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Solar ultraviolet radiation on the ground level of Isfahan

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Introduction: Ultraviolet (UV) radiation affects human organs such as skin, eyes and immune system, as well as animals and plants. The main natural source of UV radiation is the Sun. To study the effects of solar UV radiation there is a need to quantify variations of solar energy received on the earth surface at different intervals. ***Materials and Methods:*** To measure UV radiation a broadband fiber optic UV spectrometer was used. With the spectrometer, the energy received at earth surface was measured from wavelength 100 to 400 nm (the UV spectrum). Measurement duration was from January first to the end of December 2003, and from sunrise to sunset. ***Results:*** The received UVC at the ground level was too low to be measured. The measured UVA was between 11 to 21 times higher than UVB energy during the measurement period. The minimum UV received on the ground level was in January and it was 14.5×10^5 J/m^2 while the maximum was in July and it was 80.14×10^5 J/m^2. Total UV radiation received on the ground level was during the year of measurement period 579 $\times10^5$ J/m^2. ***Conclusion:*** The measurement showed that UVC intensity on the earth surface was negligible. As the wavelength increased the receiving UV energy at the ground level also increased. From the results, it has become clear that the main health consequences of solar UV were related to UVA band. As the intensity of the UVR during summer is too high, a method of UV health risk reduction should be devised. **Iran. J. Radiat. Res., 2007; 5 (2): 101-104**

Keywords: *Ultraviolet radiation, solar UVR, spectrophotometry, skin cancer.*

INTRODUCTION

Nearly every one and every thing is likely to be exposed to sunlight and the ultraviolet (UV) for various period of time, during their lives. UV radiation affects health[1]. It causes photoaging [2], eye disease [3-6], sunburn [7], tanning [8], immune suppression [9-11], DNA mutation [11, 12] and cancers.[13, 14], The probability of occurrence of these diseases depends on the received doses by the target organ.

The amount of solar ultraviolet radiation at the earth's surface depends on the incoming solar energy and the transmission properties of the atmosphere. Ultraviolet radiation (UVR) is strongly absorbed by ozone in the spectral range of 200-310nm, while the attenuation is increasingly weaker at higher wavelength.[15], Moreover the UV field is affected by complex absorption and scattering processes in the atmosphere, in which both astronomic and atmospheric factors (solar zenith angle, earth distance, cloud cover, turbidity, albedo, pressure, temperature, humidity, ...) play an important role. Some of these factors, in turn, may have a time behavior characterized by trends or long period fluctuations.

An analysis of the observed spectral and integrated irradiances to derive a geographic pattern of solar UV fluxes in terms of different parameters could be helpful in assessing UV doses of different population groups.

The UVR doses of Isfahan residence were never measured. However, it is necessary for assessing the risk of UV related health effects, especially during growing the age and childhood, as well as decisions on preventive actions.

MATERIALS AND METHODS

Measurements of UV radiation were performed using a broadband fiber optic UV spectrometer made by Ocean Optic Company. The instrument consisted of a one meter quartz fiber optic with 400 nm diameter. The fiber optic was attached to a SD2000 grating spectrometer. The spectrometer was connected to an A/D converter AD1000. The obtained signal (converted UV radiation

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pulse to electric signal by SD2000) digitized by AD1000 and recorded by a laptop computer. The signal was processed and displayed as a graph of wavelength vs energy intensity. Figure 1 shows the spectrometer black diagram.

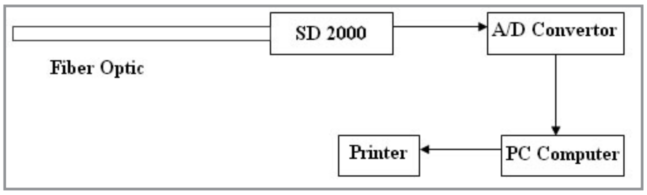

Figure 1. Black diagram of the UV spectrophotometer.

To measure UV spectrum it is necessary to measure dark spectrum which is the obtained spectrum when the input is blocked and subtracted from the spectrum when the input to the spectrum is open. The result is the actual UV spectrum. Before any measurement the spectrometer was calibrated using a Deutriun-Tritium standard UV source.

