Day–night variability of EC, OC, WSOC and inorganic ions in urban environment of Indo-Gangetic Plain: Implications to secondary aerosol formation

Kirpa Ram, M.M. Sarin*

Physical Research Laboratory, Ahmedabad, Gujrat 380 009, India

A R T I C L E   I N F O

Article history:
Received 23 April 2010
Received in revised form 23 September 2010
Accepted 24 September 2010

Keywords:
Organic carbon
Elemental carbon
Secondary aerosols
Urban-haze
Indo-Gangetic Plain
Diurnal variability

A B S T R A C T

This manuscript reports on the day- and night-time variability of EC, OC, WSOC and inorganic ions in ambient aerosols (PM$_{2.5}$ and PM$_{10}$) sampled from an urban site (Kanpur) in the Indo-Gangetic Plain. The chemical data also provide evidence for the secondary aerosol formation and variability in the composition of particulate matter. The aerosol mass is dominated by fine-mode particles and PM$_{2.5}$/PM$_{10}$ mass ratio exhibit significant temporal variability (range: 0.46 to 0.86). The chemical composition suggests that total carbonaceous aerosols (TCA = 1.6 × OC + EC) and water-soluble inorganic species (WSIS) account for nearly 50 and 20% of the PM$_{2.5}$ mass, respectively. The mass concentrations of PM$_{2.5}$, EC and OC show about 30% increase during night-time. A significant linear relation between EC-OC ($R^2 = 0.66$) and OC-K$^+$ ($R^2 = 0.59$) and their characteristic ratios suggest biomass burning emission as a dominant source. The average WSOC/OC ratio is relatively high in the day-time samples (0.66 ± 0.11) compared to that in the night-time (0.47 ± 0.07); suggesting increased contribution of secondary organic aerosols. The mass fraction of particulate NO$_3^-$ increases by a factor of five during night-time due to relatively stable NH$_4$NO$_3$ and/or its secondary formation from the hydrolysis of N$_2$O$_5$. Although the concentration of SO$_4^{2-}$ is noticeably higher during day-time (~20%), the day–night variability of particulate-NH$_3$ is insignificant. The concentrations of OC, EC and inorganic species (K$^+$, NH$_4^+$, NO$_3^-$ and SO$_4^{2-}$) show 2 to 4 fold increase during the haze events.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

Atmospheric aerosols, derived from natural and anthropogenic sources, significantly affect the air-quality, visibility, atmospheric chemistry and Earth’s radiation budget. The formation of secondary aerosols, in conjunction with the airborne particles of primary origin, have been recently recognized as a dominant cause for the air pollution over mega-cities (e.g. Lee and Sequeira, 2002; Dall’Osto et al., 2009; Guo et al., 2010; Zhang et al., 2010). The secondary formation of particulate NO$_3^-$ is of significant interest because it influences NO$_x$ (NO + NO$_2$) levels and their life-time. During the daytime photochemical reactions, NO$_x$ act as a catalyst in the formation of O$_3$; whereas it acts as a sink for O$_3$ in the lower troposphere during nighttime (Brown et al., 2004). Day-time photochemical formation of NO$_x$ also facilitates the oxidation of volatile organic compounds (VOCs) to form secondary organic aerosols (SOA), which in turn increases the hygroscopicity of aerosols (Brown et al., 2006). Furthermore, atmospheric aerosol acidity has potential to enhance the SOA formation (Jang et al., 2002).

The hygroscopic growth of secondary aerosols changes the scattering property of the atmosphere and decreases the visibility (Malm et al., 1996). The visibility is directly linked to aerosol extinction coefficient ($b_{ext}$), defined as the sum of scattering and absorption coefficients (i.e. $b_{ext} = b_{scatt} + b_{abs}$), and is related to the abundances of anthropogenic species and formation of secondary aerosols (Malm et al., 1996; Cheung et al., 2005). Thus, there is an ongoing interest in studying the regional aerosol chemical composition, secondary formation and their role in fog and haze events. For example, Lee and Sequeira (2002) had suggested that SO$_4^{2-}$ aerosols are the prominent species responsible for reducing the visibility over Hong Kong. In a recent study, Guo et al. (2010) found that secondary inorganic aerosols (SIA; sum of the concentrations of NH$_4^+$, NO$_3^-$ and SO$_4^{2-}$) contribute ~55% of the fine-aerosol (<1.8 μm) mass over Beijing during summertime and are responsible for the regional-scale pollution.

The fog–haze weather conditions and reduction in the visibility, during wintertime (Dec–Feb), over the entire Indo-Gangetic Plain (IGP) in northern India provides an ideal site to study the role of primary pollutants and secondary aerosol formation. The studies reported in the literature have suggested that carbonaceous aerosols contribute ~30–35% of the total suspended particulate (TSP) mass over IGP during the wintertime (Rengarajan et al., 2007;