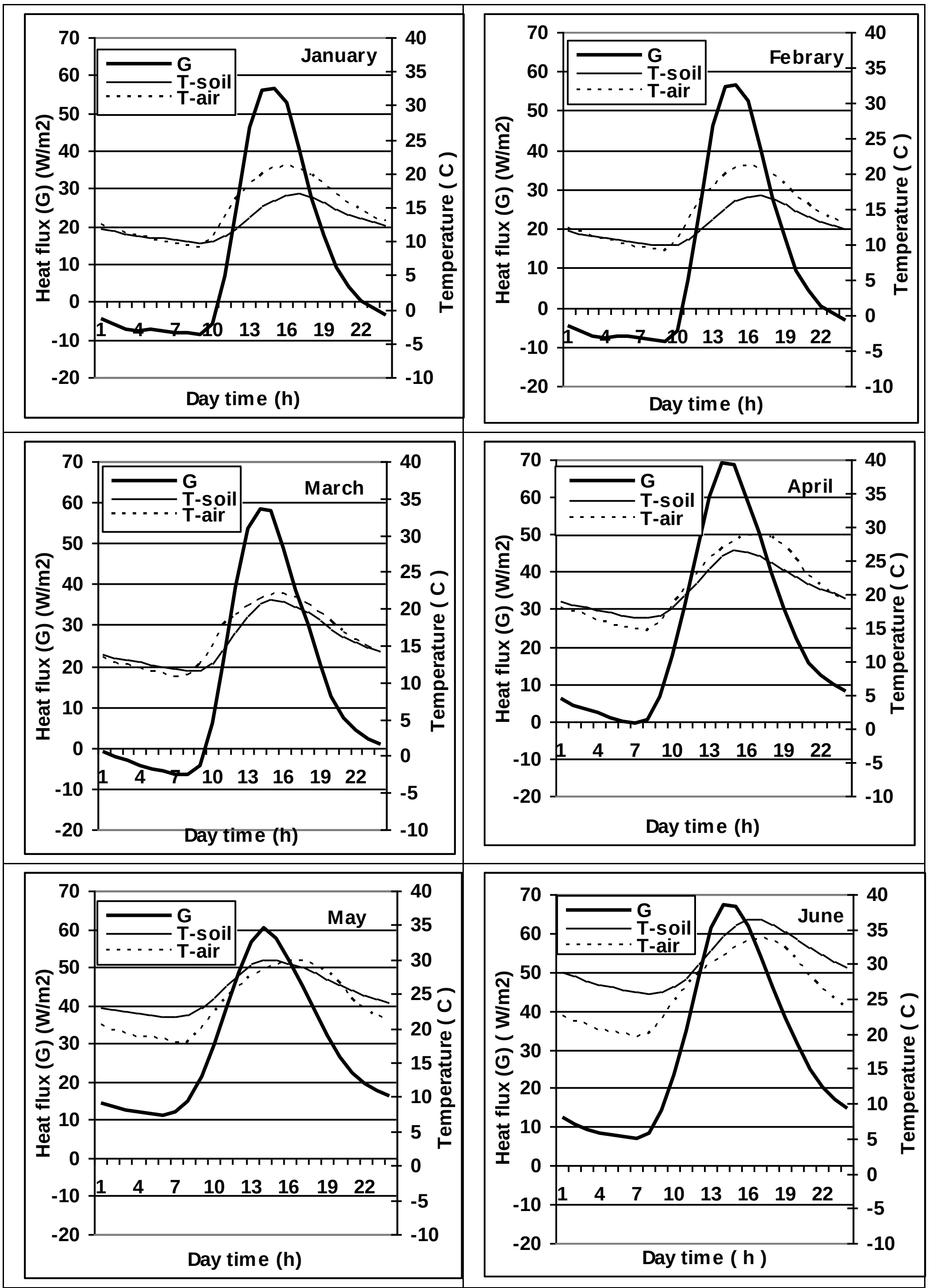


Fig (3): Soil heat flux, soil temperature at 0.05m depth and air temperature for the months of January to June.

