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Nanotechnology for measuring effects of temperature and solar radiation on ultraviolet radiation in Anbar governorate

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Ultraviolet (UV) radiation is a significant component of the solar spectrum, with considerable environmental and health implications. The intensity of UV radiation reaching the Earth's surface is influenced by various factors, primarily ambient temperature and solar radiation levels. This study investigates the effects of temperature and solar radiation on UV radiation levels in the Anbar Governorate, a region known for its distinct climatic conditions, including high temperatures and intense solar radiation throughout most of the year. The research used utilized climatic data collected in 2023 from the weather monitoring station at the University of Anbar in Ramadi (Upper Euphrates Center for Sustainable Development Research), using the Vantage Pro2 device. The analysis revealed that the highest solar radiation values occurred in July (346 W/m²) and August (321.91 W/m²), with the highest average temperature recorded in August (42.02°C). In contrast, the UV radiation values are relatively low, generally ranging from 0 to 1.6. The results indicate an inverse relationship between the maximum temperature and UV radiation, attributed to the dependence of UV intensity on solar angle and ozone concentration rather than temperature alone. Conversely, a direct relationship is observed between solar radiation and UV levels, as UV radiation constitutes a part of total solar radiation and is influenced by solar elevation and atmospheric clarity. The use of statistical analysis confirmed the reliability and validity of the findings.

Keywords: UV; Solar; Nanotechnology.

1. INTRODUCTION

Nanotechnology can significantly improve solar cells by increasing their performance, reducing manufacturing costs, and enhancing their durability. Nanoscale solar cells have higher light energy than conventional solar cells. Furthermore, the graded layer created by the nanostructures allows the cells to absorb light rather than repeatedly reflect it. Although current nanoscale solar cells are not as efficient as conventional cells, their thermal costs are potentially lower those of conventional solar cells. An electromagnetic wave with a wavelength longer than X-rays but shorter than visible light is called ultraviolet radiation. Because violet has the shortest wavelength of any color in the visible spectrum, it is often referred to as ultraviolet (UV) [1]. Its energy varies from 3 to 124 electron volts, and its wavelengths range span from 10 to 400 nanometers [2]. The three main categories of the UV radiation are ultraviolet A (UVA), ultraviolet B (UVB), and ultraviolet C (UVC). This classification is based on the wavelengths of the UV radiation [3]. Despite some UVB radiation reaching the earth, UVA radiation makes up the majority of UV radiation that reaches the planet today Although UVA is more consistent throughout the year and penetrates deeper into the skin, both UVB and UVA radiation can have an impact on health [4]. UV radiation is used frequently in medical and dental procedures as well as industrial processes for a number of reasons, including phototherapy, sun tanning, curing inks, and resins, producing fluorescent effects, and killing bacteria [5][6]. The positive effect of UV-induced vitamin D creation is vital for human health [7]. Vitamin D supports the formation of bones and aids in the body's absorption of calcium and phosphorus from meals [8]. Two to three times a week, the World Health Organization (WHO) advises getting five to fifteen minutes of sun exposure [9]. Sunburn is a result of short-term overexposure, but premature and skin cancer are side consequences of long-term UV exposure [10]. Without eye protection, UV exposure increases the risk of potentially blinding eye disorders [11]. Overexposure to UV radiation can have major health consequences, including cancer [12][13]. To shield oneself from ultraviolet light. Avoid direct sunlight, especially during the middle of the day [14][15]. Emissions of electromagnetic radiation from the Sun are known as solar radiation [16][17]. Thermal radiation emanates from the Earth and solar radiation enters the Earth's system, driving virtually all known physical and biological cycles [18]. Solar radiation is one of the elements that has a significant impact on the amount of solar energy reaching the surface [19]. This is among the most important elements that influence the emission and absorption of radiation [20]. The second factor is that suspended materials are crucial to the physical processes that occur in the atmosphere [21]. They function as nuclei to condense water vapor, which in turn forms cloud droplets, or they directly contribute to the Earth's climate through a variety of processes that scatter, reflect, and absorb solar radiation [22]. Furthermore, the majority of gases in the atmosphere have an impact on the climate system's radiation balance and are crucial for both radiation emission and absorption [23]. The so-called spectrum of emission depicts the distribution of radiation based on wavelength, with shortwave (SW) radiation at the top of the atmosphere having greater energy than longwave (LW) radiation because the shortwave radiation will suffer from three processes known as attenuation processes scattering, absorption, and reflection [24]. The absorption of radiation by water vapor, carbon dioxide, oxygen, and nitrogen, the Rayleigh scattering of radiation by aerosols, or the reflection of radiation by clouds, contaminated air, and the Earth's surface all contribute to the attenuation of shortwave solar radiation [25]. The atmosphere can absorb a greater amount of longwave radiation than shortwave energy [26]. Direct solar radiation is the term used to describe the solar radiation that reaches the Earth's surface unaffected by attenuation mechanisms [27]. Indirect solar radiation occurs when solar radiation is subjected to attenuation mechanisms, which results in a decrease in the intensity of the radiation that reaches the Earth's surface [28]. Longwave radiation is emitted from the Earth's surface when it is heated by the absorption of solar radiation [29]. The majority of the radiation released within the thermal infrared spectrum reaches the range of (4.0-100) µm since the average surface temperature of the Earth is 285°K [30]. The primary source of radiation throughout the night and solar radiation at a range of (0.2-4) µm is this radiation, which is known as terrestrial radiation since it originates from the Earth's surface and is sometimes referred to as night radiation or longwave radiation [31]. The primary source of radiation during the day is this radiation, which is known as shortwave radiation [32]. Temperature is one of the most important climate elements affecting human life and the environment [33]. It is a measure of the amount of thermal energy present in the atmosphere or on the Earth's surface [34]. Temperature depends largely on solar radiation, the primary source of energy on planet Earth [35]. This energy arrives in the form of electromagnetic waves that include visible, infrared, and ultraviolet radiation [36]. Ultraviolet (UV) radiation is part of solar radiation, but it does not directly affect the temperature as infrared radiation does. However, it is related to solar radiation in terms of the source and daily and seasonal variations [37]. Therefore, the relationship between temperature, solar radiation, and ultraviolet radiation is complementary, helping us understand the climate dynamics and various health and environmental impacts [38,39]. The aim of this study measuring the effects of temperature and solar radiation on ultraviolet radiation in Anbar Governorate.

