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A theoretical and practical study for the incident solar radiation intensity in the Basrah province (south of Iraq)

Asaad Rehman Saeed Al-Hilphy
Food Sciences Dept., Agric. College, Basrah Univesity, Basrah, Iraq

Abstract: - A theoretical and practical study was conducted to the incident solar radiation intensity on a horizontal surface and another making an angle 30^o with the horizontal at Basra province, Iraq, during the years 2006 and 2011. The results showed that the intensity of solar radiation increased significantly ($p<0.05$) as daylight hours increasing reaching a maximum value of 740 `W/m^2 at midday and then decreased after that. This was found to be the trend throughout all months of the two years of our investigation. The intensity of solar radiation varied from one month to another. In addition, the solar radiation falling on the inclined surface is higher than that falling on a horizontal surface. The study also found that there was a significant difference in the intensity of solar radiation between 2006 and 2011. Empirical equations of the fourth order were developed to predict the incident solar radiation on a horizontal, as well as another inclined surface in the Basra province (south of Iraq)

Keywords*: solar radiation, Basrah, horizontal surface*.

I. INTRODUCTION

The performance of any solar thermal system depends on the solar radiation available to it. Solar radiation is characterized by it's variability. Even when abundant, it varies during the day, reaching a maximum at noon when the path length through the atmosphere is the shortest. Unless the collector is continuously turned to face the sun, the sun changing altitude and azimuth will reduce the collected heat below the potential maximum. The hours day light also vary seasonally, being the shortest in winter when the need for heat is the greatest [1].

A know ledge of the local solar-radiation is essential for the proper design of building energy systems, solar energy systems and a good evaluation of thermal environment within buildings [2, 3, 4, 5, 6 and 7]. In the design and study of solar energy, information on solar radiation and its components at a give location is very essential. Solar radiation data are required by solar engineers, architects, agriculturist sand hydrologists for many applications such as solar heating, cooking, drying and interior illumination of buildings[8]**.** Predicted to be the clean energy of tomorrow, solar energy has been in the forefront of energy development in many developed countries and a potential source of energy to developing countries like Malaysia[9].

Madhi [10] Found in the city of Basrah, the measured and calculated solar radiation intensity that incident on the inclined surface 20 deg. angle in September 1984 was increased with the increase in daylight hours and up to the maximum value at midday and then down to the end of the day, when daylight hours 9, 10, 12, 14 and 16, the values of the measured solar radiation intensity were 965, 1070, 945, and 500 W/m^2 also, the calculated were 770, 910, 990, 850 and 450 W/m^2 respectively.

Sabbah [11] stated that the highest value of incident solar radiation intensity on the sloped surface by angle of 35 deg. in Saudi Arabia in the midday is 1330 W and its lowest value is 805 W at four o'clock pm. As mentioned Jensen [12] In Ghana in January 2000 that the incident solar radiation intensity on the sloped surface of 30 deg., when daylight hours are 9, 10, 12, 14, 16 300, 600, 820, 670 and 500 W/m^2 respectively. Sebaii [13] in Egypt, are explained that the intensity of solar radiation on 4 August 2000 is reached to 1010 W/m^2 at midday, then decreased to 300 W/m^2 at four o'clock pm. [14 and 15] were confirmed that the incident solar radiation intensity on inclined surfaces was increased with increasing daylight hours and up to a maximum at midday then decreased thereafter.

The average of intensity of solar radiation in Australia is reached to 27.1 and 19.4 on 20 January and 18 March 2000 respectively [16]. Katiyar & Pandey [17] stated that the maximum of solar radiation intensity in India was 700 W/m^2 at midday in July. Because no detail studies about incidence solar radiation intensity in Basrah province during different times, therefore the aim of present study to investigation the incidence theoretical and practical solar radiation intensity on the Basrah province and study it's changes during different times.

II. MATERIALS AND METHODS

Solar radiation intensity was measured by pyranometer device which manufactured by Kipp and Zonen company, Netherlands, type CM11. Theoretical results were compared with practical also; mathematical equations have been resolved by the Excel program to extract the values of theoretical solar radiation intensity. A factorial experiment with completely randomized design was used. LSD test at 0.05 significantly level was used to compare among treatments means using SPSS software [18]. The monthly average of solar radiation intensity was taken to three different days of each month.