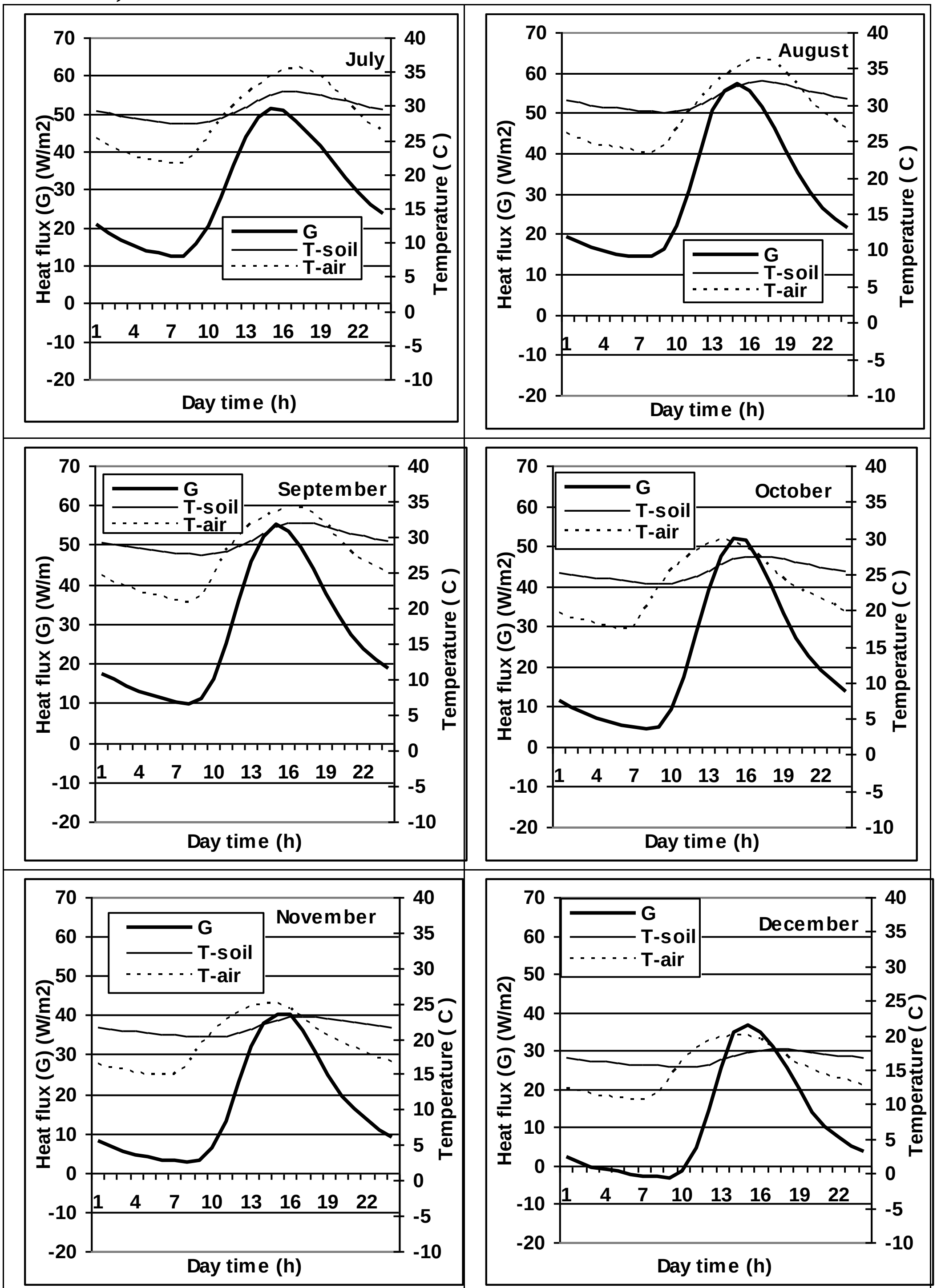


Fig (3): Cont. for the months of July to December.

The significant values of T-test of the regression equations indicating the effect of soil and air temperature on the soil heat flux are shown in Table (6, B). Soil temperatures had significant effect on soil heat flux, except for the months of March, June, July and September. Air temperature had more significant effect on soil heat flux, except for the moth of March, which was non-significant.