2. METHODOLOGY

2.1 Data source and study station

The work is implemented using data from the meteorological station located in Ramadi, which is located at latitude (33.4258° north) and longitude (43.2990° east), Anbar University, Upper Euphrates Center for Sustainable Development Research. Hourly data are taken for solar radiation, ultraviolet rays, and temperature for one year only (2023). The weather station provides meteorological data such as solar energy, solar radiation, ultraviolet radiation, heating, cooling, humidity, dew point, sunrise, and sunset times, etc. Figure 1. Display the site Weather Station Ramadi Station is at the University of Anbar. The station includes a special software program called Weather Link to display the station's data on a computer and save the data. The wireless weather station also plots and displays relationships and charts between meteorological factors. The station's software includes a special setting to provide data every minute, five minutes, fifteen minutes, or half an hour. The data is then converted to an Excel sheet. The wireless weather station is specialized in measuring data and the station is located at an altitude of 45 meters above sea level and 18 meters above the ground level to avoid any natural influences such as tall trees or artificial influences such as tall buildings that lead to blocking the total amount of solar radiation falling in addition to other reasons that reduce the efficiency of the station and it is installed on (11/20/2020).

Figure 1 The site Weather Station (Ramadi Station) is at the University of Anbar.

2.2 Sigma Plot Version 14.0

For the Microsoft Windows operating system, Sigma Plot is a technical graphing tool. Numerous graphs and charts can be made using it. Sigma Plot makes graph construction simple. Readable big icons are a feature of the interactive Graph Wizard and the Graph Toolbar [11]. Use SigmaPlot to plot the relationship between UV rays, solar radiation, and temperature to determine the changes that occur during 2023.

