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Sodar studies of aerosol size distribution and concentration at Delhi*

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Aerosol size distribution and concentration have been measured using Andersen Particle Cascade Impactor and GMW High Volume Sampler respectively. Sampling was done as per the stability conditions of fumigation period, unstable convective conditions (free mixing), and nocturnal stable period. Size distribution and concentration of particulate matter have been found to be related to sodar determined stability and mixing height of the boundary layer at Delhi.

1 Introduction

The size and concentration of particulate matter present in atmospheric air defines the extent of air pollution while the changes in the mixing height and stability determine its variability with time. Based on our investigations of the stability conditions and changes in the mixing height and turbulence through the use of sodar[1], we have studied the aerosol size distribution and concentration in the atmospheric boundary layer (ABL) at Delhi as a function of the changes in the stability conditions and mixing height.

2 Experimental details

Andersen Particle Cascade Impactor has been used for size distribution studies. Samples were collected for the period December 1985 to June 1986 covering winter (December-March) and summer (April-June). Based on our experience of stability effects on dispersion and diffusion of pollutants in the atmosphere, three distinct periods, namely, fumigation (0500-1100 hrs), convective (1100-1700 hrs), and stable (2300-0500 hrs) were chosen for collection of samples. Each sampling period lasted for about 80 h spread over 13-14 days, sucking a total volume between 120 and 150 m^3 for each sampling period.

Total suspended particulate (TSP) samples for concentration studies were collected by GMW High Volume Sampler. Studies have been made for a period of one year from April 1986 to March 1987. These samples were also collected for the three distinct periods, namely, fumigation, convective and stable. Each sampling period lasted for about 6 h. The total air sucked in one sampling period was 300-400 m^3.

3 Results and discussion

Figure 1 shows the plots of mass/size distribution and mass median diameter (MMD) of total aerosols for the three periods of fumigation, convective and stable for winter and summer. In this figure, smaller particles of submicron size represent A mode while coarser particles of supermicron size represent B mode[2].

From the plot for winter [Fig. 1(a)] it can be seen that for convective period the mass collected is small and MMD is 5.0 μm. The supermicron B mode predominates over submicron A mode. For fumigation period, the mass collected is large and MMD is 0.8 μm. A mode predominates over B mode. For stable period the mass collected is less than that of fumigation period. MMD is again 0.8 μm. A mode predominates over B mode.

From the plot for summer [Fig. 1(b)], it may be seen that the mass collected is greater in the fumigation period than those in the other two periods. MMDs for the total aerosols for all the periods are in the supermicron region and are 4.1, 1.5 and 4.4 μm for fumigation, convective and stable periods respectively. There is predominance of coarser particles in all the periods.

In order to establish a relationship between the concentration of total suspended particulates (TSPs) and sodar structure height, we have plotted TSP concentration as a function of sodar structure height

