Plant Archives Vol. 20, No. 1, 2020 pp. 47-55 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

IMPACT OF SOME ATMOSPHERIC FACTORS ON ULTRAVIOLET RADIATION FOR SELECTED MONITORING STATIONS IN IRAQ

Osama Tareq Al-Taai*, Iqbal Khalaf Al-Ataby and Basim Abdulsada Al-Knani

Department of Atmospheric Sciences, College of Science, Mustansiriyah University, Baghdad, Iraq.

Abstract

The Ultraviolet radiation Index is an international standard used to describe the level of UV radiation on the Earth's surface. The indicator ranges from 0 to +11, and indicates the level of exposure to this radiation. There are three types of UV rays: UVA, UVB, and UVC, which are harmful to the human body. Iraq is one of the countries where the ultraviolet radiation is moderately strong from 0 to +5, where the high values of ultraviolet radiation in the southwestern and northwestern regions is greater than the middle and eastern regions. In this study, the data of the UV radiation and Atmospheric factors (temperature and relative humidity) data from the European Centre for Medium-Range Weather Forecasts (ECMWF) were used as monthly mean and for a period eleven years (2003-2013) of six different monitoring stations in Iraq. The highest monthly and annual mean of UV radiation was found in Anah station 4.7 watt/m^2 and 2.8 watt/m^2 respectively, the highest monthly and annual mean of temperature in Nasiriyah station 47°C and 37°C respectively, the highest monthly and annual mean of relative humidity in Anah station 79% and Karbala station 59% respectively, the lowest monthly and annual mean of UV radiation at the Khanaqin station 0.4 watt/m^2 and Baghdad station 2 watt/m^2 respectively, the lowest monthly and annual mean of temperature in Anah stations 6.5°C and 19°C respectively, the lowest monthly and annual mean of relative humidity was in the Nasiriyah station 19% and 32% respectively, and found that there is a strong positive relationship between the monthly mean of temperature and UV radiation, and was the strongest correlation coefficient In Mosul and Karbala stations (R=+0.9), there was a strong inverse relationship between the monthly mean of relative humidity and UV radiation and was the strongest correlation coefficient in the stations of Anah, Baghdad and Karbala (R= -0.9).

Key words : Ultraviolet radiation Index, Temperature, Relative humidity, ECMWF, Iraq.

Introduction

Ultraviolet (UV) radiation, defined as electromagnetic radiation having wavelengths within the range 100–400 nm, composes 8.73% of the solar spectrum at the top of the atmosphere and represents a smaller part of the spectrum at the Earth's surface (Foyo-Moreno *et al.*, 1998; Canada *et al.*, 2000; Ogunjobi *et al.*, 2004). However, UV radiation is very important because of its biological and photochemical effects, therefore, understanding the amount of UV near the Earth's surface and its spatial and temporal availability is of significance to a wide range of disciplines. (Zerefos, 1997; He *et al.*, 2002). The study of solar ultraviolet radiation has received considerable attention in the past few years because of its biological, ecological, and physic effects produced by short-wave radiation received at the surface of the earth. Ultraviolet radiation is divided into three spectrum ranges according to the length of waves: UVA (315–400 nm), UVB (280–315 nm) and UVC (100–280 nm) (Alados, *et al.* 2004).

The shorter are the waves, the higher energy they have and the more harmful radiation they possess (Masserot, *et al.*, 2002). The ozone layer absorbs almost all the UVC beams, a major share 95% of UVB and only a very small share 5% of UVA beams. UVB is the most dangerous radiation that reaches the earth's surface (Koronakis, *et al.*, 2002).UV radiation from the sun has both important beneficial and detrimental effects on humans. It damages the main building blocks of human life, *i.e.*, deoxyribonucleic acid (DNA). Surface UV levels are mainly affected by solar zenith angle, clouds, aerosol and surface albedo in addition to ozone. The sun emits

***Author for correspondence :** E-mail : osamaaltaai77@uomustatnsiriyah.edu.iq

energy across the electromagnetic spectrum but mainly in wavelength between 200 and 400 nm. Energy emitted as a function of wavelength is very similar to what is expected from a black body with a temperature of 6000 K, which is close to the sun's photosphere temperature, while the averaged energy flux density emitted at the photosphere is 6.2×107 watt/m^2 (Weeb *et al.*, 1980). One of the most important phenomena that influence UV radiation is the absorption by photochemical reactions.

Those phenomena in general are involved in the ozone creation-destruction cycle which take place basically in the stratospheric, virtually absorb all radiation in the UVC band even if stratospheric ozone greatly reduced, all UVC which would still be totally absorbed (Mardonich *et al.*, 1998). The average UV radiation was found to comprise 3.25% of the global radiation. Therefore, most of the 47% reduction in received incoming global solar UV radiation is due to scattering and absorption in the atmosphere. The changes of UV radiation intensity resulting from the changes of the stratospheric ozone quantity could alter the concentration of reactive tropospheric gases, including ozone. The influence of UV intensity changes could be relevant to the regional scale air quality, since it could alter the short-term and long-term concentrations of photo oxidants in the boundary layer. Increased UV radiation intensity enhances photochemical activity in the troposphere (Pounds, *et al.*, 1994). Control of temperature and relative humidity is critical in the preservation of library and archival collections because unacceptable levels of these contribute significantly to the breakdown of materials. Heat accelerates deterioration: the rate of most chemical reactions, including deterioration, is approximately doubled with each increase in temperature of 10°C. High relative humidity provides the moisture necessary to promote harmful chemical reactions in materials and, in combination with high temperature, encourages mold growth and insect activity. Extremely low relative humidity, which can occur in winter in centrally heated buildings, may lead to desiccation and embrittlement of some materials. Fluctuations in temperature and relative humidity are also damaging. Library and archival materials are hygroscopic, readily absorbing and releasing moisture. They respond to diurnal and seasonal changes in temperature and relative humidity by expanding and contracting. Dimensional changes accelerate deterioration and lead to such visible damage as cockling paper, flaking ink, warped covers on books, and cracked emulsion on photographs. In some situations, however, materials may be protected from moderate fluctuations. Mild changes appear to be buffered by certain types of storage enclosures and by books being packed closely together. Installation of adequate climate controls and operation of them to maintain preservation standards will retard the deterioration of materials considerably. Climate control equipment ranges in complexity from a simple room air conditioner, humidifier, and/or dehumidifier to a central, building-wide system that filters, cools, heats, humidifies, and dehumidifies the air.

