STUDY OF THE INDOOR AIR QUALITY IN OFFICES BUILDING

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ABSTRACT

The main objective of our study was to know more about indoor air quality in offices building over a long period. Our study has been carried out in one building located downtown Lyon (France). Measurements have been carried out one day each month during a one year period. Indoor air quality in the offices along with the one of air flows of the HVAC (Heating, Ventilating and Air Conditioning) installation (outdoor air, blown air and returned air) has been characterised by temperature and relative humidity of air, dust concentration level, air biocontamination and CO_2 concentrations. Air flow from the fan coil units has been measured too. Air filters of the HVAC installation have been characterised in the field and in laboratory (fractional efficiency, pressure drop and mass of dust arrested by the filters). Our results show how the measured parameters have changed over the period and how the HVAC installation works. The HVAC installation of this offices building may be considered as a well working installation giving chance to the occupants to live in spaces where indoor air quality may be regarded as good.

INDEX TERMS

Indoor air quality, HVAC, Air filters, Particles, Air biocontamination.

INTRODUCTION

People breathe approximately 15000 litres of air each day and spend more or less 80 % of their time in indoor spaces. So, quality of indoor air is of major importance regarding health and comfort of people and there is naturally an increase of the need of “good” indoor air quality. After a literature survey has been carried out in 2000, the French member companies of CETIAT have decided to study indoor air quality in buildings over a long period. The aim of this study is to know more about how an HVAC installation works over a long period, to obtain data on HVAC installation working, to obtain data on indoor air quality and to record how it changes along a long period, and to develop test procedure for indoor air quality measurements. Measurements have been carried out between July 2001 and June 2002, and this paper presents results obtained up to march 2002 while all the results are to be presented during the congress held in October 2002.

METHODS

Our study has been carried out in one offices building (13 stages) located downtown Lyon (France). Offices of the building are ventilated with a mixture of fresh air (outdoor) and recycled air. Air comes from an HVAC installation (located on the roof of the building) and is distributed in the offices through fan coil units. Air filtration of the HVAC installation

includes F6 class (EN 779) bag filters and F7 compact filters mounted in series. Filters have been changed just before the measurements have begun. The four offices (having one to five occupants) chosen for indoor air quality measurements are located at the 13th floor of the building. Windows are non-opening. Air is sucked out of the building through devices located in the corridors. The air flow rate of the HVAC system is constant while ratio of recycled air to outdoor air may change depending on outdoor air temperature. Air cooling is done with a coil fed with cold water while air heating is done with coil fed with hot water. Both outdoor (fresh air) and returned air temperatures are measured. If returned air temperature becomes smaller than the outdoor air temperature then recycling mode (at least 70 % of air comes from outdoor) of the HVAC installation is switched on if cooling of air is necessary. When the HVAC system works in recycling mode, cooling of air is switched on if returned air temperature is greater than 23 °C. When the HVAC installation does not work in recycling mode, returned air is not recycled and is blown outside of the building.

Measurements are carried out each month for a one day continuous measurement, during a one year period (July 2001 – June 2002). Indoor air quality in the offices is characterised by temperature and relative humidity of air, dust concentration level (total), air biocontamination (bacteria and fungi) and CO_2 concentrations. Air flow from the fan coil units has been measured too. Air flow rates (outdoor air, blown air and returned air) of the HVAC installation have been measured (in duct air velocity profile measurements) and characterised with air temperature and relative humidity, dust concentration level (total), air biocontamination (bacteria and fungi) and CO_2 concentrations. Air filters have been characterised in the field (EUROVENT 4/10. 1996) and in laboratory (fractional efficiency, pressure drop, mass of dust arrested by the filters). For field measurements, techniques used for filters characteristics determination have been validated in the past (Ginestet, A., Pugnet, D., Salazar, J.H. and Grange, P. 2001). For filters laboratory measurements, one filter of each rank is removed out of the HVAC installation and installed again after measurements have been done.

RESULTS

As shown in Figure 1, no significant changes have been recorded on air flow rate (blown air) of the HVAC installation. Air flow rate blown in the offices is expressed according to the number of persons in the offices (expressed in m_/h/person). Values presented in Figure 2 show that no significant changes have occurred since the beginning of the measurements.

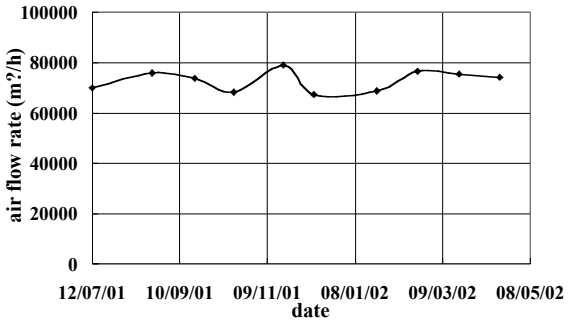

Figure 1: The air flow rate (blown) of the HVAC installation according to time.

