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An investigation into the relationship between the major chemical components of particulate matter in urban air

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HIGHLIGHTS

- The major components of particulate matter (MCP) were investigated in the urban air.
- The behavior of TSP is evaluated to assess the interactive roles between the MCP.
- The composition of MCP generally varied in the descending order: anions, OC, cations, EC, and metals.
- The measured MCP was able to account for 60% of total TSP composition during the study period.

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ABSTRACT

Particulate matter (PM) generally comprises such chemical components as inorganic ions, organic carbon (OC), elemental carbon (EC), and metals. In terms of environmental studies, these major chemical components of particulate matter (MCP) are important in understanding PM distribution, behaviors and source apportionment. In this study, the MCP fractions of total suspended particles (TSP) were measured at an urban residential area in Seoul, Korea from February to December in 2009. The behavior of each individual MCP was studied in order to explain their relationship to environmental conditions and sources. The MCP measured during this study period was able to account between 54% (spring) to 67% (fall) of total TSP composition. During the study period, it was found that the TSP sampled comprised mostly: anions, OC, cations, EC, and metals in decreasing order of abundance. Although such relative ordering seems to remain fairly constant over time, the relative balance of this relationship may be altered by variations in environmental conditions.

1. Introduction

Particulate matter (PM) is emitted into the atmosphere by both natural (i.e., crustal matter, sea-salt, etc.) and anthropogenic sources (i.e., industrial processes, transportation, combustion, etc.) (Zheng et al. 2004; Fang et al., 2006; Hwang and Hopke, 2011). As PM contains harmful metals and organic compounds and can adsorb gaseous pollutants from the air, it acts as the main media for the transfer of hazardous pollutants across various environmental reservoirs (Greco et al., 2007). Information concerning the distribution and composition of PM is also important, as the individual components may be harmful to human health upon ingestion or inhalation (Seaton et al., 1995; Harrison and Yin, 2000).

Megacities have high densities of population and traffic activity. Because emissions of airborne pollutants resulting from high densities of PM-emitting activities cause diverse socio-economic problems, many governments have implemented policies aimed at improving air quality. For example, a policy to control the emission of sulfur from fuel has been the driving force in reducing sulfur dioxide (SO_2) in Korea since 1981 (National Institute of Environmental Research (NIER), 2007). The implementation of such polices in Korea has also been helpful in the recent past to reduce concentration levels of certain important pollutants such as PM_{10} and some PM-bound metallic components like Pb and Cd

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(Kim, 2007a, b; Kim, 2010) as well as certain gaseous components like CO and NOx (Pandey et al., 2008; Kim and Shon, 2011; Shon and Kim, 2011). Similar patterns of abatement have commonly been reported in many developed and developing countries (e.g., Fenger, 1999; Begum et al., 2011; Kim and Shon, 2011). However, it should be noted that levels of change in total suspended particles (TSP) levels, although decreasing gradually since 1990, have not matched the dramatic reductions observed for other pollutants in Korea (e.g., NIER, 2010; Kim, 2010).

The important chemical components of TSP in air which are regularly measured by air quality networks are inorganic ions, organic carbon (OC), elemental carbon (EC), and crustal metals (such as Fe, Al, S and Si) (Kang et al., 2009). The remaining fraction of TSP is generally comprised of multiple chemical components at low abundance, and these are generally not routinely quantitatively measured. In order to precisely describe the sources of PM and its behavior in the atmosphere, it is important to have a better understanding of the relationship between the MCPs (Woodruff et al., 1997; Biswas et al., 2009).

In this study, the concentrations of TSP and its MCP fraction were measured at an urban residential area (Yang Jae district in Seoul, Korea) during the months of February through December 2009. These measurement data were analyzed to assess the relationship between the MCP fractions and between the MCP and the concurrently measured environmental parameters. The results of this study will help us extend a better knowledge on the major chemical components of TSP fractions in urban environments and the basic factors influencing the distribution, behavior, and source apportionment of PM under various conditions.

