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### Abstract

Measurements of the aerosol physical and chemical properties were made to study the Suspended particulate matter (SPM), sources of PM<sub>2.5</sub> and PM<sub>10</sub>, chemical composition, trace gases (SO<sub>2</sub> and NO<sub>2</sub>) and their seasonal variations, in Delhi region at from November 2005 to December 2007 at National Physical Laboratory (NPL) (Lat. 28°38'N & long. 77°10'E) and Jamia Millia Islamia (JMI), New Delhi (lat. 28°33'N & long. 77°16'E) using high volume sampler (HVS), Anderson cascade impactor (ACI), Quartz crystal microbalance (QCM) cascade impactor, Flame Atomic Absorption Spectrophotometer (AAS), Ion Chromatograph (IC), UV-Visible Spectrophotometer (UV-Vis) and pH meter. Airmass back trajectory was computed by the Hybrid Single Particle Lagrangian Integrated Trajectory-National Oceanic and Atmospheric Administration (HYSPLIT-NOAA) to understand aerosol pathway.

The Delhi climate is semi-arid and consists of mainly three distinct seasons, viz; summer (March-June), monsoon (July-October) and winter (November-February). Average concentrations of SPM, NO<sub>2</sub> and SO<sub>2</sub> during entire study period have been observed to be 384±232, 33±15 and 15±7 µg m<sup>-3</sup> (excluding the dust storm events), respectively. A good correlation is observed between NO<sub>2</sub> and SO<sub>2</sub> with SPM (r<sup>2</sup>=0.73 for NO<sub>2</sub> & SPM; r<sup>2</sup>=0.86 for SO<sub>2</sub> & SPM), indicating that NO<sub>2</sub> and SO<sub>2</sub> contribute equally to SPM. The concentration level of NO<sub>2</sub>, SPM and PM<sub>10</sub> have recorded a significant increase since 2005 largely due to growing vehicular population and construction activity in Delhi, whereas SO<sub>2</sub> concentration levels have come down in the past few years due to reduced content of sulphur in fuel and tighter emission control by government. Average concentration of PM<sub>10</sub> and PM<sub>2.5</sub> is observed to be 310±176 and 140±82 µg m<sup>-3</sup>, respectively. In summer, because of frequent dust storms, coarse particles are more dominant than those of fine particles and, during winter, the boundary layer is relatively lowered down and the emission remains trapped in the near surface. A very good correlations between PM<sub>25</sub> & PM<sub>10</sub> (r<sup>2</sup>=0.82) and between PM<sub>25</sub> & PM<sub>2.5</sub> (r<sup>2</sup>=0.72) were observed, which implies that variation in PM<sub>25</sub> is due to the variation in PM<sub>10</sub> or PM<sub>2.5</sub> and can also be attributed to the process of transport in the

atmosphere by winds, which carry the particulate matter. The average value of  $\text{NH}_4^+$ ,  $\text{Mg}_2^+$ ,  $\text{Ca}_2^+$ ,  $\text{Na}^+$  and  $\text{K}^+$  are observed to be  $8.39 \pm 6.53$ ,  $1.02 \pm 0.51$ ,  $8.24 \pm 4.60$ ,  $12.38 \pm 5.65$  and  $5.14 \pm 3.69 \mu\text{g m}^{-3}$ , respectively. Soil dust suspended in the lower layer of the atmosphere due to daytime convection and western disturbances are understood to be the major source of  $\text{Ca}_2^+$ ,  $\text{Mg}_2^+$  and  $\text{K}^+$ . However a fraction of the  $\text{K}^+$  is contributed by burning of wood and dry leaves in winter.  $\text{NH}_3$  concentration in winter is more because of low-level inversion, ammonia is trapped in the lower layers. Concentration of  $\text{Mg}_2^+$  is found to be high in summer. The average concentrations of major anions;  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$  and  $\text{NO}_3^-$  are observed to be  $1.99 \pm 1.38$ ,  $14.76 \pm 4.12$ ,  $12.93 \pm 7.17$  and  $10.33 \pm 5.49 \mu\text{g m}^{-3}$ , respectively. A good correlation ( $r_2=0.94$ ) between  $\text{NH}_4^+$  and  $\text{SO}_4^{2-}$  suggest that most of  $\text{NH}_4^+$  may be in the form of sulphate salts.  $\text{Na}^+$  varied from  $8.38 \mu\text{g m}^{-3}$  to  $16.56 \mu\text{g m}^{-3}$ , with an average value of  $10.5 \pm 2.33 \mu\text{g m}^{-3}$ .  $\text{Na}^+$  concentration shows a rising trend in summer with the increase in humidity.  $\text{Cl}^-$  to  $\text{Na}^+$  molar ration (1.39) in Delhi samples is close to that of seawater (1.16) and have a good correlation ( $r_2=0.70$ ), indicating significant contribution due to sea salts, effect of western disturbances and possibly due to emission of  $\text{Cl}^-$  from fabric bleaching activity in a number of export garments factories.

Comparative study of atmospheric aerosols at two different locations (NPL and JMI) shows a considerable difference in the concentrations of  $\text{SO}_4^{2-}$  and  $\text{NO}_3^-$ . The major sources of  $\text{SO}_4^{2-}$  are possibly the thermal power plants, soil re-suspension and vehicular exhaust. Relatively high concentrations of  $\text{SO}_4^{2-}$  and  $\text{NO}_3^-$  were observed at NPL in fine mode, suggesting local sources and secondary production is dominating the aerosol loadings in winter season. The observed concentration of  $\text{Na}^+$  and  $\text{Mg}_2^+$  at both sites is comparable, suggesting that sources are not local and may be influenced by sea sources. NPL shows high concentration ( $12.2 \mu\text{g m}^{-3}$ ) of  $\text{Ca}_2^+$  then JMI ( $5.8 \mu\text{g m}^{-3}$ ) may be due to soil re-suspension and western disturbance. The high concentration ( $7.3 \mu\text{g m}^{-3}$ ) of  $\text{K}^+$  at NPL may be due to intensive biomass burning in winter in the surrounding area. During winter, high concentration of aerosol is observed at NPL, compared to JMI. High concentration of aerosol is observed in all particle size range at JMI during summer, whereas in winter the fine particles are contributing more to aerosol loading at NPL. These findings are useful in understanding the role of aerosols mass and size characterization for their radiative forcing properties.