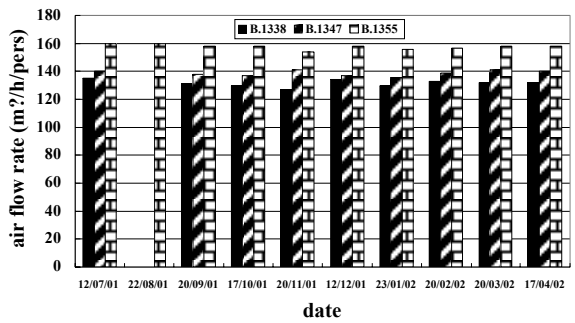

Figure 2: The air flow rate blown in the offices according to time.

During the first 2 months, the filtration efficiency of the HVAC installation did not change significantly then it started to increase especially against particles smaller in size than 1 µm (Figure 3). Laboratory measurements (EUROVENT 4/9. 1997) have shown that the increase of the fractional efficiency has been small for bag filters (in depth loading ; Figure 4) but much higher for compact filters (surface loading ; Figure 5).

The mass of the filters (mass of dust arrested) increases linearly according to time (Figure 6) but this increase is much more pronounced for bag filters. It can be observed that the filtration efficiency started to increase when the pressure drop of the bag filters started to increase too (Figure 7). For bag filters, the increase of pressure drop has started after 2 months of use while it was after 4 months of use for compact filters.

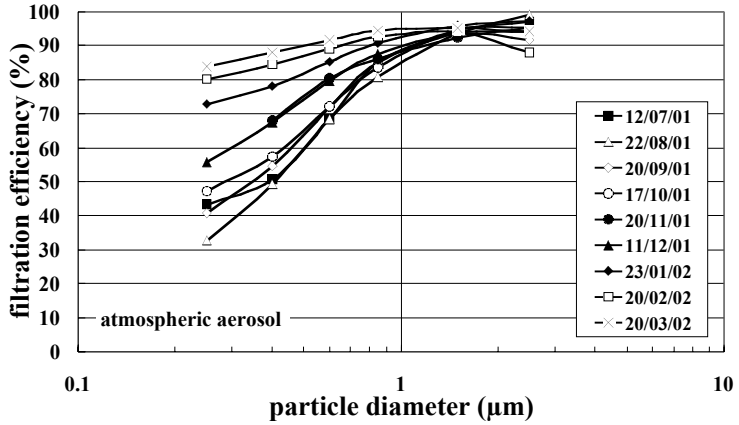

Figure 3: The in situ fractional efficiency of the HVAC installation, according to time.

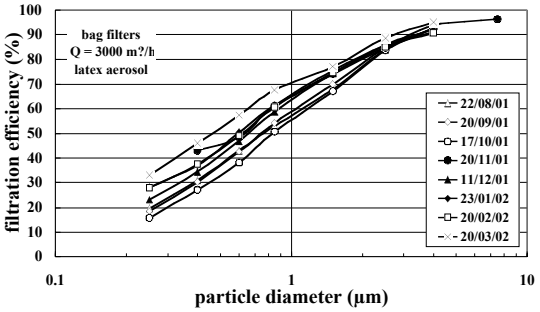

Figure 4: The fractional efficiency of the bag filters measured in laboratory.

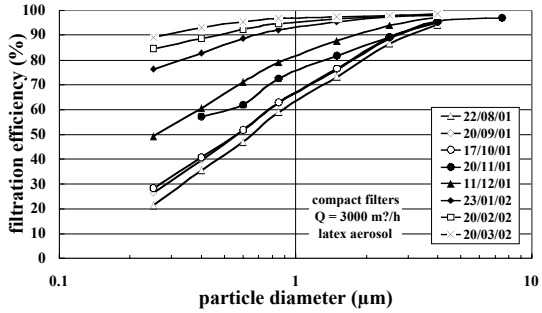

Figure 5: The fractional efficiency of the compact filters measured in laboratory.

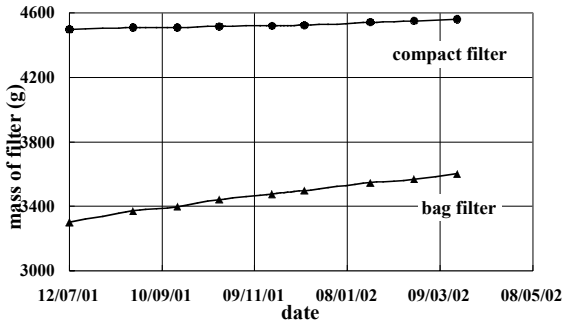

Figure 6: The mass of filters according to time.

