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EFFECT OF ANTHROPOGENIC POLLUTION ON GROUND REACHING SOLAR UV-B RADIATION— A CASE STUDY

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ABSTRACT

Solar ultraviolet radiation reaching the earth's surface has been extensively discussed because of its biological and photochemical activity. Emphasis has been placed on the potential increase in surface UV radiation due to the depletion of stratospheric ozone. The present study deals with the variations of UV-B and Aerosol Optical Depth (AOD) with respect to hazy-day and day-after scavenging due to heavy rain washout in a tropical urban environment. Special variation of AOD showed high aerosol loading at 380 nm, suggesting dominant accumulation mode particle loading. Comparison of UV-B intensities with AOD on hazy-day and day-after heavy rain washout suggests ~45% increase in UV-B intensities. The results are discussed in detail in the article.

INTRODUCTION

The amount of solar UV radiation penetrating the earth's surface is critically important to the health of biological systems. Practically no solar radiation reaches the ground at wavelengths shorter than 290 nm because of strong attenuation by atmospheric ozone. Erythema, which is defined as the reddening of human skin in response to irradiation, extends through UV-B (wavelengths 280-315 nm) [1]. Under normal environmental conditions, columnar ozone content in the atmosphere mainly controls the solar UV-B radiation intensities. Besides ozone, other atmospheric components like clouds, gaseous absorbers, and tropospheric aerosols influence the transmission of UV radiation through the atmosphere. The columnar aerosol content is supposed to play a major role in scattering and absorption of solar radiation. The importance of aerosol influence on the surface UV radiation has been introduced [2]. Systematic investigations on the temporal variations of UV-B radiation and its influencing parameters are still sparse. The present study addresses the variations of UV-B and aerosol optical depth on two days, i.e., May 16, 2002 and May 28, 2002 corresponding to hazy-day and cloud-free day-after heavy rains respectively. During May 17 to 20, there were heavy rains of 9.3 cm. The impact of aerosols on UV-B radiation is assessed.

EXPERIMENTAL DETAILS

The Hyderabad study area extends from 17° 10′ to 17° 50′N and 78° 10′ to 78° 50′E, the fifth largest city in India. Measurements were carred out on the premises of the National Remote Sensing Agency at Balanagar (17° .28′N, 78° .26′E), well within the urban center. The twin cities of Hyderabad and Secunderabad extend 16 km. A MICROTOPS-II sunphotometer was used to measure aerosol optical depth at different wavelengths, viz., 380, 440, 500, 675, 870, and 1020 nm, with an accuracy of ~±2% [3]. UV-B radiation measurements were carried out by the UV-B Radiometer made by Solar Light Co., USA, which measures the radiation intensities through a broad band filter in 280-315 nm range (UVerythema). UV-B intensities after convolution with action spectra are converted into the units of Minimum Erythemal Dose per Hour (MED/hr), which is defined as 1.0MED = 5.83 microwatt per cm^2. The cosine response of the instrument is ±5% with resolution of 0.01MED/hr.

RESULTS AND DISCUSSION

Figures 1 and 2 compare aerosol optical depth (AOD) on a hazy-day (May 16, 2002) and on a day-after heavy rain washout (May 28, 2002) at different wavelengths. AOD gradually decreases from 380 to 675 nm, hereafter, optical depths again increased at 870 nm and then decreased at 1020 nm. There should be a gradual decrease in the aerosol optical depth with increasing wavelength, as per Junge's inverse power law distribution. The observed spectral variation of aerosol optical depth does not show such a feature, indicating that the aerosol size distribution does not follow the Junge distribution. AOD was observed to be high at 380 nm, suggesting dominant accumulation mode particle loading. Similar spectral variation has been in other regions over India [4, 5]. Significant variations have been observed during the course of the day with lower aerosol optical depths during morning and evening hours, and high aerosol optical depths during afternoon hours. Convective turbulent processes in urban areas causes mixing of existing particles and lifting of fresh lighter aerosol particles that are generated due

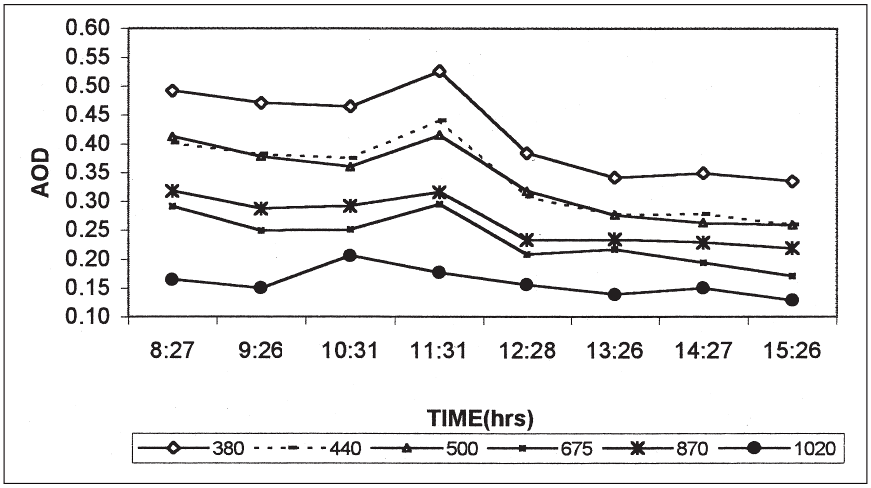

Figure 1. Temporal variation of AOD after heavy rainfall (May 28, 2002).

