

## **Atmospheric Characteristics at Trombay relating to the October 1995 Solar Eclipse**

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### **Abstract**

A study was undertaken to examine the effect of a short-term reduction in the solar intensity on the characteristics of the atmospheric environment. Meteorological parameters, solar radiation variations, major pollutant levels and aerosol characteristics were measured on the terrace of the Modular Laboratories at BARC, Trombay, on Solar Eclipse day (24th October, 1995) and on adjacent days. There was an obvious reduction in global solar radiation with no change in the proportion of the UV component. SODAR back-scattering data indicated a suppressed level of atmospheric turbulence. A 2-4 fold increase in the aerosol number and mass concentrations was observed during the eclipse.

**Key Words :** Solar eclipse, atmospheric characteristics, aerosol

### **Introduction**

The total solar eclipse of 24th October, 1995 was partially seen in Bombay (75% obscuration) from 7.25 a.m. to 9.45 a.m. with a peak at 8.31 a.m. Though the health effects due to changes in the pollutant levels, radioactive or otherwise, may be insignificant owing to the overall shortness of the event, there is a need to understand their formation and dispersion vis-a-vis the rapid and short-term changes in the atmospheric conditions. The aerosol concentration measurements are useful in interpreting changes in the ground level radiation fluxes and atmospheric conductivities occurring during the eclipse. This paper presents the results of the experiments conducted at the terrace (4th floor level) of Modular Laboratory building, BARC at Bombay.

## Experimental Procedure

Experiments were carried out to measure the changes in the solar radiation components on the eclipse day. Transient hazy conditions were prevailing on that day. Global Solar Radiation (GSR) and Normal Incident Solar Radiation (NISR) were measured in spectral ranges such as  $>525$  nm,  $>630$  nm,  $>710$  nm and in the total range of 300 to 4000 nm using Pyroheliometers with cut-off filters. The UV component (295-390 nm) of the total GSR was measured with UV radiometer. The meteorological parameters were recorded from the weather station at Trombay. The back-scatter profiles of SODAR were recorded to analyze the atmospheric thermal structure close to the earth's surface.

The ground level temporal profiles of the conventional pollutants such as ozone, sulphur dioxide and nitrogen oxides were studied using indigenously made continuous monitors based on chemiluminescence technique and using conventional chemical analysis methods. Non Methane Hydrocarbons (NMHC) and Formaldehyde concentrations were measured by the GLC method (Mohan Rao and Pandit, 1988) and 3-MBTH method (Sawicki *et al.* 1961) respectively. Aerosol concentrations, for which no data during earlier eclipse are available, were measured every ten minutes at a height of about 8m above the ground level. The mass-size distributions of the aerosols were studied as function of time using the Quartz Crystal Microbalance Cascade Impactor (QCMCI) which measures the total suspended particulate mass (SPM) concentration ( $\mu\text{g}/\text{m}^3$ ) and its distribution in ten size intervals above  $0.05 \mu\text{m}$ . The number-size distributions were monitored using two optical particle counters (OPCs of Met-One and Malvern). The Met-One OPC monitors the number concentration (No./cc)  $> 0.1 \mu\text{m}$  in six size intervals while, the Malvern OPC monitors the number in the entire size range ( $>0.003 \mu\text{m}$ ) was monitored using an indigenously made Automatic Condensation Nucleus Counter (ACNC).

