Kirkuk Journal of Science Vol. 18, Iss. 4, p 10-31, 2023. doi:10.32894/kujss.2023.142517.1114

A Comparative Study of the Theoretical and Actual Sunshine Hours and its Relationship to Climatic Factors in Iraq.

Jawdet H. Mohammed

Department of Physics, College of Science, Kirkuk University, Kirkuk, Iraq.
*Corresponding author : : jawdet77@uokirkuk.edu.iq.

Article Information

Article Type:
Research Article

Keywords:
Theoretical Sunshine Hours (TSH), Actual Sunshine Hours (ASH), Iraq, climatic factors, Simple Regression.

History:
Received: 10 August 2023.
Revised: 25 October 2023.
Accepted: 30 October 2023.
Published Online: 28 November 2023.
Published: 30 December 2023.

Citation: Jawdet H. Mohammed, A Comparative Study of the Theoretical and Actual Sunshine Hours and its Relationship to Climatic Factors in Iraq, Kirkuk Journal of Science, 18(4), 10-31, 2023, https://doi.org/10.32894/kujss.2023.142517.1114

Abstract

This study deals with the comparison of Theoretical Sunshine Hours (TSH) and Actual Sunshine Hours (ASH) in different meteorological stations in Iraq, and its relation to climatic factors (Maximum Air Temperature, Relative Humidity and Wind Speed), during the period between 1979 and 2019. The results indicate that the lowest monthly value of theoretical sunshine hours (TSH) was obtained at Mosul Station for the month of December with a value of 9.57 hours and the lowest monthly value for actual sunshine hours (ASH) was obtained at Mosul Station for the month of January with a value of 4.5 hours. The maximum monthly value of theoretical sunshine hours (TSH) at Mosul station for the month of June was obtained as 14.43 hours, and the maximum monthly value of actual sunshine hours (ASH) at Rutba station for July was obtained as 12.4 hours. The average annual values of theoretical sunshine hours (TSH) ranged between 11.77 hours - 12.15 hours, while the average annual values of actual sunshine hours (ASH) ranged between 8.19 hours - 9.19 hours. Simple regression equations were reached at the various study stations between theoretical and actual hours of sunshine and different climatic factors.

1. Introduction:

Solar energy is environmentally friendly and can be used almost anywhere on earth, whereas fossil fuels are only available in limited places in the world. In addition to the above advantages, solar energy is available and will never be affected by price changes associated with the oil market. Solar radiation can be used as solar radiation or photoelectric radiation [1].

Solar radiation is the energy source for the movement of the Earth's atmosphere and the cause of all physical phenomena in the atmosphere. Solar radiation is now also the main energy source for the Earth's ecosystem and has a significant impact on the development of the solar system [2].

View of the increasing depletion of fossil fuels and increasing environmental pollution, the use of renewable energy is becoming increasingly important. Therefore, the research and utilization of solar radiation must be expanded [3]

Accurate measurement and clear understanding of the spatial and temporal changes in solar radiation are of great significance for meteorology, hydrology and ecological processes, photosynthesis, agricultural and industrial production, and energy development and utilization [4].

Sunlight is one of the most important components of life on Earth. Year-round, the sun's rays warm land and oceans, are a direct factor in photosynthesis, drive the water cycle, and ultimately become the primary driver of Earth's weather and climate. Sunlight is a combination of light and radiant heat from the sun. In addition, it is directly related to solar energy resources, which is very important as a means to mitigate climate change and achieve greenhouse gas emission reduction goals [5].

Sunshine hours are one of the most important parameters for meteorological measurements and play an active role in determining solar radiation data. Furthermore, solar duration is the most effective parameter due to its relationship with global solar radiation, relative humidity, and other climate variables [6].

Sunshine duration refers to the time the ground is exposed to direct sunlight (that is, sunlight that reaches the surface of the earth directly from the sun). Sun duration is the period of time during which direct sunlight exceeds a threshold of 120 (W/m^2). This value corresponds to the amount of solar radiation shortly after sunrise or shortly before sunset under cloud-free conditions. It is determined by comparing the duration of sunlight recorded by the Campbell-Stokes sunlogger with actual direct sunlight [7].

The solar radiation over the region of Iraq was studied by Faleh et. al. 2014 and calculated. Empirical models for the Estimation of Global Solar Radiation depending on Sunshine Hours on Horizontal Surface in Various Cities of Iraq were produced (Baghdad, Rutba and Nassiria. The results show a good agreement between estimated and measured values [8].

Solar radiation was studied over the Iraqi country land by Gheidaa 2017, The best sun duration hours regions (maximum hours) in Iraq were estimated the metrological measured data of average monthly mean sunshine duration hours at a period (1983-2005) is used mean that the south west of Iraq is the favor place to establish solar cells farms [9].

The global solar radiation for the locations of fourteen Iraqi metrological stations was studied by Mertah et.al. 2019 and calculated. depending on sunshine duration measurements of these stations. This study showed that it is possible to calculate the values of extraterrestrial radiation (Ho) and global solar radiation (H) by means of the geographical location (latitude) and sunshine duration data [10].

Jawdet 2019, investigated the relation between the solar radiation and air temperature in the different locations of Kirkuk governorate (Latitude: 35.47°N, Longitude: 44.39°E) by calculation the correlation coefficient this indicates that the increasing in solar radiation leads to increase the values of air temperature, and the decreasing in solar radiation leads to decrease the values of air temperature [11].

Jawdet 2021, studied the effect of the amount of clouds on the number of actual hours of Sunshine in selected stations in Iraq, namely (Mosul Station, Baghdad Station, Basra Station), using data the amount of clouds and the number of actual hours of Sunshine for a period of (31 years) for the period extending from (1980 - 2010), The results indicated that there is a strong inverse correlation between both variables in The three study stations, and this indicates that with the increase in the amount of clouds the number of hours of actual hours of Sunshine decreases, and vice versa [12].

This study aimed to comparison of Theoretical Sunshine Hours (TSH) and Actual Sunshine Hours (ASH) in different meteorological stations in Iraq, and its relation to climatic factors (Maximum Air Temperature, Relative Humidity and Wind Speed), during the period between 1979 and 2019 and calculating the correlation coefficient between the variables to show the nature of their relationship to each other.

2. Theoretical Formulations:

The Theoretical Sunshine Hours (TSH) are given by the following equation [13]:

$$TSH = \frac{2W_s}{15} \tag{1}$$

Where W_s represent sunset hour angle, is given by the following equation:

$$W_s = \cos^{-1}(-tan\phi.tan\delta) \tag{2}$$

Where ϕ represent the latitude, and represent solar declination angle is given by the following equation:

$$\delta = 23.45\sin\left[360(\frac{284+n}{365})\right] \tag{3}$$

Where represent the day number of the year, as shown below in Table 1:

Table 1. The day number of the year [13].

month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
n	17	47	75	105	135	162	198	228	258	288	318	344

3. Study Area and Data Used:

The mean monthly values of Theoretical Sunshine Hours (TSH) were calculated by equ.1and Actual Sunshine Hours (ASH) were obtained from Iraqi meteorological stations from 1979 until 2019 using 10 stations well distributed in Iraq. Table 2 shows the geographical coordinators of the different stations in Iraq.

4. Results and Discussion:

4.1 Temporal Variation of TSH and ASH:

4.1.1 Monthly Mean:

Table 3 shows the mean monthly calculated values of (TSH) and measured values of (ASH) in different stations in Iraq during the period (1979-2019).

Table 2. Geographical coordinators of the different stations [14].

NO.	Station	Latitude (°)	Longitude (°)	Altitude (m)
1	Mosul	36	43	223
2	Kirkuk	35	44	331
3	Kanaqin	34	45	202
4	Baghdad	33	44	32
5	Rutba	33	40	631
6	Hai	32	46	17
7	Nagaf	31	44	53
8	Diwaniya	31	44	20
9	Nasiryah	31	46	5
10	Basra	30	47	2

Table 3 shows that during Winter months (December ,January and February) ,the maximum calculated values of TSH were obtained in Basra station with the values of 10.03 h , 10.23 and 10.94 h respectively, and the maximum measured values of ASH were obtained in Basra in December and February with the values of 6.7 h, 7.7 h, and in Rutba in January with the value of 6.6 h, while the minimum calculated values of TSH were obtained in Mosul in December and January with the values of 9.57 h, 9.83 h, and in Kirkuk in February with the value of 10.7 h, and the minimum measured values of ASH were obtained in Mosul station with the values of 4.6 h, 4.5 h and 5, 6 h respectively.

The lowest TSH and ASH values occurred in January, February and December, as these months are being characterized by high concentration of clouds in addition to that the angle of incidence of the solar radiation in these months is considered low.

In the months of Spring (March, April and May), the Table 3 shows that the maximum calculated values of TSH were obtained in Basra, Baghdad and Mosul with the values 11.81 h, 12.87 h and 13.93 h respectively, and the maximum measured values of ASH were obtained in Rutba station with the values of 8.3. h and 8.9 h in March and April and in Rutba and Baghdad with the value 10.1 h in May, while the minimum calculated values of TSH were obtained in Mosul in March and May with the values of 11.76 h, 12.76 h and in Basra station in April with the value 13.57 h, and the minimum measured values of ASH were obtained in Mosul, Kanaqin and Nasiriyah stations with the values of 6.8.6 h, 7.8 h and 9.16 h respectively.

The maximum calculated values of TSH during summer months (June, July and August) were obtained in Mosul station with the values 14.43 h,14.21 h and 13.35 h respectively, and the maximum measured values of ASH were obtained in Rutba station with the values of 12.3. h, 12.4 h and 10.7 h respectively, while the minimum calculated values of TSH were obtained in Basra station with the values of 13.98 h, 13.79 h and 13.1 h respectively, and the minimum measured values of ASH were obtained in Nasiriyah station with the values of 9.6 h, 9.9 h and 10.1 h respectively.

The highest values of TSH and ASH occurred most frequently between June and July. These months typically tend to have less cloud cover in the sky.

In the months of Autumn (September, October and November), the Table 3 shows that the maximum calculated values TSH were obtained in Mosul, Baghdad and Basra with the values 12.22 h,11.22 h and 10.42 h respectively, and the maximum measured values of ASH were obtained Basra station with the values of 10.4 h, 8.9 h and 7.6 h respectively, while the minimum calculated values of TSH were obtained in Mosul, Diwaniya and Basra stations with the values of 12.18 h, 11.05 and 10.08 h respectively, and the minimum measured values of ASH were obtained in Mosul, Baghdad and Kanaqin stations with the values of 8.9 h, 7.9 h and 6.3 h respectively, and this result is consistent with the results of reference [8, 9].

4.1.2 Seasonally Mean:

Table 4 shows the mean seasonally values of calculated values of TSH and measured values of ASH in all the studied Iraqi stations during the period (1979- 2019).

