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Chemical characteristics of PM2.5 during haze episodes in Beijing

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Haze episodes have become much more frequent in Beijing and have received more attention during the past decade because of its influences on visibility and human health. Due to the chemical characteristics and sources of haze, which are different from the normal urban aerosols, studies of haze pollution become more important for the control of air pollution in Beijing.
This study aims to investigate the chemical characteristics of PM2.5 during haze episodes in Beijing in 2013 spring and the possible sources of chemical compounds during haze episodes. Two sequential High-Volume Samplers (Digitel DHA-80, Hegnau, Switzerland) were used to collect PM2.5 samples in Beijing automatically from 10 April to 8 June 2013. The inorganic elements, inorganic water-soluble ions, EC and OC of PM2.5 were analyzed by ICP-MS, IC and thermal/optical carbon analyzers respectively. Three haze episodes were found: 18 to 25 April, 3 to 9 May and 1 to 8 June. The average PM2.5 mass concentration during haze days was 140 μg m-3 while 45 μg m-3 during clear days. SO42-, NO_3-, NH4+, Cl-, K+, Cu, Ni, Zn, As, Cd, Tl, Pb, EC and OC, mass concentrations increased during haze days, compared with concentrations during clear days. The main increase is that secondary inorganic pollutant mass concentrations (NO_3-, SO42- and NH4+) were 6 times higher and mass percentages were 2 times higher. This indicates that the major chemical species of PM2.5 during haze episodes are originated from anthropogenic sources. NO_3-, SO42- and NH4+ are basically formed by a gas-to-particle formation processes on the basis of chemical reactions of precursor gases. Mass ratio of NO_3-/SO42- is widely used as an indicator to determine the importance of mobile sources and stationary sources of sulphur and nitrogen. The mass ratio of NO_3-/SO42- during haze days (0.82) was higher than during clear days (0.68) suggesting that vehicle emission is an important reason for haze in Beijing. OC/EC mass ratio higher than 2 indicates the presence of secondary organic matter (SOC). OC/EC mass ratio during haze days was variable and lower than during clear days (4.2). SOC was estimated to be 32.5% of OC during haze while 49.0% during clear days. This gives the impression that SOC formation during that spring haze episodes is not so evident. The PM2.5/PM10 ratios were higher during haze days (0.68) than during clear days (0.38) which indicate that fine particles are the dominant factor for haze pollution. Meteorological parameters are also an important factor for particles mass loading. Haze days were found to be always accompanied with high relative humidity, low mixing layer height and low wind speed. Generally it is concluded, that secondary inorganic ions are the dominant compounds in PM2.5 during haze episodes. To define all the sources of haze in Beijing in order to improve the urban air quality there is a need to do further research on formation mechanisms: continuous determination of PM composition in all size fractions, determination of organic speciation of PM and source apportionment.