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I/O AEROSOL IN A KINDERGARTEN – CASE STUDY

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INTRODUCTION

In last decades, people spend more and more time indoors. When various indoor sources (e.g. cooking, cleaning, smoking and even presence of people in the case of common household) are present, the indoor air quality is driven mainly by these sources (He et al., 2004). Without the presence of significant indoor sources, the situation is very different and the concentration of aerosol particles in indoor environment follows behavior of outdoor particles (taking into account losses of aerosol particles due to deposition on indoor surfaces and during penetration indoors; Hussein et al., 2005). Many epidemiological studies show direct link between dose/exposition to fine (< 1μm) and ultrafine (< 100 nm) particles and adverse health effects. With regards to the fact that indoor environment is besides the adults occupied usually also by kids in longer time periods (nursery, kindergarten, school), it is very important to study the indoor environment in a great detail and to understand the behavior of aerosol particles indoors. In the case of the kids being exposed to the indoor aerosol particles, the adverse health effect can be more pronounced and the consequences more dangerous (Schwartz, 2004; Sousa et al., 2012; Mainka and Zajusz-Zubek, 2015). Nevertheles, at the same time it is necessary to monitor the outdoor environment as well by observing its changing daily pattern and trying to identify the possible sources of outdoor air pollution.

EXPERIMENTAL SETUP

Following previously mentioned facts and the request of local kindergarten, we performed a two week lasting I/O measurement campaign in a kindergarten in a small town 25 km north-east of Prague. This town has a moderate industry including iron casting and plastic tubing production. The kindergarten is located in a residential area in a large 3-storey family house. There are two classrooms each with kitchen in the ground floor, 2 bedrooms in first floor and a private apartment in the second floor. The large garden behind the house serves as a playground for the kids, when the weather conditions allow to stay outside.

The instruments used in this campaign included online aerosol spectrometers for highly time resolved information about particle number size distribution as well as offline low volume samplers for information about PM_{10} and $PM_{2.5}$ daily concentrations and following chemical analysis of the collected samples. The online instrumentation consisted of SMPS spectrometer, covering the size range of 15-700 nm (64 size channels/decade), and two OPS spectrometers, measuring in size range of 300 nm – 10 μm (16 size channels). The low volume samplers were equipped with quartz fiber filters (PM_{10} and $PM_{2.5}$) and Teflon filters ($PM_{2.5}$). The SMPS was equipped with a switching valve system allowing for alternate indoor/outdoor sampling. The other instruments were separated into two sets to cover indoor and outdoor environment simultaneously

(see Fig. 1). Indoor instruments were located in a cabinet next to a cloakroom of one of the classrooms. Due to excessive noise it was not possible to place the instruments inside the classroom. Also the OPS measuring outdoors was located inside this cabinet and equipped with a sampling tubing leading outdoors. The outdoor instruments (low volume samplers) were placed in the garden.

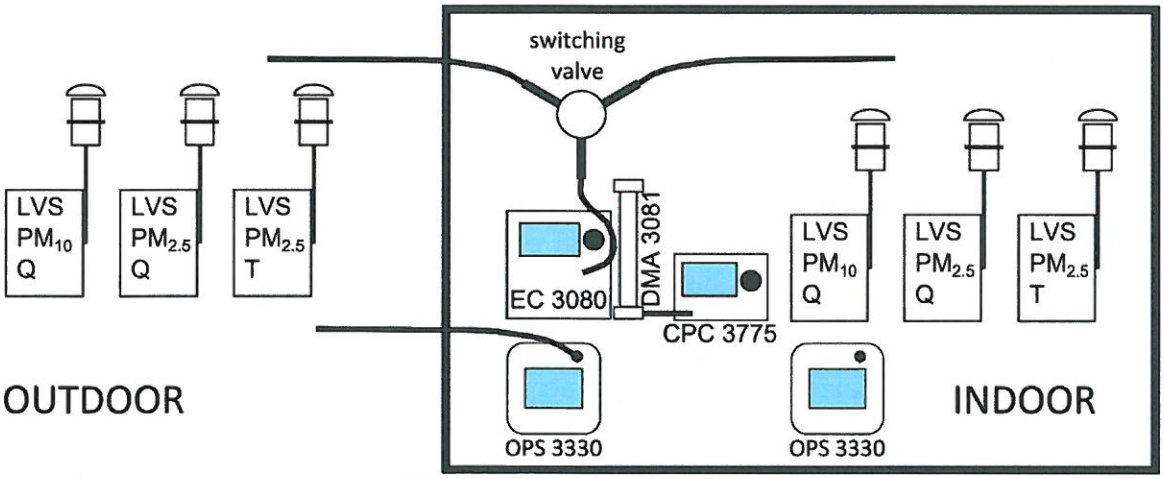

Fig. 1: Measurement setup.