Theoretical solar radiation intensity calculation

Theoretical solar radiation intensity has been calculated according to [1].
The following empirical equation is recommended for calculation of declination angle:

$$\delta = 23.45 \sin\left[\frac{(N-80)}{370} 360\right] \tag{1}$$

Where δ is Declination angle, N is the day number in the year .
Equation of time is calculated according to [19].

$$EQT = \sum_{k=0}^{k=5}\left[A_k \cos\left(\frac{2\pi kN}{365.25}\right) + B_k \sin\left(\frac{2\pi kN}{365.25}\right)\right] \tag{2}$$

Where A_k، B_k, k are constants and EQT is time of equation, can be obtained from [1 and 20].
Solar time is the time used in all of the sun-angle relationship; it does not with local clock time [21].

$$ST = Z \pm \frac{1}{15}(L_{st} - L_{loc}) + EQT \tag{3}$$

Where L_{st} is the standard meridian for the local time zone (in Basrah province is 40). L_{loc} is the longitude of the location (in Basrah province is 47.78). and the longitudes are in degree, Z is the local standard time (hour) and ST is the solar time.
Taken positive signal when the city is located east longitude local authorized record in the local time and is negative when the city west of the standard meridian, In regard to the Basrah province taken negative sign.
solar hour angle(ω) Is displacement sun from noon [22].

$$\omega = \frac{360}{24}(ST - 12) \tag{4}$$

The zenith angle(θ_z) and it's complement the sun altitude $(\propto)$ are then given by: (Lunde.1980)

$$\cos\theta_z = \sin\propto = \cos\emptyset \cos\delta \cos\omega + \sin\emptyset \sin\delta \tag{5}$$

Incident angle (θ_1) Is the angle of the fall of solar radiation on the surface of the solar collector.

$$\cos\theta_1 = \cos(\emptyset - \beta)\cos\delta\cos\omega + \sin(\emptyset - \beta)\sin\delta \tag{6}$$

Where $(\emptyset)$ is the latitude, (δ) is the solar declination and (β) is the solar collector angle.

Direct normal irradiance (I_{DN}) is calculated from the equation (7):

$$I_{DN} = A\exp.\left(\frac{-B}{\cos\theta_z}\right) \tag{7}$$

Where (B) is the extinction Coefficient and (A) is apparent extraterrestrial solar intensity.
vertical effect for direct radiation falling on a horizontal surface $(I_h)$is calculated from the following equation:

$$I_h = I_{DN}\sin\propto \tag{8}$$

The incidence diffuse radiation (I_d) falling on the horizontal surface is calculated from the following equation:

$$I_d = c \times I_{DN} \tag{9}$$

Where c is a constant.
The total incidence solar radiation (I_{th}) falling on the horizontal surface is:

$$I_{th} = I_h + I_d \tag{10}$$

The direct solar radiation falling on the inclined surface (I_t) is calculated from the following equation:

$$I_t = I_{DN} \cos\theta_1 \tag{11}$$

The diffuse solar radiation falling on the inclined surface (I_{dt}) is calculated from the following equation:

$$I_{dt} = I_h F_{sg} + \rho(I_h + I_d) F_{ss} \tag{12}$$

Shape Factor (F_{sg}) is used to rectangular surfaces and calculated according to Farber (1977).

$$F_{sg} = \frac{1 - \cos\beta}{2} \tag{13}$$

Angle factor (F_{ss}) is calculated from equation (14):

$$F_{ss} = \frac{1 + \cos\beta}{2} \tag{14}$$

To calculate the incident direct solar radiation on a horizontal surface will compensate equations (8, 9, 13 and 14) in the equation (12):

$$I_{dt} = \left[C \frac{1+\cos\beta}{2} + \rho(C + \sin\propto) \frac{1-\cos\beta}{2}\right] I_{DN} \tag{15}$$

So that the total radiation falling on the inclined surface (I_T) be:

$$I_T = I_t + I_{dt} \tag{16}$$

When compensation equations (11) and (15) in equation (16) which can calculate the solar radiation intensity falling on the inclined surface:

$$I_T = I_{DN} \left[\cos\theta_1 + C \frac{1 + \cos\beta}{2} + \rho(C + \sin\propto) \frac{1 - \cos\beta}{2}\right] \tag{17}$$

III. RESULTS AND DISCUSSION

Observed from Tables 1 to 4, which show the incidence theoretical and practical solar radiation intensity on horizontal surfaces and another making an angle 30^o with the horizontal during the daytime hours for all the months of the years 2006 and 2011. The theoretical and practical solar radiation intensity falling on horizontal surfaces and inclined surfaces with angle of 30 degrees has increased significantly ($P<0.05$) with increasing daylight hours and reached a maximum value at 12:00 noon then decreased thereafter to reach the lowest value at four o'clock pm for all months of the year 2006 and 2011. This is due to the Earth's rotation on its axis and as a result change solar angles with daylight hours, which include zenith angle and altitude angle and azimuth angle and reaches the value of the last to zero at midday and to great value at sunrise and sunst as well as changing the angle at hour angle with the daylight hours. These results are agreed with [10, 13,13,14, 23, and 24] Who confirmed that the intensity of solar radiation increases with increasing daylight hours and up to a maximum value at midday then reduced after that.

