**Transformation of Aerosol Particles during Transport from Outdoor to Indoor Environment.**

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# TRANSFORMATION OF AEROSOL PARTICLES DURING TRANSPORT FROM OUTDOOR TO INDOOR ENVIRONMENT

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## INTRODUCTION

According to many studies, people spend over 80% of their day in the indoor environment (Leung and Drakaki, 2015). It means that also adverse health effects are following the exposure of people to aerosol in indoor environment (Hussein et al., 2005). The indoor aerosol is produced mainly from common indoor sources such as cooking, cleaning, smoking, candle burning, wood burning, etc. On the other hand, when no indoor source is present, the indoor aerosol physical and chemical properties follow those in the outdoor environment (Diapouli et al, 2013). The originally outdoor aerosol undergoes several physical and chemical changes.

One summer (2014) and one winter (2015) campaign (both lasting three weeks) were conducted to assess the indoor/outdoor physical and chemical properties of aerosol in an unoccupied apartment. The main purpose of these campaigns was to observe the changes in aerosol particles before and after their transport from outdoors to indoors. The most important parameter – the I/O ratio was obtained from indoor/outdoor measurements of aerosol number size distribution as well as chemical composition. The I/O ratios can reveal the changes in particle size and physicochemical characteristics indoors in relation to the size distribution and chemical composition outdoors, and physical parameters such as wind speed, temperature, and RH.

## EXPERIMENTAL SETUP

Both measurement campaigns were conducted in a guesthouse of the Institute of Chemical Process Fundamentals. The apartment was unoccupied during the whole measurement campaign. The study included two seasons of the year - summer 2014 (from 16$^{th}$ August to 8$^{th}$ September) and during winter 2015 (from 5$^{th}$ to 24$^{th}$ February). The kitchen was selected as an indoor sampling room, while the instruments were placed in one of the bedrooms (Fig. 1). The tubing for indoor and outdoor sampling had the same length in order to avoid different particle losses between indoor and outdoor sampling point. Switching between indoor and outdoor was accomplished using automated electromagnetic 3-way valve.

The extensive set of aerosol instruments was used during both campaign. For this study, only several instruments were selected to assess the aerosol particle

transformation. The online instruments used within this study include SMPS (3936, TSI), c-TOF AMS (Aerodyne Research) and field EC/OC analyser (Sunset Laboratory).