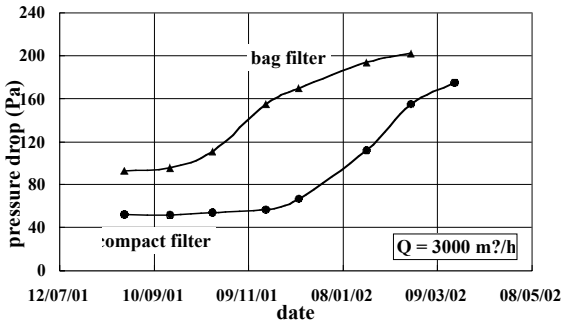

Figure 7: The pressure drop of filters according to time.

In Figure 8 we have reported the values of dust concentrations measured outdoors, in the air blown by the HVAC installation and in the offices. These values show that the filtration efficiency of the HVAC installation is high (concentration in blown air is much smaller than the one in outdoor air) and that indoor concentrations are generally smaller than outdoor concentrations even if sometimes they can be higher.

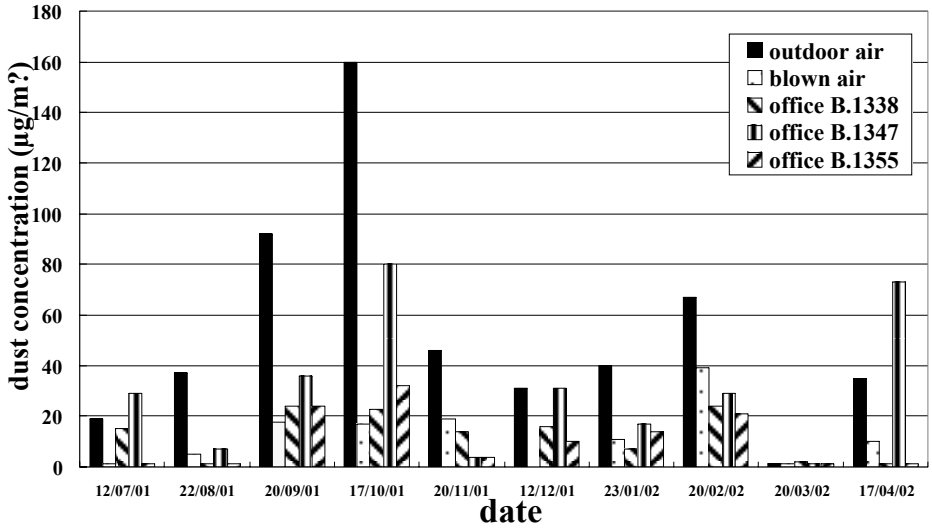

Figure 8: The dust concentration (total) according to time.

Bacteria concentration values are presented in Figure 9 while those concerning fungi concentrations are given in Figure 10. Concentrations measured in the blown air are much smaller than those measured in outdoor air at the inlet of the HVAC installation. Bacteria concentrations are higher in indoor air than in blown air and can be higher inside than outside. Fungi concentrations are much smaller inside than outside.

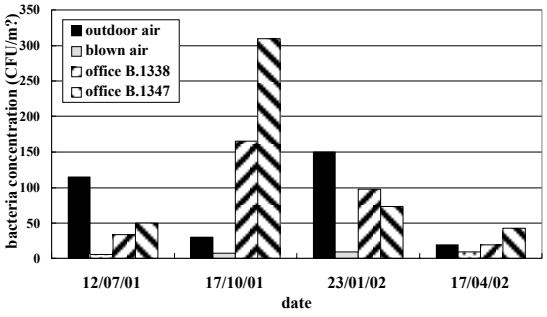

Figure 9: Bacteria concentration according to time.

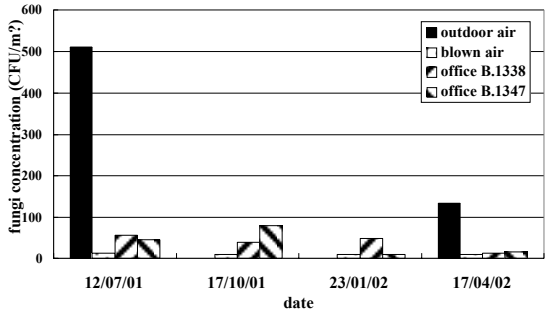

Figure 10: Fungi concentration according to time.

