Computational fluid dynamics of indoor aerosols – Modelling the ventilation effect on indoor air quality

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PMx is a major indoor pollutant with adverse effects on human health. Correlation between i) indoor emitting activities; ii) ventilation rates; iii) outdoor PMx levels; iv) deposition fluxes; v) secondary aerosol formation and interparticle coalescence with vi) indoor PM measurements is a challenge modelling task. Workers can spend 8 or more hours per day in indoor spaces with air pollution levels above those observed outdoors.

Hourly measurements of $PM_{1.0}$ and $PM_{2.5}$ over 24 hours in a copy centre shop (Figure 1) are interpreted through Computational Fluid Dynamics (CFD) modelling with the observed/measured average Air Exchange Rates (AER) of 0.4 h^{-1}. This parameter was estimated by the CO_2 decay method (Alves et al. 2013). Higher PM levels have been registered between 23h00 to 01h00, which was not due to direct emissions from copy machines. Details of the measurement methodology can be found in Vicente et al. (2016), namely air temperature and humidity and observed hourly levels of CO_2, CO, formaldehyde, ozone and TVOC. High levels of nanoparticles on copy centres have also been reported by Martin et al. (2015).

CFD simulations of the indoor space were performed through OpenFOAM with RANS, more specifically, k-e model. Dispersion of PM was simulated by a eulerian-lagrangian approach for the continuous and particulate phases. The room volume of 268 m^3 was discretised in 6 million computational cells in order to achieve a spatial resolution smaller than 6 cm. Simulations considered both mechanical (fan) and natural ventilations. Natural ventilation was only performed through the open door during the working hours as no windows are present in the copy centre.

Different imposed boundary conditions (mass flow rate inlet) revealed high sensitivity of indoor PM levels to extreme (high or low) air ventilation rates. Indeed, results for different ideal simulation scenarios revealed that simple modifications in the layout on the mechanical ventilation and operation of the copy centre can induce significant improvements in IAQ, contributing to a healthier building. The uncertainties and practical modifications in the mechanical ventilation were also analysed in order to improve the IAQ for benefiting both workers and clients.

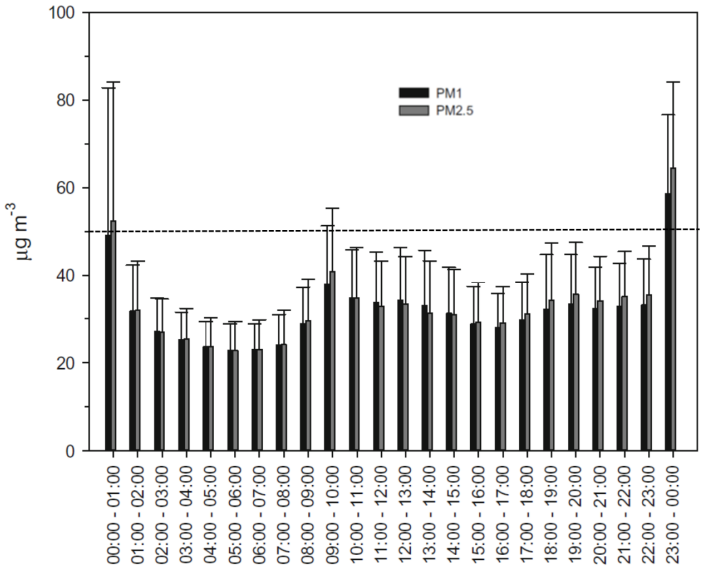

Figure 1. Indoor hourly mean PM_1 and $PM_{2.5}$ concentrations measured in a copy centre

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