2.3 Statistical

Several statistical tests are applied, although Spearman's rho test (SRT) is selected for this study. Regression analysis, particularly basic linear regression, is used to assess for the interaction between solar radiation, temperature, and UV radiation. The Sigma statistics program computed the slope (b) and probability values using the basic linear regression approach.

2.3.1 Simple Linear Regression (SLR)

Simple linear regression is the combination of independent and dependent variables for obtaining a linear relationship (a simple linear equation between these two variables). The straight line reflects the value of the independent variable when displayed on a Cartesian Coordinate System (CCS). The parametric experiment implies that the data are consistently distributed. This formula is used for an SLR and is the expression for a straight line [12]:

$$\bar{y} = a + b\bar{x} \tag{1}$$

$$b = \frac{\sum_i^n = 1(xi - \bar{x}) - (yi - \bar{y})}{\sum_i^n = 1(xi - \bar{x})2} \tag{2}$$

$$a = \frac{\sum y - b\Sigma x}{n} \tag{3}$$

where $\bar{y}$ Independent Variable, $\bar{x}$ Dependent variable, a Constant gradient, b Slope of the regressions, n Sample size.

2.3.2 Probability Value(P-Value)

The chance of being inaccurate in terms of whether the data is normally distributed is a number used for evaluating the statistical scale, which reveals whether the value of the relevant factor is effective or not. If the (P-value) is less than 0.05, the related factor is the effective in the variable for which we are investigating the change. May consider effective factor even if the value of (P- Value) is equal to 0.1, but if increased by approximately 0.1, this factor should be omitted from the model [13].

2.3.3 Spearman Rho Test (SRT)

Spearman's correlation coefficient is a statistical measure of a monotonic relationship between two data points. rs is a non-parametric range test for an unlimited number of data {Xi, i = 1, 2... n}. It shows the correlation between any two variables, based on the null hypothesis that all (Xi) values are independent and have the same distribution. To calculate the Spearman coefficient statistical (rs), the original model must be transformed to the ranks by organizing them in ascending order in terms of magnitude, then calculating the amount of (di) through ($d_1 = k_1$-i), where (i) value ranging from 1 to n. where n= The number of measurements in each of the two variables in the correlation. d_1 is the ranking difference between the readings for both variables. The following equation gives the Spearman rank correlation coefficient (rs) [14];

$$rs = 1 - \frac{6\sum_{i=1}^{n} + di^2}{n(n^2-1)} \tag{4}$$

To determine the value of the degree of correlation interpretation of the test transactions for the test, see Table 1.

Table 1 The degree of correlation and interpretation of the test transaction [14].

Value	Degree of correlation	Interpretation of the relationship
0.00-0.19	Very low	No relationship
0.20-0.39	Low	Small
0.40-0.69	Middle	Acceptable
0.70-0.89	High	Special
0.90-1.00	Very high	Strong

3. RESULTS AND DISCUSSION

3.1 Analysis of relationship between ultraviolet radiation intensity and monthly average maximum temperatures

By observing Figure 2, it becomes clear that the type of relationship between the maximum temperature and the ultraviolet rays is inverse. As the temperature values increase, the ultraviolet rays decrease, and vice versa. The blue line in the diagram represents the maximum temperature, the black line represents the UV index, and the red line represents the UV dose. The UV Index is a measure used to determine the level of UV intensity at a given time, in contrast, the UV Dose is a measure that indicates the total amount of UV radiation to which a person is exposed during a given period. UV is strongest during the spring and summer. The UV values ranged from 0-1.6 i.e., low values and did not have any harmful or dangerous effects. The UV index scale ranges from zero low values to 11 (extreme values), which are very dangerous. That is, its values Uv Index are very low during January, February, October, November, and December, and its values are higher during March, April, May, June, July, and August. This depends on where the stronger the sun is and its temperature is higher during the day such as at noon or in the summer, the more ultraviolet rays there are because the sun is at its highest point and its rays reach directly. The values of ultraviolet rays decrease when there are dense clouds, and the density of ozone increases, and when the air is polluted with dust particles, smoke, and fog. This is what is observed in the graphs and data. The highest temperatures are recorded during July and August because the sun is very strong in June and July, and the Earth needs time to store this heat, so the maximum temperatures reached their highest values. The lowest values are during January and February.

