Characterization of Fine Particulate Matter at Elementary Schools in Central and Southeastern Ohio

Kevin Crist[1], Amol Kulkarni[2], Sunil Kumar[2], and Kuruvilla John[2]

[1]Ohio University, Athens, Ohio 45701

[2]Department of Environmental Engineering, Texas A&M University – Kingsville
Kingsville, Texas 78363

This paper presents the results of a chemical characterization analysis of fine particulate matter ($PM_{2.5}$) measured at three elementary schools in Central and Southeastern Ohio. This project supports a larger study undertaken by Ohio University. The core focus of the larger Ohio study was to determine the potential health risk associated with air pollutants in Ohio. $PM_{2.5}$ aerosol samples were collected on teflon filters from an outdoor, and an indoor monitor and from a personal exposure sampler at each monitoring location from February 1, 1999 through August 31, 2000. The monitoring sites were located in elementary schools in the Columbus, Ohio metropolitan area (Koebel, & New Albany elementary) and in Athens Ohio (East elementary). The collected filter samples were then analyzed at Texas A&M University–Kingsville using an ion chromatography unit and an X-ray fluorescence spectrophotometer. Concentrations of Cl^-, NO_3^-, SO_4^{-2}, PO_4^{-3}, Li^+, Na^+, NH_4^+, K^+, Mg^{+2}, Ca^{+2}, Si, P, S, Cl, K, Ca, Ti, Co, Ni, V, Mn, Fe, Cu, and Zn were determined for each site and inter-compared. Sulfate comprised the largest fraction (~20-25%) of the total $PM_{2.5}$ mass. Sulfate concentrations were found to be maximum at the rural site (East elementary), which is located near the Ohio River valley. Other abundant components included nitrate and ammonium ions and silicon. The anion and cation average concentrations followed the pattern $SO_4^{-2} > NO_3 > Cl^-$ and $NH_4^+ > Ca^{+2} > Na^+ > K^+ > Mg^{+2}$. Significantly higher levels of sodium, chloride, and potassium were found in the rural samples. Heavy metals such as titanium, vanadium, manganese, iron, copper, and zinc were found in all the samples. Iron was the most abundant metal found on the filter samples.

An analysis of the ambient mass concentration distribution revealed slightly higher $PM_{2.5}$ concentrations at the urban site (Koebel) as compared to the suburban (New Albany) and the rural site. There were also significant seasonal variations in the concentrations of $PM_{2.5}$ observed. For the outdoor concentrations sulfate ion showed strong seasonal variations with maximum concentrations observed during the summer months. Indoor concentrations were sometimes higher than the outdoor concentrations. Soil percentage was significant in the indoor samples.

Additional data analysis included a comparison of $PM_{2.5}$ with meteorological parameters such as temperature, relative humidity, precipitation, wind direction, and wind speed. It was noted that $PM_{2.5}$ concentrations tended to increase with rising temperatures, drop significantly during precipitation events and decreased with increasing wind speeds.

Correlating wind direction with $PM_{2.5}$ at New Albany site indicated that the $PM_{2.5}$ concentration was highest when the winds were blowing from the southeast despite the low frequency of occurrence of this particular wind direction. A similar pattern was observed at the Koebel site in Columbus. The East Athens site, however, showed a slightly different pattern in the sense that the $PM_{2.5}$ concentration was highest when the winds were blowing from the south and the southeast direction. This analysis suggests that when the PM levels are elevated, the Ohio River valley appears to be one of the main source regions of PM precursors in Ohio.