## Results

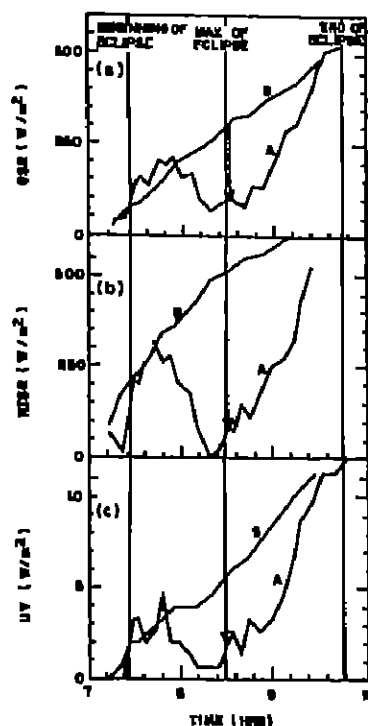
### *Solar Radiation Components*

The time profiles of the solar radiation components are shown in Fig. 1. The maximum reduction in GSR (70%) is in proportion to the maximum solar disk obscurity (72%) (Srivastava *et al.*, 1982). NISR in the complete range showed a slightly higher reduction (84%). The UV component was minimum (67%) at the peak of the eclipse. However, its proportion remained unchanged at about 2% of the total GSR on both normal, as well as on the eclipse day.

### *Meteorological Parameters*

The wind speed was marginally reduced during the eclipse ( $\approx 3$  kmph as compared to 4-7 kmph on other days). Similarly, lower values of wind direction,  $\sigma_0$  ( $5-7^\circ$ ) were observed as

compared to other days (10-11°). A fall of about 2°C in the screen level air temperature and a rise in relative humidity from 74% to 80% was observed during the peak eclipse period.



**Figure 1 :** Temporal variation of (a) GSR (b) NISR and (c) UV Component of GSR. A curve for 24.10.95 (eclipse day) and B for 25.10.95.

### *Sodar Observations*

The SODAR echogram during the eclipse revealed reduced turbulence in the lower layers (upto 100 m) of the atmosphere. This was expected in view of the fall in temperature and consequent increase in atmospheric stability close to the surface.

### *Air Pollution Measurements*

On the eclipse day, low ozone concentrations (3-5 ppb) were found upto 1000 hrs owing to the hazy conditions prevailing during morning hours, which reduced the photochemical activity, thus reducing the production of ozone from  $\text{NO}_x$  cycle resulting in a maximum of  $\text{NO}_x$  level. The earlier observations also revealed no detectable changes in the ground ozone levels, except in Gadag where a reduction of about 10% was reported (Chatterjee *et al.*, 1982). The levels of  $\text{SO}_2$  did not show any change attributable to the eclipse. NMHC concentrations showed a marginal increase, especially, during 0600-0800 hrs which may be due to reduced photochemical activity. Formaldehyde concentration showed a trend similar to that of ozone including the minimum observed during the eclipse time.

## Aerosol Measurements

### a. Mass-size Distribution

As seen from Fig. 2a, the behaviour of the SPM concentration on the eclipse day is distinctly different from that on the other days. The levels were significantly high in the early morning (0700 hrs) due to haze. The most noticeable aspect is the sharp increase from 0850 hrs to about 1020 hrs. The duration of this peak ( $\approx 90$  minutes) is comparable to that of the eclipse (80 minutes), although the concentration peak manifests with a time lag of about 85 minutes with respect to the beginning of the eclipse. This is to be expected since the aerosol behaviour is coupled to several complex atmospheric processes related to the reduction in the solar intensity and consequent cooling. After this period, the levels remained higher than those found on the other days.