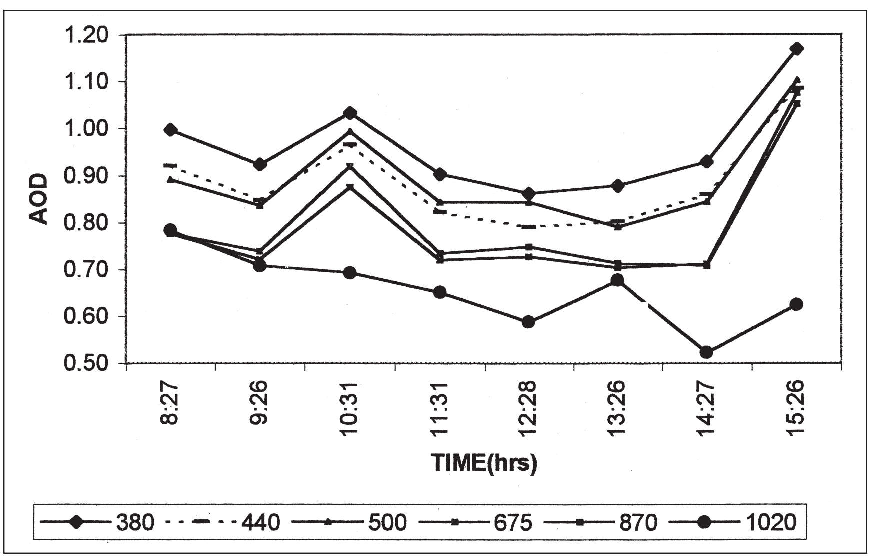

Figure 2. Temporal variation of AOD during hazy day (May 16, 2002).

to anthropogenic activities around the measuring site. Changes in aerosol optical depth during mid-day hours have been attributed to the advection of pollution from surroundings and convective activity leading to changes in aerosol particle number distributions and gas-to-particle conversions (photochemical processes), while those during forenoon hours could be attributed to the impacts of radiative cooling and turbulent processes on aerosol characteristics during previous night.

Figure 3 shows temporal variations of UV-B intensities on a hazy-day (May 16, 2002) and on a day-after heavy rain washout (May 28, 2002) over the study area. Temporal variations of UV-B suggest that the UV-B intensity is moderately stronger during afternoon hours. Direct UV radiation is greatly reduced by the increased absorption by stratospheric ozone during its increased path length through the atmosphere. The radiation at the UV wavelengths is scattered much more than visible light, which further decreases the direct component and increases the diffuse component. As the sun rises above the horizon, the amount of absorption in the stratosphere and scattering in the troposphere will be reduced, resulting in drastic increases in ground-reaching UV radiation. The slantpath is at a minimum during summer (March-May), leading to the largest UV exposures. The comparison of UV-B intensities on a hazy-day and on a day-after heavy rain washout suggests an approximately 45% increase in UV-B intensities on the day-after heavy rain washout, in agreement with other studies [6, 7]. Comparison of AOD on hazy-day and on a day-after heavy rain washout suggests

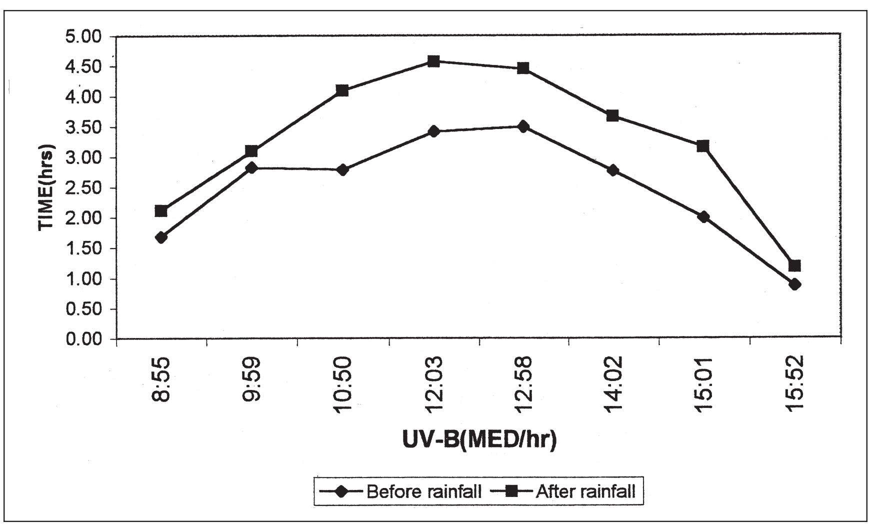

Figure 3. Variation of UV-B intensities on hazy day and after heavy rainfall.

an approximately 60% reduction in AOD after heavy rain washout (Figures 1 and 2). The columnar ozone values derived from Total Ozone Mapping Spectrometer (TOMS) data shows that there is no appreciable change in columnar ozone for these two days. Change in columnar ozone of 3 Dobson Units has been observed between hazy-day and the day-after rainfall. This 1% change in columnar ozone can produce a maximum of 2% change in UV-B radiation intensities [8]. The observed change of some 45% in UV-B intensities on these two days cannot be explained through the change in columnar ozone only. The observed increase in UV-B has been attributed to the reduction in AOD due to scavenging of aerosols by rainfall. The observed change in AOD during hazy-day and day-after rainfall over the study area is in agreement with other studies over India [8-10]. The magnitude of the change in AOD suggests the possibility of an intense aerosol effect on UV-B radiation. Further, the effect of aerosols on UV-B radiation remains negligible when AOD values are of the order of 0.1 or less [8], they play a major role when AOD values are of the order of 1 or more.

CONCLUSIONS

Synchronous observations on AOD and ground-reaching UV-B radiation have been made over an urban environment during hazy-day and day-after rainfalls. The results of the study suggests an approximately 45% attenuation of ground-reaching UV-B radiation during hazy days.

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