The maximum mean seasonal values of calculated values of TSH were obtained in Mosul station in the seasons of Spring and Summer with the values of 12.87 h, 13.99 h respectively and in Basra station in the seasons of Winter and Autumn with the values of 10.92 h, 11.27 h respectively, and the maximum measured values of ASH were obtained in Basra station in Winter with value of 7.53 h and in Rutba station in the seasons of Spring and Summer with the values of 9.1 h and 12.13 respectively and in Hai station in Autumn with the value of 9.1 h.

The minimum seasonal values of calculated values of TSH were obtained in Mosul station in Winter with the value of 10.03 h, and in Basra station in Spring and Summer with values of 12.71 h and 13.62 h and in Nagaf station in Autumn with the values of 7.91 h, and the minimum measured values of ASH were obtained in Mosul station in Winter with the value of 4.9 h, and in Kanaqin station in Spring with the value of 7.93 h and in Nasiriya station in Summer with the value of 9.86 h, and in Baghdad and Kanaqin stations in Autumn with the value of 8.13 h, and this result is consistent with the results of reference [8, 9].

4.1.3 Annually Mean:

Table 4 shows the mean annual values of calculated values of TSH and measured values of ASH in different stations. The maximum mean annual value of calculated values of TSH were obtained in Basra station with a value of 12.15 h, and the maximum mean annual value of ASH was obtained in

Table 3. Mean values of TSH and ASH in different stations in Iraq during the period (1979-2019).

NO.	Station	Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	Mosul	TSH	9.83	10.7	11.76	12.93	13.93	14.43	14.21	13.35	12.22	11.05	10.06	9.57
		ASH	4.5	5.6	6.8	7.9	9.5	12.1	12.2	11.5	10.4	8.2	6.3	4.6
2	Kirkuk	TSH	9.89	10.7	11.77	12.91	13.87	14.36	14.14	13.31	12.21	11.08	10.11	9.64
		ASH	5.4	6.3	7.3	7.9	9.4	11.3	11.2	11.3	10.2	8.2	6.7	5.5
3	Kanaqin	TSH	9.9	10.74	11.77	12.91	13.87	14.36	14.14	13.31	12.21	11.08	10.12	9.65
		ASH	5.6	6.4	6.9	7.8	9.1	11.1	11.1	10.8	9.8	7.9	6.7	5.4
4	Baghdad	TSH	9.98	10.79	11.78	12.87	13.79	14.26	14.05	13.25	12.22	11.12	10.2	9.75
		ASH	6.2	7.3	7.9	8.8	10.1	12.1	11.9	11.6	8.9	8.3	7.2	6.2
5	Rutba	TSH	10.06	10.84	11.79	12.83	13.72	14.17	13.97	13.12	12.19	11.15	10.27	9.84
		ASH	6.6	7.4	8.3	8.9	10.1	12.3	12.4	11.7	10.2	8.6	7.5	6.3
6	Hai	TSH	10.08	10.85	11.79	12.82	13.7	14.14	13.95	13.19	12.19	11.16	10.29	9.86
		ASH	6.5	7.5	7.9	8.5	9.8	11.6	11.6	11.5	10.2	9.5	7.6	6.6
7	Nagaf	TSH	10.15	10.89	11.8	12.8	13.65	14.07	13.88	13.15	12.19	11.19	10.35	9.93
		ASH	6.4	7.2	7.9	8.5	9.3	11.3	11.5	11.1	10.1	8.4	7.3	6.2
8	Diwaniya	TSH	10.16	10.9	11.8	12.79	13.63	14.05	13.86	13.14	12.18	11.19	10.36	9.95
		ASH	6.2	7.2	7.9	8.4	9.4	11.6	11.6	11.3	10.2	8.5	7.4	6.5
9	Nasiryah	TSH	10.16	10.9	11.8	12.79	13.63	14.06	13.87	13.14	12.18	11.19	10.35	9.95
		ASH	6.5	7.4	8.1	8.3	9.1	9.6	9.9	10.1	9.8	8.6	7.3	6.4
10	Basra	TSH	10.23	10.94	11.81	12.76	13.57	13.98	13.79	13.1	12.18	11.22	10.42	10.03
		ASH	6.5	7.7	8.2	8.5	9.7	11.5	11.2	11.1	10.4	8.9	7.6	6.7

(Rutba) station with a value of 9.19 h, while the minimum mean annual value of calculated values of TSH were obtained in Nagaf station with a value of 11.17 h, and the minimum mean annual value of ASH was obtained in Mosul station with a value of 8.19 h.

4.2 Spatial Variation of TSH and ASH:

Figure 1 and 2 show the spatial variation of the mean monthly values of TSH and ASH in all the studied Iraqi stations during the period (1979- 2019). From the figures, we can select three different parts:

The First Part: represents the north part of Iraq (Mosul and Kirkuk). The values of calculated values of TSH in this part ranged between 9.57 h – 10.7 h in Winter months, 11.76 h – 13.39 h in Spring months, 13.31 h – 14.43 h in Summer months and 10.06 h – 12.22 h in Autumn months, respectively, while the values of measured values of ASH ranged between 4.5 h – 6.3 h in Winter months, 6.8 h – 9.5 h in Spring months, 11.2 h – 12.2 h in Summer months and 6.3 h – 10.4 h in Autumn months, respectively.

The Second Part: represents the middle part of Iraq (Kanaqin, Baghdad, Rutba, Hai). The values of calculated values of (TSH) in this part ranged between 9.65 h – 10.08 h in Winter months, 11.77 h -13.87 h in Spring months, 13.12 h – 14.36 h in summer months and 10.12 h -12.22 h in Autumn months, respectively, while the values of measured values of (ASH) ranged between 5.4 h – 7.5 h in Winter months, 6.9 h – 10.1 h in Spring months, 10.8 h – 12.4 h in summer months and 6.7 h – 10.2 h in Autumn months, respectively.

The Third Part: represents the south part of Iraq and involves (Nagaf, Diwaniya, Nasiriya and Basra) stations. The values of calculated values of (TSH) in this part ranged between 9.93 h – 10.94 h in Winter months, 11.8 h -13.57 h in Spring months, 13.10 h – 14.07 h in Summer months and 10.35 h – 12.19 h in Autumn months, respectively while the values of measured values of (ASH) ranged between 6.2 h – 7.7 h in Winter months, 7.9 h – 9.7 h in Spring months, 9.6 h – 11.6 h in Summer months and 7.3 h – 10 .4 h in Autumn months, respectively, and this result is consistent with the results of reference [8, 9].

The reason for the difference between the calculated Values of TSH and ASH in Study Stations is the result of the fact that the actual hours of Sunshine are affected by dusty phenomena, the presence of clouds, fog, atmospheric pollutants, and the percentage of water vapor in the atmosphere. These factors work to absorb solar radiation and reflect it, so the number of actual Sunshine hours is always less than the number of theoretical Sunshine hours.

Figure 3 shows the spatial variation of TSH and ASH in different stations. From the figure we can nearly see three

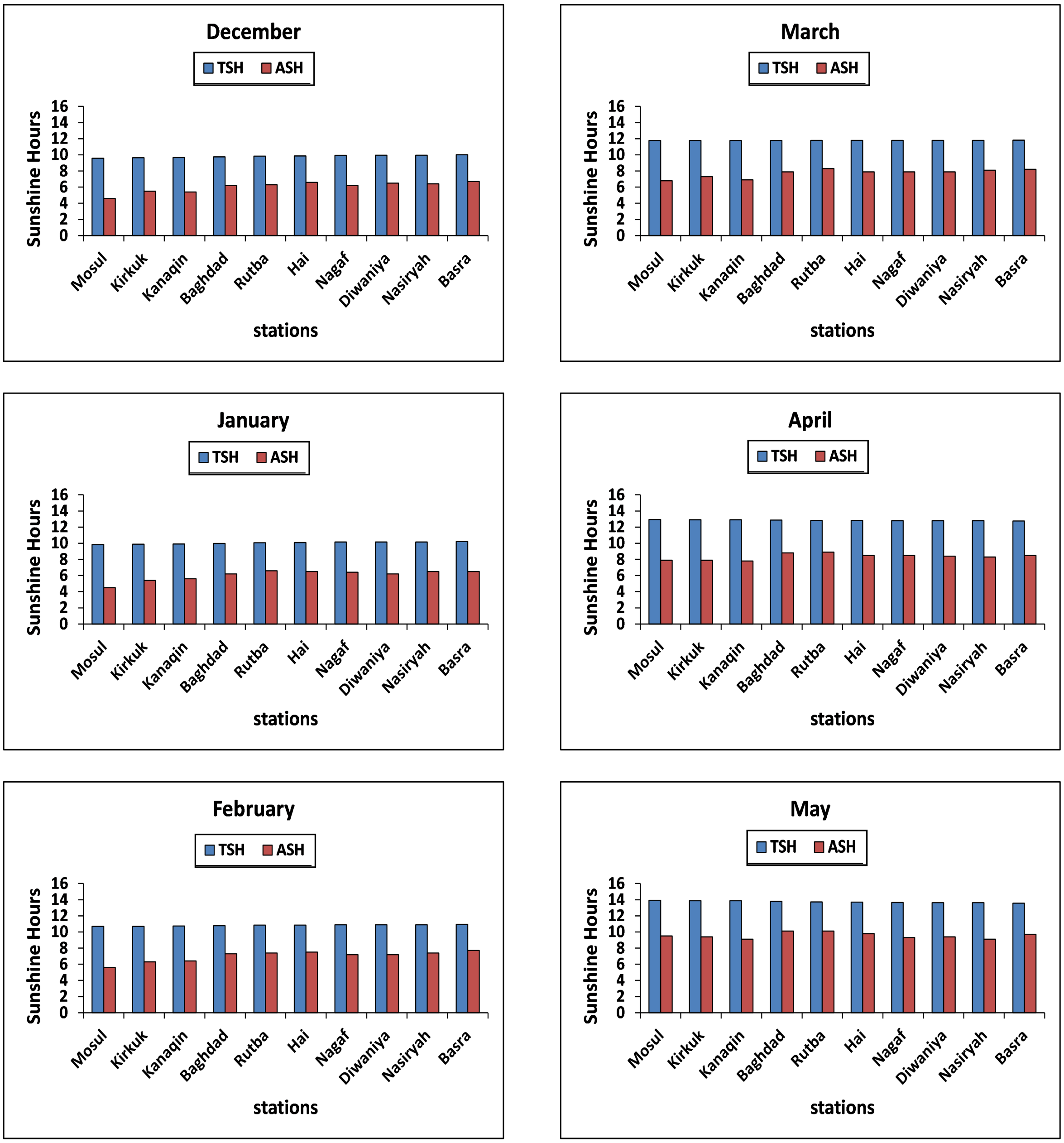


Figure 1. Spatial variations of TSH and ASH values for Winter and Spring months.