It is always advisable to seek the guidance of an experienced climate control engineer prior to selection and installation of equipment. Additional measures can be taken to control temperature and relative humidity. Buildings should be kept well maintained. Cracks should be sealed as soon as they occur. External doors and windows should have weather stripping and should be kept closed to prevent exchange of unconditioned outside air. In areas of this country that experience cold winter weather, windows can be sealed on the inside with plastic sheets and tape. In storage areas windows can be sealed using both wallboard and plastic. Authorities disagree on the ideal temperature and relative humidity for library and archival materials. A frequent recommendation is a stable temperature no higher than 21.1°C and a stable relative humidity between a minimum of 30% and a maximum of 50%. Research indicates that relative humidity at the lower end of this range are preferable since deterioration then progresses at a slower rate. In general, the lower the temperature the better. The temperature recommendations for areas used exclusively for storage are much lower than those for combination user and storage areas. Cold storage with controlled humidity is sometimes advisable for remote storage or little-used materials. When materials are taken out of cold storage, however, the radical, rapid temperature changes they experience may cause condensation on them. In such cases, gradual acclimatization may be required. Maintaining stable conditions is crucial. An institution should choose a temperature and relative humidity within the recommended ranges that can be maintained twenty-four hours a day, 365 days a year. The climate-control system should never be turned off, and settings should not be lowered at night, on weekends, or at other times when the library or archives is closed. Additional costs incurred by keeping the system in constant operation will be far less than the cost of future conservation treatment to repair damage caused by poor climate. While these recommendations may be expensive or even impossible to achieve in many libraries and archives, experience and scientific testing indicate that the useful life of materials is significantly extended by maintenance of moderate, stable levels of temperature and relative humidity. Where economics or inadequate mechanical systems make it impossible to maintain ideal conditions year round, less stringent standards may be chosen for summer and winter with gradual changes in temperature and relative humidity permitted between the two seasons. The seasonal standards should be as close to the ideal as possible.

It is important to note that temperature and relative humidity requirements of non-paper-based materials in the collections may differ from those of paper-based materials. Also, maintaining the ideal level of temperature and relative humidity may damage the fabric of the building that houses the collections. Difficult choices and compromises may be unavoidable. Temperature and relative humidity should be systematically measured and recorded. This is important since the data produced 1) documents existing environmental conditions; 2) supports requests to install environmental controls; and 3) indicates whether available climate-control equipment is operating properly and producing the desired conditions. Remember that changing one factor may alter others. If measures are taken without considering the environment as a whole, conditions may worsen rather than improve. It is essential to know (from recorded measurements) what conditions actually are and to seek the advice of an experienced climate-control engineer before making major changes (Lull, *et al.*, 1995).

Materials and Methods

Statistical Methods

Simple Linear Regression (SLR)

Linear Regression assumes an association between the independent and dependent variable that, when graphed on a Cartesian coordinate system, produces a straight line. Linear Regression finds the straight line that most closely describes, or predicts, the value of the dependent variable, given the observed value of the independent variable. The equation used for a Simple Linear Regression is the equation for a straight line (Yazdani, *et al.*, 2011).

$$y = a + bx \quad .... (1)$$

$$b = \frac{\sum_{i=1}^{n}(x_i - x) - (y_i - y)}{\sum_{i=1}^{n}(x_i - x)^2} \quad .... (2)$$

Where, y is the dependent variable, *x* is the independent variable, *b* is the intercept, or constant term (value of the dependent variable when *x*=0, the point where the regression line intersects the y axis), and *b* is the slope, or regression coefficient (increase in the value of *y* per unit increase in *x*).

As the values for *x* increase, is the slope, or regression coefficient (increase in the value of y per unit increase in *x*).

As the values for x increase, the corresponding value for *y* either increases or decreases by *b* corresponding value for y either increases or decreases by *b* Linear Regression is a parametric test, that is, for a given independent variable value, the possible values for the dependent variable are assumed to be normally distributed with constant variance around the regression line.

Spearman Rank Order Correlation (SROC)

Use Spearman Rank Order Correlation when to measure the strength of association between pairs of variables without specifying which variable is dependent or independent. The residuals (distances of the data points from the regression line) are not normally distributed with constant variance. If you want to assume that the value of one variable affects the other, use some form of regression. If you need to find the correlation of normally distributed data, use the parametric Pearson Product Moment Correlation (Lehman, 2005).

Spearman Correlation Coefficient (R)

The Spearman correlation coefficient (R) quantifies the strength of the association between the variables. (R) Varies between -1 and +1. A correlation coefficient near +1 indicates there is a strong positive relationship between the two variables, with both always increasing together. A correlation coefficient near -1 indicates there is a strong negative relationship between the two variables, with one always decreasing as the other increases. A correlation coefficient of zero indicates no relationship between the two variables. When written in mathematical notation the Spearman Rank formula as follows (Myers, *et al.*, 2003):

$$R = 1 - \frac{6\sum d_i^2}{n^3 - n} \quad .... (3)$$

Where, the difference in the ranks (d) this is the difference between the ranks of the two values, Square the differences (d^2) to remove negative values and then sum them, the value (*n*) is the number of sites at which you took measurements. This, in our example is 10. Substituting these values into $n^3 - n$ we get (1000 – 10).