Table (4): Average monthly maximum, minimum and average soil heat flux (G) at 0.05m depth, soil and air temperatures.

Month	Soil heat flux (G) (W/m^2)			Soil temperature (^oC) at 0.05m depth			Air temperature (^oC)		
	Max	**Min**	**Aver**	**Max**	**Min**	**Aver**	**Max**	**Min**	**Aver**
Jan.	56.47	- 8.56	11.09	16.97	9.89	12.84	21.00	9.11	14.41
Feb.	66.41	- 9.58	14.40	19.23	10.85	14.40	19.78	10.07	14.43
Mar.	58.40	- 6.69	15.10	21.40	11.60	15.60	21.90	10.70	16.00
Apr.	69.01	- 0.39	23.39	26.45	16.56	20.79	28.79	14.50	21.07
May	60.10	11.30	28.50	30.00	21.60	25.30	29.80	17.90	23.40
Jun.	67.38	6.84	28.98	36.56	25.91	30.46	33.65	19.53	26.10
Jul.	51.04	12.42	29.19	32.20	27.46	29.64	35.62	21.45	28.06
Aug.	57.32	14.23	30.48	33.31	29.07	30.93	36.44	23.29	29.10
Sept.	55.01	9.72	27.11	32.12	27.58	29.58	34.19	20.71	27.00
Oct.	51.94	4.26	21.90	27.56	23.75	25.49	29.60	17.31	23.06
Nov.	40.36	2.76	16.37	23.25	20.32	21.67	24.89	14.76	19.28
Dec.	36.80	- 3.50	10.60	18.10	15.50	16.70	20.00	10.60	14.80
Jan.	41.34	- 5.68	10.82	16.46	13.06	14.41	19.79	9.33	14.12

Table (5) Correlation coefficient of the measured soil heat flux (G) with soil temperature T- soil and air temperature T- air

Correlation for six months	Correlation coefficient					
	Flux (G)	**Flux (G)**	**Flux (G)**	**Flux (G)**	**Flux (G)**	**Flux (G)**
	Jan.	**Feb.**	**Mar.**	**Apr.**	**may**	**Jun.**
T- soil	0.806 0.000	0.846 0.000	0.922 0.000	0.915 0.000	0.958 0.000	0.827 0.000
T- air	0.920 0.000	0.890 0.000	0.930 0.000	0.878 0.000	0.889 0.000	0.905 0.000
Correlation of Six months	**Flux (G)**	**Flux (G)**	**Flux (G)**	**Flux (G)**	**Flux (G)**	**Flux (G)**
	Jul.	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
T- soil	0.904 0.000	0.782 0.000	0.824 0.000	0.855 0.000	0.750 0.000	0.747 0.000
T- air	0.977 0.000	0.957 0.000	0.977 0.000	0.846 0.000	0.879 0.000	0.856 0.000

Table (6, A): Liner regression of measured soil heat flux (G) with soil temperature (T-soil) and air temperature (T-air) (n = 24).

Y	a ± bX ± cX	r	Significance
Jan-G	- 25.8 - 7.84 Jan-T-soil + 9.54 Jan-T-air	0.951	***
Feb-G	- 50.8 - 14.00 Feb-T-soil + 18.50 Feb-T-air	0.918	***
March-G	- 76.0 + 2.37 March-T-soil + 3.38 March-T-air	0.934	***
April-G	- 146.0 + 12.10 April-T-soil - 3.93 April-T-air	0.926	***
May-G	- 157.0 + 10.90 May-T-soil - 3.86 May-T-air	0.981	***
June-G	- 46.8 - 2.03 June-T-soil + 5.27 June-T-air	0.911	***
July-G	- 27.6 - 0.86 July-T-soil + 2.93 July-T-air	0.978	***
Aug-G	37.3 - 4.41 Aug-T-soil + 4.47 Aug-T-air	0.974	***
Sept-G	- 51.6 - 0.42 Sept-T-soil + 3.38 Sept-T-air	0.978	***
Oct-G	- 215.0 + 7.38 Oct-T-soil + 2.13 Oct-T-air	0.978	***
Nov-G	- 166.0 + 6.15 Nov-T-soil + 2.53 Nov-T-air	0.971	***
Dec-G	- 153.0 + 7.36 Dec.-T-soil + 2.71 Dec-T-air	0.959	***

Table (6, B): Standard deviation and significant of t-soil and t-air with the above regression equation (n = 24).