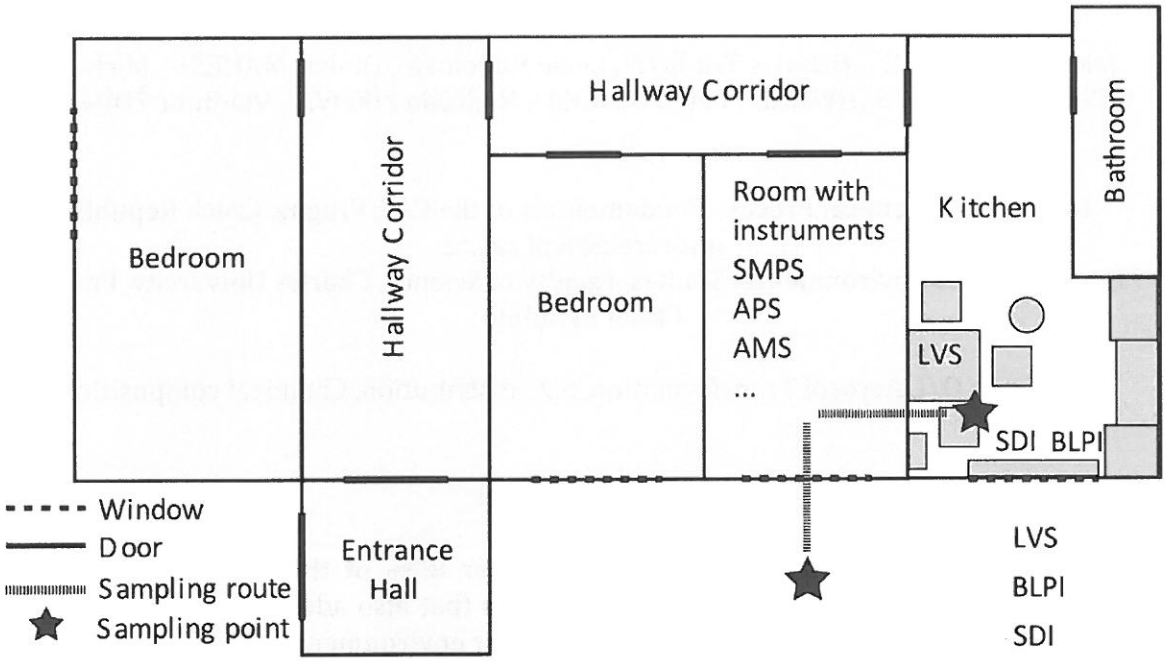


Fig. 1: Schematics of measurement set-up

The offline instrumentation is represented by Berner Low Pressure Impactor (Hauke) and Low Volume Samplers. Such combination of arosol instruments enables the analysis of size distribution and chemical composition with relatively high time resolution – sampling of the online instruments was set to 5 minutes, and at the same time detailed chemical analysis using the integral samples from BLPI and LVS. The meteorological data from monitoring station of Czech Hydrometeorological Institute located inside the campus of ICPF complemented the whole data set. The data analysis included only periods when no indoor sources were present. In addition, different ventilation scenarios were included in this study (windows and door closed, microventilation, windows and door closed with running offline instruments in the sampling room).

## RESULTS AND CONCLUSIONS

The daily patterns of overall particle number concentration (PNC) measured by SMPS for summer and winter season were similar despite seasonal differences in sources and sinks acting to increase and reduce PNC during specific periods of the day (Fig. 2). Particle number size distribution showed these differences, exhibiting afternoon increases during summer (secondary organic aerosol and new particle formation events) and early evening increases (domestic heating and low boundary layer) during winter.

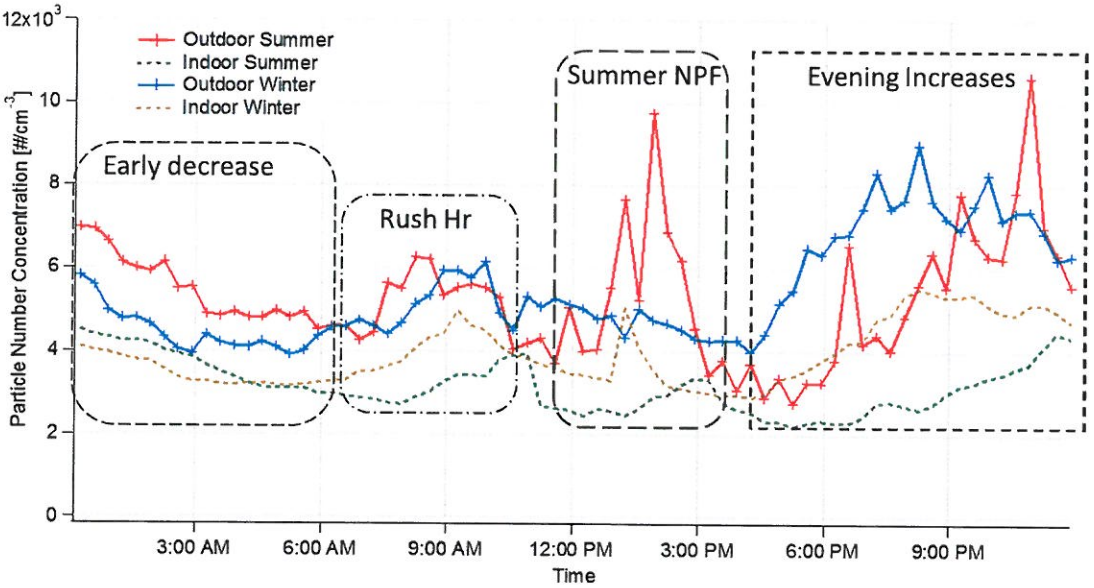


Fig. 2: Total particle number concentration in daily pattern (SMPS).