The chemical analysis included ion chromatography (IC), OC/EC analysis and PIXE elemental analysis. The analysis of water soluble ions was performed on quartz fiber filters using IC Dionex ICS-5000 (Thermo Scientific, USA). The analysis of OC/EC was conducted on samples from quartz fiber filters using field OC/EC analyzer (Sunset Lab. Inc., USA). The PIXE analysis will be performed on Teflon filters to obtain detailed information about elemental composition of PM_{10} and $PM_{2.5}$ samples.

RESULTS AND CONCLUSIONS

The online data were analysed mainly from SMPS spectrometer. The data were divided into four groups including indoor and outdoor data and working and non-working hours. Working hours include measurements between 7 a.m. and 5 p.m. which corresponfs to operational hours of the kindergarten. Correspondingly, the non-working hours involve the periods from 5 p.m. to 7 a.m. during working days and the weekends. Figure 2 shows the average size distributions for the respective periods mentioned in the previous text. There is obvious difference between working and non-working periods for both indoor and outdoor environments - the concentrations are lower and the size distribution is close to unimodal shape during non-working hours. Overall, the lowest concentration and the lowest interquartile span was observed for non-working period and indoor environment, which corresponds to no indoor sources present and very stable conditions indoors. The only source of particles indoors in this case is the penetration from outdoor air. On the other hand, the highest concentration (especially for smallest particles) and the largest interquartile span can be seen for working hours and outdoor environment. Based on the multimodal shape of the particle size distribution the particles are most probably resulting mainly from traffic, domestic heating and close industrial sources.