Y	StDev		T- test	
	T- soil	T- air	T- soil	T- air
Jan-G	2.41	4.12	- 3.60 ***	7.49 ***
Feb-G	2.85	3.44	-2.57 *	4.10 ***
March-G	3.33	3.97	1.13 ns	1.93 ns
April-G	3.39	5.02	3.55 **	- 1.70 *
May-G	2.96	4.30	9.95 ***	-5.10 ***
June-G	3.69	5.00	- 1.20 ns	4.23 ***
July-G	1.61	5.02	- 0.78 ns	8.12 ***
Aug-G	1.46	4.60	- 3.67 **	11.70 ***
Sept-G	1.52	4.66	- 0.47 ns	11.42 ***
Oct-G	1.28	4.28	10.94 ***	10.55 ***
Nov-G	0.99	3.59	7.87 ***	11.79 ***
Dec-G	0.89	3.36	7.03 ***	9.75 ***

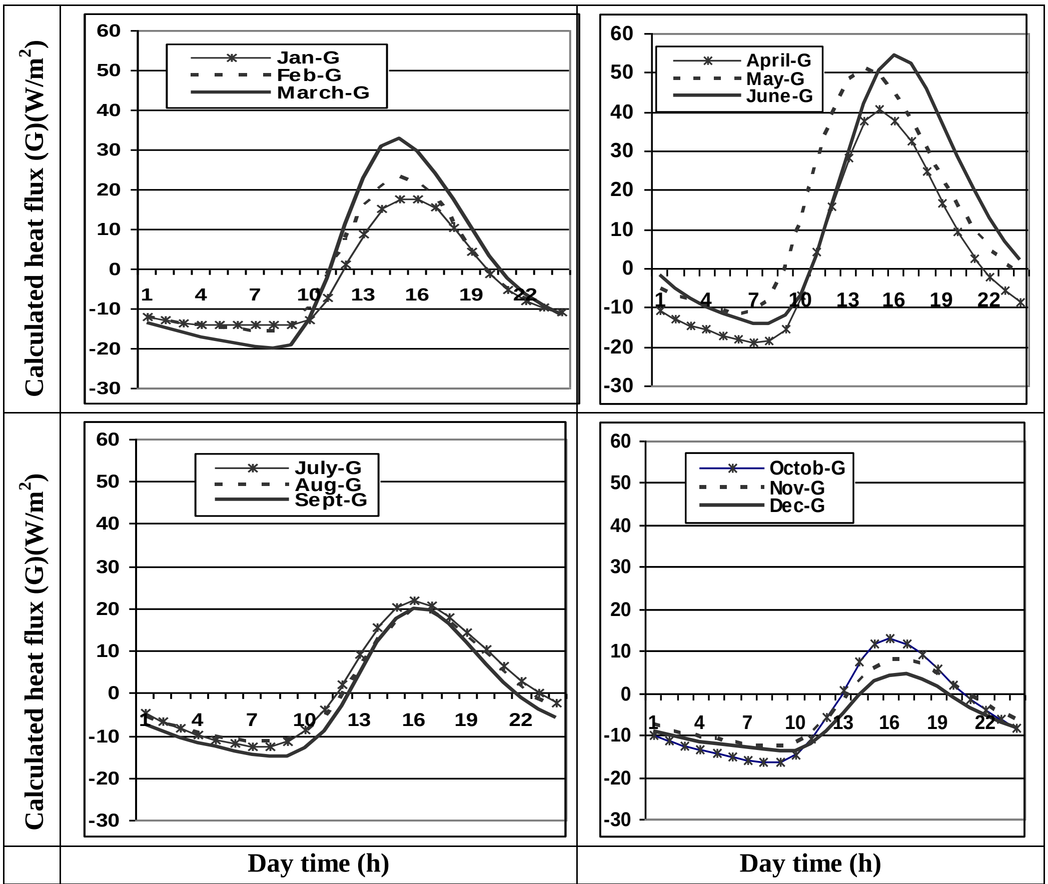
*** = significant at 10%, ** = significant at 5%, *** = significant at 1, ns = non-significant**

Table (7): Average monthly maximum, minimum and average soil temperatures at 0.3 m depth.

