Long-term characterization of ionic species in aerosols from urban and high-altitude sites in western India: Role of mineral dust and anthropogenic sources

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Abstract

Concentrations of water-soluble-ionic-species (NH$_4^+$, Na$^+$, K$^+$, Mg$^{2+}$, Ca$^{2+}$, Cl$^-$, NO$_3^-$, SO$_4^{2-}$ and HCO$_3^-$) in the ambient aerosols and their temporal variability have been studied for a 3-year period (2000–2002) from an urban site (Ahmedabad, 23.0°N, 72.6°E, 49 m asl) and a high-altitude station (Mt Abu, 24.6°N, 72.7°E, 1680 m asl) located in a semi-arid region of western India. During the drier months (January–April, September–December), the average concentrations ($\mu$gm$^{-3}$) of water-soluble species in the aerosols over Ahmedabad are: HCO$_3^-$: 4.95, SO$_4^{2-}$: 4.57, Ca$^{2+}$: 2.96, NO$_3^-$: 2.07, Cl$^-$: 0.99, Na$^+$: 0.81, K$^+$: 0.76, NH$_4^+$: 0.48, Mg$^{2+}$: 0.25. During the wet period of the SW-monsoon (May–August), the contribution of Na$^+$ (2.42 $\mu$gm$^{-3}$) and Cl$^-$ (3.96 $\mu$gm$^{-3}$) are significantly enhanced. In spite of the geographic and altitude differences, the composition of aerosols from the two sites shows comparable ratios among the major species (Ca$^{2+}$, HCO$_3^-$ and SO$_4^{2-}$). On average, during dry period, nss-SO$_4^{2-}$/nss-Ca$^{2+}$ and HCO$_3^-$/nss-Ca$^{2+}$ ratios over Ahmedabad are 1.6 and 1.7; and those over Mt Abu are 1.9 and 2.0, respectively. During wet phase, the corresponding ratios are 1.3 and 1.7 over Ahmedabad and 1.2 and 1.8 over Mt Abu. Although the concentrations of several species are significantly different over the two sites and exhibit large seasonal variations, their inter-annual variability is nowhere pronounced. Unlike the chemical characteristics reported over other urban regions, aerosols sampled in this study are of alkaline nature with major neutralizing component as Ca$^{2+}$ rather than NH$_4^+$. As a result, significant uptake of acidic species (NO$_3^-$ and SO$_4^{2-}$ derived from pollution sources) by mineral aerosols (CaCO$_3$) is a dominant chemical transformation process over the study sites.

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1. Introduction

It has been well recognized that ambient aerosols can influence the atmospheric radiative forcing by absorp-