P-Value

The P-value is the probability of being wrong in concluding that there is a true association between the variables. The smaller the P-value. The greater the probability that the variables are correlated. Traditionally, you can conclude that the independent variable can be used to predict the dependent variable when P < 0.05

(Dodge, 2010).

The Data and Study Monitoring Stations

Were used data of the European Centre for Medium-Range Weather Forecasts (ECMWF) (Angelucci, *et al.*, 1998), for Temperature (T), Relative Humidity (RH) and Ultraviolet Radiation (UV) for six monitoring stations in Iraq, from north to south (Mosul, Anah, Khanaqin, Baghdad, Karbala, and Nasiriyah), for eleven years (2003-2013) (Osama, *et al.*, 2017). These monitoring stations represent different regions of Iraq (North, Central and South) in terms of temperature, relative humidity and UV radiation as in Table 1 and Fig. 1.

Table 1: Longitude, latitude and elevation of the six monitoring stations in Iraq from north to south.

Monitoring Stations	Longitude (°E)	Latitude (°N)	Elevation (meter)
Mosul	43.150	36.317	223
Anah	41.950	34.467	134
Khanaqin	45.433	34.300	200
Baghdad	44.233	33.233	34
Karbala	44.017	32.617	28
Nasiriyah	46.233	31.083	9

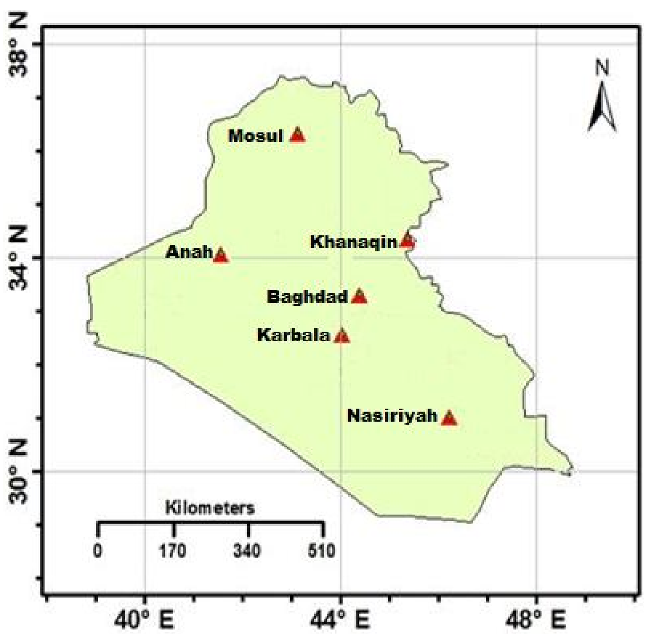


Fig. 1: Iraq map shows the six monitoring stations from north to south.

Results and Discussion

The Monthly Mean of UV Radiation

The Fig. 2, show the monthly mean for the eleven years (2003-2013) of the amount of UV radiation for the six monitoring stations in Iraq, where it was found that the highest value of UV radiation in the Anah station 4.7 watt/m^2 in July, this is due to the height of this station from sea level. The value of solar radiation is generally high. Therefore, the value of UV radiation is high as well, and the value of UV radiation in all monitoring stations is highest in July. The lowest UV radiation value was in the Khanaqin station 0.4 watt/m^2 in November, and the value of UV radiation in all monitoring stations is lowest in November.

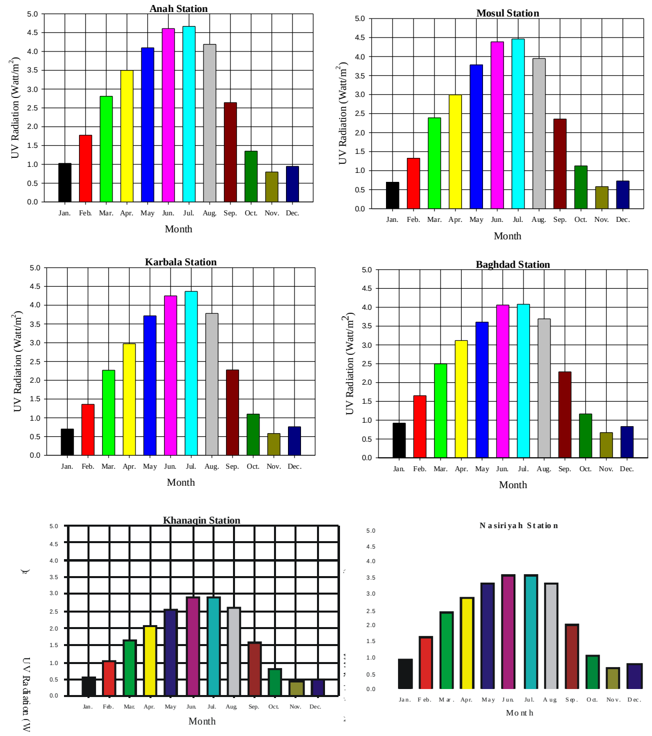


Fig. 2: The monthly mean of UV radiation for six monitoring stations in Iraq.

The Monthly Mean of Temperature

In Fig. 3, which shows the monthly mean of temperature, where the temperature is different for all stations, the highest monthly mean of temperature was Nasiriyah station 47°C in August because the Nasiriyah station from the stations that are located in southern Iraq, where the high temperature because it is considered of low-lying arid areas within the Western Sahara region.

The Monthly Mean of Relative Humidity

The Fig. 4, shows the monthly mean of relative humidity for the six stations in Iraq for the period (2003-2013). The monthly mean of relative humidity was inversion the monthly mean of the temperature.