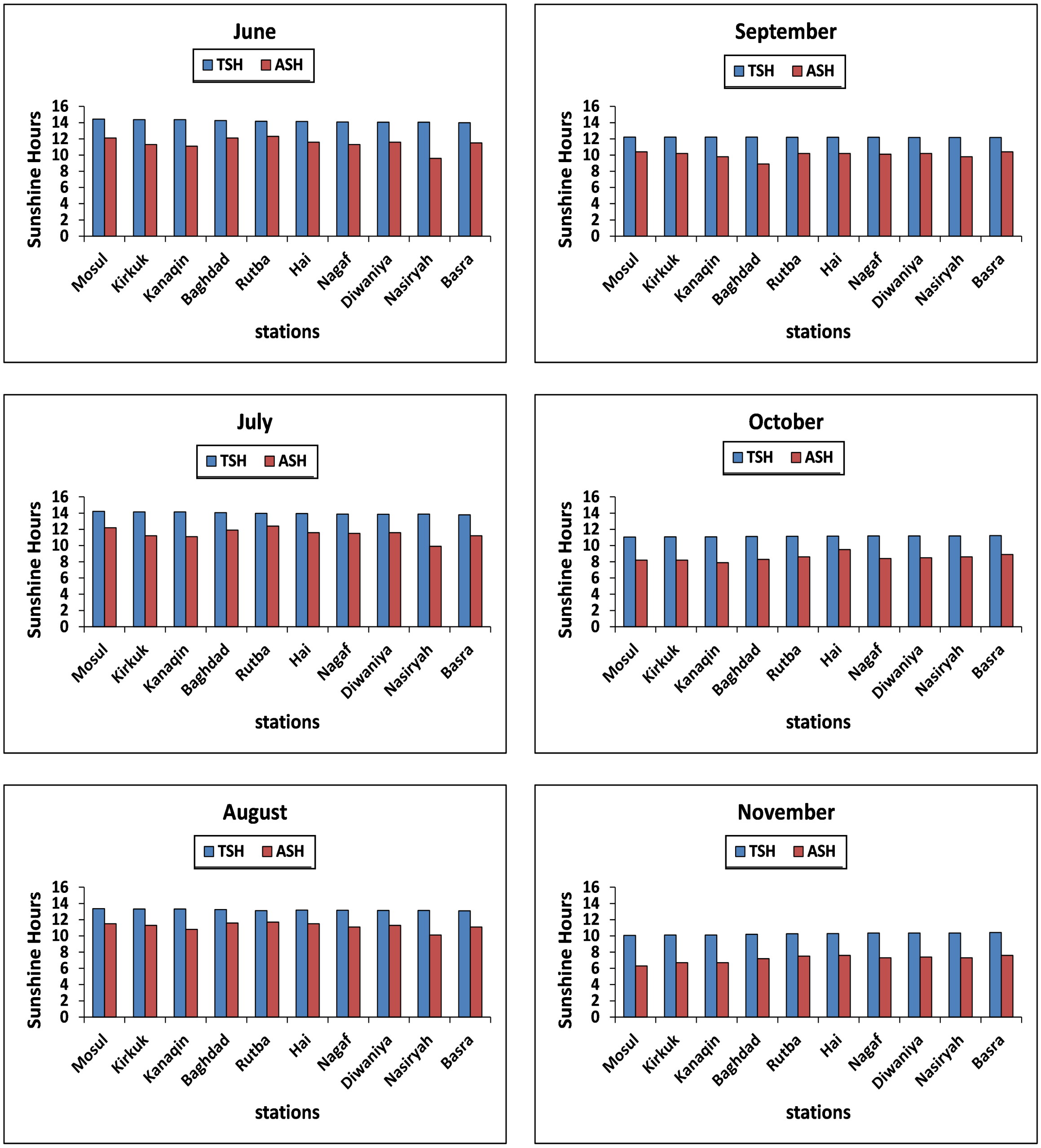


Figure 2. Same as Figure 1, for Summer and Autumn months.

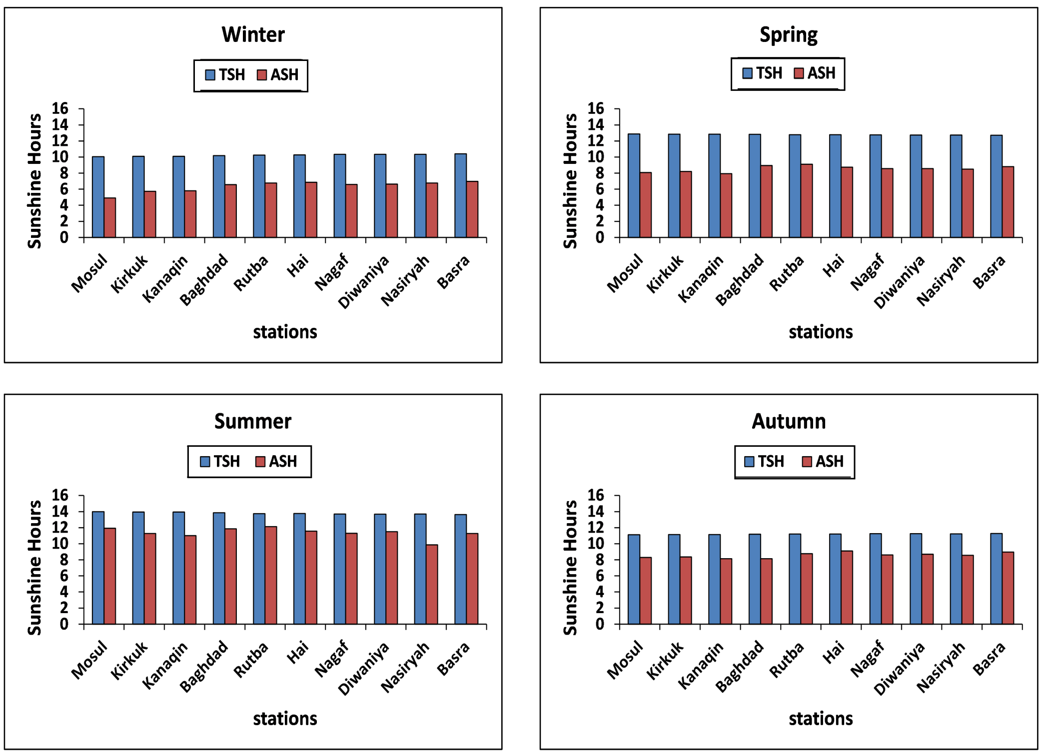


Figure 3. Spatial variations of TSH and ASH in the four seasons in Iraq.

Table 4. Mean seasonal and annual calculated values TSH and ASH in different stations in Iraq during the period (1979-2019).

NO.	Station	Season	Winter	Spring	Summer	Autumn.	Annual Mean
1	Mosul	TSH	10.03	12.87	13.99	11.11	12
		ASH	4.9	8.06	11.5	8.3	8.19
2	Kirkuk	TSH	10.07	12.85	13.93	11.13	11.99
		ASH	5.73	8.2	11.26	8.36	8.38
3	Kanaqin	TSH	10.09	12.85	13.93	11.13	12
		ASH	5.8	7.93	11	8.13	8.215
4	Baghdad	TSH	10.77	12.81	13.85	11.18	12.15
		ASH	7.13	8.93	11.86	8.13	9.01
5	Rutba	TSH	10.24	12.78	13.75	11.20	11.99
		ASH	6.76	9.1	12.13	8.76	9.19
6	Hai	TSH	10.26	12.77	13.76	11.21	12.00
		ASH	6.86	8.73	11.56	9.1	9.06
7	Nagaf	TSH	10.32	12.75	13.7	7.91	11.17
		ASH	6.6	8.56	11.3	8.6	8.76
8	Diwaniya	TSH	10.33	12.74	13.68	11.24	12.00
		ASH	6.63	8.56	11.5	8.7	8.85
9	Nasiryah	TSH	10.33	12.74	13.69	11.24	12.00
		ASH	6.76	8.5	9.86	8.56	8.42
10	Basra	TSH	10.92	12.71	13.62	11.27	12.13
		ASH	7.53	8.8	11.26	8.96	9.14

parts in all the seasons. The maximum value of calculated values of TSH and measured values of ASH in different stations in all these seasons was obtained in Basra station, while the minimum value calculated values of TSH and measured values of ASH in all stations was obtained in Mosul station.

4.3 Correlations between TSH and ASH:

Study the correlations between mean monthly values of TSH and ASH and mean monthly values of different climatic factor Maximum Air Temperature, Relative Humidity and Wind Speed,

4.3.1 Maximum Air Temperature:

Figures 4, 5 and 6, 7 show the linear regression equations and values of the correlation coefficient between mean monthly values of TSH and ASH with Maximum Air Temperature (MAT) respectively, where it is noted that there is a strong positive correlation between the two variables, and this result is consistent with the results of reference [10].

4.3.2 Relative Humidity:

Figures 8, 9 and 10, 11 show the linear regression equations and values of the correlation coefficient between mean monthly values of TSH and ASH with Relative Humidity respectively, where It is noted that there is a strong Negative correlation between the two variables, and this result is consistent with the results of reference [10].

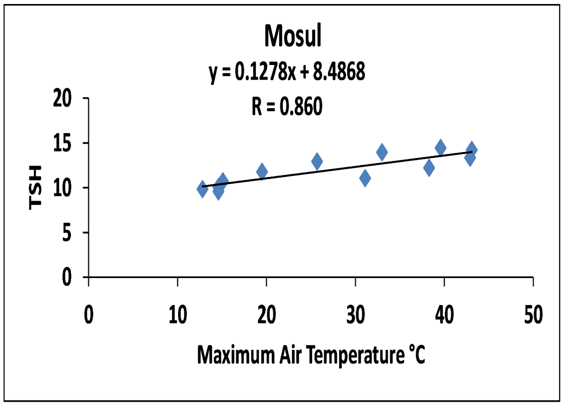
4.3.3 Wind Speed:

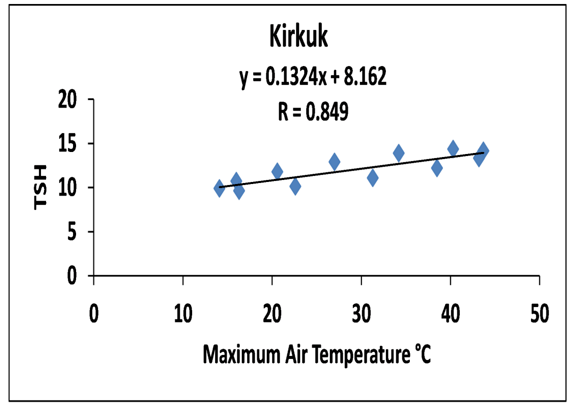
Figures 12, 13 and 14, 15 show the linear regression equations and values of the correlation coefficient between mean monthly values of TSH and ASH with Wind Speed respectively, where it is noted that there is a Positive correlation between the two variables and this result is consistent with the results of reference [10].

