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Field test data for 42 liter per minute $PM_{2.5}$ aerosol sampler used during the PMTACS-NY intensives held at Queens College, Queens, NY

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Abstract

A 42 l min^{-1} (lpm) sampler (Hi-flo) was used to collect 6-h samples during the 2001 summer and the 2004 winter $PM_{2.5}$ Technology Assessment and Characterization Study-New York (PMTACS-NY) intensives held at Queens College in urban Queens, NY. A sum total of 146 samples collected in 2001 and 113 samples collected in 2004. The samples were water-extracted and analyzed for sulfate by ion chromatography. In addition the 2001 samples had 15 metals determined by inductively coupled plasma mass spectroscopy after water extraction (a soluble fraction) and also after a rigorous microwave digestion (total). The Hi-flo sampler allowed trace metal concentrations to be determined on 6-h samples with nearly the same minimum reporting level (mass loading) as 24-h samplers collected with commercial samplers that operate at 16.7 lpm. We present a comparison of the concentrations of SO_4 and 15 selected trace metals measured on the filters collected with Hi-flo and co-located commercial $PM_{2.5}$ samplers. The Hi-flo sampler is demonstrated to accurately reproduce SO_4 and certain elements during the urban intensive. The average slopes of the regressions with a co-located commercial sampler differed from 1 by $\pm 3\%$. Most aerosol species measured in the 6-h samples collected at Queens College during the 2001 intensive had maximum daily concentrations for the 0600–1200 h sample except sulfate which was maximum for the 1200–1800 h sample and Sb which was uniquely maximum between 0000 and 0600 h. Supporting data suggest afternoon maximum for sulfate is due to more efficient mixing down from aloft the air that was transported from distant sources rather than local photochemistry.

Keywords: Supersites; Particulate matter; Sulfate; Trace elements; $PM_{2.5}$; Urban aerosols; Aerosol sampling

1. Introduction

Particulate matter (PM) that can remain buoyant in the atmosphere varies in size from a nanometer to tens of micrometers in diameter. PM with a diameter less than 2.5 μm ($PM_{2.5}$) is important,

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because these aerosols can readily enter the lungs where they may activate a medical response in humans (Dockery et al., 1993; Dockery and Pope, 1994; Gwynn et al., 2000). $PM_{2.5}$ is also designated as fine PM. As a part of the USEPA Supersite program, the $PM_{2.5}$ Technology Assessment and Characterization Study-New York (PMTACS-NY) project, has been continuously collecting 24-h $PM_{2.5}$ filters at four sites: Queens on the roof of public school 219 (PS219), The Bronx on the roof of intermediate school 52, Whiteface Mountain lodge (WFML), and Pinnacle State Park (PSP). The first two are urban while the later two are rural background sites. A discussion of sulfate results from filters collected at these sites can be found elsewhere (Dutkiewicz et al., 2004). In addition, the consortium of researchers ran two intensives on the campus of Queens College (QCOL), Queens, New York, which is adjacent to PS219, plus a third intensive at rural WFML. During these campaigns a wide variety of state-of-the-art on- and off-line techniques for physical and chemical aerosol analysis were run (Drewnick et al., 2003, 2004a, b; Hogrefe et al., 2004) along with well-accepted filter-based techniques. Filter samples were collected at the three intensives with Rupprecht & Patashnick Model 1400a particle mass analyzers with ACCU sampler attachments and a non-standard 42 lpm high flow cyclone (Hi-flo). Dutkiewicz et al. (2006) and Qureshi et al. (2006) present the elemental composition of daily $PM_{2.5}$ aerosols for 15 months at the Queens site. This includes a comparison of seasonal changes in aerosol composition and solubility at this site and the impact of two major events on aerosol composition: the collapse of the World Trade Center Towers in Manhattan on 11 September 2001 and smoke from Quebec wildfires that covered the Northeast in early July 2002 (Qureshi et al., 2006). In another paper sulfate and the inter-elemental variations at PS219 are explored and used to evaluate the $PM_{2.5}$ sources impacting the site (Dutkiewicz et al., 2006).

Commercial $PM_{2.5}$ filter samplers, in general, operate at 16.7 l min^{-1} (lpm) or lower. While a 24-h filter collected at this flow rate yields adequate loadings for mass determination and for measurements of major ionic species present at $\mu g\,m^{-3}$ levels and even some trace metals that are present at $ng\,m^{-3}$ levels, shorter sampling times would yield prohibitively high detection levels. The 42 lpm Hi-flo sampler provides mass loadings 2.5 times higher than commercial samplers, and thus provides a means to collect $PM_{2.5}$ aerosols at shorter time intervals for speciation and special event sampling projects. In this short paper, we discuss the design of the Hi-flo sampler, and we validate the sampler by comparing measurements of the concentrations of SO_4 and 15 selected trace metals (Mg, Al, Ca, V, Cr, Mn, Fe, Co, Ni, Zn, As, Se, Cd, Sb, and Pb) to those measured with co-located commercial samples during the 2001 intensive and 2002 intensives. In addition, some implications of the speciation results from the 6-h samples collected at QCOL are presented.

2. Experimental

2.1. Filter samplers

The first intensive was run at QCOL between 29 June 2001 and 6 August 2001. As a part of this study, two $PM_{2.5}$ aerosol collectors were co-located on the ground at QCOL, while several hundred yards away on the roof of PS219 (four-story building) a third aerosol collector was operated. The ground-level site was on the eastern edge of a paved parking lot overlooking athletic fields. One collector at each site was an ACCU sampler. The ACCU sampler uses a sharp-cut cyclone inlet that operates at 16.7 lpm. After size separation, the air stream is split, and 13.7 lpm is directed through the ACCU sampler to collect on filters, while the remainder goes to the TEOM aerosol mass analyzer. In this case, 47-mm 2 μm pore size Zefluor filters (Pall Corporation) were used to collect aerosol samples for 24 h, midnight to midnight (EST). The samplers were operated using the standard operating procedures provided by the manufacturer. The second collector at the ground-level QCOL site was the Hi-flo used to collect 6-h samples. Starting times were 0000, 0600, 1200 and 1800 h EST. During the second QCOL intensive run between 8 January 2004 and 6 February 2004, an additional set of 6-h samples was collected, to provide seasonal contrast to the results from the 2001 summer intensive but no co-located sampler ran: however, the ACCU sampler at PS219 was still operating. The site for the winter intensive was several hundred yards east of the first site, set between two one-floor temporary classroom buildings. The Hi-flo and an ACCU sampler were also run co-located in an intensive conducted during July 2002 at WFML. Due to the low elemental loadings encountered at this rural site (Husain et al., 2004; Schwab et al., 2004), the Hi-flo sampler was run for 24 h, midnight