The reason for the emergence of the differences between the theoretical and practical intensity of solar radiation because the theoretical values based on the intensity of solar radiation outside the atmosphere and the extinction Coefficient and coefficient of solar radiation scattered calculated the cities of the United States by the meteorological stations in which, and the circumstances of those cities are different from the conditions city of

Basra, which led to the occurrence of these differences. As the escalation of light dust in the air reduces the total solar radiation energy hands-on despite the survival of the sky is clear this is the inherent advantage of the summer climate of the southern city of Basra where dust billowing in the afternoon most days. The results showed that the incident solar radiation intensity on a horizontal surface and another making an angle 30^o with the horizontal was vary from one month to another in 2006 and 2011. This is due to the different sun inclination in different seasons. In the summer months the northern end of the axis of rotation of the Earth is tilted toward the sun and be a day longer than the night at each position of the northern hemisphere and the sun is closer to be perpendicular to the surface of the earth. Also noted Lunde [1] that the energy of solar radiation outside the atmosphere changing with the seasons of the year as a result of changing the distance between the sun and the earth. For example, the average intensity of solar radiation falling on a horizontal surface in January 2006 was 530.09 W/m^2 and in the July was 620.7 W/m^2.

The results also showed that the correlation between the theoretical and practical solar radiation intensity was significantly ($p<0.05$), as well as the coefficient of determination R^2 ranged from 0.752255 - 0.99469 As shown in Table 5. Figures from 1 to 4 show the relationship between the theoretical and practical solar radiation intensity, all the relationships are linear equations for all months of the year 2006.

Table 1. Incidence theoretical and practical solar radiation intensity on horizontal surfaces during the daytime hours in 2006.

year months	solar radiation	day hours								average
		9	10	11	12	13	14	15	16	
January	I_{hth}	558.51	720.71	822.27	855.44	817.77	712.04	546.36	334.76	670.98
	I_{hp}	457.54	584.50	648.59	711.14	679.37	584.28	396.16	179.11	530.09
February	I_{hth}	534.12	698.73	804.36	842.91	811.50	712.48	553.40	347.63	663.14
	I_{hp}	392.72	558.23	693.50	753.56	738.01	646.82	437.08	256.96	559.61
March	I_{hth}	525.77	681.51	779.11	810.98	774.72	673.06	513.94	311.34	633.80
	I_{hp}	352.78	498.71	589.15	648.43	603.15	543.36	424.36	221.22	485.15
April	I_{hth}	508.30	648.81	732.78	753.50	709.37	603.83	445.53	249.85	581.50
	I_{hp}	429.97	564.19	668.24	712.45	667.51	577.15	498.85	276.86	549.40
May	I_{hth}	491.51	624.04	701.40	717.31	670.50	564.70	408.89	219.23	549.70
	I_{hp}	491.58	601.47	696.07	725.27	710.00	611.16	474.32	343.19	581.63
June	I_{hth}	467.14	600.55	680.42	700.11	658.07	557.67	407.50	223.20	536.83
	I_{hp}	551.03	635.72	731.75	685.76	730.95	663.23	579.85	399.65	622.24
July	I_{hth}	449.60	586.99	671.92	697.27	661.03	566.11	420.57	239.21	536.59
	I_{hp}	469.73	626.35	723.11	779.31	753.35	672.83	544.02	396.92	620.70
August	I_{hth}	466.62	606.15	691.80	716.48	678.22	580.09	430.35	244.09	551.73
	I_{hp}	422.94	587.25	663.67	710.21	694.19	617.10	464.95	339.49	562.48
September	I_{hth}	530.62	668.98	749.25	765.08	715.25	603.63	439.40	238.74	588.87
	I_{hp}	439.92	572.45	560.94	677.01	661.22	586.09	452.03	301.89	531.44
October	I_{hth}	591.96	726.81	799.71	805.05	742.42	616.62	437.84	223.75	618.02
	I_{hp}	376.86	466.71	628.48	599.43	539.76	464.17	285.39	180.73	442.69
November	I_{hth}	620.12	757.52	831.05	835.17	769.56	639.17	454.39	232.94	642.49
	I_{hp}	394.52	594.35	716.35	702.73	701.09	545.82	406.10	190.82	531.47
December	I_{hth}	604.09	753.01	838.77	854.89	800.20	678.75	499.98	279.87	663.69
	I_{hp}	419.90	595.09	738.34	770.16	706.00	546.41	493.97	195.62	558.19