The lowest monthly mean of temperature was Mosul station 7°C in January. The Mosul station is one of the stations in northern Iraq where the cold sedimentary climate and the abundance of vegetation cover and the

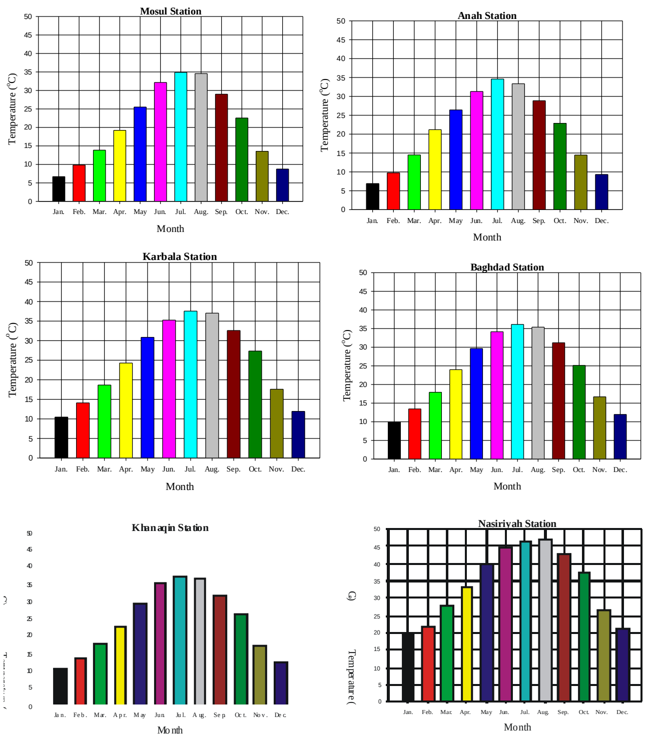


Fig. 3: The monthly mean of Temperature for six monitoring stations in Iraq.

proximity of mountainous areas and highlands in the northern part of Iraq and also characterized by heavy rain in winter and spring.

Where the highest monthly mean of relative humidity of the Anah station 79% in January, is one of the stations located in western Iraq and abundant water springs, lakes and agricultural areas. The lowest relative humidity was Nasiriyah station 61%, which is characterized by high temperatures.

The highest monthly mean of ultraviolet radiation was Anah station in July and the lowest was Khanaqin station in November and the highest monthly mean of temperature was Nasiriyah station in August and the lowest value was Mosul station and Anah station in

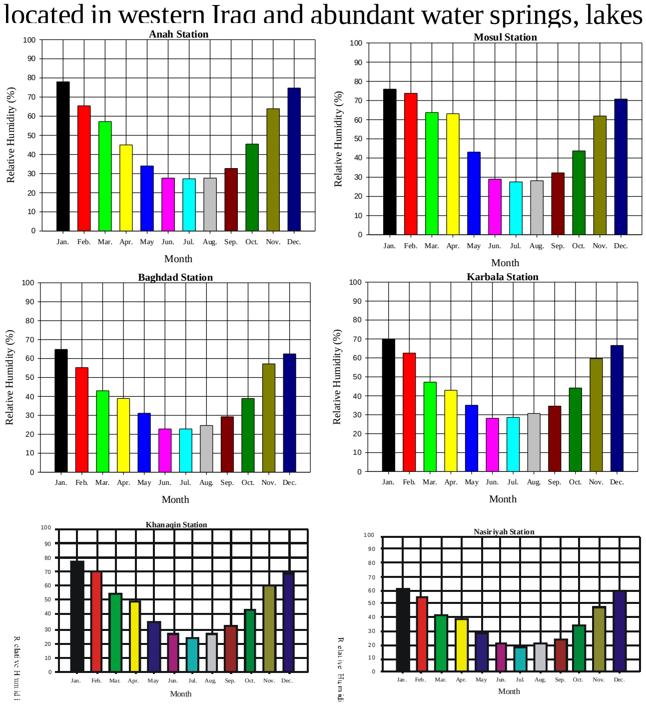


Fig. 4: The monthly mean of Relative humidity for six monitoring stations in Iraq.