2. Materials and methods

2.1. Site characteristics

In order to assess the behavior of the MCPs, the concentrations of OC, EC, metal, and inorganic ions were analyzed along with TSP total mass from the Yang Jae (YJ) site (E–W 127°01.55′, N–S 37°27.51′) in Seoul, Korea during the months of February through December 2009 (Fig. 1). The site was selected, as it can represent one of the urban background areas consisting dominantly of residential facilities. The city of Seoul has a population of 10 464 051 with 4 116 660 households as of 2009 (Seoul Metropolitan Government (SMG), 2010). Because the YJ site belongs to one of the subdistricts of the Seo Cho district, the basic characteristics of the YJ site can be explored by the general descriptions of the Seo Cho district. According to the SMG (2010), Seo Cho district has a population of 431 131 with a density of 9172 persons per square kilometer. There are a total of 30 registered air pollutants emitting

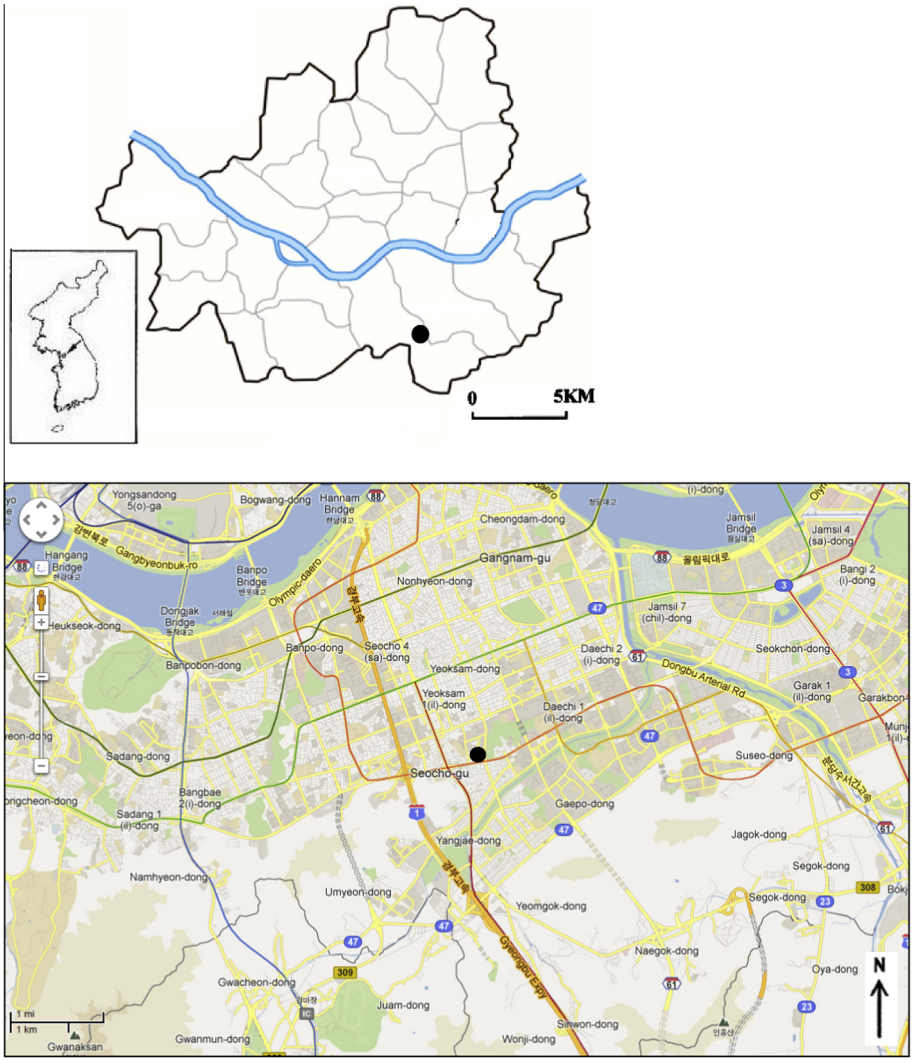

Fig. 1. Geographical location of Yang Jae (YJ) district in Seoul, Korea (from Google map).