I_{hth} : theoretical solar radiation on the horizontal surfaces W/m^2

I_{hp} : practical solar radiation on the horizontal surfaces W/m^2

Table 2. Incidence theoretical and practical solar radiation intensity on horizontal surfaces during the daytime hours in 2011.

year months	solar radiation	day hours								everage
		9	10	11	12	13	14	15	16	
January	I_{hth}	498.79	679.93	761.90	860.65	803.86	653.36	302.08	217.80	597.30
	I_{hp}	558.51	720.71	822.27	855.44	817.77	712.04	546.36	334.76	670.98
February	I_{hth}	571.79	777.95	866.35	909.83	852.95	732.74	610.19	406.17	716.00
	I_{hp}	534.12	698.73	804.36	842.91	811.50	712.48	553.40	347.63	663.14
March	I_{hth}	541.37	759.57	890.93	940.58	938.86	744.95	664.57	241.35	715.27
	I_{hp}	525.77	681.51	779.11	810.98	774.72	673.06	513.94	311.34	633.80
April	I_{hth}	602.20	777.95	878.64	922.13	871.36	781.59	598.11	364.97	724.62
	I_{hp}	508.30	648.81	732.78	753.50	709.37	603.83	445.53	249.85	581.50
May	I_{hth}	553.54	716.69	792.62	823.77	760.90	690.00	501.45	382.63	652.70
	I_{hp}	491.51	624.04	701.40	717.31	670.50	564.70	408.89	219.23	549.70
June	I_{hth}	583.96	741.19	835.63	860.65	840.67	787.70	640.40	482.70	721.61
	I_{hp}	467.14	600.55	680.42	700.11	658.07	557.67	407.50	223.20	536.83
July	I_{hth}	687.00	879.00	996.00	1030.00	980.00	849.00	720.00	620.00	845.13
	I_{hp}	449.60	586.99	671.92	697.27	661.03	566.11	420.57	239.21	536.59
August	I_{hth}	700.00	914.00	1028.52	1059,81	900.00	872.28	664.28	352.05	775.88
	I_{hp}	466.62	650.15	791.80	816.48	678.22	680.09	530.35	244.09	607.23
September	I_{hth}	787.05	969.06	1075.06	1032.13	893.83	780.00	680.50	366.13	822.97
	I_{hp}	530.62	668.98	749.25	765.08	715.25	603.63	439.40	238.74	588.87
October	I_{hth}	577.87	692.19	798.77	879.10	822.26	738.85	573.94	376.74	682.46
	I_{hp}	591.96	726.81	799.71	805.05	742.42	616.62	437.84	223.75	618.02
November	I_{hth}	492.71	645.94	784.88	849.10	838.52	743.73	556.60	314.69	653.27
	I_{hp}	620.12	757.52	831.05	835.17	769.56	639.17	454.39	363.67	658.83
December	I_{hth}	583.95	707.50	792.62	820.69	727.15	577.03	371.56	300.22	610.09
	I_{hp}	604.09	753.01	838.77	854.89	800.20	678.75	499.98	346.94	672.08

I_{hth} : theoretical solar radiation on the horizontal surfaces W/m^2

I_{hp} : practical solar radiation on the horizontal surfaces W/m^2

Table 3. Incidence theoretical and practical solar radiation intensity on inclined surfaces with angle of 30 degrees during the daytime hours in 2006.

months	solar radiation	day hours								everage
		9	10	11	12	13	14	15	16	
January	I_{Tth}	697.24	879.88	993.62	1030.70	988.59	870.16	683.50	395.23	817.37
	I_{Tp}	521.77	660.88	730.49	800.06	765.28	660.88	452.13	208.71	600.03
February	I_{Tth}	699.16	892.82	1016.37	1061.35	1024.71	908.94	721.94	428.87	844.27
	I_{Tp}	469.46	660.88	817.39	886.95	869.62	765.28	521.77	313.06	663.05
March	I_{Tth}	713.38	901.73	1019.00	1057.20	1013.74	891.56	698.99	396.59	836.52
	I_{Tp}	433.08	606.31	713.10	783.87	730.17	660.88	521.43	278.30	590.89
April	I_{Tth}	685.85	854.28	954.24	978.85	926.42	800.55	609.94	317.97	766.01
	I_{Tp}	521.77	678.31	800.07	852.24	800.06	695.70	608.74	347.85	663.09
May	I_{Tth}	672.24	827.07	916.58	934.92	880.89	758.03	574.32	270.59	729.33
	I_{Tp}	573.92	695.70	801.80	834.80	819.13	709.56	558.24	417.40	676.32
June	I_{Tth}	635.08	787.57	877.79	899.94	852.61	738.83	565.88	267.33	703.13
	I_{Tp}	625.89	714.84	819.13	766.90	819.20	747.88	662.61	471.34	703.47
July	I_{Tth}	621.61	780.88	878.07	906.96	865.66	756.85	587.50	288.38	710.74
	I_{Tp}	540.48	713.02	819.20	881.75	853.95	766.98	627.79	471.28	709.31
August	I_{Tth}	655.67	823.01	924.61	953.76	908.55	791.95	611.65	305.69	746.86
	I_{Tp}	506.12	695.71	782.67	836.59	819.20	732.23	558.30	419.16	668.75
September	I_{Tth}	732.57	900.84	997.78	1016.85	956.77	821.58	620.44	308.02	794.36
	I_{Tp}	646.999	834.848	815.027	983.034	962.163	857.808	669.959	461.25	778.89
October	I_{Tth}	785.05	945.78	1032.26	1038.58	964.32	814.54	599.50	285.77	808.23
	I_{Tp}	453.94	558.30	749.63	714.84	645.26	558.30	347.85	227.84	532.00
November	I_{Tth}	780.08	936.66	1020.13	1024.80	950.34	801.84	589.48	284.02	798.42
	I_{Tp}	454.29	680.06	817.45	801.80	801.80	627.87	473.08	229.58	610.74
December	I_{Tth}	736.50	901.23	995.69	1013.43	953.24	819.22	620.56	327.80	795.96
	I_{Tp}	469.60	660.88	817.45	852.24	782.67	608.74	556.21	226.07	621.73

