Effect of airflow rate on CO_2 concentration in downflow indoor ventilation

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Indoor ventilation plays a vital role in the removal of anthropogenic contaminants such as CO_2 gas or airborne respiratory droplets. The dispersal of these contaminants is often controlled by the effects of temperature variations. Using direct numerical simulations, we study the downflow ventilation setup (shown in figure 1a). At low airflow rate (figure 1b), the buoyant plume of hot air generated due to the presence of the occupant creates a stratified layer of warmer contaminated air close to the ceiling. At high airflow rate (figure 1c), the large inflow velocity causes a portion of the stratified layer close the ceiling to be advected away through the outlet. The airflow rate is, therefore, very important in determining the concentration of contaminants in this setup. However, larger airflow rates lead to greater energy consumption which is not favorable in view of the climate change and environmental concerns. Therefore, it is vital to optimize the ventilation setup towards increased removal of contaminants for the lowest possible energy expenditure. By studying the CO_2 concentrations in this downflow setup, we aim to investigate the possibility of enhanced contaminant removal at lower airflow rates when compared to other ventilation setups.

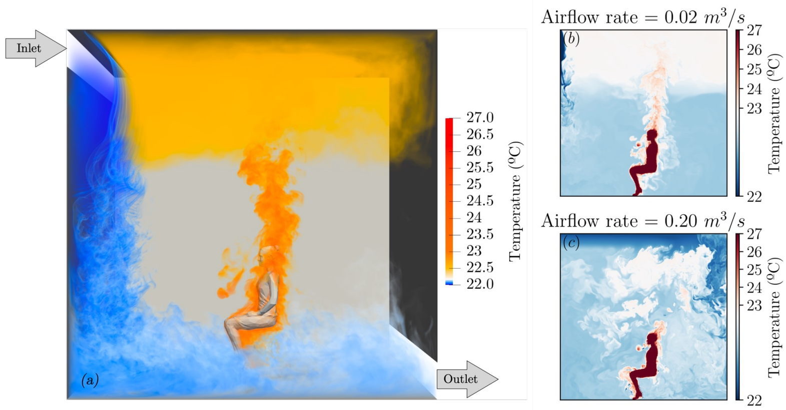

Figure 1: (a) The schematic of the ventilation setup with the inlet and outlet indicated. The thermal plume generated by the occupant is visible along with the stratified layer of warm air close to the ceiling of the setup. The airflow rate for the visualization is 0.10 m^3/s. (b) The 2D snapshot of temperature for airflow rate of 0.02 m^3/s and (c) for airflow rate of 0.20 m^3/s highlighting the difference in low and high ventilation rate paradigms.

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