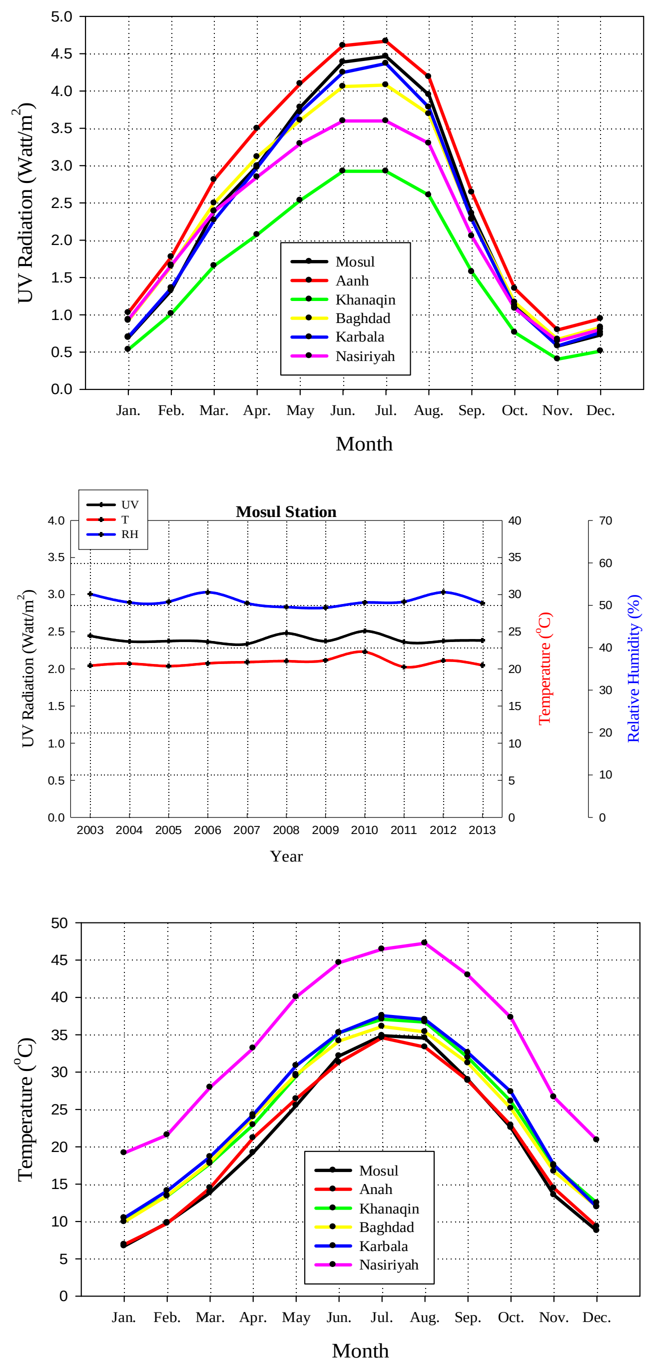


Fig. 5: Comparison of monthly mean between UV, T, and RH for six selected monitoring stations in Iraq for the period (2003-2013).

January and the highest value of the monthly mean of relative humidity for the Anah station in January and the lowest was Nasiriyah station in July. See Fig. 5.

The Annual Mean of UV Radiation, Temperature, and Relative Humidity

In Fig. 6, which shows the annual mean of the study period for the UV radiation, temperature and relative humidity values of the six monitoring stations (Mosul, Anah, Khanaqin, Baghdad, Karbala, and Nasiriyah) in Iraq.

The highest annual mean of UV radiation was found in Anah station 3 watt/m^2 of the year 2011, the highest annual mean of temperature was found in Nasiriyah station 36 ^{o}C of the years 2010 and 2013, and the highest annual mean of relative humidity was Khanaqin station 60% of the year 2009. The lowest annual mean of UV radiation was Nasiriyah station 2.1 watt/m^2 of the year 2005 and the lowest annual mean of temperature was in Anah station 18 ^{o}C of the year 2011, and the lowest annual rate of relative humidity was Nasiriyah station 32% in 2010.

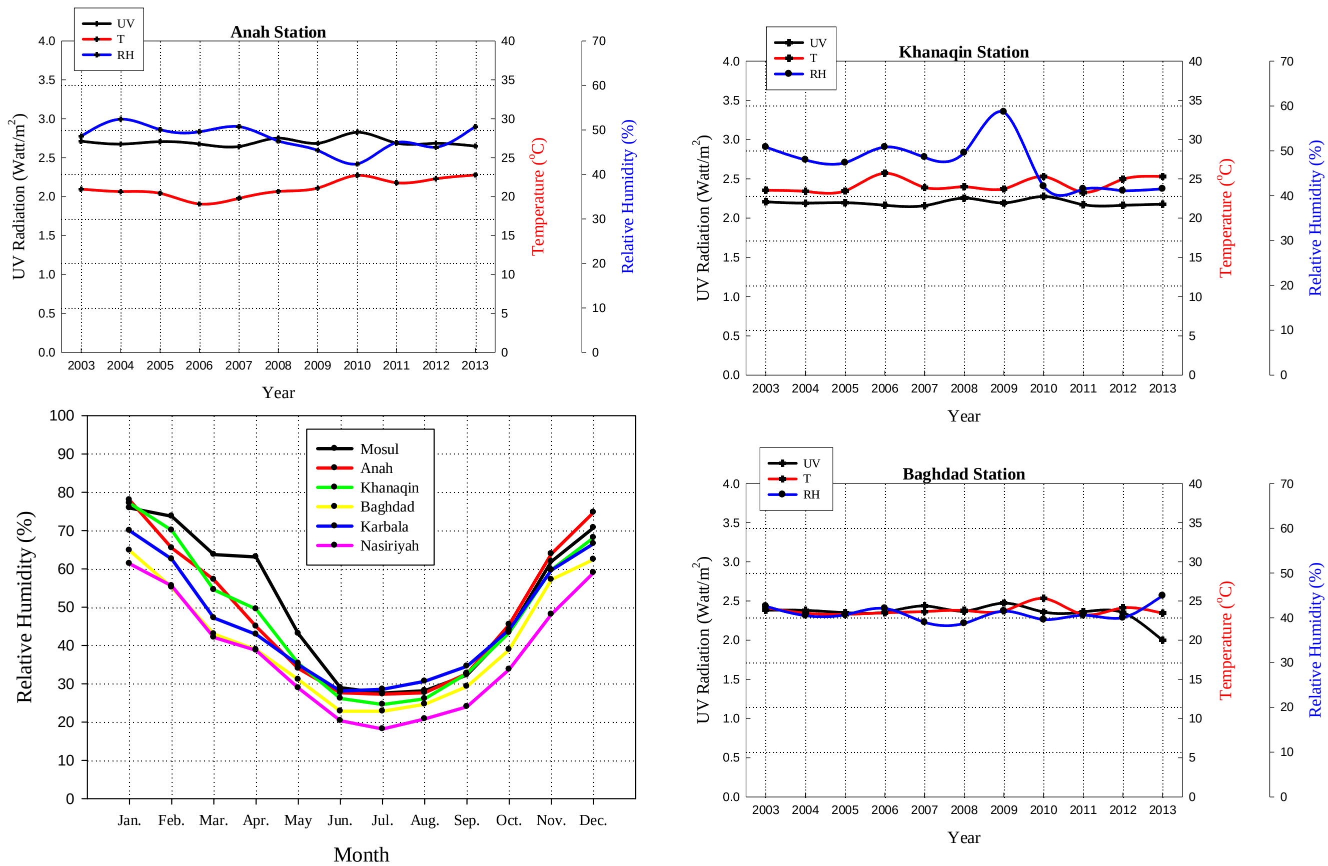
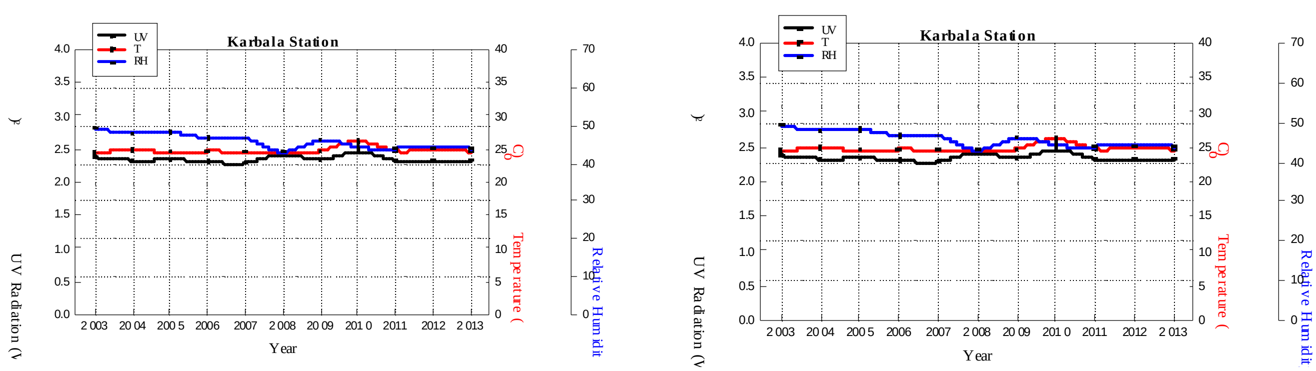