I_{hth} : theoretical solar radiation on the inclined surfaces W/m^2
I_{hp} : practical solar radiation on the inclined surfaces W/m^2

Table 4. Incidence theoretical and practical solar radiation intensity on inclined surfaces with angle of 30 degrees during the daytime hours in 2011.

months	solar radiation	day hours								everage
		9	10	11	12	13	14	15	16	
January	I_{Tth}	697.24	879.88	993.62	1030.70	988.59	870.16	683.50	395.23	817.37
	I_{Tp}	557.82	755.10	843.54	952.38	891.16	727.89	340.14	251.70	664.97
February	I_{Tth}	699.16	892.82	1016.37	1061.35	1024.71	908.94	721.94	428.87	844.27
	I_{Tp}	639.46	863.95	959.18	1006.80	945.58	816.33	687.07	469.39	798.47
March	I_{Tth}	713.38	901.73	1019.00	1057.20	1013.74	891.56	698.99	396.59	836.52
	I_{Tp}	605.44	843.54	986.39	1040.82	1040.82	829.93	748.30	278.91	796.77
April	I_{Tth}	685.85	854.28	954.24	978.85	926.42	800.55	609.94	317.97	766.01
	I_{Tp}	673.47	863.95	972.79	1020.41	965.99	870.75	673.47	421.77	807.82
May	I_{Tth}	672.24	827.07	916.58	934.92	880.89	758.03	574.32	270.59	729.33
	I_{Tp}	619.05	795.92	877.55	911.56	843.54	768.71	564.63	442.18	727.89
June	I_{Tth}	635.08	787.57	877.79	899.94	852.61	738.83	565.88	267.33	703.13
	I_{Tp}	653.061	823.129	925.17	952.381	931.973	877.551	721.088	557.823	805.27
July	I_{Tth}	621.61	780.88	878.07	906.96	865.66	756.85	587.50	288.38	710.74
	I_{Tp}	620.00	760.00	780.06	740.00	720.50	700.00	680.00	620.00	702.57
August	I_{Tth}	655.67	823.01	924.61	953.76	908.55	791.95	611.65	305.69	746.86
	I_{Tp}	720.00	740.00	760.00	820.00	760.00	700.00	640.00	600.00	717.50
September	I_{Tth}	732.57	900.84	997.78	1016.85	956.77	821.58	620.44	308.02	794.36
	I_{Tp}	720.00	780.00	800.00	820.00	840.00	820.00	780.00	720.00	785.00
October	I_{Tth}	785.05	945.78	1032.26	1038.58	964.32	814.54	599.50	285.77	808.23
	I_{Tp}	646.26	768.71	884.35	972.79	911.56	823.13	646.26	435.37	761.05
November	I_{Tth}	780.08	936.66	1020.13	1024.80	950.34	801.84	589.48	284.02	798.42
	I_{Tp}	551.02	717.35	868.98	939.59	929.59	828.57	626.73	363.67	728.19
December	I_{Tth}	736.50	901.23	995.69	1013.43	953.24	819.22	620.56	327.80	795.96
	I_{Tp}	653.06	785.71	877.55	908.16	806.12	642.86	418.37	346.94	679.85

I_{hth} : theoretical solar radiation on the inclined surfaces W/m^2
I_{hp} : practical solar radiation on the inclined surfaces W/m^2

Table 5. The correlation coefficient(R^2) between Incidence theoretical and practical solar radiation intensity on horizontal surface and inclined surfaces with angle of 30 deg.

