Physico-Chemical Characteristics of Visibility Impairing Aerosol Measured at Two Urban Sites in Seoul and Incheon, Korea

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ABSTRACT

In order to investigate the causes of visibility impairment in Seoul metropolitan area, extensive aerosol chemical and optical monitoring had been conducted at two urban sites, Junnong, Seoul and Younghyun, Incheon during three seasonal intensive monitoring periods; 5 - 26 August, 20 - 28 October 2002, and 10 - 24 January 2003. Light extinction and scattering coefficient were measured simultaneously with a transmissometer and a nephelometer, respectively. During the first IMP, average light extinction coefficient and visual range were measured to be 692±283 Mm^{-1} and 5.7±8.0 *km* at Junnong and 366±232 Mm^{-1} and 10.7±9.6 *km* at Younghyun, respectively. They were measured to be 354±194 Mm^{-1} and 11.5±7.7 *km* at Junnong and 229±119 Mm^{-1} and 17.1±7.7 *km* at Younghyun during the second IMP and 702±567 $Mm^{-1}$and 5.6±6.9 *km* at Junnong and 1123±831 $Mm^{-1}$and 3.5±4.7 *km* at Younghyun during the third IMP. Mean light extinction budget for five major aerosol components; ammonium sulfate, ammonium nitrate, fine carbonaceous particles (EC+OC), fine soil, and coarse particle were calculated to be approximately 13, 15, 48, 2, 22% for Junnong and 12, 9, 53, 2, 24% for Younghyun, respectively. The contribution of EC to visibility impairment was about three times larger than that of OC. In addition, visibility impairment occurred not only under atmospheric stagnation condition with low wind speed < 1m/sec, but also under higher wind speed > 3m/sec. It was implied that regional or long-range transport of secondary air pollutants might affect local visibility impairment.

1. Introduction

According to MOE (Ministry of Environment Republic of Korea, http://www.me.go.kr), owing to a variety of air pollution reduction policies, including the use of clean fuel, expanded supply of low-sulfur oil and introduction of low-emission vehicles, the pollution concentration levels of sulfur dioxide, carbon monoxide and lead have improved dramatically in Korea since 1990. However, visibility impairment is still persistent in most urban areas in Korea. Korean national air quality standard for particulate matter is set not for fine PM2.5 particles but for PM10. It has been reported that visibility impairment is sensitive to PM2.5 concentration in an urban area [Eldred et al., 1990; Malm et al., 1996; Pitchford et al., 1999; Kim et al., 2001; Watson, 2002]. This is the reason that it is difficult to estimate the causes of visibility impairment in Korea accurately since no data about temporal variation of PM2.5 concentration are available. In order to investigate the causes of visibility impairment in Seoul metropolitan area extensive aerosol and visibility monitoring was conducted at two urban sites, Junnong, Seoul and Younghyun, Incheon during three seasonal intensive monitoring periods; 5 - 26 August, 20 - 28 October 2002, and 10 - 24 January 2003. The monitoring consisted of aerosol sampling for chemical components and continuous measurement of atmospheric optical properties.

2. Measurements

During the intensive monitoring periods (IMPs), aerosol measurements were performed in the urban atmosphere of cities of Seoul and Incheon, Korea. Routine aerosol monitoring was carried out to collect aerosol samples using five samplers; $PM_{2.5}$ URG cyclones with three filter-packs, a PM_{10} URG cyclone with a filter-pack, and a PM_{10} Anderson high volume air sampler. Diurnal 24-hour sampling beginning 9 A.M. was carried out every day during the extensive monitoring periods. A Sartorius model Micro microbalance was used to measure gravimetric mass of particles collected on Teflon filters. They were then used to analyze trace element concentrations using Perkin Elmer model Optima 4300DU ICP/AES (Inductively Coupled Plasma/Atomic Emission Spectrometry) & / VG Elemental model PQ3 MS (Mass Spectrometry) and UNICAM model SOLAAR989 AAS (Atomic Absorption Spectrometry). They were also prepared for IC (Ion Chromatography) analysis of ionic species (Cl^-, NO_3^-, SO_2^-, Na^+, NH_4^+, K^+, Mg^{2+}, and Ca^{2+}) after being extracted by 10 ml of distilled water using Dionex model DX-120 IC. Optical monitoring provides a quantitative measure of each component of ambient light extinction coefficient representing visibility condition. Optical monitoring at two urban sites included continuous measurements of light extinction coefficient, b_{ext} and light scattering coefficient, b_{scat}, using a LPV-2 long-path transmissometer and a NGN-3 integrating nephelometer, respectively.