5. Conclusions

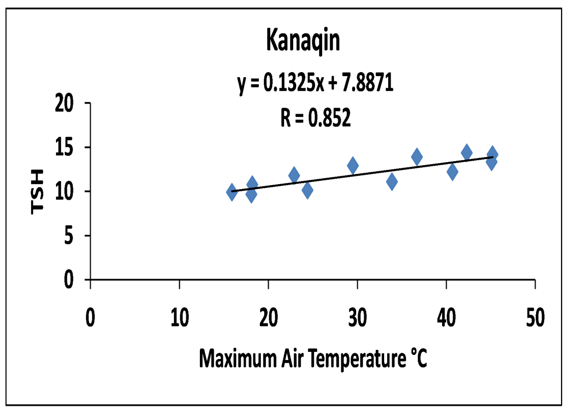
In this study, the spatial and temporal variation of comparison of TSH and ASH in different meteorological stations in Iraq during the period (1979- 2019) were studied. The results showed that:

1. TSH and ASH varies with the geographical location and period of the year.
2. Spatial variation of TSH and ASH in Iraq shows that Iraq can be divided into three parts: north, middle and south.
3. The minimum monthly value of TSH was obtained in Mosul station in December with value of 9.57 h and the minimum monthly value of ASH was obtained in Mosul station in January with value of 4.5 h.
4. The maximum monthly value of TSH was obtained in Mosul station in June with value of 14.43 h and the maximum monthly value of ASH was obtained in Rutba station in July with value of 12.4 h.
5. The mean annual values of TSH ranged between 11.77 h – 12.15 h, while the mean annual values of ASH ranged between 8.19 h – 9.19 h.
6. Simple regression equations were found between mean monthly values of TSH and ASH and mean monthly values of different climatic factors (Maximum Air Temperature, Relative Humidity and Wind Speed) in study stations. These correlations gave (positive, negative and positive) correlation coefficient between these variables respectively.

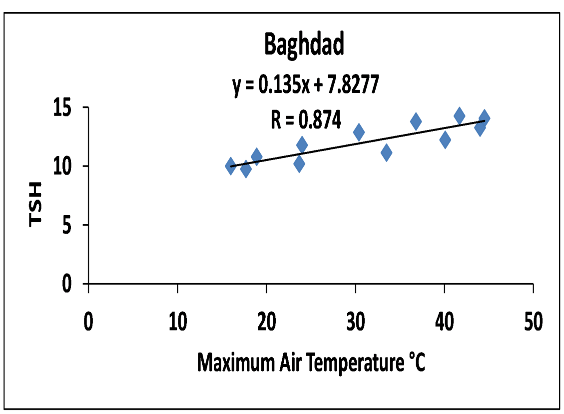


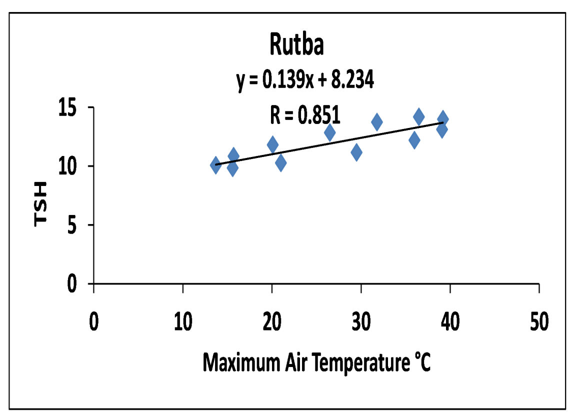


a b



c





d e

Figure 4. The simple linear regression equations and values of correlation coefficients between mean monthly values of TSH and Maximum Air Temperature (MAT) in (a) Mosul, (b) Kirkuk, (c) Kanaqin, (d) Baghdad, (e) Rutba.

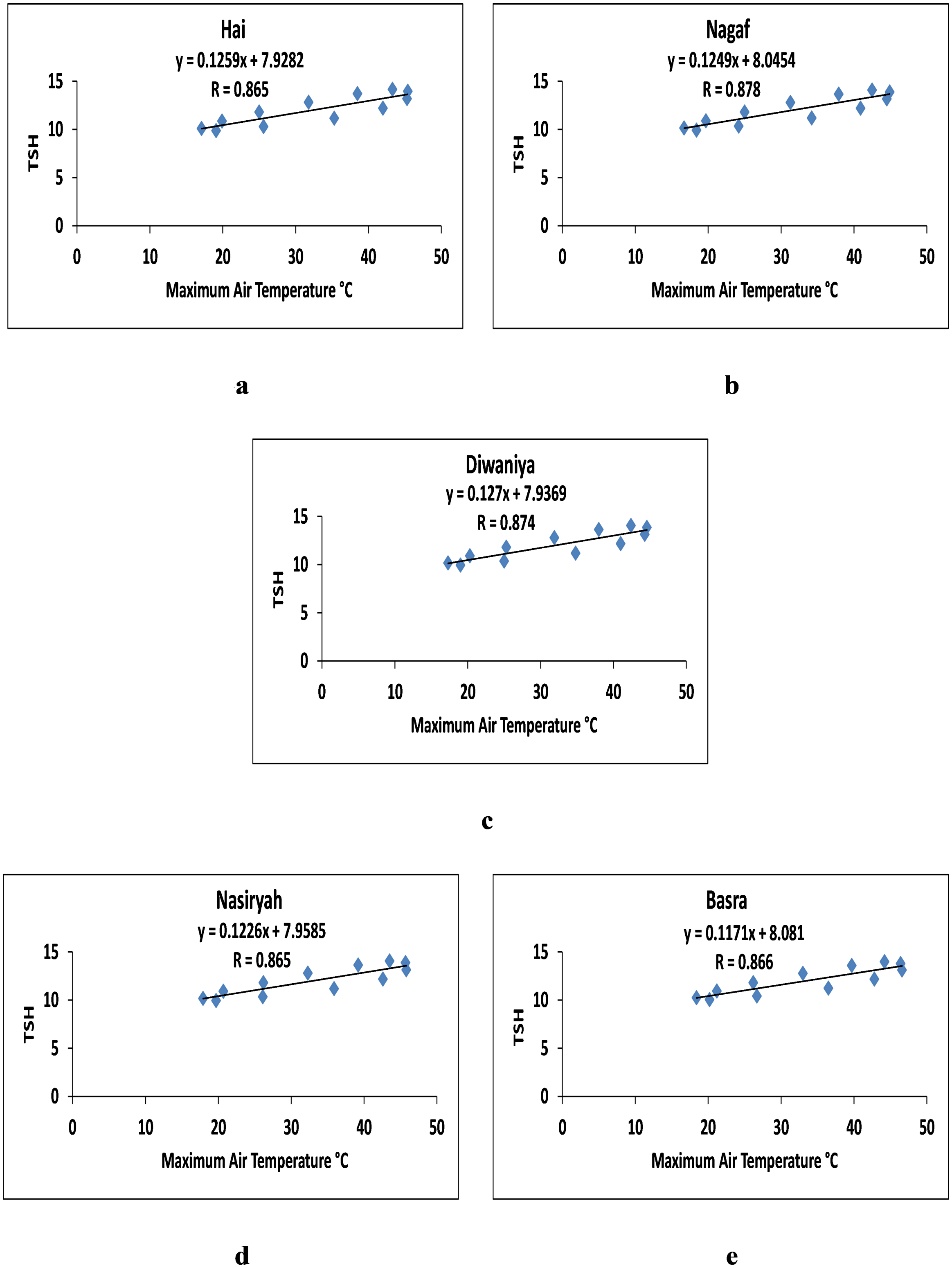
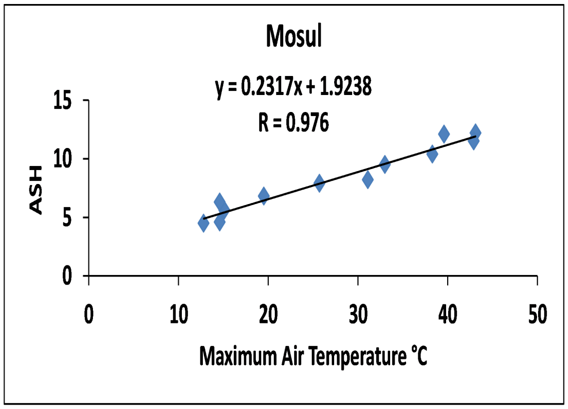
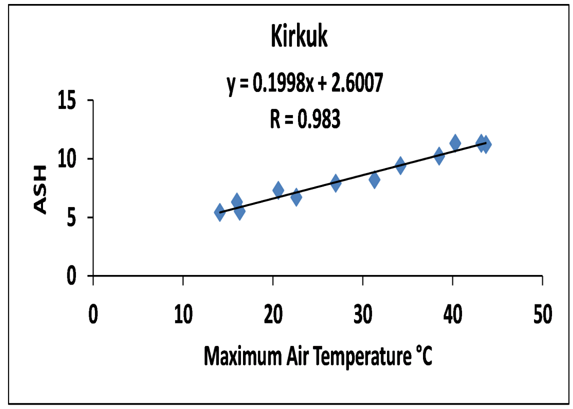


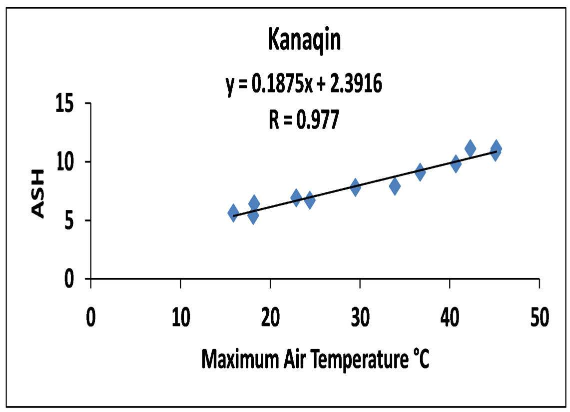
Figure 5. The simple linear regression equations and values of correlation coefficients between mean monthly values of TSH and Maximum Air Temperature (MAT) in (a) Mosul, (b) Kirkuk, (c) Kanaqin, (d) Baghdad, (e) Rutba.



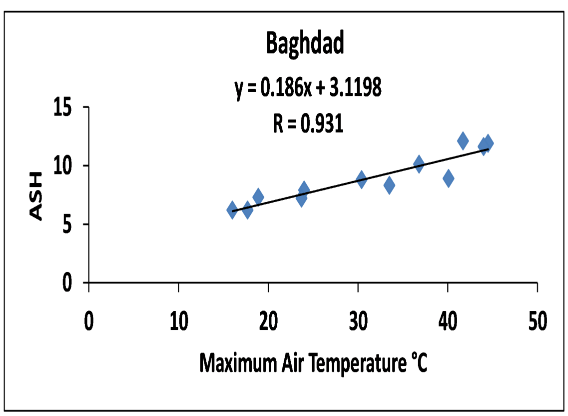
a



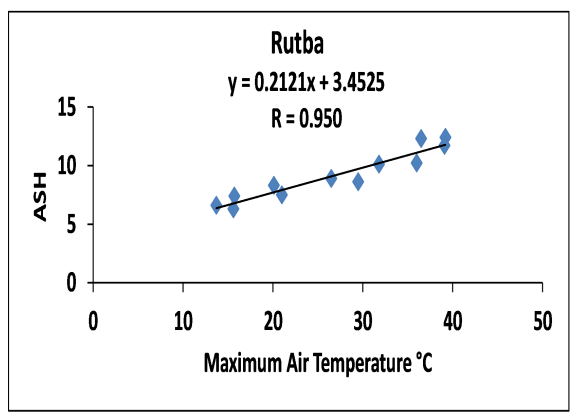
b



c



d



e

Figure 6. The simple linear regression equations and values of correlation coefficients between mean monthly values of ASH and Maximum Air Temperature (MAT) in (a) Mosul, (b) Kirkuk, (c) Kanaqin, (d) Baghdad, (e) Rutba.