	2006		2011	
	Horizontal	inclined 30°	Horizontal	inclined 30°
January	0.99286	0.99469	0.96692	0.957284
February	0.988274	0.98134	0.9942	0.990272
March	0.981994	0.97852	0.977686	0.980066
April	0.966595	0.96234	0.99193	0.988878
May	0.978315	0.96423	0.986728	0.971088
June	0.956898	0.95653	0.956827	0.937612
July	0.959335	0.93505	0.96414	0.829901
August	0.968237	0.94813	0.983334	0.921733
September	0.933968	0.92600	0.972434	0.752255
October	0.968655	0.95906	0.940408	0.935491
November	0.956332	0.95111	0.873959	0.886201
December	0.961394	0.95893	0.982523	0.959767

The relationship between the daylight hours and the intensity of solar radiation falling on the surface of the horizontal and another making an angle 30° with the horizontal is the equation of the fourth order $I_T = a+b_0t+b_1t^2+b_2t^3+b_3t^4$,the coefficient of determination between them more than 0.96, as shown in Tables 6 and 7 are show that constants of the equation which governing the relationship between the daylight hours and the intensity of solar radiation.

Table 6. The equations constants which used for prediction of practical solar radiation intensity on horizontal surfaces in 2006 and 2011.

years	months	a	b_0	b_1	b_2	b_3	R^2
2006	January	6704.8	-2578.7	359.07	-20.056	0.3808	0.9971
	February	16843	-6283.5	848.03	-47.839	0.9582	0.9973
	March	-5550.3	1394	-120.19	5.2222	-0.1091	0.9963
	April	-7479	2035.4	-194.99	8.9835	-0.1783	0.9877
	May	14209	-5204.2	702.92	-39.974	0.8116	0.9992
	June	-12550	4111.4	-488.58	26.456	-0.5512	0.9683
	July	4825.2	-2190.4	342.08	-20.843	0.4336	0.9995
	August	4558.6	-2117.3	334.34	-20.561	0.4315	0.9947
	September	9665.5	-3394.3	441.38	-23.847	0.452	0.9561
	October	16364	-6200	856.46	-49.939	1.0424	0.9779
	November	-8772.8	2074.3	-154.74	4.6771	-0.0575	0.9931
	December	-15354	4349.6	-445.46	20.984	-0.3959	0.9703
2011	January	343.08	-683.31	157.07	-10.74	-0.3959	1
	February	390.26	-699.36	157.57	-10.669	0.2214	1
	March	425.55	-693.49	155.66	-10.587	0.2212	1
	April	543.81	-703.83	154.93	-10.59	0.224	1
	May	651.74	-724.06	155.97	-10.649	0.2265	1
	June	712.91	-743.05	156.86	-10.614	0.2246	1
	July	735.97	-755.29	157.48	-10.562	0.2218	1
	August	-33620	10570	-1225.6	63.808	-1.2641	0.9692
	September	522.52	-697.16	155.55	-10.719	0.2282	1
	October	411.62	-660.89	154.54	-10.876	0.2345	1
	November	16225	-6196.5	873.88	-51.918	1.102	0.9978
	December	8428.6	-3490.7	522.89	-31.8	0.6739	0.9994
	January	343.08	-683.31	157.07	-10.74	-0.3959	1

Table 7. The equations constants which used for prediction of practical solar radiation intensity on inclined surfaces with angle of 30 deg. in 2006 and 2011.

The year	months	a	b_0	b_1	b_2	b_3	R^2
2006	January	10366	-3787.7	507.04	-27.832	0.5285	0.9975
	February	19434	-7241.8	976.97	-55.083	1.1025	0.9972
	March	-7308.4	1909.3	-175.26	8.0225	-0.1671	0.996
	April	-9506.6	2649	-262.21	12.403	-0.2472	0.9864
	May	16540	-6028.3	811.95	-46.125	0.9369	0.9991
	June	-13925	4588.1	-547.31	29.686	-0.6179	0.9637
	July	5482.3	-2463.8	383.64	-23.371	0.4872	0.9994
	August	5373	-2475	389.96	-23.979	0.504	0.9941
	September	13980	-4885.1	633.39	-34.163	0.6473	0.9523
	October	19589	-7400.6	1020.5	-59.444	1.2403	0.9767
	November	-10619	2592.3	-206.71	7.0652	-0.1015	0.9927
	December	-17914	5147.3	-536.82	25.71	-0.4895	0.9685
2011	January	60855	-21373	2764.8	-154.2	3.1308	0.976
	February	6704.8	-2578.7	359.07	-20.056	0.3808	0.9966
	March	-28536	8974.4	-1046.7	55.852	-1.1531	0.9966
	April	-4097.4	780.58	-19.867	-1.1166	0.0258	0.9992
	May	5330.8	-2521.8	411.15	-26.111	0.5669	0.9913
	June	-5434.6	1313.9	-92.874	2.8559	-0.0451	0.9966
	July	-33762	10893	-1275.8	65.815	-1.2648	0.9966
	August	22474	-7559	963.77	-53.321	1.0795	0.9677
	September	-2214.5	846.53	-95.189	5.1768	-0.1136	0.9835
	October	18815	-6684	878.34	-48.628	0.9599	0.9835
	November	11544	-4341.4	589.59	-32.618	0.6248	0.9998
	December	36382	-13129	1754.1	-100.69	2.0969	0.9981
	January	60855	-21373	2764.8	-154.2	3.1308	0.976