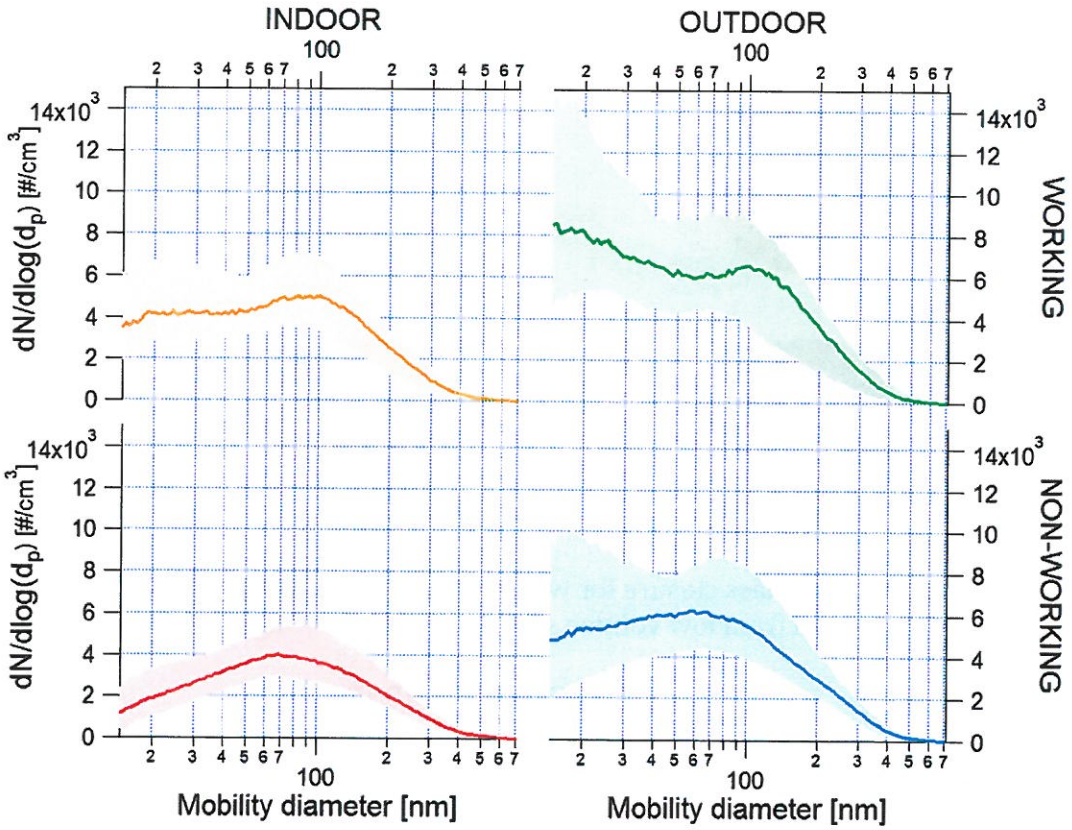

Fig. 2: Average particle size distributions measured by SMPS for working and non-working hours indoors and outdoors, shaded areas depict the interquartile span.

The average mass closure calculated from available data on chemical composition shows similar behavior for both PM_{10} and $PM_{2.5}$ samples. Therefore, only $PM_{2.5}$ mass closure is discussed in this abstract (see Fig. 3). The results are split again into four groups – indoor/outdoor and working days and weekends. In this case, only the whole days were taken into account, because the low volume samplers were operating for 24 hours or 48 hours in the case of the weekends. The mass closure revealed that the highest percentage can be attributed to organic matter, which is connected with traffic and industrial sources mainly. In the case of $PM_{2.5}$, the outdoor contribution of organic matter is higher than indoors for both working days and weekends, which points to most of the part of organic matter being in the fine size range with higher particle losess when penetrating from outdoor to indoor environment. Another easily visible feature is the dissociation of nitrates with much higher percentage outdoors compared to indoor values in both working days and weekends. This can be attributed to dissociation of nitrates when penetrating from colder outdoor environment into much warmer indoor environment. Increased concentrations of Ca^{2+} indoors are most probably caused by the presence of kids/people in the kindergarten inducing resuspension of coarse particles. The most surprising fact was very high contribution of Cl^- in indoor environment. Such a high concentration is not very usual for indoor environment, but in this case can be ascribed to cleaning using some chloride cleaning agents nad partially also to a road salt.

Nevertheles, for complete mass closure it would be useful to have also the results from elemental analysis which is not yet available.

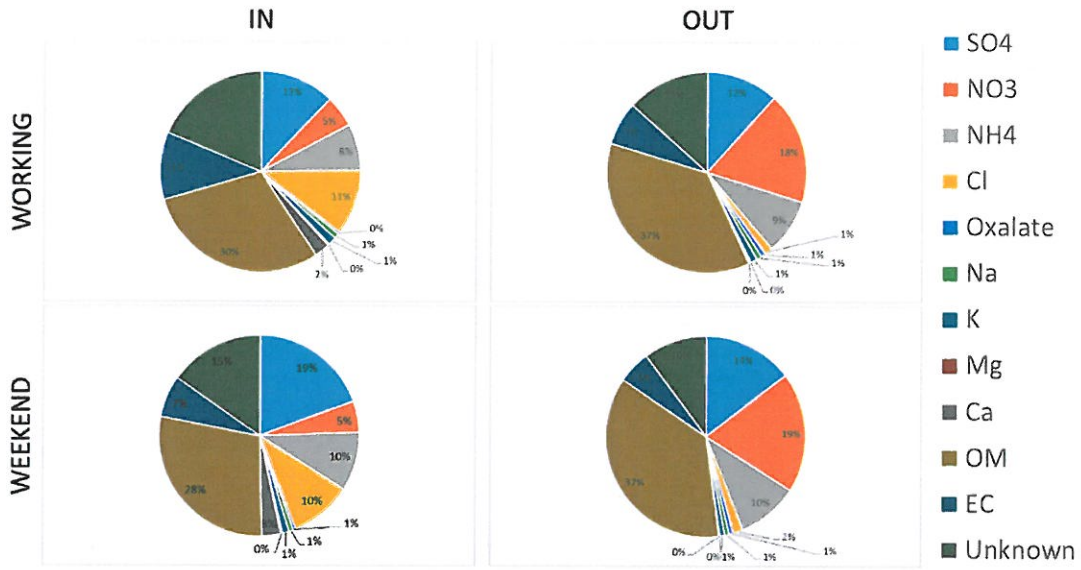

Fig. 3: $PM_{2.5}$ average mass closure for working and non-working hours indoors and outdoors obtained from low volume samplers and following chemical analysis.

ACKNOWLEDGEMENT

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