Sources, sinks, chemical composition and transport of aerosol particles in a university lecture hall

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An intensive aerosol research program was conducted in a university lecture hall at the Eötvös University, Faculty of Science, Budapest, Hungary to determine time-resolved aerosol mass and number concentrations, CO_2 concentration, size-resolved chemical composition of aerosol particles, and to evaluate them together with micro-meteorological variables. A computational fluid dynamics (CFD) model was developed to estimate the spatial distribution of the experimental and derived data within the hall and the transport of aerosol particles.

PM_{10} mass, particle number (N) and CO_2 concentrations, particle number size distributions and meteorological parameters were determined with high time resolution, and daily aerosol samples were collected in the $PM_{10-2.0}$ and $PM_{2.0}$ size fractions for chemical analysis in the middle of the lecture hall for one week. Median concentrations for the PM_{10} mass and N of 15.3 $\mu g\ m^{-3}$ and $3.7\times10^3\ cm^{-3}$, respectively were derived. The data are substantially smaller than the related outdoor levels or typical values for residences. There were considerable concentration differences for workdays, weekends and various lectures. Main sources of PM_{10} mass include the usage of chalk sticks for writing, wiping the blackboard, ordinary movements and actions of students and cleaning. High PM_{10} mass concentration levels up to 100 $\mu g\ m^{-3}$ were realised for short time intervals after wiping the blackboard. The mass concentrations decreased rapidly after the emission source ceased to be active. Two classes of coarse particles were identified. General indoor dust particles exhibited a residence time of approximately 35 min, while the residence time for the chalk dust particles was approximately 15 min as lower estimates. Emission source rate for wiping the blackboard was estimated to be between 8 and 14 $mg\ min^{-1}$. This represents a substantial emission rate but the source is active only up to 1 min. Most aerosol constituents have smaller indoor concentrations than their outdoor counterparts. At the same time, Ca and S showed larger indoor enrichment factors than the other constituents. This is explained by the chalk (made mainly of gypsum) usage for writing and drawing, and suspension of the chalk dust particles. The crustal enrichment factors and $PM_{2.0}/PM_{10-2.0}$ concentration ratios revealed that mechanical disintegration is the major source for many aerosol constituents. Contribution of ambient aerosol via the heating, ventilation and air conditioning (HVAC) facility was considerable for time intervals when the indoor sources of PM_{10} mass were not intensive. The HVAC facility introduces, however, the major amount of aerosol particles from the outdoors as far as their number concentration is regarded. Mean contribution of ultrafine particles to the total particle number was (69±7)%, which is smaller than for the related outdoor urban environment. This can indicate aged ultrafine aerosol. The major amounts of CO_2 arrive from the corridors through open doors by infiltration.

Spatial distribution of the PM_{10} mass concentration within the hall was derived by CFD modelling, and spatial inhomogeneities were obtained as indicated in Figure 1. A plume of particles is created along the central longitudinal band of the hall. Sitting at the outermost seats seems favourable, and the lecturers who use chalk sticks intensively are exposed to higher concentration levels than the students.

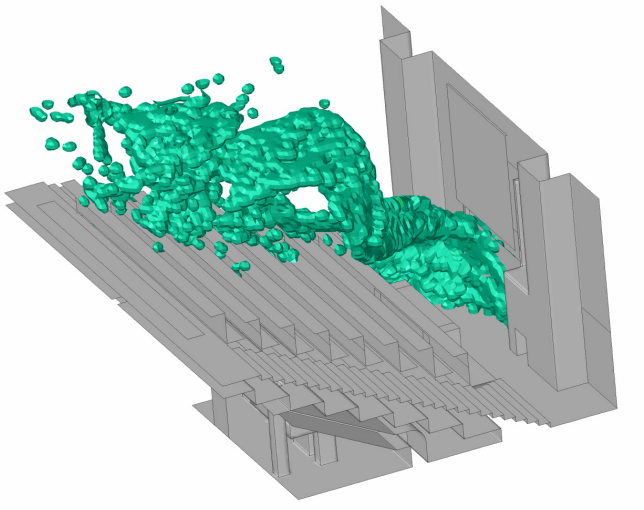

Figure 1. Modelled three-dimensional spatial distribution of PM_{10} aerosol particle after wiping the blackboard.

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