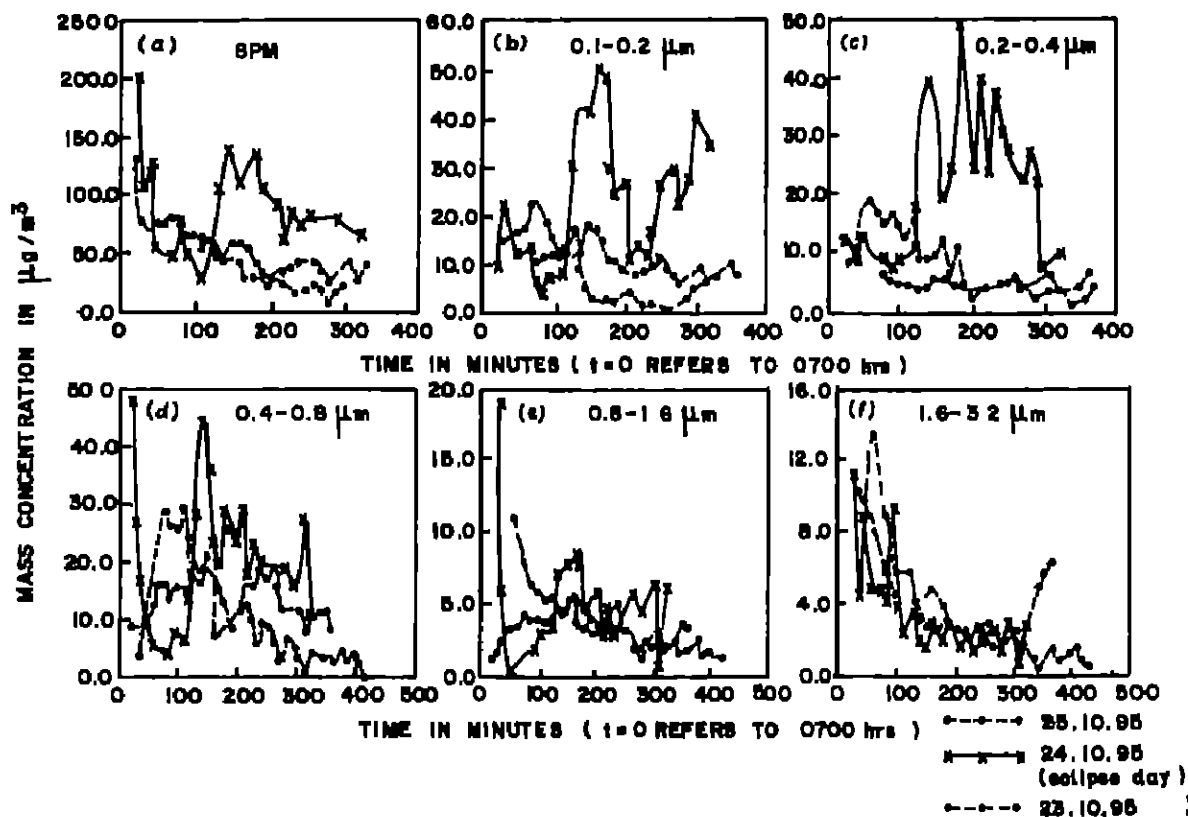


Figure 2 : Variation of mass concentration (Monitored by QCM).

A size-resolved analysis (Figs. 2b to 2f) indicates that a significant part of the increases observed is attributable to the particles in the 0.1-0.4  $\mu\text{m}$  MMAD range.

### b. Number-size distribution

The concentrations as measured by Met-One OPC in the size group  $>0.3 \mu\text{m}$ , presented in Fig. 3a, show a similar peak as in Fig. 2a with the crest-to-trough ratio of about 3.5. The elevated concentrations during the early hours as well as in the post-eclipse period are reproduced here. The size-resolved analysis (Figs. 3b to 3e) shows a significant contribution to this increase from  $0.3-0.5 \mu\text{m}$  particles. Similar results are obtained with the Malvern OPC. The ACNC response was similar to that of the other instruments, the main difference being the appearance of a wider peak ( $\sim 160$  minutes) with a greater lag time.