Fig. 6: The annual mean of UV radiation, temperature and relative humidity for six monitoring stations in Iraq.



Followed Fig. 6

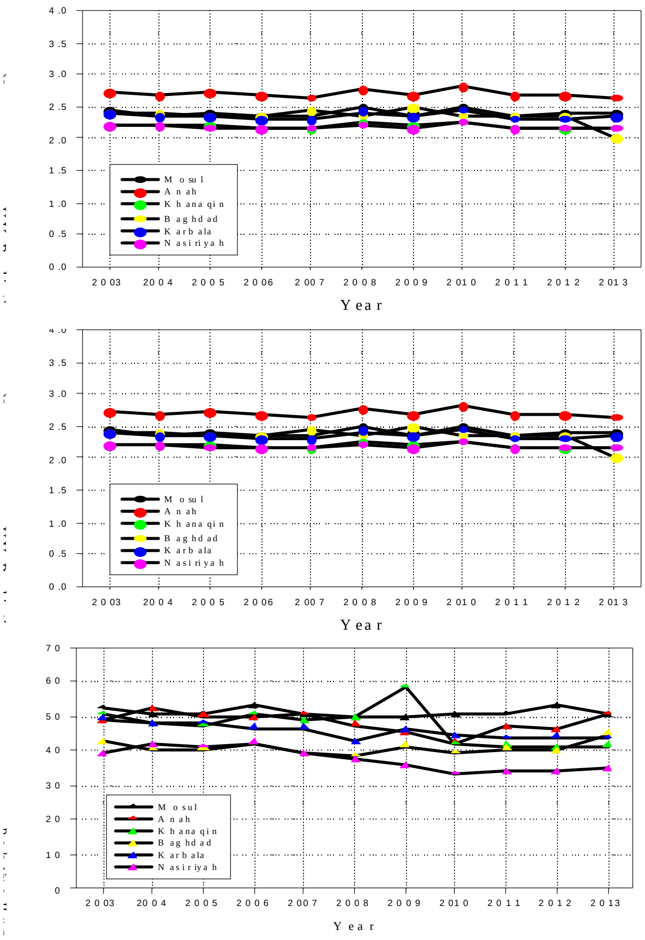


Fig. 7: Comparison of annual mean between UV, T, and RH for six monitoring stations in Iraq of the period (2003-2013).

In Fig. 7, showing the annual mean of UV radiation, temperature and relative humidity for the period (2003-2013) and the distribution of monitoring stations in Iraq.

The Total Annual Mean of UV Radiation, Temperature and Relative Humidity

In Fig. 8, which shows the total annual mean for the study period eleven years (2003-2013) and for all the study stations. The highest value of the total annual mean of UV radiation was found in Anah station 3 watt/m^2, the highest total annual mean of temperature in Nasiriyah station 34 ^{o}C and the highest total annual mean of Relative humidity in the Mosul station 53%. The lowest total annual mean of UV radiation was Khanaqin station 2 watt/m^2, the lowest total annual mean of temperature was Mosul station 20.5 ^{o}C, and total annual mean of relative humidity was Nasiriyah station 38%.

The Relationship between UV Radiation and Temperature, Relative Humidity

The Fig. 9 and Table 2, shows the relationship between the values of the monthly mean of UV radiation and temperature for the period (2003-2013) for the six

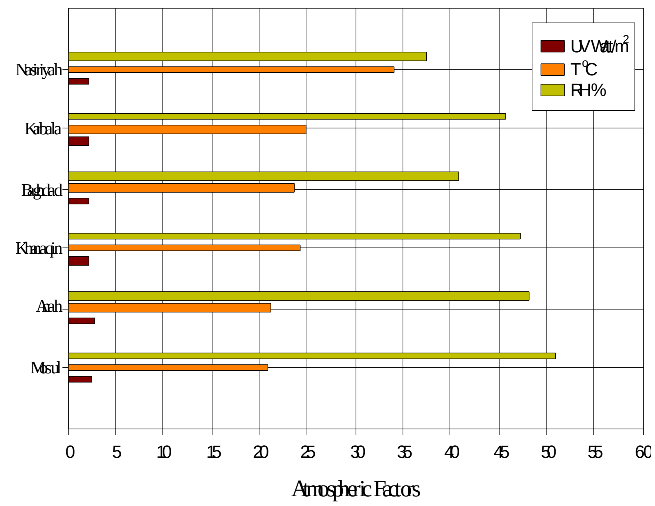


Fig. 8: The total annual mean of UV radiation, temperature and relative humidity for six selected monitoring stations in Iraq.

study stations in Iraq, where it was found that there is a strong positive relation to all stations and that the highest correlation coefficient of the UV radiation and temperature was in Mosul and Karbala stations.

