Aerosol particles in a mechanically ventilated office in Helsinki, Finland – studying the infiltration of outdoor air and particle characteristics

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Introduction

The evaluation of human exposure to particulate matter is commonly based on data from outdoor environments. However, many people spend most of their day indoors and using only outdoor data can be misleading. Thus, it is necessary to also study indoor environments to accurately describe the exposure to particulate matter.

A common indoor environment is the office. Most particles in office air originate from outdoor sources (Bo et al., 2017) and are transported indoors via ventilation, open doors and windows or leaks in the building envelope. Indoor/Outdoor particulate pollution is often studied using gravimetric methods, but high time and size resolution measurements are needed to gain a deeper understanding of the mechanisms that govern particle infiltration.

The aim of our study was to characterize the physical and chemical properties of indoor and outdoor particles in a mechanically ventilated office building in Helsinki. We studied the effect of various parameters, such as wind direction and pressure difference over the building envelope, on indoor and outdoor particle concentrations and characteristics. We also analysed how different conditions influenced the fraction of outdoor particles that infiltrated into indoor air.

Methods

The measurements were performed in an unoccupied room of a mechanically ventilated office building in central Helsinki, Finland, March 12.-29., 2021. Indoor and outdoor particles were studied with a wide range of aerosol measurement instruments. Weather data was obtained from a nearby FMI (Finnish Meteorological Institute) weather station.

Particle number concentrations were analysed using condensation particle counters. Particle size distributions and alveolar deposition of particles were measured with two electrical low-pressure impactors (ELPI+). Black carbon mass concentration was measured indoors using an aethalometer (AE33). A soot-particle aerosol mass spectrometer (SP-AMS) was used to study the chemical composition of indoor particles. Using diverse instrumentation, we gained a detailed picture of the indoor environment.

Results

We found that the outdoor particle concentration significantly influenced the indoor concentration in the studied office. Figure 1 shows the measured lung deposited surface area (LDSA) size distributions indoors and outdoors during day hours (solid line) and night hours and weekends (dotted line). A reduction in indoor concentrations is observed during night hours and weekends, when the mechanical ventilation flow rate was decreased.

The ambient particle size distribution had a considerable impact on the infiltration of particles. This was observed during a long-range transport event, when the increase in particle size resulted in decreased infiltration. The wind direction also affected infiltration: highest infiltration was observed when the wind blew towards the windows of the office room. Opening the windows in the office room for a short period caused a threefold increase in indoor black carbon mass concentration.

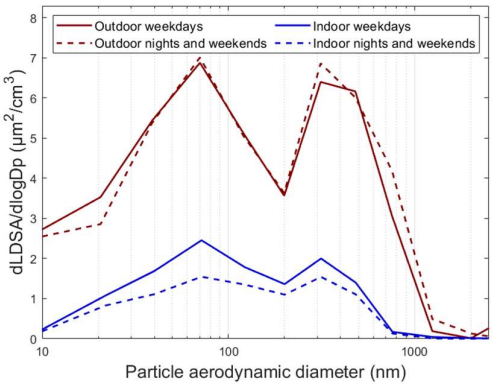

Figure 1: Lung deposited surface area size distributions outdoors and indoors.

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