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SHORT-TERM PARTICULATE MATTER MASS AND AEROSOL-SIZE DISTRIBUTION MEASUREMENTS: TRANSIENT POLLUTION EPISODES AND BIMODAL AEROSOL-MASS DISTRIBUTIONS

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Abstract–Aerosol-size distribution of fine aerosols were measured in Pocatello, Idaho along with hourly average PM_{10} mass concentrations. Aerosol size distribution measurements are made with a laser optical particle counter while short-term mass concentrations are measured with a Tapered Element Oscillating Microbalance. The short-term mass concentration measurements show wide variations in mass concentration over 24 h periods. The accumulation mode of the aerosol-size distribution is bimodal in a few cases, primarily when elevated mass concentrations exist. © 1998 Elsevier Science Ltd. All rights reserved

Key word index: Aerosol-size distribution; bimodal; optical particle counter.

INTRODUCTION

The size distribution of atmospheric aerosols can be described as containing three modes: a coarse mode (particles greater than 2 μm in diameter), an accumulation mode (0.1–2 μm in diameter), and a nuclei mode (less than 0.1 μm in diameter) (Willeke and Whitby, 1975). Recently, the bimodal nature of the accumulation mode has been described (Hering and Friedlander, 1982; John *et al*., 1990; Sloane *et al*., 1991; Hering *et al*., 1997). Two types of size distributions in the accumulation-mode range are described, with a mode at 0.2 μm and another mode at 0.6 μm. John *et al*. (1990) labeled these as the "condensation" and "droplet" modes, indicating that the smaller mode particles are attributed to homogeneous gas-phase processes and the larger mode is thought to be a result of heterogeneous processes. These modes have been identified in the distributions of individual chemical constituents with impactor measurements (Hering and Friedlander, 1982; John *et al*., 1990; Sloane *et al*., 1991) and in the total, physical size distribution made with optical particle counters and electrical aerosol analyzers (Hering *et al*., 1997). Meng and Seinfeld (1994) showed that addition of water to condensation-mode particles cannot explain the droplet mode, and a plausible explanation is the activation of condensation-mode particles by fog or clouds. The ensuing chemistry and evaporation results in the formation of the droplet mode.

The impactor measurements described above are collected over 4–12 h periods due to the need to collect a large enough sample for analysis. Optical measurements can be made over a shorter period of time, but are frequently averaged to filter sampling periods (4–24 h). In addition, the measurements previously reported are made in urban, polluted locations in the U.S. In this paper, we will investigate the modes of aerosol-size distributions in a more rural, less-polluted location. In addition, 1 h average measurements of the PM_{10} mass are described. The short-lived nature of pollution episodes will be described and the coincidence changes in aerosol-size distributions will be presented.

EXPERIMENTAL

During the winter of 1995/1996, a sampling program was carried out in Pocatello, Idaho to investigate the nature of this area's particulate matter air-pollution problem. Pocatello is located in the southeastern corner of Idaho, and is surrounded by mountains to the west, south and east. The Snake River Plain extends to the north. Two sampling sites were set up in the City of Pocatello. One site was in the northwest corner of the city on the property of the sewage treatment plant (STP), and the other was located approximately 4 miles to the southeast, closer to downtown Pocatello, at the corner of Garrett and Gould Streets (G&G). The local

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industries include a phosphate ore processing plant and a phosphate fertilizer plant. Most of the industry is located in the northwest area of the city. Pocatello was selected for this study because of high PM_{10} concentrations that are observed, primarily in the winter. Fine aerosol ($PM_{2.5}$) samples were collected with filters at the two sampling sites, meteorological data were collected, and the G&G site was outfitted with a nephelometer (Belfort 1550), a Tapered Element Oscillating Microbalance (Rupprecht and Patashnick, Albany, NY) and an active scattering laser optical particle counter (Particle Measuring Systems Model LAS-X, Boulder, CO). The G&G site is a location where the state of Idaho collects PM_{10} samples using EPA approved samplers (HiVol). The tapered element oscillating microbalance (TEOM) and nephelometer are operated by the State of Idaho Division of Environmental Quality on a continuous basis. The laser optical particle counter (OPC) was brought to the site specifically for this study. The nephelometer, TEOM, and OPC were housed inside of a heated trailer that was maintained at approximately 22°C. Samples were collected through Teflon tubing that was run in the shortest, least curved route possible from the outer wall to the instrument. The TEOM was fitted with a PM_{10} inlet (General Metals) whereas the OPC measures the aerosol-size distribution from 0.09 to 3 μm in 16 channels.