In Fig. 10 and Table 2, which shows the relationship between the values of the monthly mean of UV radiation and relative humidity for the period (2003-2013) for the six study stations in Iraq where it was found that there is a strong inverse relationship in all study stations, the

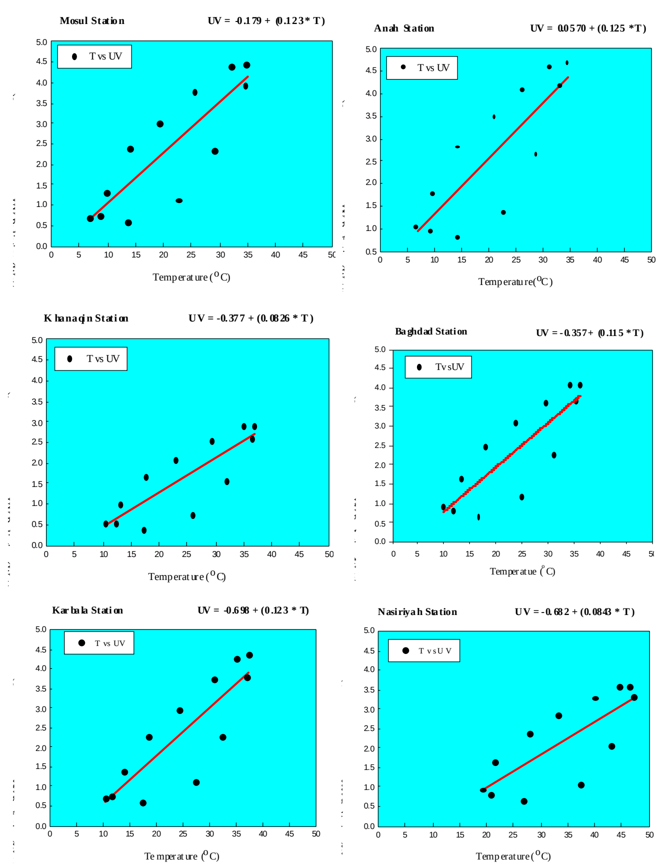


Fig. 9: The relationship between UV radiation and temperature for six monitoring stations in Iraq.

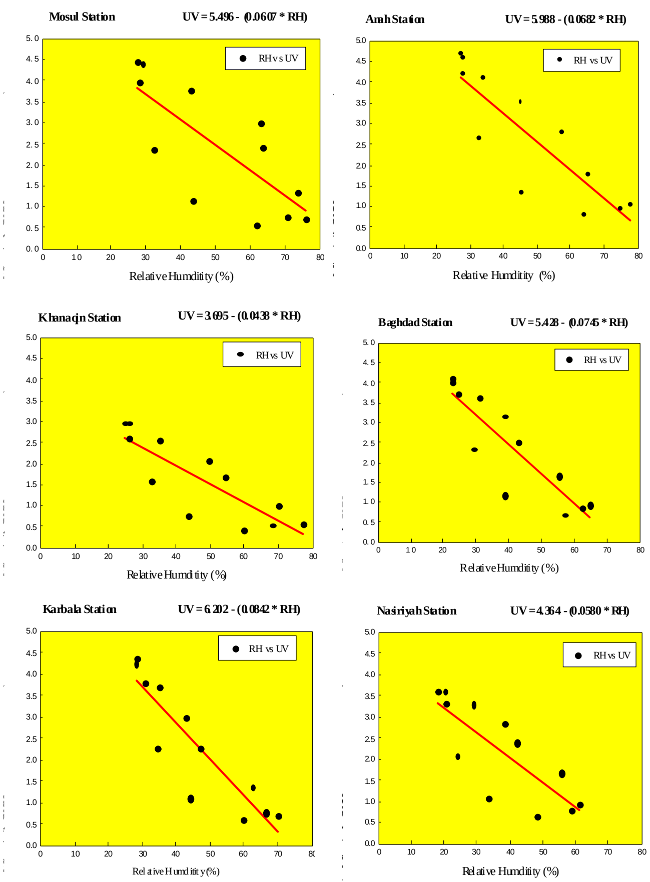


Fig. 10: The relationship between UV radiation and relative humidity for six monitoring stations in Iraq.

highest correlation coefficient of the UV radiation and relative humidity was in Baghdad and Karbala stations.

Conclusions

- The highest monthly mean of UV radiation was Anah station in July, and the lowest monthly mean was Khanaqin station in November.
- The highest monthly mean of temperature was Nasiriyah station in August, and the lowest monthly mean was Anah station in January.
- The highest monthly mean of relative humidity was Anah station in January, and the lowest monthly mean was Nasiriyah station in July.
- The highest annual mean of UV radiation was Anah station in 2011, and the lowest annual mean was in Nasiriyah station in 2005.
- The highest annual mean of temperature was Nasiriyah station in 2010, and the lowest annual mean was Anah station in 2011.
- The highest annual mean of relative humidity was Khanaqin station in 2009, and the lowest annual mean was Nasiriyah station in 2010.
- There was a strong positive relationship between the monthly mean of temperature and the monthly mean of UV radiation for all six monitoring stations, and the strongest correlation coefficient in Mosul and Karbala stations.
- There was a strong inverse relationship between the monthly mean of relative humidity and the monthly mean of UV radiation for all six monitoring stations, and the strongest correlation coefficient in the stations (Anah, Baghdad and Karbala).