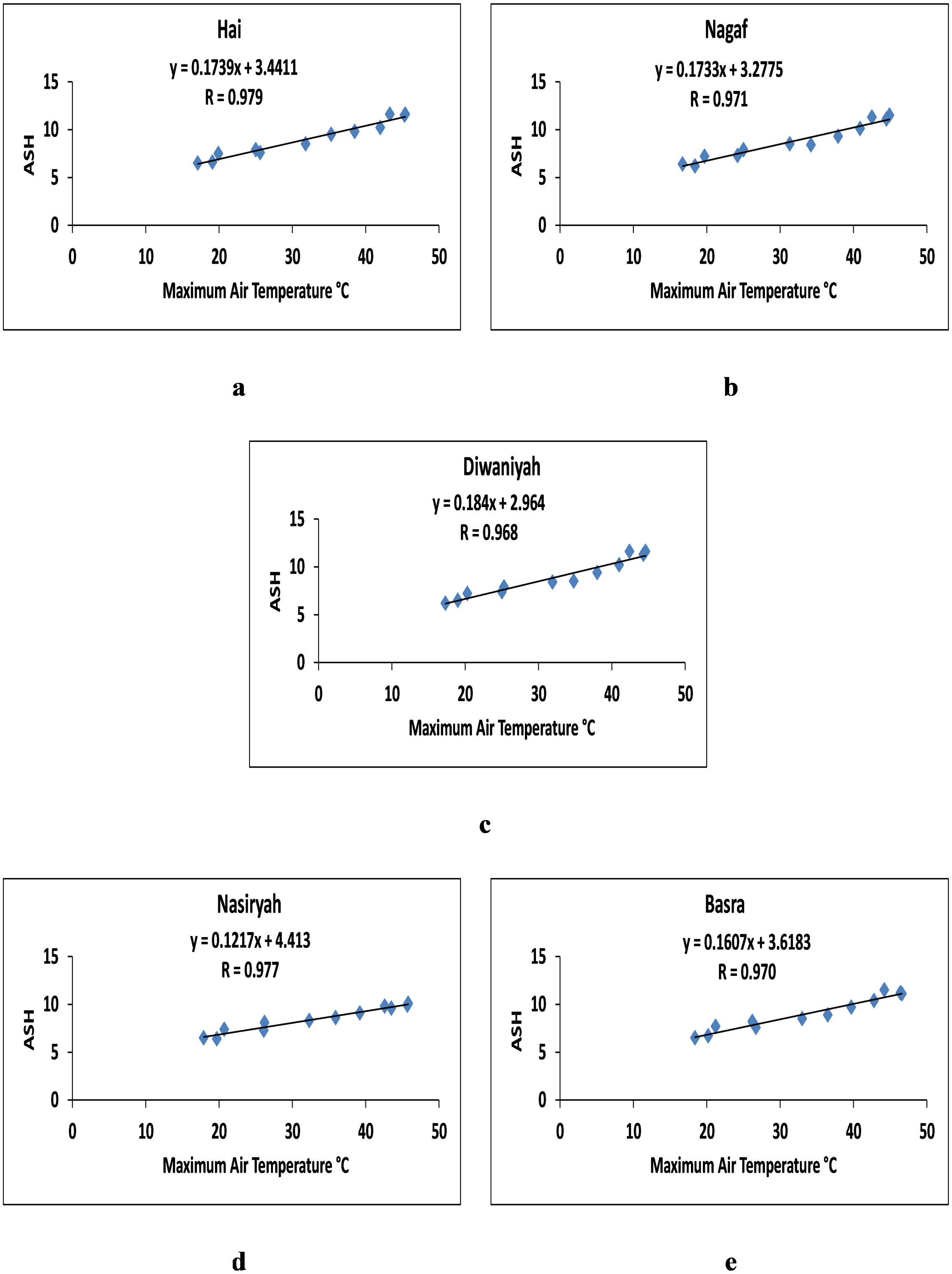


Figure 7. The simple linear regression equations and values of correlation coefficients between mean monthly values of ASH and Maximum Air Temperature (MAT) in in (a) Hai, (b) Nagaf, (c) Diwanya, (d) Nasiryah, (e) Basra.

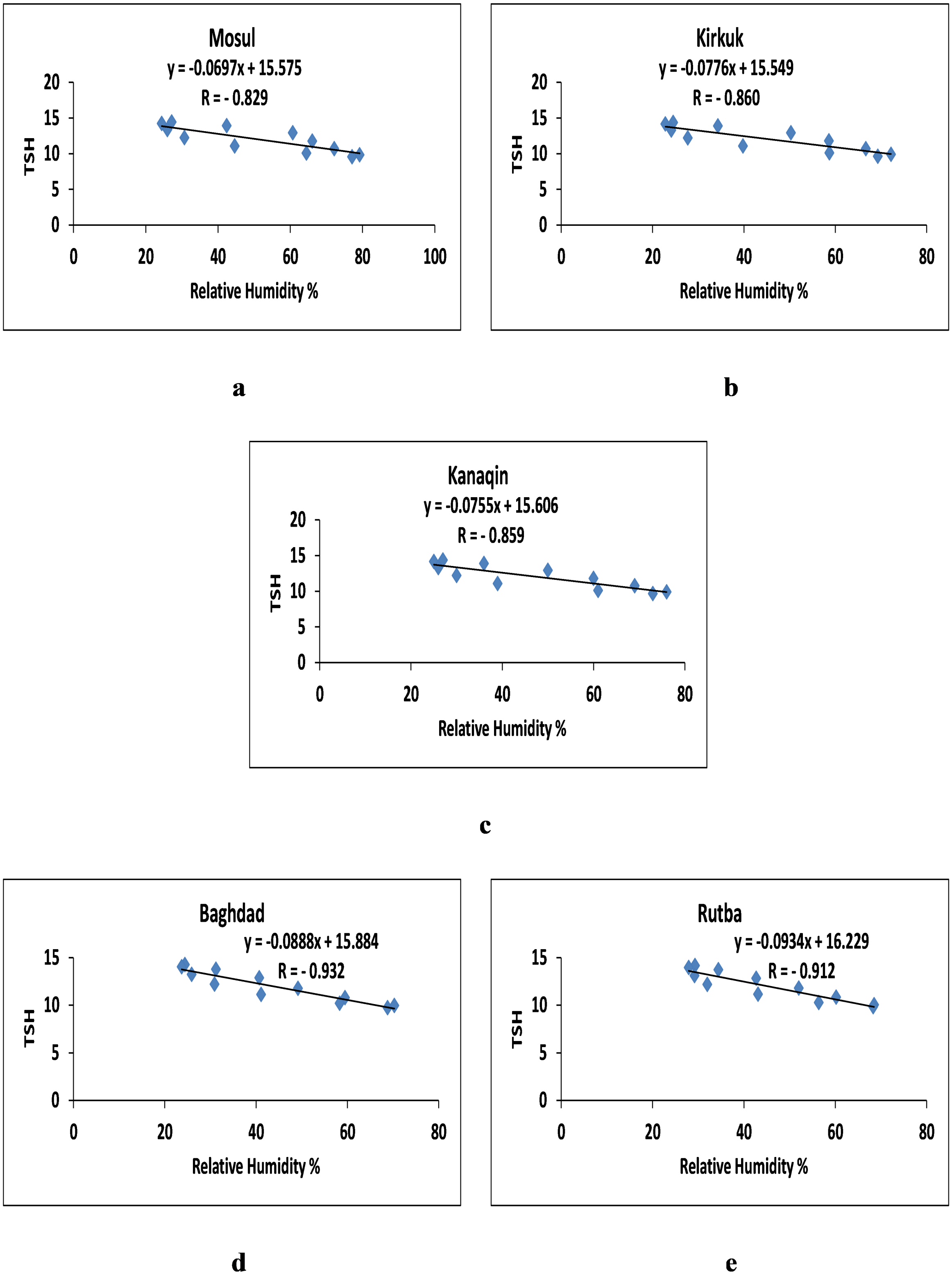
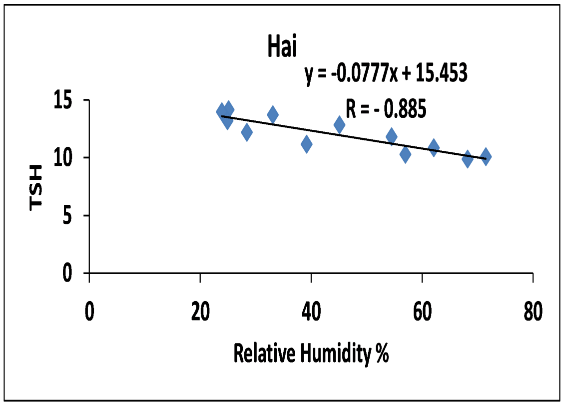
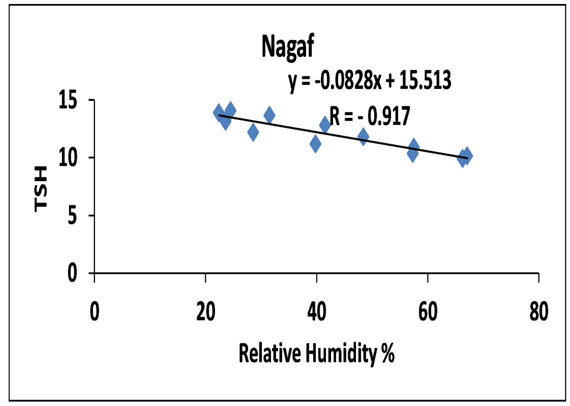
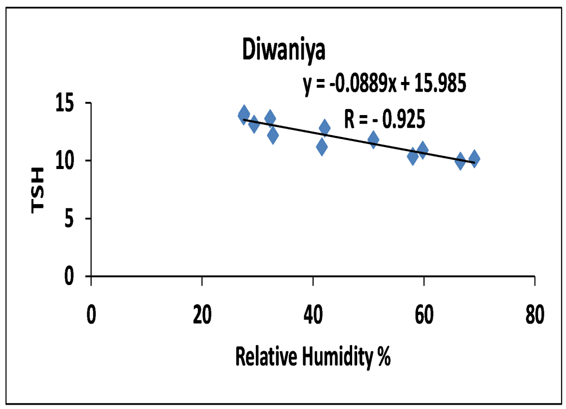


Figure 8. The simple linear regression equations and values of correlation coefficients between mean monthly values of TSH and Relative Humidity in (a) Mosul, (b) Kirkuk, (c) Kanaqin, (d) Baghdad, (e) Rutba.