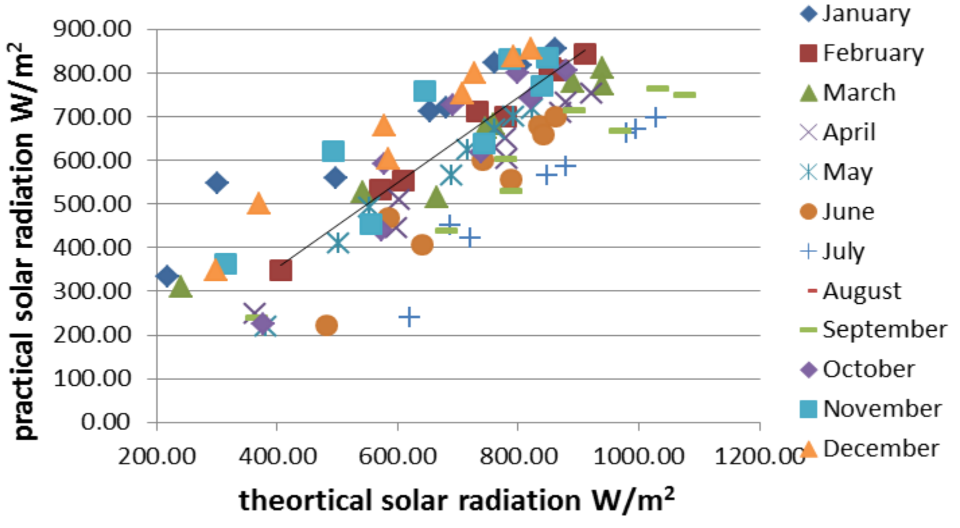

fig. 2: Theoretical solar radiation vs. practical solar radiation at diffrent months in 2011. on the horizontal surfaces.

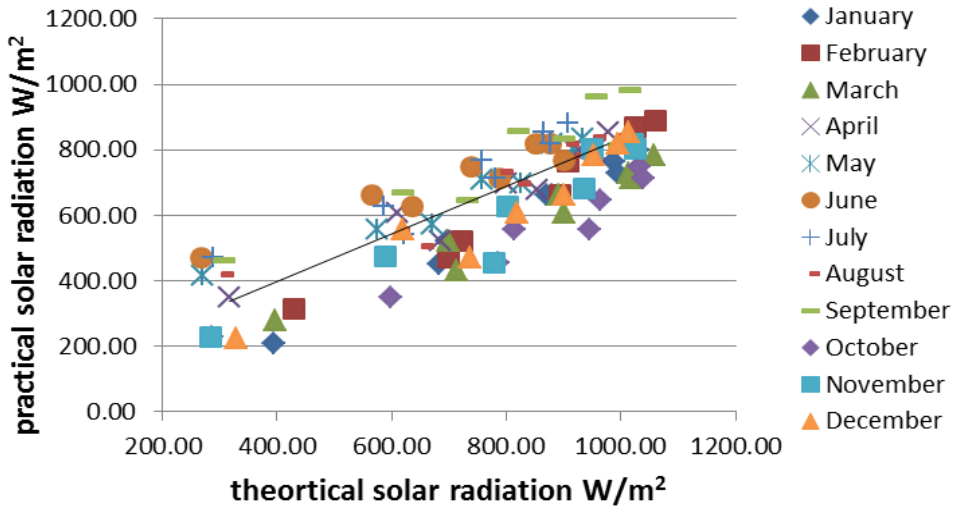

fig. 3: Theoretical solar radiation vs. practical solar radiation at diffrent months in 2006. on the inclind surfaces of 30 deg. .

