Black Carbon Aerosols in Urban Air in South Asia

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Black (BC) and organic (OC) carbon bearing aerosols contribute large fractions of fine particle mass. BC represents the fraction that absorbs visible light and cause global warming. South Asia has recently received increased attention due to its rapidly rising pollutant emissions, including carbonaceous aerosols. To assess the regional and global climate change caused by aerosols in South Asia, detailed information is required on the atmospheric concentrations of carbonaceous aerosols in the region. Husain et al. [2007] recently reported extensive measurements of EC, OC and BC in Lahore, Pakistan from November 2005 to January 2006. Briefly, black carbon concentrations, [BC], were very high, ranging from about 5 to 110 g m⁻³, and daily mean was 21.7 µg m⁻³. Total carbonaceous aerosols averaged 96 µg m⁻³ of carbon, and contributed around 69% of the PM₂.₅ mass. As the overall data on carbonaceous aerosols in South Asia are sparse, we undertook a year long study of BC aerosols in Karachi, the largest city in Pakistan. Results from a full year of Aethalometer BC measurements made in Karachi from April 2006 to April 2007 were used to investigate the temporal trends, diurnal and seasonal variations, and emission sources.

Karachi is a coastal city on the Arabian Sea with a population of about 14 millions, an area around 3, 500 km² and a large industrial base. The AE21 Aethalometer (Magee Scientific) was operated out the third floor window of the HEJ Research Institute of Chemistry building on the University of Karachi campus (24.941° N, 67.123° E) between 17 April 2006 and 14 April 2007. The AE21 measures [BC] by collecting the particulate matter on rolled quartz filter with a cellulose fiber backing and continuously monitoring the transmission intensity of light beams at 880 and 370 nm wavelengths. The manufacturer’s recommended absorption coefficients were used; 16.6 and 39.5 m² g⁻¹, respectively for the 880 nm and 370 nm channels. We exclusively report the [BC] from the 880- nm channel. The AE21 was operated with a cyclone inlet (BGI corporation) equipped with a bug and rain guard at a flow rate of 4 lpm (liters per min). This makes the cut-point around 3.2 µm. Five-minute averaging times were used. The instrument was set to advance to a new filter spot when the total attenuation was equivalent to a BC loading of 1,250 ng and it was operated with the 1 in 10 dilution option to minimize frequent filter advances.

Daily mean [BC] varied from about 1 to 15 µg m⁻³. However, short term spikes exceeding 40 µg m⁻³ were common, occurring primarily during the morning and evening rush-hours. [BC] concentration was highest during November through February, ~ 10 µg m⁻³, and lowest during June through September, ~2 µg m⁻³. Diurnal, seasonal, and day-of-the-week trends are discussed. It is demonstrated that these trends are strongly impacted by meteorological patterns. A simple box model was applied to the concentration profiles to separate the impact of meteorological conditions and elucidate the underlying emissions patterns. Daily emissions varied from 14,000 to 22,000 kg of BC per day, or 6.5 kilometric tons per year. This was based on the area of metropolitan Karachi and 17.5 kilo metric tons emissions per year. Folding in the populations of each area yields a BC footprint of from 0.68 to 1.1 kg per person per year. Expanding the model to previously collected data yields annual emissions of 11.8 to 8.7 kilometric tons per year for Lahore. The higher value includes contributions from regional biomass burning. The lower estimate translated into a BC emission footprint of 1.0 kg per person per year for Lahore, or on the order of the higher estimate for Karachi.

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