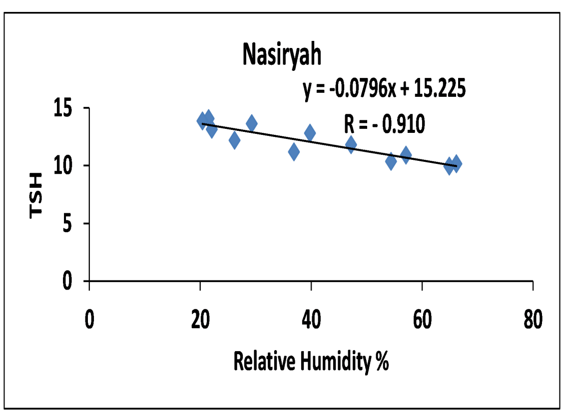


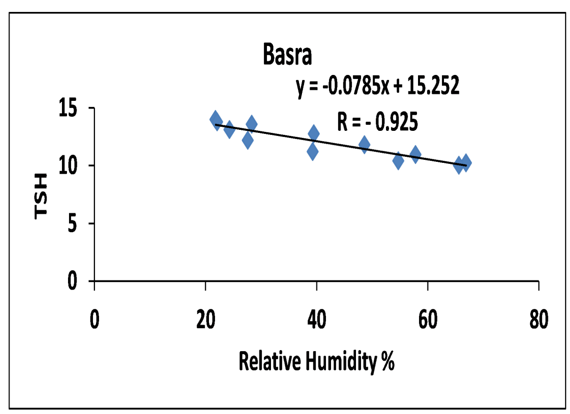


a **b**



c





d **e**

Figure 9. The simple linear regression equations and values of correlation coefficients between mean monthly values of TSH and Relative Humidity in (a) Hai, (b) Nagaf, (c) Diwanya, (d) Nasiryah, (e) Basra.

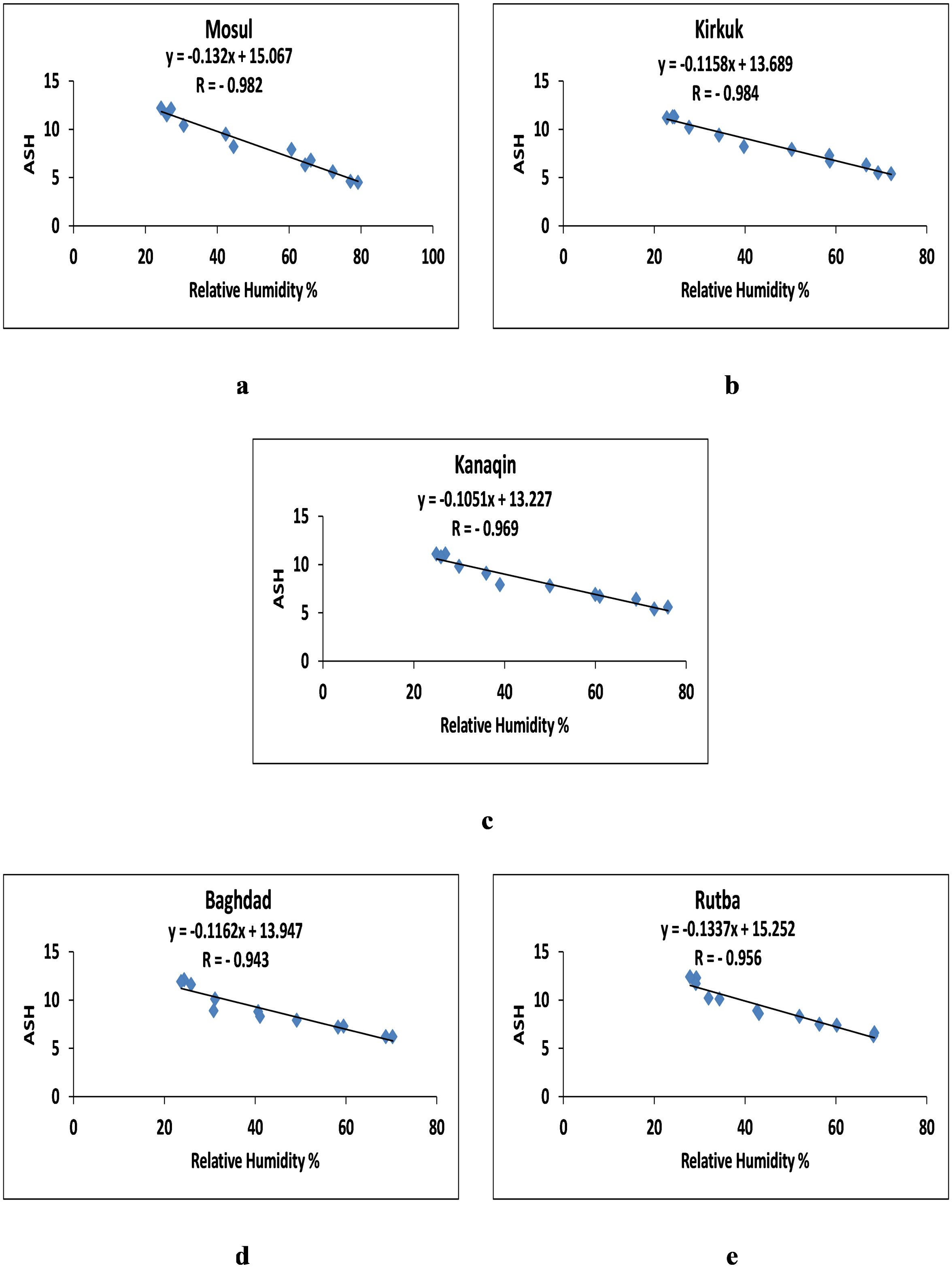
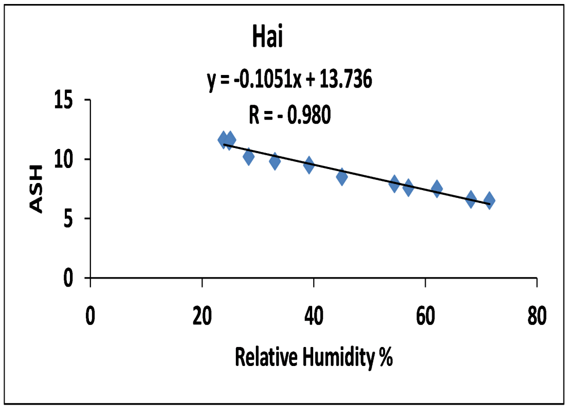
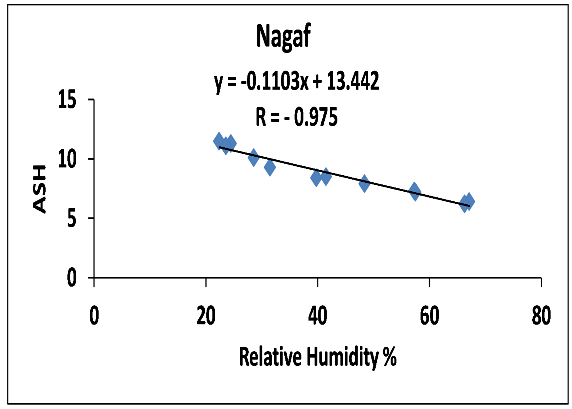


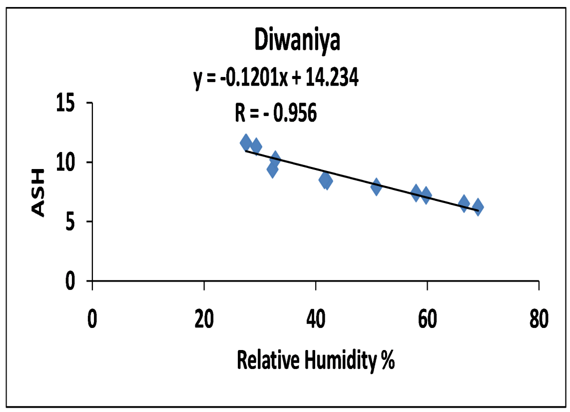
Figure 10. The simple linear regression equations and values of correlation coefficients between mean monthly values of ASH and Relative Humidity in (a) Mosul, (b) Kirkuk, (c) Kanaqin, (d) Baghdad, (e) Rutba.



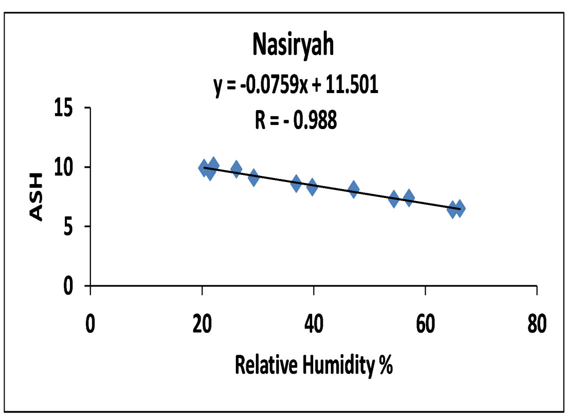
a



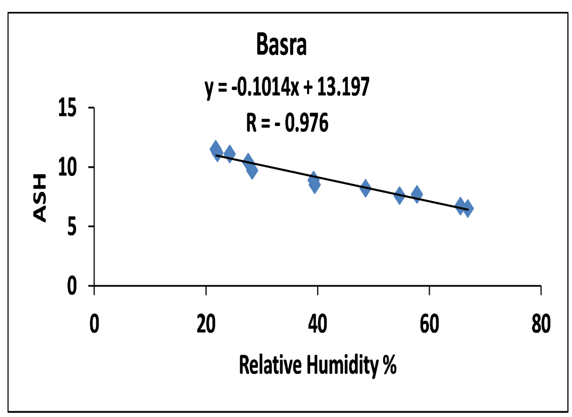
b



c



d



e

Figure 11. The simple linear regression equations and values of correlation coefficients between mean monthly values of ASH and Relative Humidity in (a) Hai, (b) Nagaf, (c) Diwanya, (d) Nasiryah, (e) Basra.