3. Results and Discussions

During the first IMP, average light extinction coefficient and visual range were measured to be 692±283 Mm^{-1} and 5.7±8.0 *km* at Junnong, 366±232 $Mm^{-1}$and 10.7±9.6 *km* at Younghyun, respectively. They were measured to be 354±194 $Mm^{-1}$and 11.5±7.7 *km*, 229±119 Mm^{-1} and 17.1±7.7 *km* during the second IMP and 702±567 $Mm^{-1}$and 5.6±6.9 *km*, 1123±831 $Mm^{-1}$and 3.5±4.7 *km* during the third IMP.

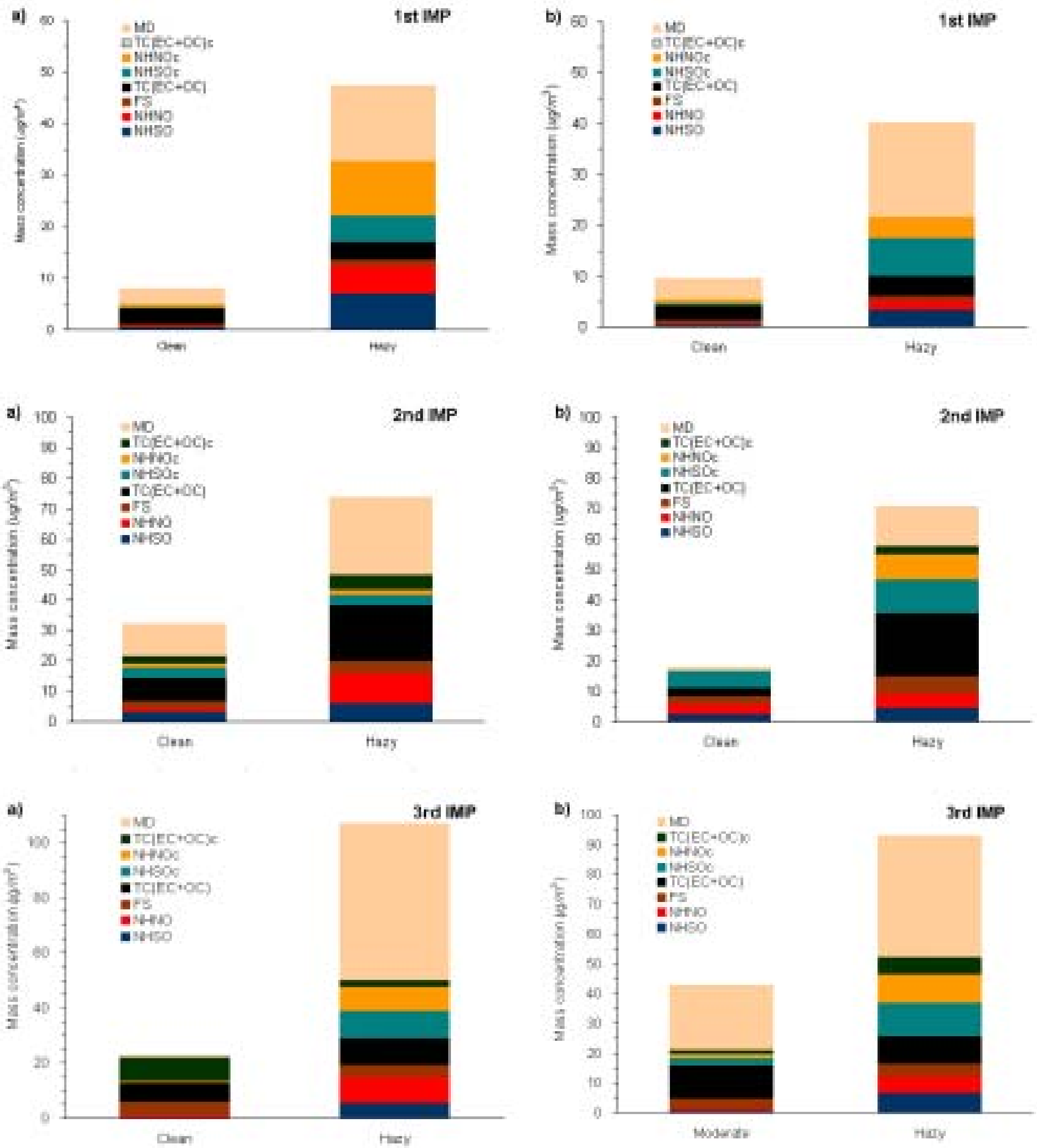

Figure 1. Variation of mean mass concentration for aerosol components in the PM_{10} mode under clean and hazy atmospheric conditions during the three intensive monitoring periods: a): Junnong and b): Younghyun. NHSO: $(NH_4)_2SO_4$, NHNO: NH_4NO_3, FS: fine soil, EC: elemental carbon, OC: organic carbon in the fine mode, NHSOc: $(NH_4)_2SO_4$, NHNOc: NH_4NO_3, MD: mineral dust, ECc: elemental carbon, OCc: organic carbon in the coarse mode.

Variations in the mean mass concentration of key aerosol components in the PM10 mode under clean and hazy atmospheric conditions are illustrated in Figure 1. Mean mass concentrations of carbonaceous particles at Junnong and Younghyun sites under hazy days were measured to be 13.2 ± 6.2 and 14.1 ± 6.9 $\mu g/m^3$, respectively. Carbonaceous particle concentration was the largest contributor to $PM_{2.5}$ mass concentration under hazy atmospheric condition. Mean light extinction budget for five major aerosol components; ammonium sulfate, ammonium nitrate, fine carbonaceous particles (EC+OC), fine soil, and coarse particle were calculated to be approximately 13, 15, 48, 2, 22% for Junnong and 12, 9, 53, 2, 24% for Younghyun, respectively as shown in Figure 2. The contribution of EC to visibility impairment was about three times larger than that of OC.