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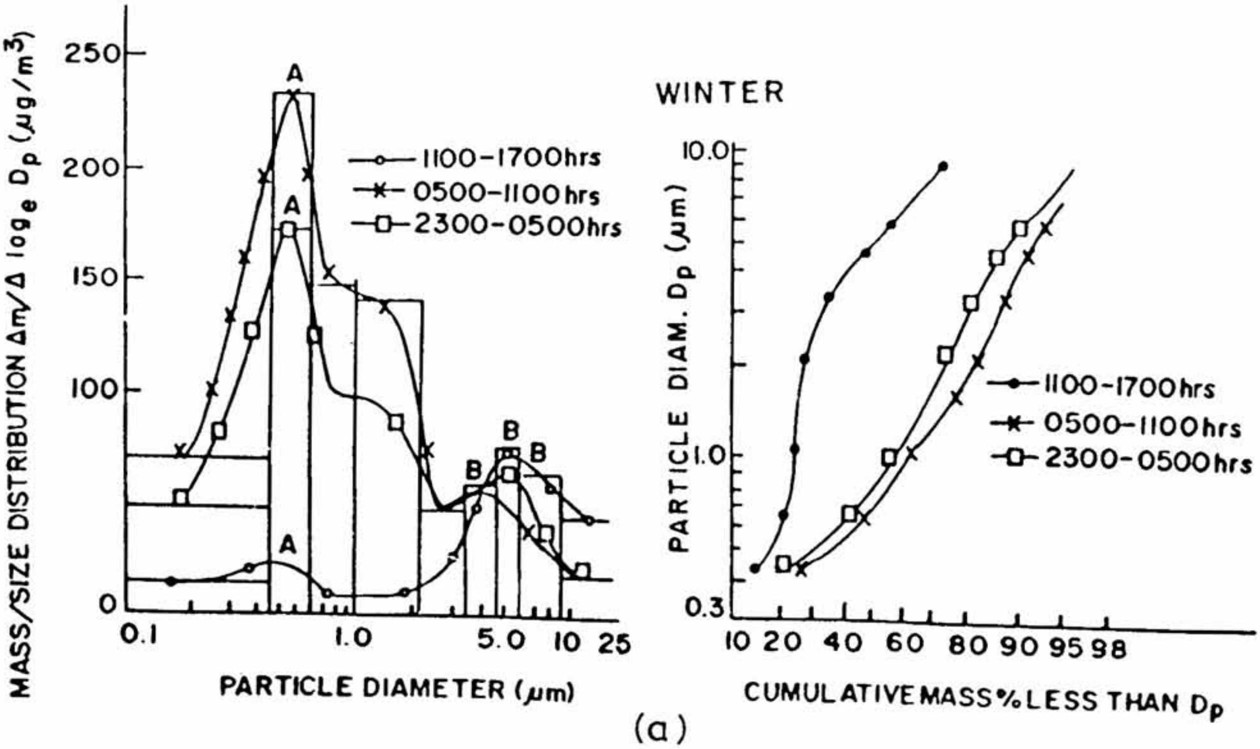