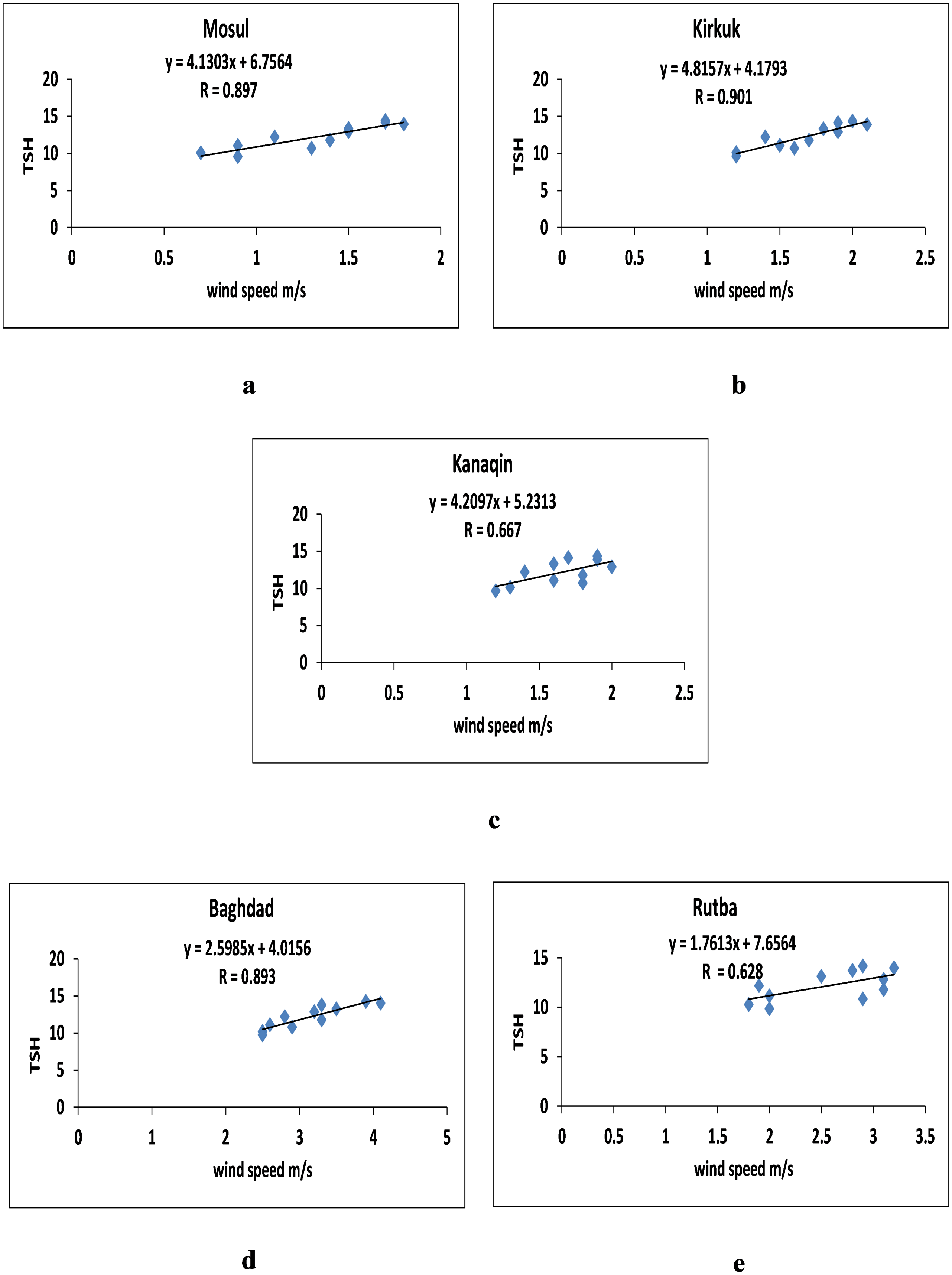
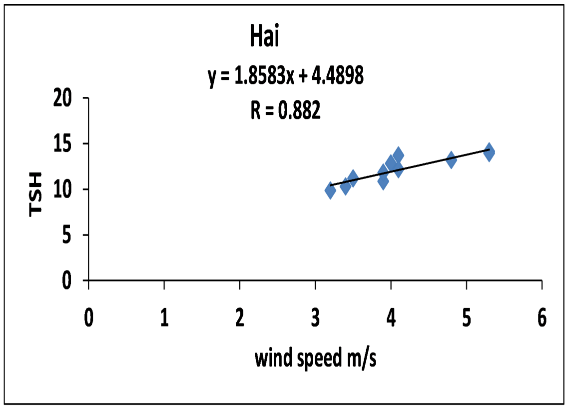
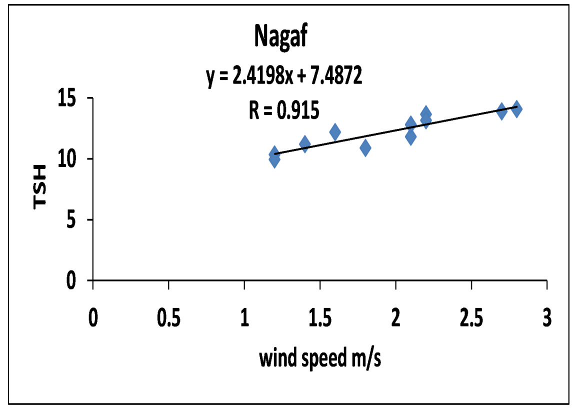
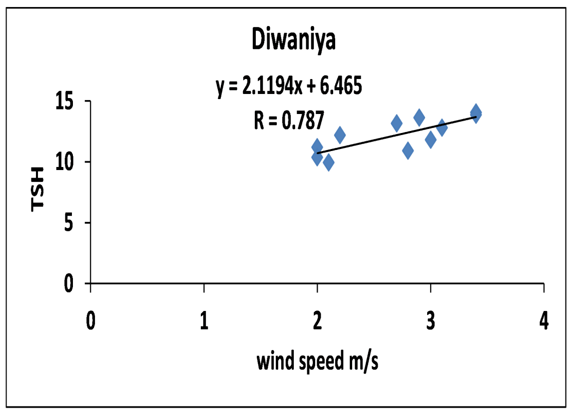


Figure 12. The simple linear regression equations and values of correlation coefficients between mean monthly values of TSH and Wind Speed in (a) Mosul, (b) Kirkuk, (c) Kanaqin, (d) Baghdad, (e) Rutba.

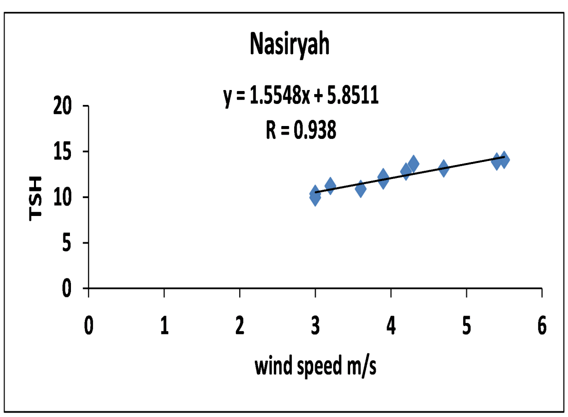


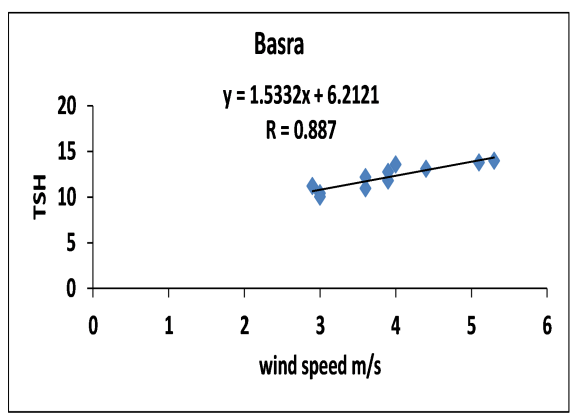


a **b**



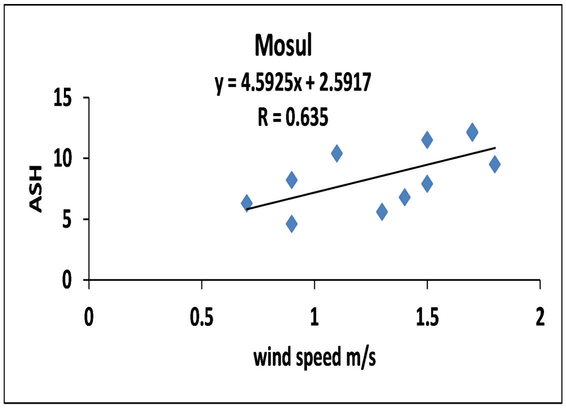
c

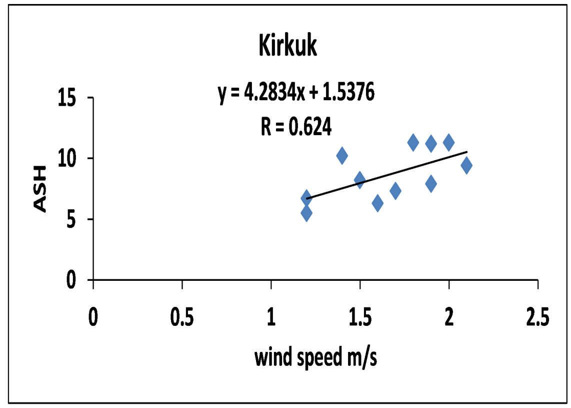




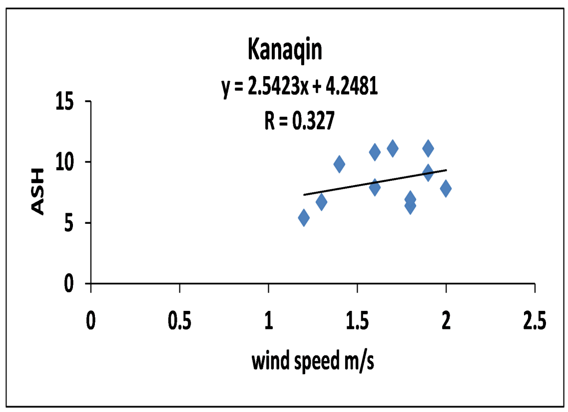
d **e**

Figure 13. The simple linear regression equations and values of correlation coefficients between mean monthly values of TSH and Wind Speed in (a) Hai, (b) Nagaf, (c) Diwanya, (d) Nasiryah, (e) Basra.