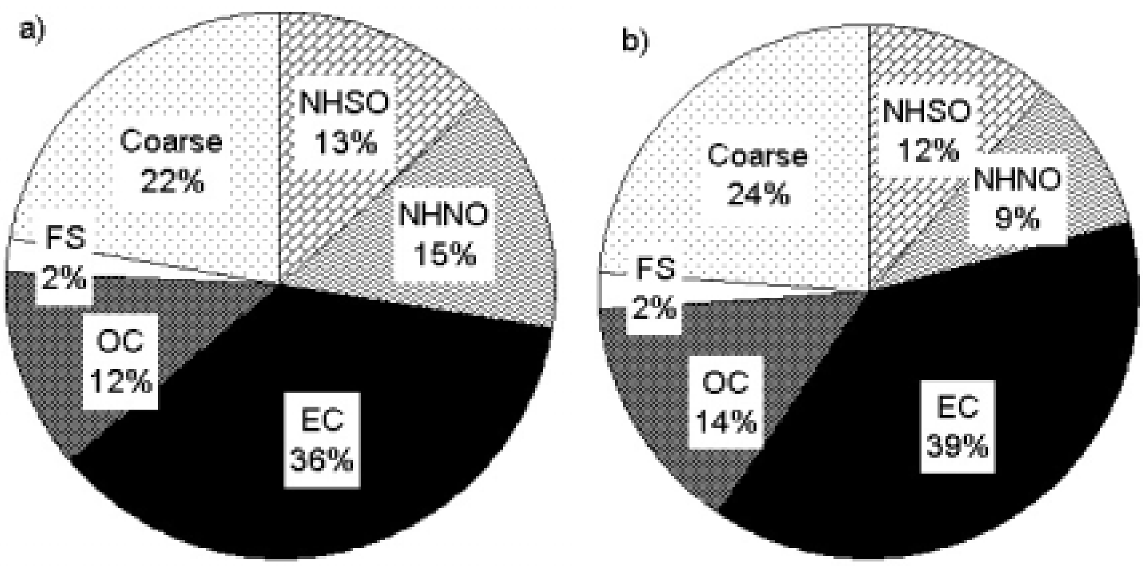

Figure 2. Mean light extinction budgets for aerosol components at (a)Junnong and (b)Younghyun during the extensive monitoring periods.

Figure 3 shows the air mass back-trajectory results for hazy days using the Hysplit model 4.5 [Draxler, 1996]. Visibility impairment occurred not only under atmospheric stagnation condition with low wind speed < 1m/sec, but also under higher wind speed >

3m/sec. It was implied that regional or long-range transport of secondary air pollutants might affect local visibility impairment.

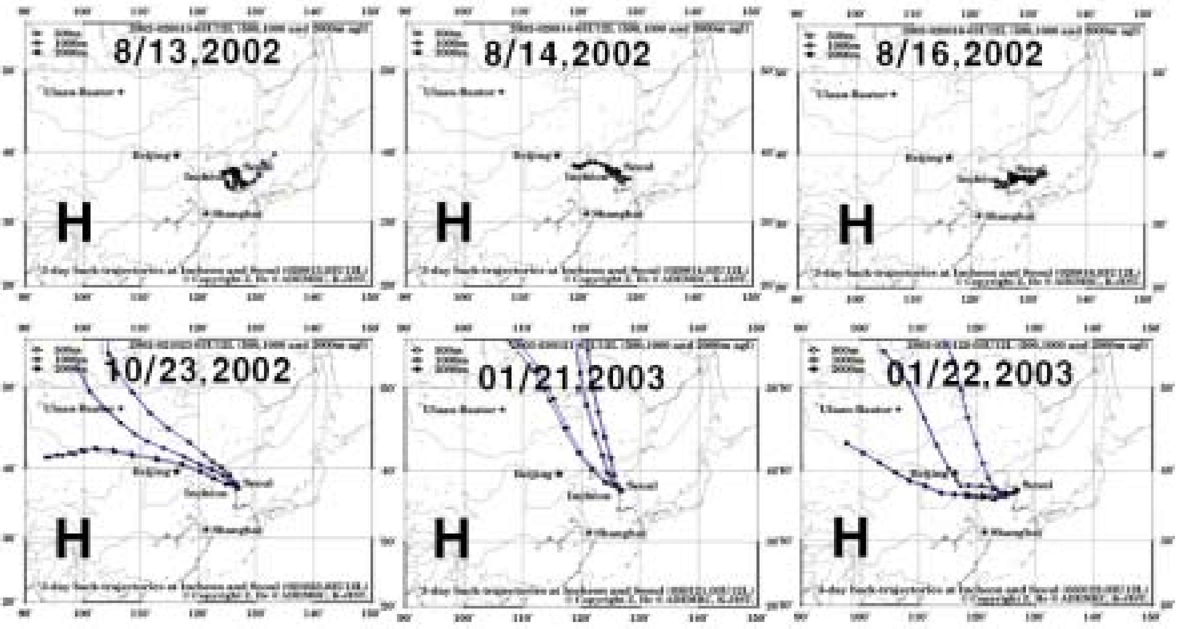

Figure 3. Air mass back-trajectory results for hazy days using the Hysplit model 4.5.

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