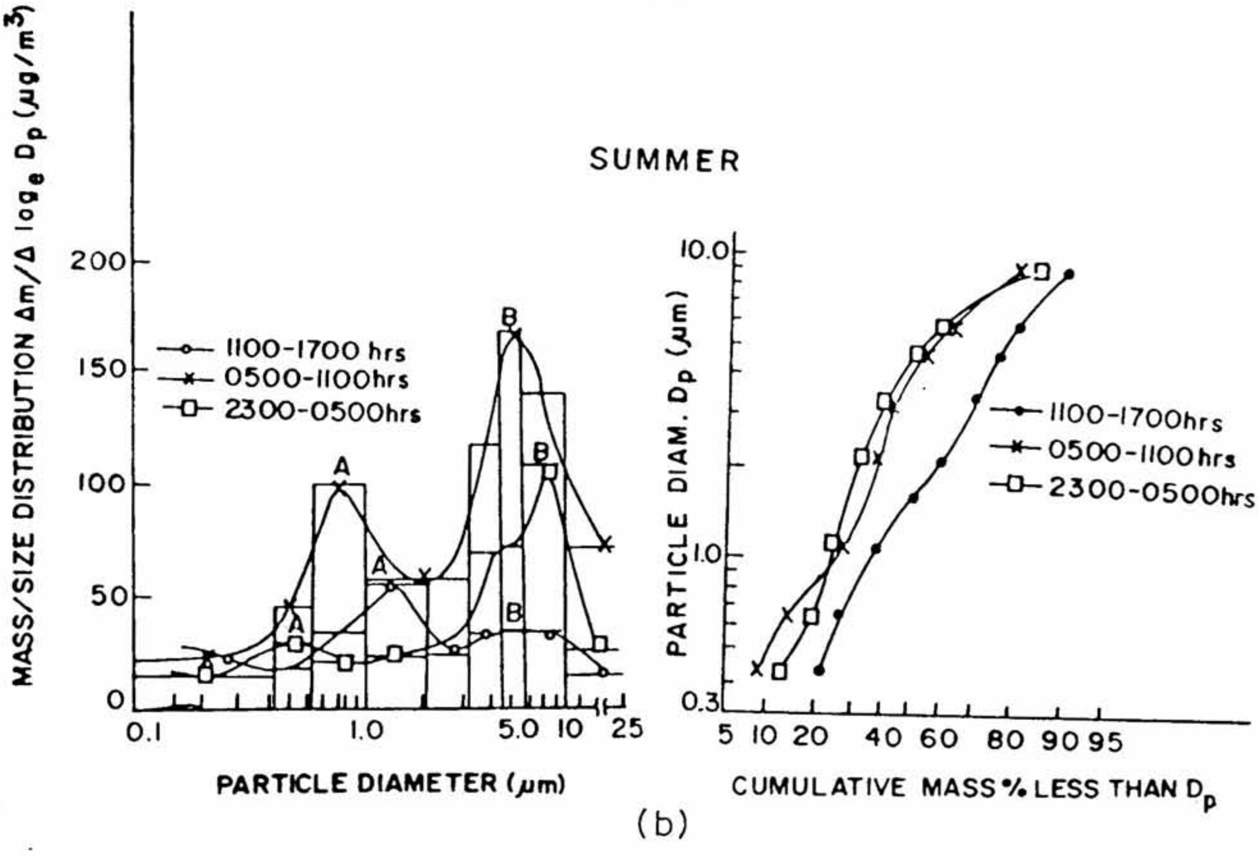

Fig. 1—Plots of mass/size distribution and mass median diameter (MMD) of total aerosols for the three stability periods of fumigation; convective and stable for winter and summer seasons. Δm is the concentration of total aerosols and $\Delta \log_e D_p = \log_e D_{p_{n-1}} - \log_e D_{p_n}$, where D_{p_n} is the value of 50% effective cut-off diameter of nth stage.

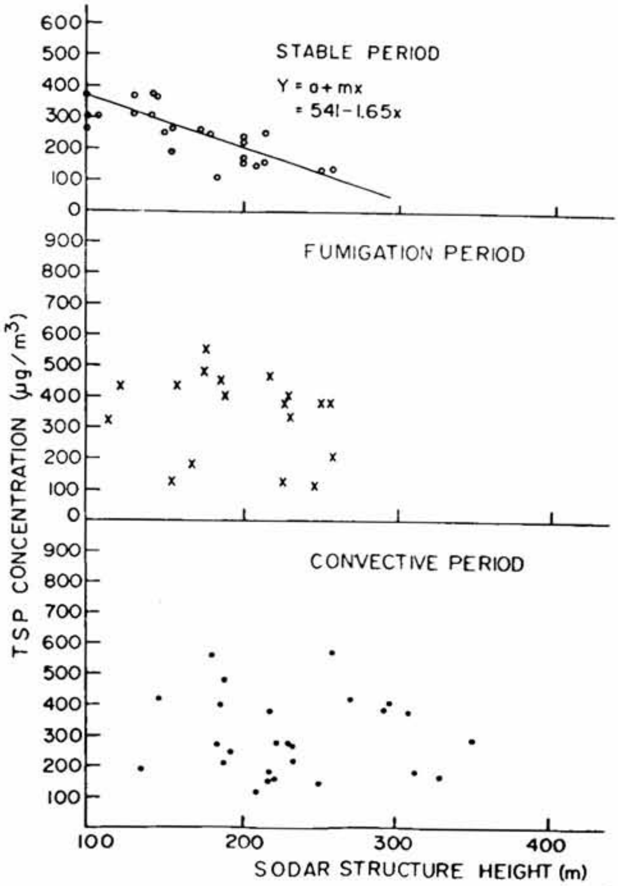

Fig. 2—TSP concentration for the three stability periods as a function of sodar structure height.

for the three periods for the duration April 1986-March 1987 (Fig. 2). It may be seen that for the stable period, the concentration is inversely proportional to the sodar structure height, while for the fumigation and convective periods such a trend does not exist. Since sodar structure height during the stable period represents inversion height or turbulent mixing height, so concentration is inversely proportional to mixing height for this period.

From size distribution details[3], the elements can be traced to their sources. For example, elements with MMD smaller than about 2 μm are commonly associated with high temperature anthropogenic processes and those with MMD greater than 2 μm are emitted mainly by natural processes such as crustal erosion. Of course some anthropogenic activities may also contribute to airborne concentrations of large particles on a local scale. In summer as MMDs for all the three periods are in supermicron mode the origin may be crustal in nature. During winter for the fumigation and stable periods the MMDs are in the submicron range and the masses of the particulate matter are higher than that of the convective period. Thus the sources may be anthropogenic and traffic. Further, since mixing height is low during winter[1], higher concentrations of particulate matter during this season can be associated with shallow mixing heights.

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