A substantial reduction in indoor mass concentration was observed for all aerosol chemical species during the winter phase of the study, which could not be fully accounted for particle drying (Fig. 3).

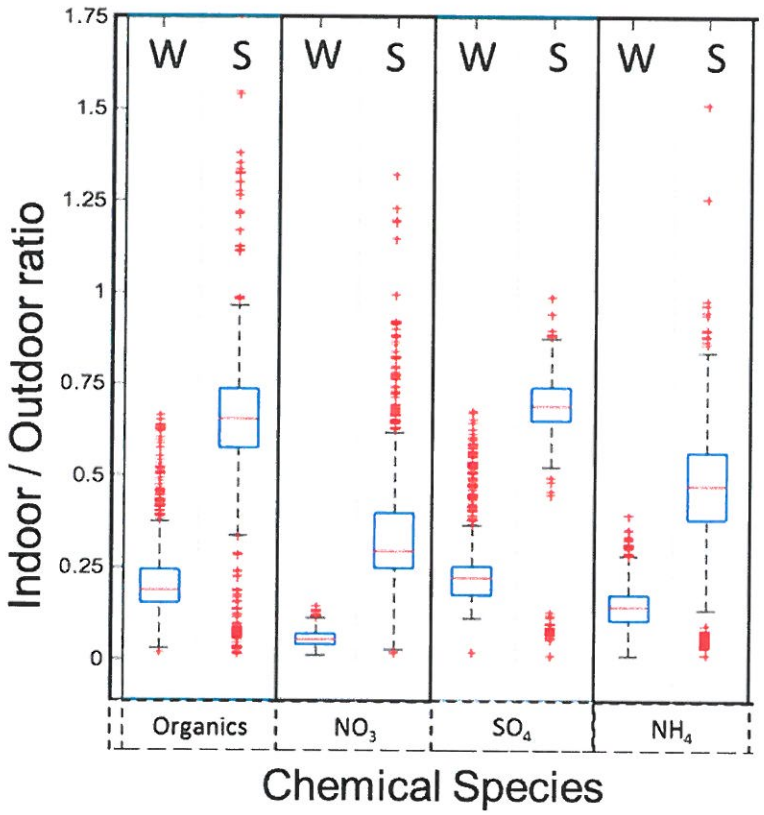


Fig. 3: Seasonal differences in I/O ratio chemical species (AMS); red line= Median value; edge of the boxes = 25/75 percentiles; whiskers = 95 percentiles.

Tab. 1: Seasonal changes in I/O ratio chemical composition.

| | I/O ratios | | % |
|---|---|---|---|
| | Winter | Summer | Difference |
| Organics | 0.48 | 0.72 | 67 |
| $SO_4^{2-}$ | 0.50 | 0.76 | 66 |
| $NH_4^+$ | 0.32 | 0.48 | 67 |
| $NO_3^-$ | 0.20 | 0.32 | 63 |

A decrease in I/O ratios between 34–38% for all of the species during the winter was attributed to physical factors affecting all species rather than chemical processes acting upon each chemical species individually (Tab. 1) The analysis of the data using Spearman rank statistical tests identified negative correlation of wind speed with indoor concentrations for all the species.

Generally, the aerosol particles were dehydrating during outdoor (lower temperature, higher humidity) to indoor (higher temperature, lower humidity) transport especially during winter season. This effect was not that much pronounced during summer season due to lower difference in temperatures and RH between indoors and outdoors. Moreover, lower indoor mass was observed during winter season measurement, which can be attributed to rather physical than chemical processes (deposition and shrinking). The combination of online (almost real-time transformations and showed a $NO_3^-$ presence indoors) and offline (particle shrinking and identification of coarse mode $NO_3^-$) instrumentation proved to be suitable for investigation of ammonium nitrate dissociation and I/O relationships in general.

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