Penetration of the ambient ultrafine aerosol into a cardiac rehabilitation facility in Rochester, NY

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INTRODUCTION:

Epidemiological studies have suggested a link between increases in ambient particulate matter (PM), essentially particle numbers, and an accelerated onset of cardiorespiratory mortality and morbidity. Such studies imply that vigorous studies be conducted to establish relationships between PM concentrations in the indoor environment and those measured in the outdoors. In this study, the relationship between indoor and outdoor levels of particulate matter was examined for a functional cardiac rehabilitation facility located in a commercial building in Rochester, NY. The facility offers both preventive and rehabilitative care for individuals recovering from or at risk for heart disease and is located approximately two miles from the University of Rochester Medical Center. Continuous size-fractionated particulate matter samples were simultaneously measured from indoor and outdoor air of the facility using an MSP Wide-range Particle Spectrometer (WPSTM). The rehabilitation facility data were spatially compared with concurrently-measured SMPS data from the New York State Department of Environmental Conservation (NYS DEC) site located a few miles from the facility site by computing the spatial correlation index (Haining, 1990) for the time-size plots for each of the days of the study. Indoor/outdoor penetration fractions were also estimated.

DATA ACQUISITION:

An MSP Wide-range Particle Spectrometer (WPSTM), Model 1000XP was used to simultaneously measure continuous size-fractionated particulate matter samples from indoor and outdoor air of a functional cardiac rehabilitation facility located in Rochester, NY. The Spectrometer was run in SMS mode allowing for measurement of particles in the size range 10-500 nm every four minutes. The initial sampling period was July 2004 and a second set of measurements were made in November-December 2004. Also, outdoor number concentrations and size listributions of fine and ultrafine particles in the same size range (10 - 500 nm) are being measured every five minutes at the New York S tate Department of Environmental Conservation (NYS DEC) monitoring site in Rochester, NY (Figure 1). NYS DEC site measurements are being nade using an SMPSTM consisting of a DMA and CPC (TSI Models 3071 and 3010, respectively). For comparison purposes, clean air neasurements were also made from early January, 2005 to mid August, 2005 in an environmental chamber located in the University of Rochester Medical Center (URMC) using the same WPS TM system. This chamber has been designed for human clinical exposure studies and was therefore expected to provide relatively much cleaner air necessary for comparative studies. The simultaneously measured outdoor concentrations at this site were compared with measurements made at the DEC site.



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Figure 1. Map showing the location of the three buildings considered for this study

DATA ANALYSIS:

Spatial Correlation Index: This is a generalized spatial autocorrelation statistic that can be used to describe the association between two maps (Haining 1990). In its simplest form, it is given by the equations:

$$= \sum_{ij} G_{ij} C_{ij} \qquad I_s = (\Gamma - E(\Gamma)) / (E(\Gamma^2) - (E(\Gamma))^2)^{\frac{1}{2}}$$

where G_{ij} is a measure of the spatial proximity of locations i and j, and C_{ij} is a measure of the proximity of i and j in terms of variable values. E(G) and E(G) are, respectively, the first and second moments of Gused to transform Ginto ?, values that can be treated as N(distribution. The two-dimensional plots of the particle size against time of day can be conceptualized as" maps" and thus, compared using this statistic. Because the DEC and the Rehabilitation Center distributions are not taken over the same time intervals, this appro provides a method for quantitative comparisons. For each of the days, ?, values were calculated and are presented in Tables 1 and 2.

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for five select days in July					
Sampling Date (2004)	Indoor Vs Outdoor	door Vs Indoor Vs outdoor DEC			
July 17 (Sat)	226.67	157.74	172.04		
July 18 (Sun)	221.74	149.02	174.72		
July 19 (Mon)	200.49	133.1	165.86		
July 20 (Tue)	215.49	137.83	167.58		
July 21 (Wed)	196.54	86.75	131.51		







RESULTS AND DISCUSSION:



measured at the URMC site and values obtained at the DEC site. r, values are Spearman Rank Correlation coefficients.



Figure 5. Characteristic plume event on April 4

2005. Plume events were generally observed

earlier at the UR site

URMC AP



Outdoor number concentrations measured at the URMC and DEC sites were correlated both on temporal and spatial scales, indicating that the WPSTM system generally reproduced the temporal and spatial variability of UFPs measured at the central site even when the actual particle numb e were different at both locations (Figures 3-5). The peaks for UFPs in the size range 0.01 - 0.1 µm were highly related to traffic rush hours in both sites (Figure 3). Spearman rank correlation coefficients (r,) were generally higher in winter than in summer. r, values ranged from 0.5 (for 0.01-0.05 µm particles) to 0.9 (for 0.1-0.47 µm particles) (Figure 4). By relating the outdoor number concentrations measured at URMC and DEC sites with wind speed and direction, particles in the compounded size range 0.01-0.47 µm appeared to have common sources, highly influenced by the busy downtown Rochester (Figure 6).

A quantitative comparison was made between the measured number concentrations at each location by computing the spatial correlation index (?) for the time-size plots for each of the days of the study. All of the calcul ated?, values were very large compared to the cut-off value of 1.6 meaning that there were highly significant correlations among hese data (Tables 1 and 2). The relationship was observed to be stronger between the indoor and outdoor values at the

Rehabilitation Center than between the outdoor and DEC or between the indoor and DEC values. The results also

0.1-0.5 µm for which the penetration fractions (I/O) were approximately 0.8 and 0.7, respectively (Table 3).

showed a high level of penetration for this building especially for summer particles in the size bins 0.01- $0.05 \,\mu m$ and



15	Sampling	0.01 - 0.05	0.05 - 0.10	0.10-0.50
re	five select days in December (see Table 2)			

Sampling Date	0.01 – 0.05 µm	0.05 – 0.10 µm	0.10 – 0.50 μm
July	0.79	0.59	0.74
December	0.24	0.36	0.34

Figure 2. Characteristic spatial plots obtained in J

	Date (2004)	Outdoor	DEC	VsI
	July 17 (Sat)	226.67	157.74	172
),1)	July 18 (Sun)	221.74	149.02	174
ach	July 19 (Mon)	200.49	133.1	165
	July 20 (Tue)	215.49	137.83	16
	July 21 (Wed)	196.54	86.75	13
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