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Atmospheric Mineral Dust and Trace Metals over Urban Environment in Western India during Winter

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ABSTRACT

Trace metal concentrations in $PM_{2.5}$ and PM_{10} are studied from Ahmedabad, an urban location in western India. During winter, concentrations of Zn, Cd and Pb are in the range of 16.5–290, 0.1–5.4, 28–1023 ng/m^3 in $PM_{2.5}$ and 38–459, 0.21–8.4, 48–1223 ng/m^3 in PM_{10}, respectively. Enrichment Factor (EF) analysis with respect to Al showed significant enrichment of elements like Cd, Pb, Zn and Cu in fine mode particles, suggesting their strong anthropogenic contribution. About 43% of PM_{10} mass is constituted by mineral dust, and the dominant fraction (~88%) of the same exists in coarse fraction with a characteristic Fe/Al ratio of 0.53. The Ca/Al ratio is ~1.1 in PM_{10} and ~0.8 in $PM_{2.5}$ indicating that aerosol over this region is rich in Ca minerals compared to the average upper continental crust. Positive Matrix Factorization (PMF) analysis using trace metal and major components reveals five sources for $PM_{2.5}$ and six for PM_{10}. The PMF results suggest anthropogenic sources contribute ~80% and 40–50% of the $PM_{2.5}$ and PM_{10} mass, respectively. Incineration/industrial emission, biomass burning, vehicular emissions and re-suspended/long range transported dust are the other prominent sources identified in this work. These source contributions exhibit large temporal variations during winter, as the sampling location is influenced by air masses from different source regions.

Keywords: Trace elements; Mineral dust; PM_{10}; $PM_{2.5}$; Positive Matrix Factorization.

INTRODUCTION

Atmospheric aerosols have significant influence on human health, ecosystem biogeochemical cycles and climate. As a result of increasing population and growing urbanization, regional air pollution problems like reduced visibility and acid deposition are apparent in the South Asian region which is of interest both in regulatory as well as scientific perspectives. This region is considered as one of the significant source regions of anthropogenic emissions in the world. In addition, this region has substantial natural aerosol sources like mineral dust from deserts and arid regions and sea-salts from marine environment. Several studies have revealed that aerosols, especially fine mode particles, can lead to serious human health effects like cardiovascular and respiratory disorders (Dockery and Pope, 1994). Also, absorbing or scattering nature of aerosols, depending on their composition, makes it a potential agent to modulate the energy balance of Earth atmosphere system. Thus, it is necessary to understand the different sources of aerosols, formation processes and concentration levels of toxic pollutants in order to assess their environmental impact and implement effective control strategies.

Ambient aerosols consists of mineral dust, metals, sea salts as well as organic (EC and OC) and inorganic pollutants. Relative abundance of these components is highly variable both temporally and spatially. During winter, inhalation of trace-metal bearing particles is of particular health concern due to the toxicity of heavy metals and their potential to cause oxidative stress through generation of free radicals (Davidson *et al*., 2005; Duzgoren-Aydin, 2008). Recent studies in urban atmosphere showed that concentrations of $PM_{2.5}$ and PM_{10} (atmospheric particles with aerodynamic diameter less than 2.5 and 10 μm, respectively) exhibit direct relation with traffic-related pollutants (both diesel and gasoline vehicles) and their health effect through respiratory and cardiac diseases (Lee *et al*., 2006). Under favourable meteorological conditions, these metal-bearing particles can be transported along with other constituents to distant locations from source regions, including remote marine environment. It is well documented that atmospheric depositions of trace metals (viz., Cd, Pb, Cu and Zn) to open oceans could exceed those of reverine fluxes (Kokack *et al*., 2005) and thus assessment of their probable sources and concentrations in polluted source regions are essential. Several studies have documented aerosol concentrations and major chemical constituents in this important source region in south-east Asia, however, comprehensive studies

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