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Published in:
Prodeedings of the European Aerosol Conference 2007

2007

Link to publication

Citation for published version (APA):
Wierzbicka, A., Gudmundsson, A., Pagels, J., Dahl, A., Löndahl, J., Swietlicki, E., & Bohgard, M. (2007). Particles in various Swedish indoor environments: size distributions, number and mass concentrations. In *Prodeedings of the European Aerosol Conference 2007*

Total number of authors:
7

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Cite abstract as Author(s) (2007), Title, European Aerosol Conference 2007, Salzburg, Abstract T07A013

Particles in various Swedish indoor environments: size distributions, number and mass concentrations

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Keywords: indoor particles, indoor air quality

Even though people on average spend at least 85% of their time inside buildings, the concentration and characteristics of particles in indoor environments are not well known. Until recently most research was focused on ambient air particles. Indoor particles originate from indoor sources, penetrate from ambient air or are formed indoors as secondary aerosol (e.g. chemical reactions of ozone and terpenes). Indoor sources of coarse particles have been identified as sweeping, hoovering, dusting, resuspension from clothes and carpets (Howard-Reed et al., 2003; Ogulei et al., 2006), while the fine fraction was identified to come from cooking, gas stoves, electric ovens or toaster ovens, gas-powered clothes dryers, burning candles and incense (Wallace, 2006). The aim of this study was to gain information about particle loads and their characteristics in various Swedish indoor non-industrial environments, namely: in the school, fast food restaurant, supermarket, residential apartment close to busy road in a polluted city and residential house in a remote area. Results from the first three locations are presented here.

Measurements were performed for seven consecutive days in each location between September 2006 and February 2007. Log books of activities during the measurement period were created for the identification of particles' sources. Measurements were recorded continuously with the following instruments: an aerodynamic particle sizer TSI APS 3321, a scanning mobility particle sizer (SMPS), (consisting of differential mobility analyzer (TSI DMA 3071) and condensation particle counter (TSI CPC 3010)), and two DustTracks TSI model 8520. Into the sampling system a valve was incorporated enabling alternate measurements of indoor and outdoor, or indoor and supplied ventilation air by the SMPS. The two DustTracks were used for indirect mass concentration measurements of particles smaller than 2.5 μm (PM2.5) down to 0.1 μm, they enabled simultaneous measurement of indoor and outdoor mass concentration. PM2.5 were also collected on quartz filters for organic and elemental carbon analysis.

The highest average PM2.5 mass concentration was measured in the school (39 $\mu g/m^3$), while the lowest in the supermarket (20 $\mu g/m^3$). In the school fine particles (smaller than 1 μm) mirrored the outdoor number concentration and size distribution, it could be explained due to lack of indoor sources of fine particles (no cooking, candle burning etc.) and high penetration ratios. In the fast food restaurant and in the supermarket differences in the fine mode concentration and size distribution between indoor and supplied ventilation air are visible which indicates presence of strong indoor sources. Daily average number size distributions for the school, fast food restaurant and supermarket are given in Figure 1.

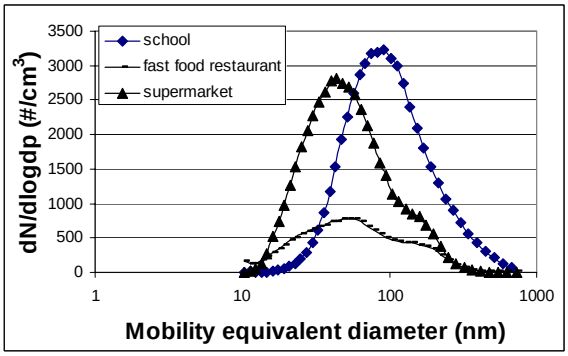

Figure 1. Daily average number size distribution of fine particles in the school, fast food restaurant and supermarket.

The average total number concentration of fine particles in the size range from 10 to 800 nm were 2100, 1900 and 700 #/cm3 for the school, supermarket and fast food restaurant, respectively. This indicates that removal of fine particles in the fast food restaurant ventilation system was more efficient than in the school.

This study shows that mass and number concentrations of particles in different indoor environments can vary to a great extent. To gain knowledge about typical levels of particles in various indoor environments more data is needed as this study is limited to just few locations at specific time.

Acknowledgements: This study was supported by the Swedish Research Council FORMAS.

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