Fine and ultrafine particles in 20 French dwellings related to time-activity diaries

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1 Introduction

Particles are a major pollutant in the indoor environment with contributions from both outdoor and indoor sources. Real-time particle measurement was performed in a subset of dwellings from the French national survey 2003-2005 conducted by the Observatory of Indoor Air Quality (OQAI) (Kirchner et al., 2007). The objective of this study is to cross the results with reported time-activity diaries in order to identify the major sources in dwellings.

2 Materials/Methods

Fine particles (FP ; > 0,3 µm diameter) were measured continuously over a week in the living room of 20 French occupied dwellings with an optical particle counter (OPC, dust monitor model 1.108, Grimm GMBH). In a subset of 10 dwellings, ultrafine particles (UFP with a diameter > 0,01 µm) were also measured with a condensation particle counter (CPC, isopropanol-based model 3007, TSI Inc.) during the first evening. Two OPCs and two CPCs were used in the study. Inter-instrument variations were below the measurement uncertainty (20% for CPC and 10% for OPC).

Outdoor concentration of particles was not assessed during the experiment. It contributes to the background particle concentration especially when the windows are opened.

The study involved other measured parameters and several questionnaires, described fully by Derbez et al. (2006) and Ramalho et al. (2006). In particular, each child or adult occupant completes a weekly diary to provide spending time and room location throughout the dwelling every 10 min. A daily diary (random day of the week) details the activities, the number of occupants at a given time (smoker or not) and the products used with a timestep of 10 min. The mean completion rate of time-activity diaries was 67% (23% standard deviation).

The minimum air exchange rate varies between 0.03 and 1 air change per hour and occurred in the middle of the night. The mean air exchange rate over the week was estimated according to the number of occupants at a given time, their metabolic production rate, the state of indoor openings, etc. It varies between 0.3 (December) and 4.6 air change per hour (July). More details for the complete ventilation data can be found in Deroubaix et al. (2009).

3 Results

Particles 1-hour median levels vary between 4.3×10^3 and 6×10^4 part/cm^3 for UFP and from 23 to 323 part/cm^3 for FP > 3 µm. Max/min ratios vary between dwellings from 10 to 257 for FP and up to 15 for UFP.

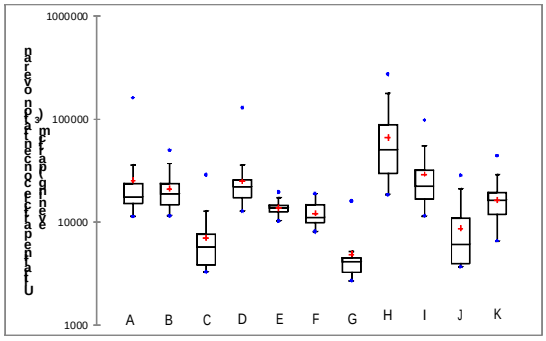

Fig. 1. Box plots of the measured ultrafine particles over an evening in the living room.

The maximum concentration for either FP or UFP occurred between 7 and 9 pm corresponding systematically with the maximum

occupancy rate of the living room defined as the number of occupants in the given room divided by the total number of occupants for each timestep (see Fig. 2).

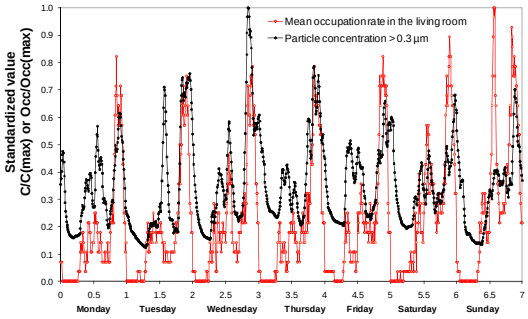

Fig. 2. Mean FP concentration profile over the week and mean occupancy level profile in the living room (standardized values). (Pearson correlation, $p < 10^{-4}$)

High concentration of FP was sometimes also associated with other measured pollutants, e.g. carbon monoxide. When this occurs, it indicates that the major source of particles involves combustion. In Fig. 3, several particle concentration peaks are related to CO peaks in the most polluted dwelling.

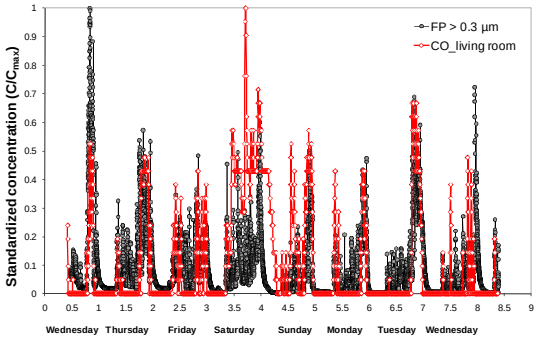

Fig. 3. Simultaneous measurement of FP and CO from Monday to Sunday in a dwelling.

The heating system was off in September. However, both occupants are regular smokers with a total of 18 smoked cigarettes per day. Practically, each peak is associated with a smoking event. Windows were opened during the day and closed at the end of the afternoon explaining that highest concentrations were observed during evening. Cooking using natural gas may also have played a role that remain difficult to assess (Wallace et al., 2004). The use of the gas oven is associated with Friday and Saturday evening peaks. The dwelling however is equipped with a ductless kitchen hood. In this particular case, smoking and gas cooking appeared as the major sources of particles indoors.

4 Conclusions

There is evidence from this study that highest particle concentration arise when occupancy level is high. With the preliminary results of this study alone it remains difficult to separate the contributions of the specific activities from the mere presence of the occupants, i.e. mechanical resuspension of deposited particles (Thatcher and Layton, 1995).

Interestingly, the mean air exchange rate is correlated with the minimum fine particle concentration ($p = 0.014$), but not with the mean or maximum. This may imply that outdoor sources contribute during the night or inoccupancy to define the indoor background level but their contribution is negligible whenever occupancy occurs. Of course, this assumption is only valid for the fine particles expressed as number concentration. It must be checked when using other parameters (different particle diameters, mass concentration, etc.).

5 References

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