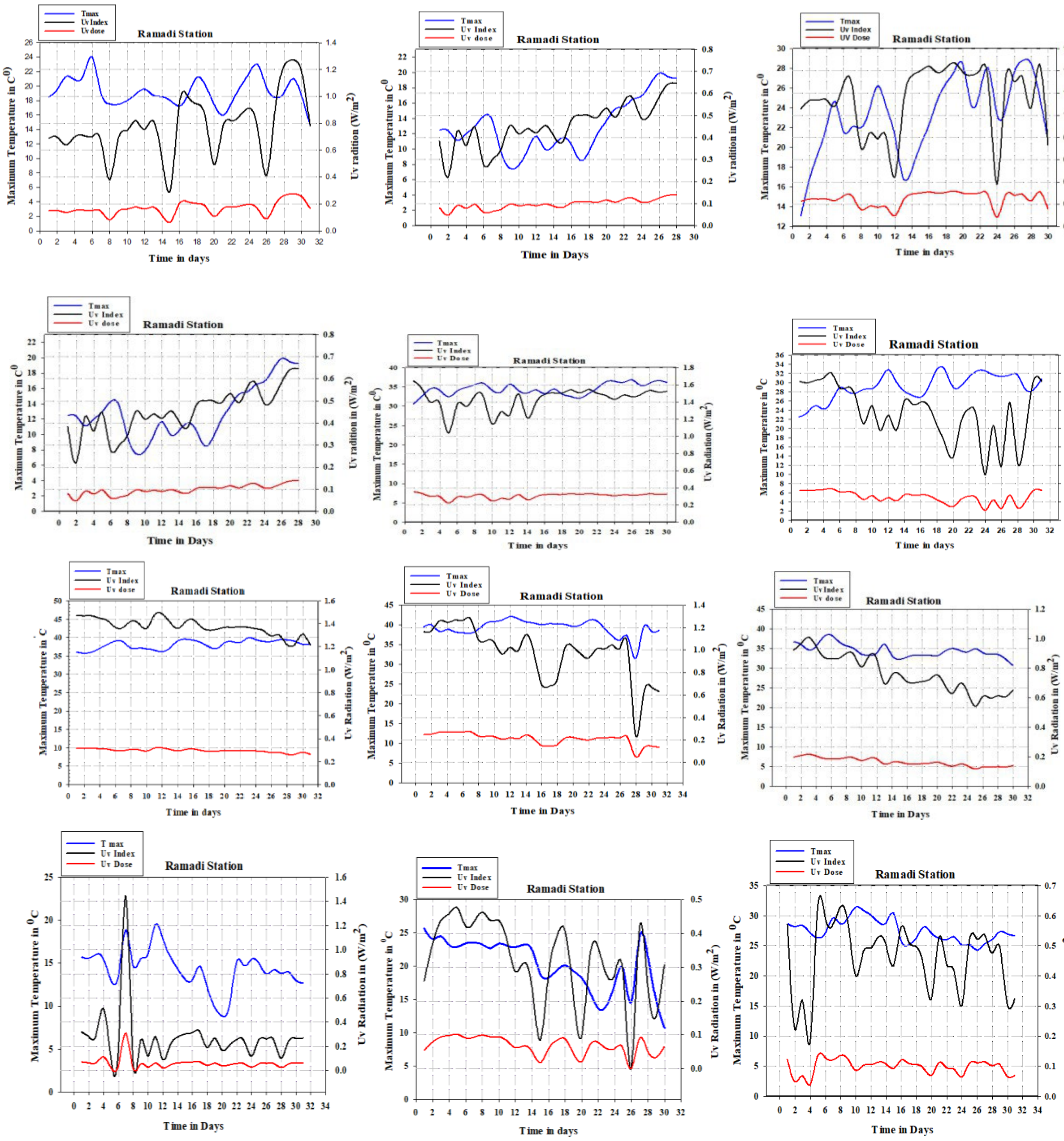

Figure 2 The relationship between Ultraviolet radiation and maximum temperatures for 2023.