All the measurements were performed on the roof of a four floor building and at a point away from any disturbing wall or building. During all of the measurements the tip of the fiber optic probe was directed toward the sun to obtain maximum intensity. UV radiation at each wavelength was measured every hour for one minute and the integrated UV radiation over the UV spectrum was calculated using the following equation:

$$E\ (\mu W/cm^2)=\Sigma_\lambda\ E_\lambda\ (\mu W/cm^2.nm)\Delta_\lambda(nm)$$

E_λ is the intensity at wavelength λ and Δ_λ is the wavelength band. The results were used to calculate cumulative UV per hour. The measurements were performed every day for one year, each day starting from sun rise to sun set.

RESULTS

The spectrum of the received UV on the ground level at 1 pm (noon time) on July 15th is shown in figure 2. The figure shows shorter UV wavelength especially UVC band is too low to be measured. It is also clear that most of the UV energy received on the ground level is UVA part of the solar spectrum. As the wavelength increases the receiving UV intensity at the ground level increases. It means that while the wavelength increases absorption, scattering of the UV wavelength will become less effective.

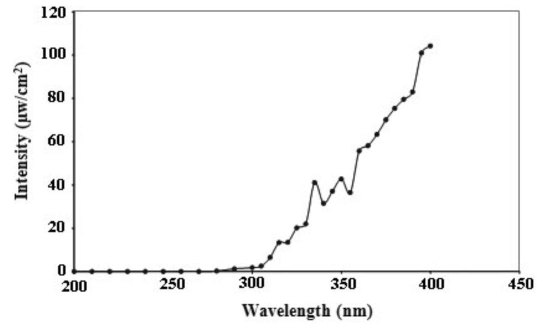

Figure 2. UVR intensity at different wavelengths at 1pm on July 15th of 2003.

As an example, figure 3 shows the variation of the UV radiation throughout a day in July. UV radiation change during the day is drastic. It is mostly due to less attenuation and scattering. As the sun rises above the horizon, the amount of absorption in the stratosphere and scattering in the qtroposphere is reduced. More than 70% of the integrated UV in the day results between 11 to 3 O'clock.

Figure 4 shows the variation of integral UV radiation during different days in January with the lowest, and July with the highest intensity. In July, it seems that the variation is nearly random although a smooth decrease toward the end of the month is clear (by 30%). The reduction might have been due to the reduction of length of the day during the month. In contrast in the month January there is a small increase toward the end of the month (by 20%), which may be due to the increase of the length of the days during this month.

In figure 5, the mean daily UV radiation throughout the year, and in figure 6 the

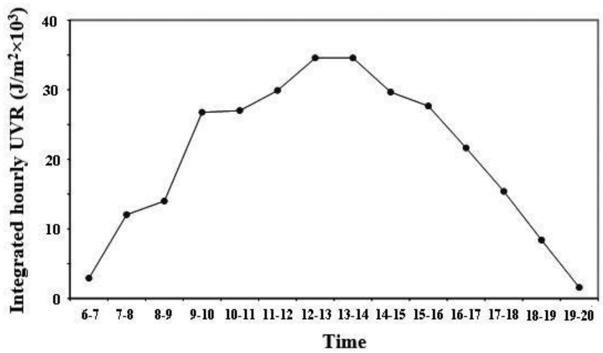

Figure 3. Integrated hourly UVR during 15th of July 2003.

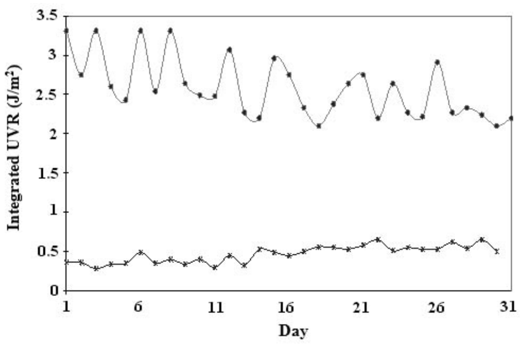

Figure 4. Integrated UVR during January (lower curve) and July (upper curve) 20.

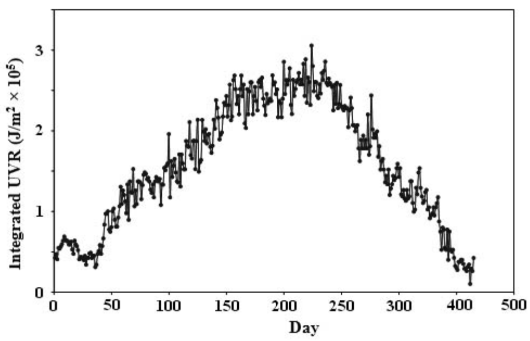

Figure 5. Integrated daily UVR during year 2003.