Table 2: The Spearman rank order correlation (SROC) and simple linear regression (SLR) Test for six monitoring stations in Iraq.

SROC		SLR		Relations	Stations
Correl.	**R**	**Interp.**	**P-Value**		
V. High Positive	+0.9	Linear	<0.001	T vs. UV	Mosul
V. High Inverse	-0.8	Linear	0.003	RH vs. UV	
V. High Positive	+0.8	Linear	<0.001	T vs. UV	Anah
V. High Inverse	-0.9	Linear	<0.001	RH vs. UV	
V. High Positive	+0.8	Linear	<0.001	T vs. UV	Khanaqin
V. High Inverse	-0.8	Linear	<0.001	RH vs. UV	
V. High Positive	+0.8	Linear	<0.001	T vs. UV	Baghdad
V. High Inverse	-0.9	Linear	<0.001	RH vs. UV	
V. High Positive	+0.9	Linear	<0.001	T vs. UV	Karbala
V. High Inverse	-0.9	Linear	<0.001	RH vs. UV	
V. High Positive	+0.8	Linear	0.003	T vs. UV	Nasiriyah
V. High Inverse	-0.8	Linear	0.002	RH vs. UV	

Acknowledgement

An acknowledgment to the European Center Medium Weather Forecasts (ECMWF) on the data used in this study, and we would also like to thanks Mustansiriyah university for providing scientific support to accomplishing this research.

References

Alados, I., J.A. Mellado, F. Ramos and L. Alados-Arboledas (2004). Estimating UV erythemal irradiance by means of neural networks, *Photochemical Photobiology*, **82(2):** 351–358.

Angelucci, M.G., N. Pinardi and S. Castellari (1998). Air-sea fluxes from operational analyses fields: Inter comparison between ECMWF and NCEP analyses over the Mediterranean area. *Phys. Chem. Earth,* **23:** 569–574.

Canada, J., G. Pedro ìs, A. Lo ìpez and J.V. Bosca ì (2000). Influences of the clearness index for the whole spectrum and the relative optical air mass on UV solar irradiance for two locations in the Mediterranean area, Valencia and *Cordoba, J. Geophys. Res.,* **105:** 4759–4766.

Dodge, Y. (2010). The Concise Encyclopedia of Statistics. *Springer-Verlag New York,* 502.

Foyo-Moreno, I., J. Vida and L. Alados-Arboledas (1998). Ground based ultraviolet (290–385 nm) and broadband solar radiation measurements in south-eastern Spain. *Int. J. Climatol.,* **18:** 1389–1400.

He, Y., Y. Zheng and D. He (2002). A summary of research on the effects of enhanced ultraviolet radiation on field ecosystems. *Chinese J. Agrometeorol.,* **1:** 47–52.

Koronakis, P.S., G.K. Sfantos, A.G. Paliatsos, J.K. Kaldellis, J.E. Garofalakis and I.P. Koronaki (2002). Interrelations of UV-global/glo-bal/diffuse solar irradiance components and UV-global attenuation on air pollution episode days in Athens. *Greece, Atmos. Environ.,***36:** 3173–3181.

Lehman, A. (2005). Jump for Basic Univar ate and Multivariate Statistics: *A Step-by-step Guide. Cary, NC: SAS Press,* 123.

Lull, William P., with the assistance of Paul N. Banks. (1995). Conservation Environment Guidelines for Libraries and Archives. Ottawa, ON: *Canadian Council of Archives*.

Madronich, S., R.L. McKenzie, L.O. Björn and M.M. Caldwell (1998). Changes in biologically active ultraviolet radiation reaching the Earth's surface. *J. Photochemical Photobiology,* **46:** 5–19.

Masserot, D., J. Lenoble, C. Brogniez, M. Houet, N. Krotkov, and R. McPeters (2002). Retrieval of ozone column from global irradiance mea-surements and comparison with TOM's data. A year of data in the Alps. *Geophys. Res. Lett.,* **29(9):** 1309, doi: 10. 1029/2002GL014823.

Myers, Jerome L., Well and D. Arnold (2003). Research Design and Statistical Analysis (2nd Ed.). *Lawrence Erlbaum,* 508.

Ogunjobi, K.O. and Y. J. Kim (2004). Ultraviolet (0.280–0.400mm) and broadband solar hourly radiation at Kwangju, South Korea: Analysis of their correlation with aerosol optical depth and clearness index. *Atmos. Res.,* **71:** 193–214.

Osama, T.A., S.A. Jamal and H.A. Iqbal (2017). Study of the Monthly and Annual Behavior of Temperature and its Impact on Climate Change in Iraq for the Period (1982-2012). *International Journal of Environment, Agriculture and Biotechnology,* **2:** 2293-2302.

Pounds, J.A. and M.L. Crump (1994). Amphibian declines and climate disturbance: The case of the golden toad and the harlequin frog. *Conserve. Biol.,* **8:** 72–8.

Webb, E.K., G.I. Pearman and R. Leuning (1980). Correction of the Flux Measurements for Density Effects Due to Heat and Water Vapour Transfer'. *Quart. J. Roy. Meteorol. Soc.,***106:** 85–100.

Yazdani, M.R., D.J. Khoshhal, M. Mahdavi and A. Sharma (2011). Trend Detection of the Rainfall and Air Temperature Data in the Zayandehrud Basin. *Journal of Applied Sciences,* **11:** 2125-2134.

Zerefos, C.S. and A.F. Bais (1997). Solar ultraviolet radiation, modeling, measurements and effects, *Springer Verlag, New York.*