3.2 Analysis of relationship between ultraviolet radiation intensity and monthly average solar radiation

By analyzing the data and graphs, the results showed that the highest values of the solar radiation rates are in July and August. The maximum radiation value in July reached 346 w/m^2 and in August 321.9w/m^2 and the lowest radiation values are in November. As for the rest of the radiation values in the remaining months, the values fluctuated from 49 to 346 w/m^2. The relationship between UV and solar radiation is a direct relationship because ultraviolet rays are part of the total solar radiation on Earth, and the highest values are often observed when the sun is vertical and the atmosphere is clear, as shown in the Figure 3.

Figure 3 The relationship between ultraviolet radiation and solar radiation for 2023.

3.3 Statistical analysis for UV index, UV dose, solar radiation and maximum temperature

The scatter plots shown for the Ramadi Station visually support the statistical findings from the correlation and regression table. Each graph demonstrates a positive linear relationship between the paired variables, in alignment with the previously reported Spearman's rho coefficients. The Solar Radiation VS Tmax plot shows a rising trend, confirming the high positive correlation R = 0.8081, suggesting that higher solar radiation levels are generally associated with higher maximum temperatures. The solar radiation VS UV Index and the UV Dose plots both demonstrate very strong Linear trends R = 0.9833, visually reinforcing their statistical significance P < 0.0001. The UV Index vs UV Dose plot presents a perfect linear relationship R = 1.000, confirming a direct dependence between these two variables. The Tmax vs UV Dose plot shows a scattered pattern but still a positive trend, matching the statistically significant but relatively weaker correlation R = 0.7514.On the other hand, the Tmax vs UV

Index plot shows a moderate scatter, which correlates with its non-significant p-value P = 0.8790 despite a numerically high Overall, the visualizations support the statistical conclusion that solar radiation is a strong driving factor for both UV exposure and temperature variation, while T_{max} has a more variable influence on UV-related me As shown in Figure 4 and Table 2.