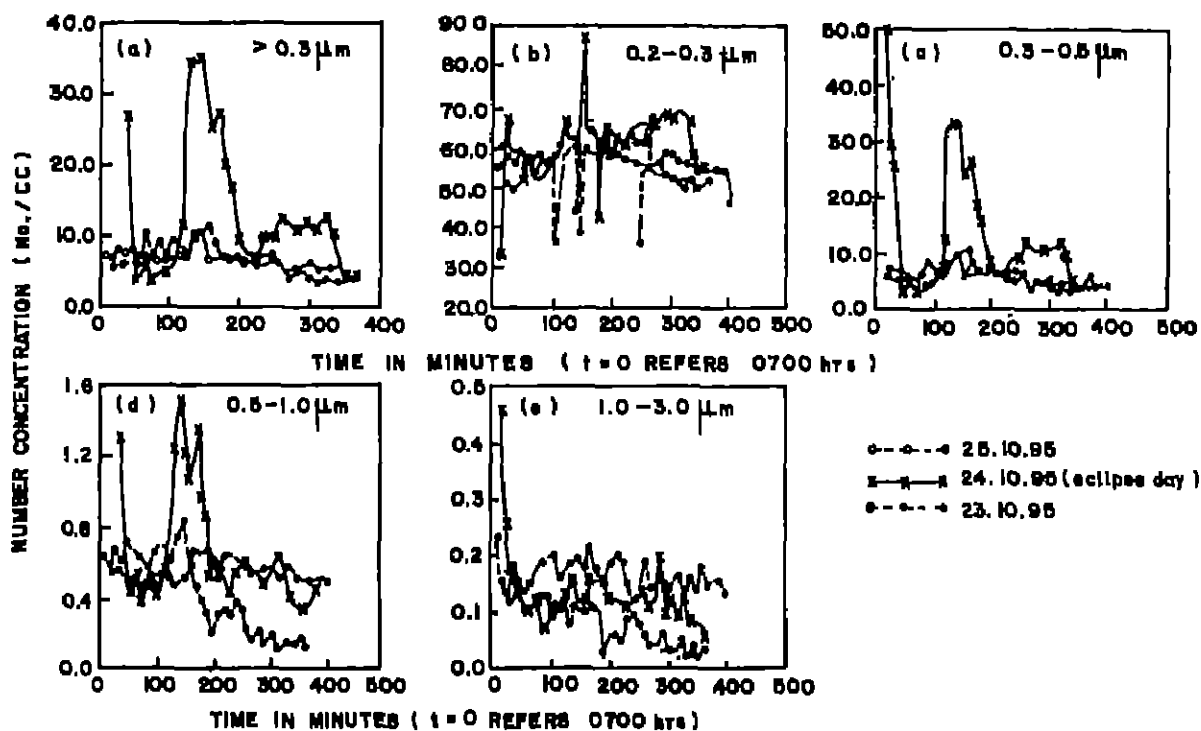


Figure 3 : Variation of particle number concentration in different size groups. (Monitored by MET-ONE OPC)

### Discussion

The reduction in GSR due to eclipse was proportional to the degree of the obscurity of solar disk. However, the proportion of UV component in GSR did not change due to eclipse. No noticeable change was observed in the levels of the conventional pollutants that could be directly attributable to the ecliptic phenomenon. A significant increase in the aerosol concentration occurred during the eclipse. The increased RH (due to lowering of the air temperature) observed on that day could lead to condensation effects, which manifest as

increases in the number concentrations of larger particles ( $>0.1 \mu\text{m}$ ) and increase in the mass concentrations. Also, the suppressed level of turbulence during the eclipse period would lead to an overall build-up of large particle concentrations. Increased ground level radon concentrations during the eclipse (Kotrappa *et al.* 1981) can give rise to an enhanced concentration of radon-generated-ion-induced nuclei in the presence of water vapour. This might be the reason, in addition to the build-up effect, for the increases observed in the total number concentrations using the ACNC.

## Conclusions

The variations in air temperature, relative humidity and atmospheric turbulence data (SODAR data) were found to have significant effect on the observed variation in the aerosol mass and number size distributions. The studies on aerosol measurements provide a direct confirmation of the expected increases in the aerosol concentrations (which have been inferred from the lowered atmospheric conductivity measurements).

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