Soil Temperature at 0.3 m							
Month	**max**	**Min**	**Average**	**month**	**Max**	**min**	**average**
Jan.	15.04	11.92	13.43	Jul.	29.95	28.73	29.42
Feb.	16.31	13.30	14.79	Aug.	31.42	30.19	30.86
Mch.	16.61	14.81	15.77	Sep.	30.31	29.02	29.76
Apr.	21.18	19.16	20.19	Oct.	26.57	25.44	26.09
May	24.14	22.65	23.42	Nov.	22.68	21.73	22.25
Jun.	29.31	27.53	28.45	Dec.	18.00	17.11	17.61

Table (8): Correlation coefficient of measured soil heat flux (G) at 0.05 m depth with the calculated soil heat flux (G) at 0.30 m depth.

	Correlation coefficient of calculated soil heat flux at 0.3m depth					
Months	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**
Flux at 0.05 m	0.975 0.000	0.976 0.000	0.974 0.000	0.976 0.000	0.992 0.000	0.900 0.000
Months	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Flux at 0.05 m	0.980 0.000	0.623 0.000	0.947 0.000	0.969 0.000	0.909 0.000	0.912 0.000



Fig(4): Calculated soil heat flux (G) at 0.3 m depth.

3-Calculated of soil heat flux (G) (W/m2) at 0.30 m depth of the sandy soil:

Results illustrated the calculated heat flux at 0.3 m values using equation (1). They used the measured soil temperatures at 0.05 and 0.3m depth and the calculated soil thermal conductivity values (Table 1), while the maximum, minimum and average soil temperatures at 0.3m depth (Table 7).

Figure (4) revealed that the peaks of flux were at the 03:00 pm in the afternoon and the depression started before midnight to early morning and continued until the 08:00 am before noon. The maximum peaks were during the months of March, May, June, and July, and minimum depressions before noon were during the months of March, April, September and October.

Table (9): Liner regression of Measured soil heat flux (G) at 0.05 m depth with calculated soil heat flux (G) at 0.30 m depth (n = 96).

Y	.a ± bX	R	Significant
Jan-G at 0.30 m	- 9.06 + 0.492 Jan-G at 0.05 m	0.975	***
Feb-G at 0.30 m	- 9.28 + 0.494 Feb-G at 0.05 m	0..976	***
March-G at 0.30 m	- 12.7 + 0.790 March-G at 0.05 m	0.974	***
April-G at 0.30 m	- 16.2 + 0.847 April-G at 0.05 m	0.976	***
May-G at 0.30 m	- 23.9 + 1.31 May-G at 0.05 m	0.991	***
June-G at 0.30 m	- 16.8 + 1.02 June-G at 0.05 m	0.900	***
July-G at 0.30 m	- 23.4 + 0.858 July-G at 0.05 m	0.980	***
Aug-G at 0.30 m	- 19.4 + 0.655 Aug-G at 0.05 m	0.924	***
Sept-G at 0.30 m	- 21.3 + 0.735 Sept-G at 0.05 m	0.947	***
Oct-G at 0.30 m	- 17.8 + 0.595 Oct-G at 0.05 m	0.969	***
Nov-G at 0.30 m	- 12.3 + 0.493 Nov-G at 0.05 m	0.909	***
Dec-G at 0.30 m	- 10.9 + 0.420 Dec-G at 0.05 m	0.912	***

Table (10): Monthly average, maximum, and minimum of measured soil heat flux (G) at 0.05m depth, and calculated soil heat flux (G) at 0.30 m depth.