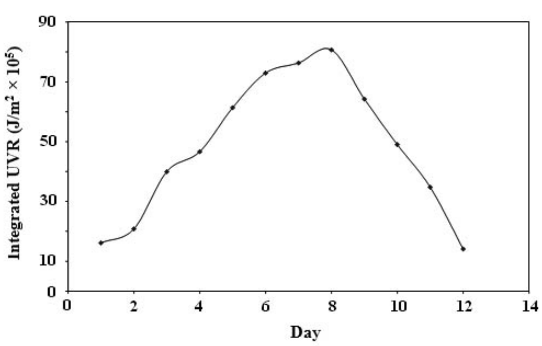

Figure 6. Integrated monthly UVR during year 2003.

monthly mean variation for the global ultraviolet solar radiation are shown. The higher integral value appears in July with intensity value of 80×10^5 Jm^{-2} while the lowest intensity value is in January with a value of 14.5×10^5 Jm^{-2}.

The annual integrated value of global ultraviolet solar radiation is 579×10^5 Jm^{-2}.

DISCUSSION

Emission from the sun includes light, heat and UV radiation. UV radiation from the sun include UVC (100-280nm), UVB(280-320nm) and UVA (320-400nm). From the obtained results (figure 2) it can be seen that shorter UV wavelength especially UVC band is too low to be measured. The reason is the high attenuation of this part of solar spectrum by ozone layer of the atmosphere. The figure also shows it is also clear that the main part of the UV energy arriving on the ground level is UVA part of the solar spectrum. These results are in agreement with the results presented by WHO[16]. Although UVA has much less diverse biological effects on human body, its amount is much higher than UVB (between 6 to 21 times) and the biological effects are considerable.

An important factor in UV radiation level is sun elevation. The higher the sun in the sky, the higher will be the UV radiation level. Thus, radiation levels vary with time of day and year. The increase in UV radiation during a day is drastic (figure 5). It is mostly due to less attenuation and scattering. As the sun rises above the horizon, the amount of absorption in the stratosphere and scattering in the troposphere is reduced. It is also clear that more than 70% of the integrated UV in the day results between 11am to 3pm O'clock (figure 3). These findings are consistent with the results reported for different locations in USA[17]. It is an important point for human health as it has been stated by WHO[16].

The highest monthly integral UV radiation appears in July with intensity value of 80×10^5 Jm^{-2} while the lowest intensity value is in January with a value of 14.5×10^5 Jm^{-2} (figure 4). It means that the amount of UV radiation to the body is about 6 times higher in July than January (figure 6). Nearly the same conclusion has been obtained by John et al. for Spain.[17], UV radiation reaches the ground surface as direct component (normal to the sun) and its diffuse component (from all directions). UV radiation reaching the top of the troposphere is mostly its direct component as there are few molecules to scatter radiation. Decreases in UV radiation intensity are resulted due to the absorption by ozone layer.

The annual integrated value of global ultraviolet solar radiation in Isfahan is 579×10^5 Jm^{-2} , which is higher than the reported for Pian Rosa in Italy[18]. This amount of UV radiation is associated with a high risk level for human health[19].

As UV radiation can neither be seen nor

felt, it is important to provide a tool to raise awareness of the problem and alert people on a daily basis in order to take prompt, appropriate and protective action. For this purpose, an index of UVI (UV Index) was developed internationally[20]. It is a dimensionless index in units of Wm^{-2}, weighted by the erythema action spectrum. Vulnerable groups such as children are particularly sensitive to UV radiation and require special protection[21].

The prediction of future UV radiation levels depends on many factors. On short time scale of the order of few days or a week, UV radiation forecasts incur all of the difficulties of forecasting weather (especially clouds), at estimating atmospheric profile of ozone and other gases and particles. These factors make accurate UV forecasts impractical beyond a few days. Next day forecasts based on metrological analysis are now being made with some success, with UV radiation levels expressed as UVI.

Long term UV predictions (year, decade, or longer) are exceedingly difficult and uncertain; a therefore, it is only appropriate in a statistical sense at averages, variabilites and broad geographical patterns[22].

So, many assumptions must be made not only about the future states of ozone layer, but also about possible long term changes in clouds, troposphere pollutants, and changes in surface albedo.

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