Geophysical Research Abstracts
Vol. 18, EGU2016-220-1, 2016
EGU General Assembly 2016

Chemical $PM_{2.5}$ Speciation in Major Cities Worldwide

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We examined the chemical composition of fine particulate matter ($PM_{2.5}$) across 13 globally dispersed urban locations (including Atlanta, Buenos Aires, Beijing, Manila, and Dhaka), as part of the Surface PARTiculate mAtter Network (SPARTAN). At each site sampling was conducted over 4 to 24 months for the years 2013 to 2015.

Analysis of filter samples revealed that several $PM_{2.5}$ chemical components varied by more than an order of magnitude between sites. Ammonium sulfate ranged from 2 μg m^{-3} (Ilorin) to 17 μg m^{-3} (Kanpur). Ammonium nitrate ranged from 0.2 μg m^{-3} (Atlanta) to 6.7 μg m^{-3} (Kanpur). Effective black carbon ranged from 0.4 μg m^{-3} (Atlanta) to 5 μg m^{-3} (Dhaka and Kanpur). The all-site mean values of major $PM_{2.5}$ constituents were ammonium sulfate (20 $\pm$ 10 %), crustal material (12 $\pm$ 6.5%), effective black carbon (10 $\pm$ 7.4 %), ammonium nitrate (3.7 $\pm$ 2.5%), sea salt (2.2 $\pm$ 1.5%), trace element oxides (0.9 $\pm$ 0.7 %), water (7.2 $\pm$ 3.0%) and residue materials (44 $\pm$ 24%).

Based on the evaluation with collocated studies we treated residue material as mostly organic. Major ions generally agreed well with previous studies at the same urban locations (e.g. sulfate fractions agreed within 4% for eight out of 11 collocation comparisons). Enhanced crustal material (CM) concentrations with high Zn:Al ratios at large cities (e.g. Hanoi, Dhaka, Manila) imply significant anthropogenic CM contributions that deserve more attention.

Detailed chemical speciation also aided our characterization of site-specific $PM_{2.5}$ water retention. The expected water contribution to aerosols was calculated via the hygroscopicity parameter for each filter. Hourly $PM_{2.5}$ at specified relative humidity (35%) was inferred from nephelometer measurements of light scatter at ambient relative humidity and 9-day filter measurements of $PM_{2.5}$ mass. Our $PM_{2.5}$ estimates compared favorably with a beta attenuation monitor (BAM) at the nearby US embassy in Beijing, with a coefficient of variation of r^2 = 0.67.