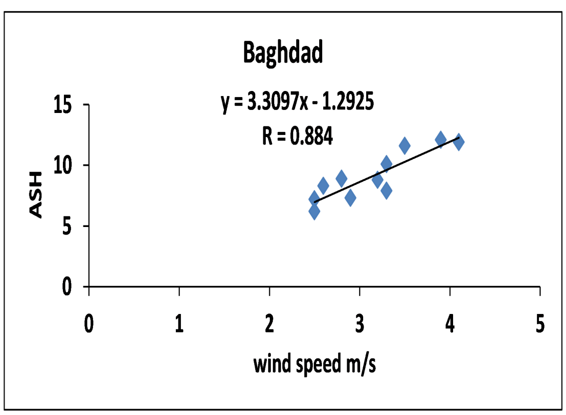


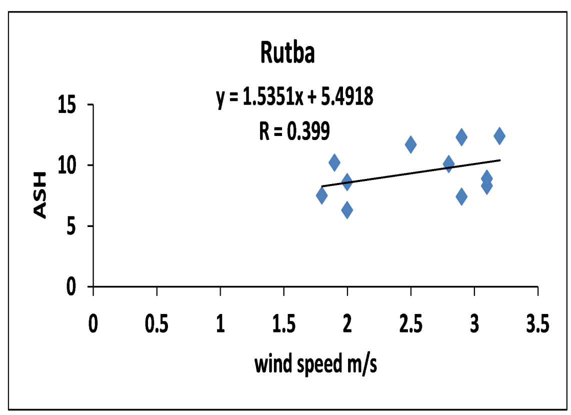


a **b**



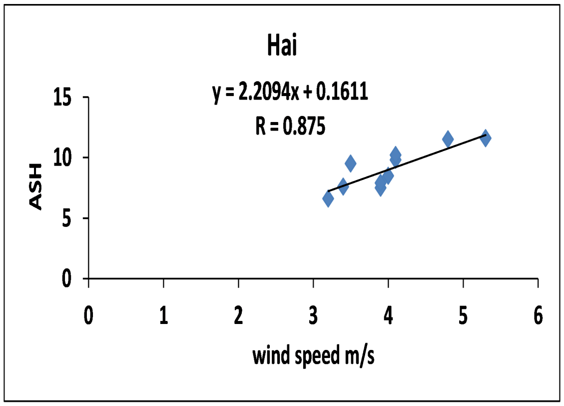
c



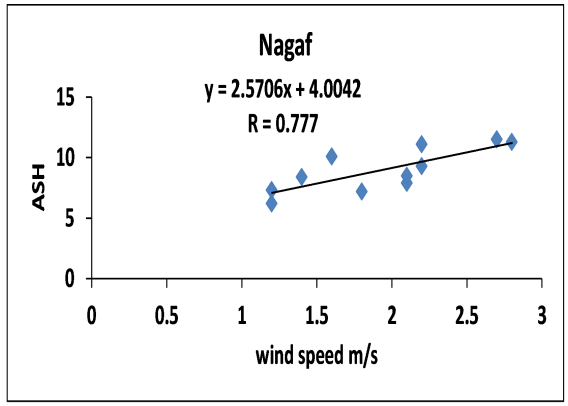


d **e**

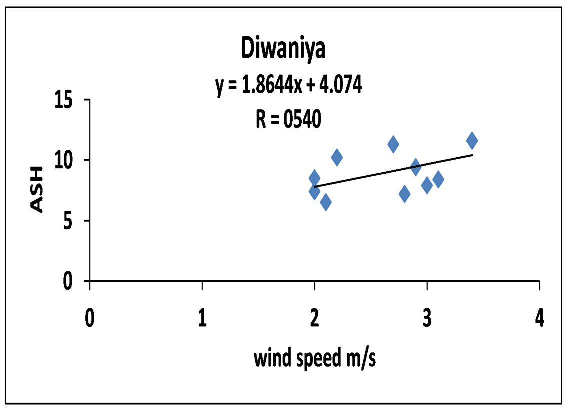
Figure 14. The simple linear regression equations and values of correlation coefficients between mean monthly values of ASH and Wind Speed in (a) Mosul, (b) Kirkuk, (c) Kanaqin, (d) Baghdad, (e) Rutba.



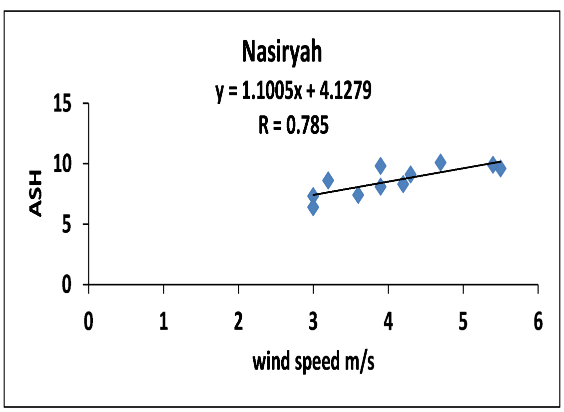
a



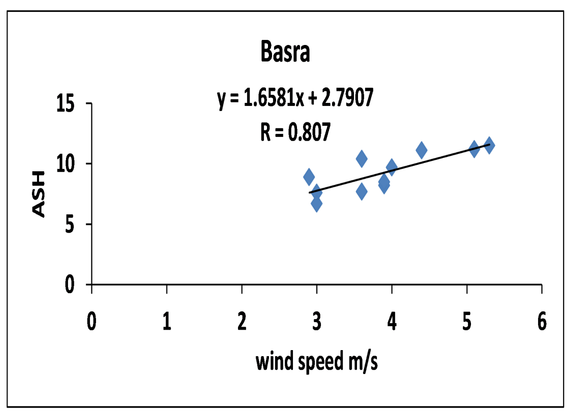
b



c



d



e

Figure 15. The simple linear regression equations and values of correlation coefficients between mean monthly values of ASH and Wind Speed in (a) Hai, (b) Nagaf, (c) Diwanya, (d) Nasiryah, (e) Basra.

Funding: None.

Data Availability Statement: All of the data supporting the findings of the presented study are available from corresponding author on request.

Declarations:
Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: The manuscript has not been published or submitted to another journal, nor is it under review.

References

[1] K. Karume, EJKB. Banda, J. Mubiru1, and M. Majaliwa. Correlation between sunshine hours and climatic parameters at four locations in uganda. *Tanz Journal of Science*, 33(2): 93–100, 2007, doi:10.4314/tjs.v33i1.44279.

[2] M. Sheik and C. V. Rao. Empirical models for estimating the global solar radiation of jubail industrial city, the kingdom of saudi arabia. *SN Applied Sciences*, 3: 1–11, 2021,doi:10.1007/s42452-020-04043-9.

[3] Y. Zhou, Y. Liu, D. Wang, and X. Liu. Comparison of machine-learning models for predicting short-term building heating load using operational parameters. *Energy Build*, 253: 111505, 2021, doi:10.1016/j.enbuild.2021.111505.

[4] H. Yakoubi, Y. El Mghouchi, N. Abdou, A. Hajou, and A. Khellouki. Correlating clearness index with cloud cover and other meteorological parameters for forecasting the global solar radiation over morocco. *Optik*, 242: 167145, 2021, doi:10.1016/j.ijleo.2021.167145.

[5] Fatemeh Rahimzadeh, Mojdeh Pedrama, and Michael C. Krukb. An examination of the trends in sunshine hours over iran. *Meteorological Applications*, 14(1): 80–90, 2012, doi:10.1002/met.1334.

[6] M. D. Umoh and S. O. Udoh. Estimation of global solar radiation from sunshine hours for warri, nigeria. *Global Journal of Environmental Sciences*, 9(1&2): 51–56, 2010, doi:10.22034/gjesm.2024.

[7] A. M. Muzathik, W. B. W. Nik, M. Z. Ibrahim, K. B. Samo, K. Sopian, and M. A. Alghoul. Daily global solar radiation estimate based on sunshine hours. *International journal of mechanical and materials engineering*, 6(1): 75–80, 2011.

[8] Faleh H.Mahmood and Gheidaa Sabeeh Al-Hassany. Syudy global solar radiation based on sunshine hours in iraq. *Iraqi Journal of Science*, 55(4A): 1663–1674, 2014, doi:10.24996/ijs.2019.55.12.

[9] Gheidaa Sabeeh Al-Hassany. Estimation of the best areas of sun duration hours in iraq by applying idw type of interpolation techniques by using gis program. *Iraqi Journal of Science*, 58(1A): 182–191, 2017, doi:10.24996/ijs.2019.60.12.

[10] Mertah naji abd and Gheidaa Sabeeh Al-Hassany. Estimation of average of global solar radiation depending on sunshine duration hours for iraqi meteorological stations. *Iraqi Journal of Science*, 60(12): 2742–2752, 2019, doi:10.24996/ijs.2019.58.12.

[11] Jawdet H. Mohammed. Study the relationship between the solar radiation and the air temperature in kirkuk governorate. *Kirkuk Journal of Science*, 14(3): 116–132, 2019, doi:10.32894/kujss.2019.14.3.10.

[12] Jawdet H. Mohammed. Study the effect of the amount of clouds on the number of actual hours of sunshine at selected stations in iraq. *Kirkuk Journal of Science*, 16(1): 145–159, 2021, doi:10.32894/kujss.2021.167891.

[13] M. Iqbal. *An Introduction to Solar Radiation*. Academic Press, New York, 1^{st} edition, 1983.

[14] Iraqi Meteorological Organization and Seismology. Actual sunshine hours, maximum air temperatures, relative humidity and wind speed data. *Department of Climate*, for the period (1979-2019).

دراسة مقارنة لساعات السطوع الشمسي النظرية والفعلية وعلاقتها بالعوامل المناخية في العراق

جودت هدايت محمد أحمد

قسم الفيزياء، كلية العلوم، جامعة كركوك، كركوك، العراق.

* **الباحث المسؤول:** *jawdet77@uokirkuk.edu.iq*

الخلاصة

تتناول هذه الدراسة مقارنة ساعات السطوع الشمسي النظرية والفعلية في محطات الأرصاد الجوية المختلفة في العراق، وعلاقتها بالعوامل المناخية (درجة حرارة الهواء العظمى، الرطوبة النسبية، سرعة الرياح)، خلال الفترة ما بين عامي 1979 و 2019. تشير النتائج إلى أنه تم الحصول على أدنى قيمة شهرية لساعات سطوع الشمس النظرية (*TSH*) في محطة الموصل لشهر كانون الأول بقيمة 9.57 ساعة وتم الحصول على أدنى قيمة شهرية لساعات سطوع الشمس الفعلية (*ASH*) في محطة الموصل لشهر كانون الثاني بقيمة 4.5 ساعة. كما تم الحصول على القيمة الشهرية القصوى لساعات سطوع الشمس النظرية (*TSH*) في محطة الموصل لشهر حزيران بقيمة 14.43 ساعة وتم الحصول على القيمة الشهرية القصوى لساعات سطوع الشمس الفعلية (*ASH*) في محطة الرطبة لشهر تموز بقيمة 12.4 ساعة. وتراوح متوسط القيم السنوية لساعات سطوع الشمس النظرية (*TSH*) بين 11.77 ساعة 12.15 ساعة، في حين تراوح متوسط القيم السنوية لساعات سطوع الشمس الفعلية (*ASH*) بين 8.19 ساعة 9.19 ساعة. كما تم التوصل الى معادلات الانحدار البسيط في محطات الدراسة المختلفة بين ساعات السطوع الشمسي النظرية والفعلية وعوامل مناخية مختلفة.

الكلمات الدالة: ساعات السطوع الشمسي النظرية؛ ساعات السطوع الشمسي الفعلية؛ العراق؛ العناصرالمناخية؛ الانحدار البسيط.

التمويل: لايوجد.

بيان توفر البيانات: جميع البيانات الداعمة لنتائج الدراسة المقدمة يمكن طلبها من المؤلف المسؤول.

اقرارات:

تضارب المصالح: يقر المؤلفون أنه ليس لديهم تضارب في المصالح.

الموافقة الأخلاقية: لم يتم نشر المخطوطة أو تقديمها لمجلة أخرى، كما أنها ليست قيد المراجعة.