Field measurements of seasonal variation in air change rate and spatial distribution of gaseous pollutants in five Danish homes

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1 Introduction

Air change rate (AER) measurements performed during shorter time intervals, as it is done in many cross sectional studies, may not be representative of the general AER over the course of a year. Occupant behavior has in previous studies been shown to influence AER and may be the main reason for seasonal changes in residential AER (Wallace et al., 2002). Especially occupant window opening behavior is of importance and should be incorporated when estimating human exposure to indoor air pollutants (Howard-Reed et al., 2002). This study investigates seasonal variation in AER and redistribution of a gaseous pollution sources within an occupied residence.

2 Materials/Methods

The ongoing study "Centre for Indoor Air and Health in Dwellings" (CISBO) investigates the indoor environment in Danish homes and its impact on health (Sigsgaard et al., 2011). As part of the study, five occupied homes are being intensively investigated through the course of one year (April 2010 - April 2011). The homes consist of three detached houses (Home A, B and D), one row-house (Home C) and an apartment (home E).

The homes were, due to the intrusive nature of the measurements, selected among colleagues or family of the project staff, thereby reducing the risk of subjects dropping out of the project.

Measurements were conducted during five days of each season (so far data from spring, summer and autumn have been collected).

Active tracer gas measurements were carried out using an Innova Multi-gas Monitor Type 1302 and an Innova Multipoint Sampler and Doser 1303. Dosing and sampling locations were chosen in five-six different rooms in each home to represent different zones. The first 24-36 hours redistribution of a gaseous pollution source was simulated by dosing tracer gas in only one location and sampling in all locations. In the remaining part of the measurement period (2-4 days which included a weekend) continuous AER measurements were conducted using a constant concentration method with a target value of 4 ppm of tracer gas (Freon®).

In addition, the CO_2 concentration, temperature and relative humidity were continuously measured throughout the homes. AER calculations based on occupant produced CO_2 as a tracer gas and monthly average AER measurements using passive tracer gas (PFT) were performed (Bekö et al., 2011 and Frederiksen et al. 2011). Various measurements of microbial particulate and chemical pollutants were also completed.

All measurements were done in occupied homes. A short questionnaire on occupant behavior was filled out by occupants every day of the measurement period. No means were taken to control the user behavior.

3 Results

The average AER for all homes in spring was 0.6 h^{-1} (range = 0,1-1,2 h^{-1}), in summer 2,1 h^{-1} (range = 1,4 - 3,1 h^{-1}) and in autumn 0,5 h^{-1} (range = 0,1-1,1 h^{-1}). Substantial spatial variation in AER within each home was found. However, this is out of the scope of this abstract.

The diurnal changes in the AER for each home are illustrated in Figure 1. Each time interval of four hours represents the average AER in the whole residence, based on all rooms and all measurement days. The horizontal line indicates an AER of 0,5 h^{-1} which, according to the Danish building code, is the minimum 24 hour average requirement for AER in new residences.

There was a strong seasonal variation in the AER with low AER in spring and autumn. Home B and E had AER above 0,5 h^{-1} during most of the measured time of each season. This may imply that new apartments and older houses have higher ventilation rate. However, larger studies are required to verify this hypothesis. In summer the ACH generally was above the recommended limit. Diurnal changes occurred with the same pattern for all homes where the lowest AER was found during the night. This trend was less pronounced in autumn.

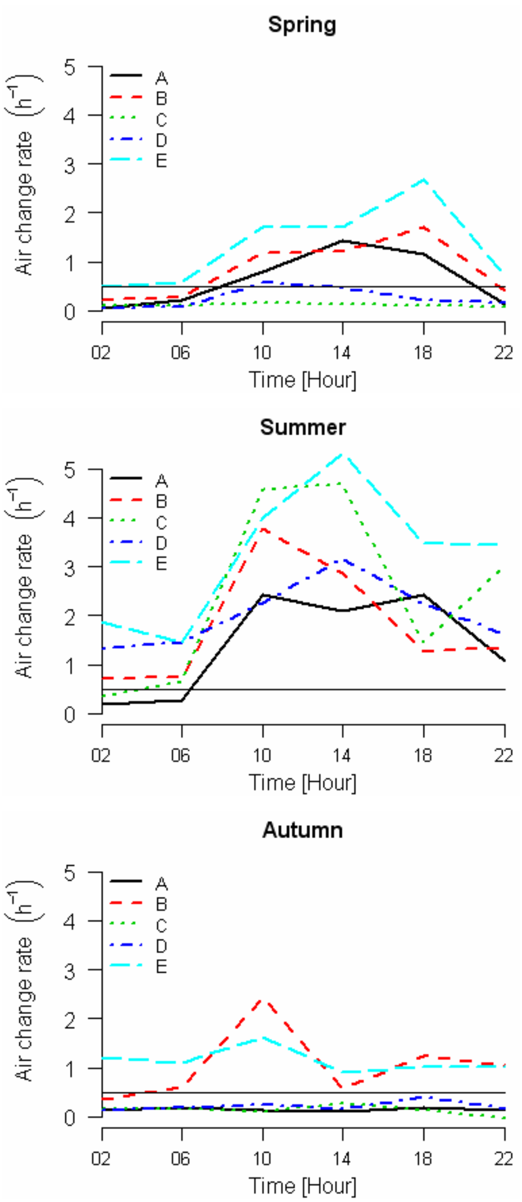

Figure 1 Diurnal air exchange rates in four hour intervals are illustrated for spring, summer and autumn. Curve A-E represent each of the five homes.

The results of the redistribution of tracer gas from one room to the rest of the dwelling indicate a substantially better mixing of air between rooms on the same floor than between rooms on different floors. Further results regarding this will be presented at the conference.

4 Conclusions

Information on inter-zonal air flows and seasonal variation of ventilation rates is needed to better understand the distribution of various pollutants within a home. The results from this study can be useful in relation to verifying whether AER measurements of shorter duration in only one season of the year can serve as a general representation of the AER in a residential building, and if so how it will be possible to convert it into a value which would represent an annual AER of the home.

5 References

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