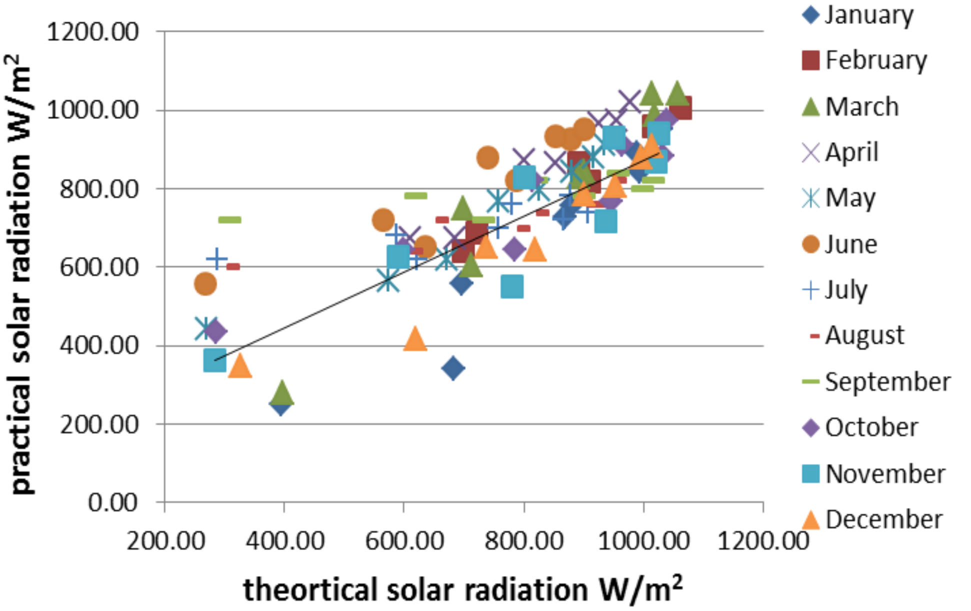

fig. 4: Theoretical solar radiation vs. practical solar radiation at diffrent months in 2011. on the inclind surfaces of 30 deg. .

Seen from Figure 5, which shows the average of the theoretical and practical solar radiation intensity falling on a horizontal surface and another making an angle 30^{o} with the horizontal. Theoretical and practical solar radiation intensity falling on the surface of the inclined angle of 30 degrees was significantly ($p<0.05$) higher than those falling on the horizontal surface, and also rate the incidence practical solar radiation intensity falling on a horizontal surface and another on the surface of the inclined angle of 30 degrees in 2011 was highest significantly ($p<0.05$) of those fallen in 2006.

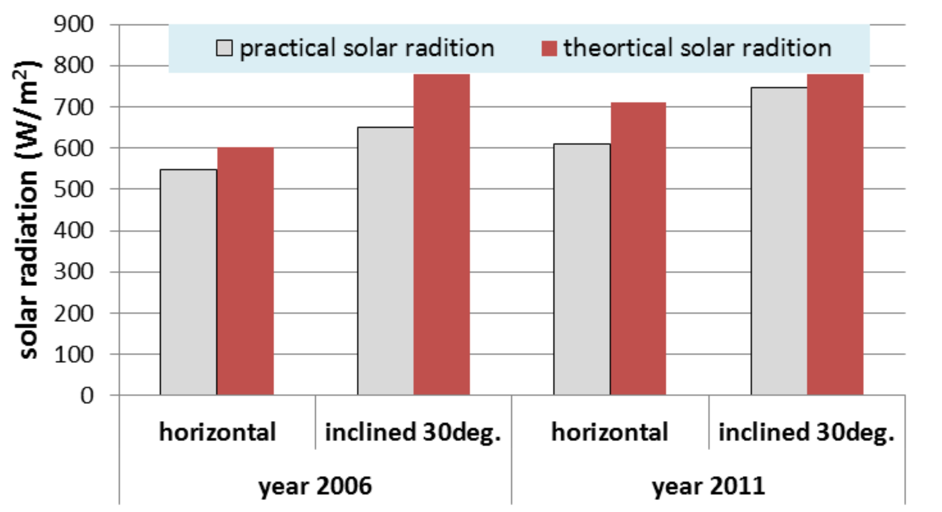

fig. 5: A practical and theortical solar radiation on horizontal and inclind of 30 deg. in 2006 and 2011.

IV. CONCLUSION

We can conclude from the current study that the intensity of theoretical and practical solar radiation is change with daylight hours and up to highest value at midday. As the intensity of theoretical and practical solar radiation is vary from one month to another. Empirical equations were concluded of the fourth order strongly to predict solar radiation in the southern city of Basra. Intensity of solar radiation in 2011 was higher than in 2006. We recommend conducting subsequent studies in the coming years to identify strongly increase solar radiation in the southern city of Basrah.

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