This paper will focus on a subset of the measurements made during this experiment, specifically, the TEOM and the OPC. TEOM data are collected with short averaging times (5 min) and then later averaged to 1 and 24 h periods for comparison with other instruments. HiVol samples are collected for 24 h periods (midnight to midnight). The OPC data were collected for this study over 10 min averaging periods. These data were then averaged to 1 h time frames for comparison with the TEOM. Coincident data from the TEOM and OPC are available from 1 January 1996 through 11 January 1996. Filter samples were collected over 12 h sampling periods using a sampler designed after the Caltech filter samplers (Solomon *et al.*, 1989). Filter substrate preparation and analysis details can be found in Glasgow (1997).

RESULTS

The daily average PM_{10} mass concentration measured by the TEOM is compared to the measurement made with the HiVol PM_{10} samplers. HiVol PM_{10} samples are collected over a 24 h period on a preweighed filter. The weight of the filter is measured after sampling and thus a 24 h average PM_{10} mass measurement is made. This is one of the most widely used methods for assessing the PM_{10} mass to determine compliance with EPA standards. The TEOM is a PM_{10} equivalent method, and has the advantage of allowing for mass measurements to be made over averaging periods shorter than 1 h. Differences may occur between the measurements because the TEOM was located inside a heated trailer while the PM_{10} HiVol samples were collected in the ambient conditions. This may create a bias towards lower mass measurements with the TEOM. As shown in Fig. 1, there is good agreement in 24 h average PM_{10} mass measurements between the TEOM and HiVol measurements. Over the sampling period of 1 January–11 January the average ratio of TEOM 24 h average PM_{10} mass to HiVol 24 h average mass is 1.00. These measurement both show that the daily average PM_{10} mass concentrations range from less than 5–36 $\mu g\,m^{-3}$.

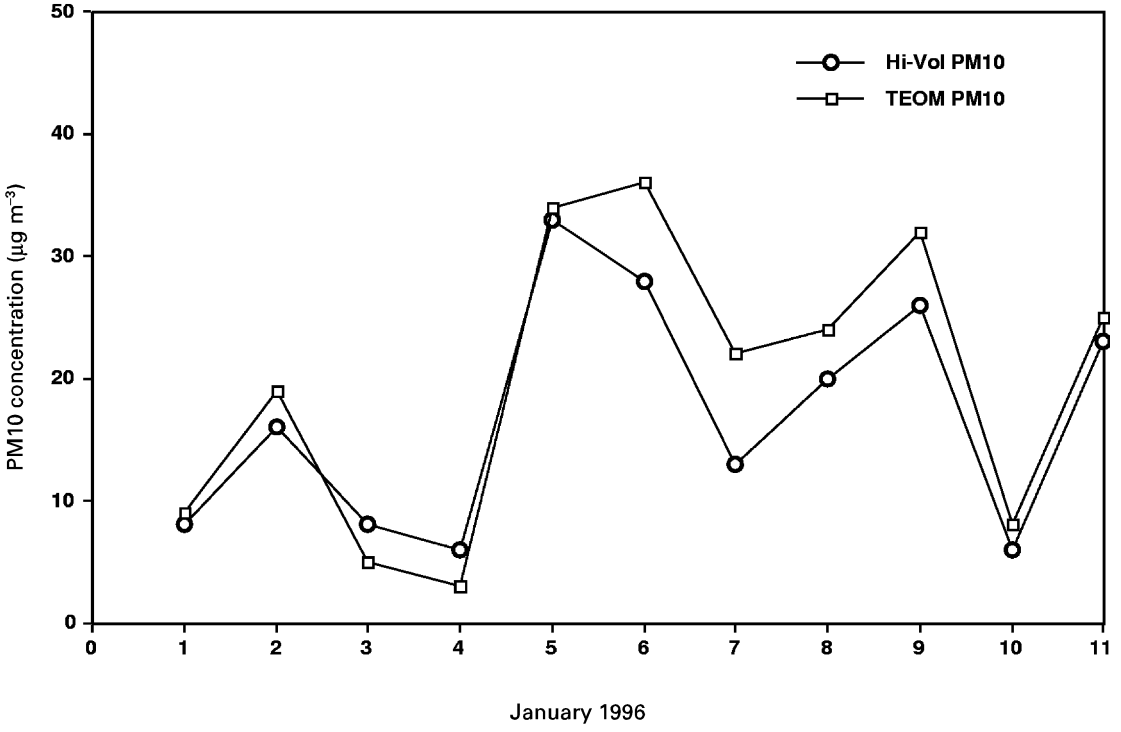

Fig. 1. Comparison of 24 h average PM_{10} mass concentration measured with the TEOM and HiVol during January 1996 in Pocatello, Idaho at the G&G sampling site.