Month	Measured soil heat flux (G) at 0.05 m depth			Calculated soil heat flux (G) at 0.30 m depth		
	Max	Min	Aver	Max	Min	Aver
Jan	58.213	- 8.558	11.114	17.833	-14.133	- 3.587
Feb	69.310	- 9.690	14.407	23.192	-15.616	- 2.173
Mar	58.465	- 6.692	15.056	32.843	-20.026	0.786
Apr	70.391	- 0.403	23.407	40.844	-18.713	3.617
May	60.113	11.223	28.508	51.443	-11.372	13.490
Jun	67.796	6.836	28.997	54.279	-14.393	12.684
Jul	51.144	12.273	29.195	22.100	-12.724	1.632
Aug	57.316	14.178	30.450	19.534	-11.535	0.550
Sep	55.008	9.678	27.109	19.997	-15.083	- 1.398
Oct	52.292	4.103	21.900	13.020	-16.415	- 4.751
Nov	40.662	2.494	16.365	8.152	-12.553	- 4.279
Dec	36.958	- 3.489	10.618	4.532	-13.766	- 6.453

Results in Table (8) showed that correlation and in Table (9) the regression between measured soil heat flux (G) at 0.05 m depth and calculated soil heat flux (G) at 0.30 m depth. The relations were highly significant, which reflects the relation between measure at a depth and calculated at the deepest one. The statistical parameters in the Table (10) revealed that the maximum, minimum and the average measured heat flux (G) values at 0.05 m were higher than those at 0.30 m.

ACKNOWLEDGMENT

The author wish to thank Prof.Dr. Ahmed Taher .Abdel Sakek Mostafa. for valuable advice and sincere helpful during this study

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تدفق الحرارة فى الأرض الرملية وعلاقتها بدرجة حرارة التربة والهواء

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وضعت وحدة قياس تدفق الحرارة على عمق ٠.٠٥ متر وكذلك الأسلاك الحرارية على عمق ٠.٠٥و ٠.٣متر من سطح أرض رملية مغطاه بالحشائش . تم تسجيل تدفق الحرارة (وات / المتر المربع) وكذلك درجات حرارة التربة (درجة مئويه) والحرارة الجويه (درجه مئويه) يوميا كل ساعه، وكان الهدف دراسة تدفق الحرارة عند عمق ٠.٠٥متر وعلاقة ذلك بدرجة حرارة التربة والهواء وكذلك حساب تدفق الحرارة عند عمق ٠.٣ متر وعلاقتها بتدفق الحرارة عند ٠.٠٥ متر وبعد تحليل البيانات كانت النتائج كمايلى.

كان تدفق الحراره المسجله عند عمق ٠.٠٥ متراًاعلى ما يمكن حيث كانت قمة المنحنى عند منتصف النهار. فهى تبدأ بقيم سالبه فى الليل وتستمر خلال الصباح ثم ترتفع فى النهار وذلك خلال شهور ديسمبر، يناير، فبراير ومارس. ثم تكون بقيم موجبه ولكنها منخفضه فى الليل وتستمر خلال الصباح ثم ترتفع خلال النهار وذلك فى بقية الأشهر.

تأثر تدفق الحرارة المسجله بدرجة حرارة التربة وكذلك درجة حرارة الهواء، ولكن حرارة الهواء كانت اكثر تأثير من حرارة التربة فيما عدا شهرى مايو ويونيه حيث كانت حرارة التربة اكثر تأثيرا، ولكن خلال شهر مارس تشابها فى التأثير على تدفق حرارة التربة.

كان معامل الأرتباط ومعادلات الأنحدار بين تدفق حرارة التربة المسجله (وات/متر المربع) ودرجة حرارة التربة والهواء معنويا خلال الشهور من يناير حتى ديسمبر.

قيم تدفق حرارة التربة المحسوبه عند عمق ٠.٣٠ متر كانت اقل من مثيلتها المقاسة عند عمق ٠.٠٥ متر بالرغم من معنوية الأنحدار والأرتباط فيما بينهما.

الكلمات الداله : تدفق حرارة التربة المسجله (وات/متر المربع) ، حرارة التربة (درجة مئويه)، حرارة الهواء (درجه مئويه).