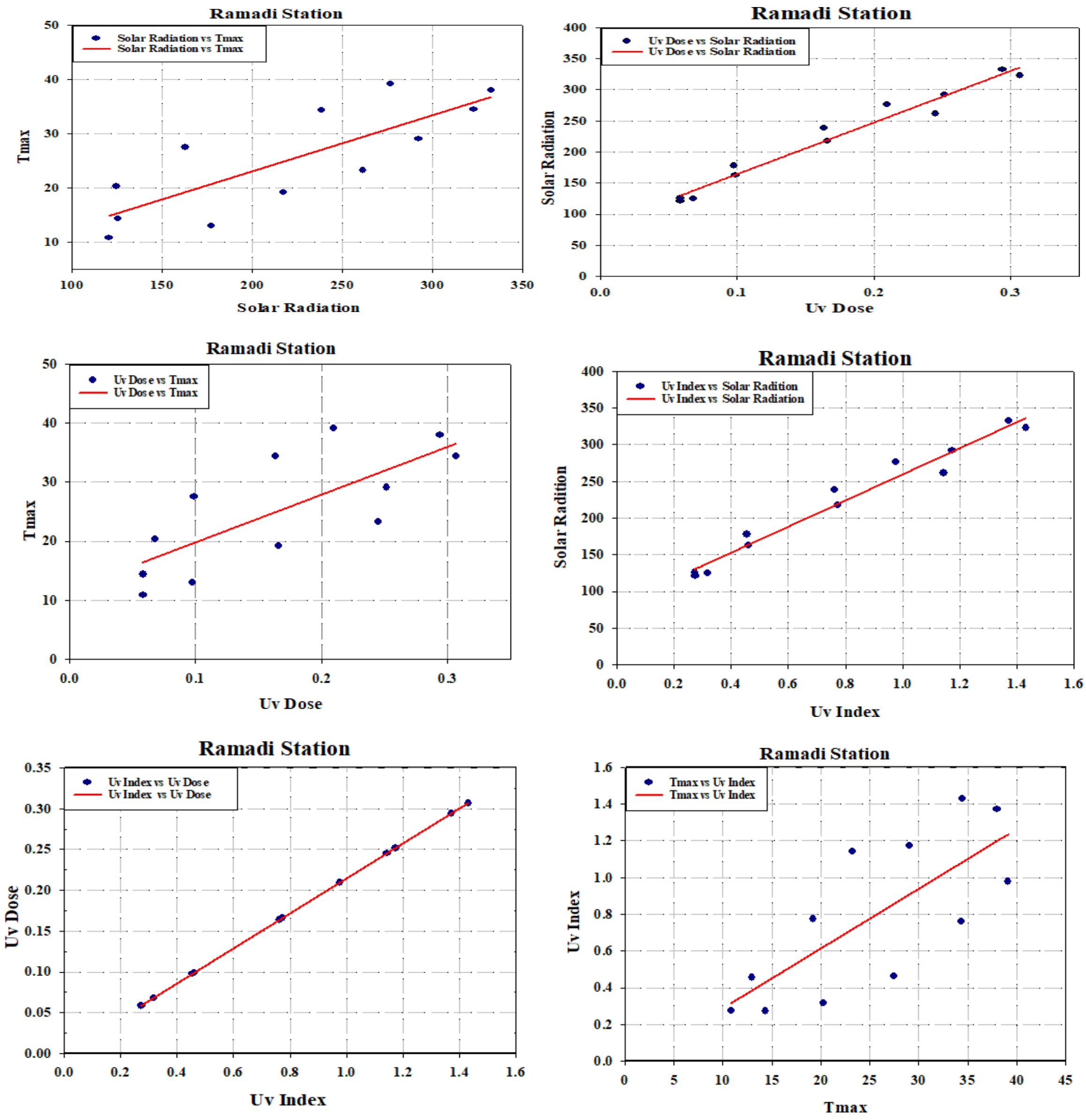

Figure 4 Statistical analysis for the UV Index, UV Dose, Solar radiation, Maximum temperature for the year 2023.

Table 2 Relationship between variables and statistical analysis for the Ramadi station for 2023.

Variables	Spearman rho test		Simple linear regression	
	rs	Correlation degree	P-Value	Correlation degree
Solar radiation VS Uv Index	0.98	Very high positive correlation	<0.0001	Linear relation
Solar radiation VS Tmax	0.80	High positive correlation	<0.0001	Linear relation
Solar Radiation VS UV Dose	0.98	Very high positive correlation	<0.0001	Linear relation
Tmax VS UV Dose	0.75	High positive correlation	<0.0001	Linear relation
Tmax VS UV Index	0.75	High positive correlation	<0.0001	Linear relation
Uv Index VS Uv Dose	0.90	Very high positive correlation	<0.0001	Linear relation

4. CONCLUSIONS

The results of this study indicate that solar radiation is the primary factor influencing ultraviolet (UV) radiation levels and temperature variations in the Anbar Governorate. A direct relationship was observed between the intensity of solar radiation and UV levels, where higher UV values were recorded during periods when the sun angle was nearly vertical and sky conditions were clear. Conversely, an inverse relationship was identified between maximum air temperature and UV levels, which can be attributed to the fact that UV radiation is mainly governed by solar angle and ozone concentration rather than temperature alone. The months of July and August recorded the highest values of solar radiation and air temperature; however, UV levels during these months remained relatively low, ranging between 0 and 1.6. Statistical analyses and graphical representations further confirmed that solar radiation is the dominant factor affecting both UV exposure and temperature, while the influence of maximum temperature on UV variation was less consistent. Continuous monitoring of solar radiation and ultraviolet levels is strongly recommended to better understand seasonal variations and potential health risks, particularly during summer months when solar activity is at its peak. Public awareness campaigns should be conducted to educate the population about the hazards associated with ultraviolet radiation exposure and effective preventive measures, such as the use of sunscreen and protective clothing during periods of intense solar radiation. In addition, urban planning strategies in the Anbar Governorate should take into account the impact of solar radiation on public health by increasing shaded areas and enhancing green spaces to reduce UV exposure. Finally, further studies are recommended to investigate the role of atmospheric components, especially ozone concentration, in modulating ultraviolet radiation levels in the region.

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