The effect of ventilation performance on risk of indoor airborne transmission of SARS-CoV-2

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SUMMARY
Ventilation performance plays a significant role in distributing contaminants and airborne infections indoors. Thus, poorly ventilated public spaces may be at high risk due to the presence of both infectious and susceptible people. Adapting HVAC ventilation systems to mitigate virus transmission requires considering ventilation rate, airflow patterns, air balancing, occupancy, and feature placement. The study aims to identify poorly ventilated spaces where airborne transmission of pathogens such as SARS-CoV-2 could be critical. This study is focused on evaluating the ventilation performance of the building stock and the safety of using the facilities based on measured indoor CO_2. The results revealed the spaces with the potential risk of indoor airborne transmission of COVID-19. The study proposes recommendations for utilising air ventilation systems in different use cases.

KEYWORDS
Indoor air quality, Carbon dioxide concentration, COVID-19, Ventilation system

1 INTRODUCTION

The Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV- 2) as a responsible agent of the COVID-19 pandemic has caused severe harm to people and massive economic downturn over the last years. In response to the current challenges of minimising the coronavirus spread indoors, recently published studies have deepened the knowledge about possible transmission pathways. Unlike large respiratory droplets that quickly fall onto the ground within a few meters after being exhaled, the expired aerosol remains suspended into the air over more extended periods, especially inside crowded and poorly ventilated indoor spaces (Li et al. 2021). Exceeding CO_2 concentration in indoor spaces is usually due to human exhalation, which could identify the increased risk of infection by inhaling breath exhaled by other people (Di et al. 2021). The study aims to identify poorly ventilated spaces where airborne transmission of pathogens such as SARS-CoV-2 could be critical by analysing CO_2 concentration measurements in different buildings.

2 METHODS

The CO_2 measurements were conducted in 440 spaces for different building types; office, shopping centre, hospital and educational buildings during February 2019. The measurement data is obtained from Granlund Manager software, cloud-based property management and energy management software. Due to the anonymous processing, only the following data was available: date and time, room type, sensor (space) name and CO_2 concentration. Every space is presented by one CO_2 sensor. The intervals of the measurement data were 5 and 15 minutes.

3 RESULTS

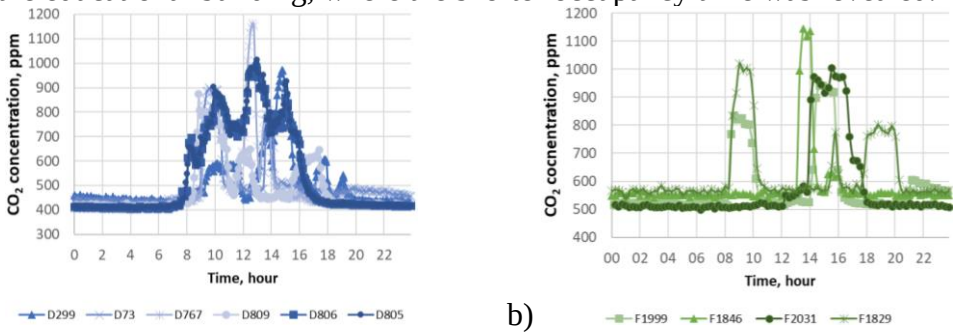
This section presents the selected measurement results in offices and educating buildings. The measurement data were selected with a maximum carbon dioxide concentration limit of 800

ppm. Table 1 shows the number of premises by building type and carbon dioxide concentrations <800 ppm and ≥800 ppm. The CO_2 concentrations were significantly higher in the educational buildings.

Table 1. CO_2 concentration profiles in the selected buildings

Building type	Number of premises	CO_2 concentration	
		≥ 800 ppm	< 800 ppm
Office, Series D	88	33 (38%)	54 (62%)
Educational building, Series F	231	164 (71%)	68 (29%)

The next step in processing the measurement data is to focus on periods when the state concentration exceeds 800 ppm in the Office series D (Figure 2a) and Educational building Series F (Figure 2b). Figure 2 depicts the concentration profiles measured on the same day in different premises, which are marked with the series letter (D and F) and the sensor number. The CO_2 concentrations above 800 ppm were observed in both room types during the occupied period. However, the occupancy profile in the office space was more distributed than in the educational building, where the shorter occupancy time was revealed.



a) b)

Figure 1. CO_2 concentration profiles in the a) office building and b) educational building.

4 DISCUSSION

The measurements of CO_2 concentration give general information about ventilation efficiency and occupancy profile that can be utilised by adjusting ventilation control. However, CO_2 monitoring cannot account for non-ventilation mechanisms for removing infectious aerosols. In addition, since the occupancy time significantly affects both contaminant concentration and the infection risk, future studies should also focus on occupancy prediction and control.

5 CONCLUSIONS

The CO_2 concentrations above 800 ppm were observed in both room types during the occupied period. Therefore, ventilation systems should be adopted to guarantee more effective fresh air exchanges. Furthermore, conclusions can be made based on the CO_2 concentration measurements about ventilation efficiency in different types of premises.

ACKNOWLEDGEMENT

The study is a part of the Licence to Breathe project funded by Tampere University.

6 REFERENCES

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