As an example of typical results that have been obtained, air temperature and relative humidity of air of the HVAC installation are given in Figure 11 (air temperature) and in Figure 12 (relative humidity of air) according to October's measurements. Both parameters are expressed according to time (7:00 to 16:00) and show how the installation works. Outdoor air temperature has continuously increased over the day period while the outdoor relative air humidity has decreased (sunny day). Recycling mode has started at 13:30 when outdoor air temperature had almost reached returned air temperature, and the cooling battery had been

switched on. As a result, blown air temperature has decreased while its relative humidity has increased. Finally, it is important to note that both temperature and relative humidity of the returned air were more or less constant over the day period, that means that climatic conditions within the offices were almost constant over the day period which is a good point regarding comfort of people.

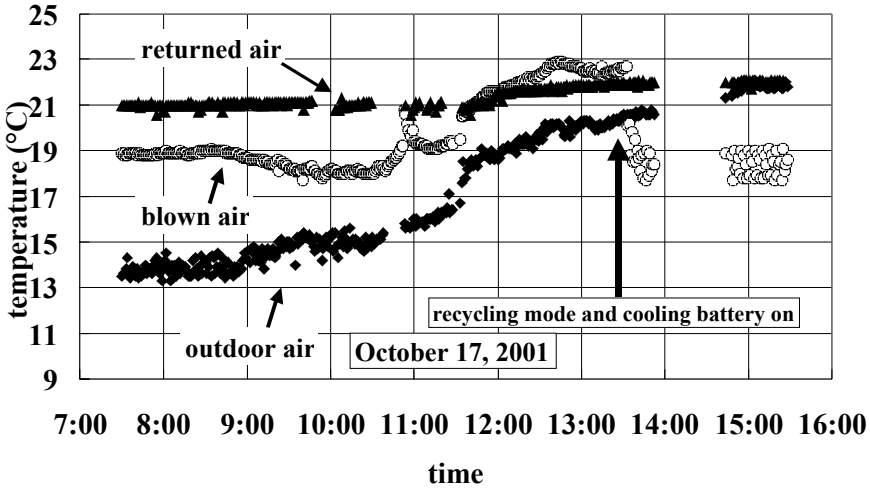

Figure 11: The air temperature of the HVAC installation air flows according to time.

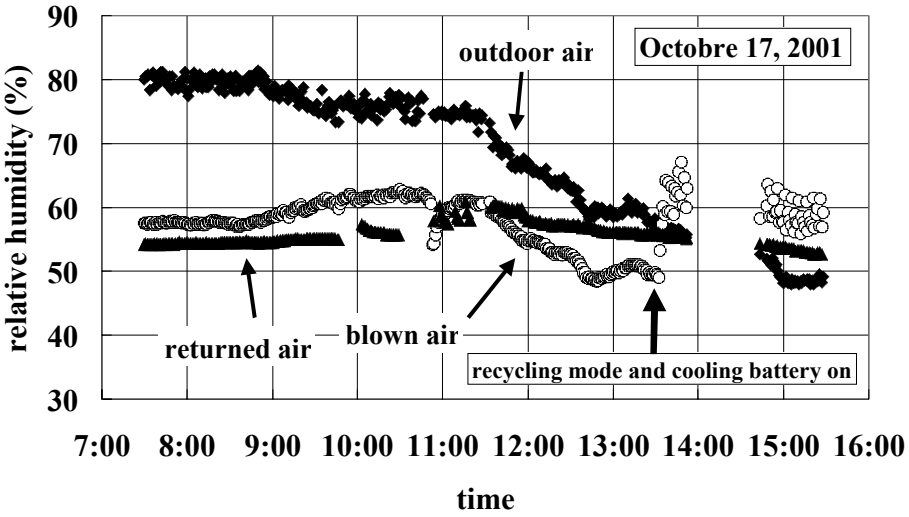

Figure 12: The air relative humidity of the HVAC installation air flows according to time.

DISCUSSION

Regarding the HVAC installation, the filtration efficiency has started to increase after two months of use of the filters. Laboratory measurements show that this increase is mainly due to the increase of the efficiency of the compact filters. Dust concentration data and air biocontamination data also show the high filtration efficiency level. Air temperature and relative humidity of the HVAC installation have shown that the installation works well

according to what is programmed (recycling mode, setting temperatures). Air temperature as well as air relative humidity in the offices are more or less constant along a day period which is a very important point regarding comfort of people. Air flow blown by the HVAC installation has remained constant over the first eight months period. It can be observed that these values are quite common according to the volume of the offices (about 5 h^{-1}) but are very high according to the number of occupants. These values are much greater than those required according to hygienic regulation (at least 25 m_/h/person) but do not comply with the energy building regulation (in France). On the other words, energy conservation might be probably obtained by decreasing air ventilation without decrease of the indoor air quality. This overventilation could explain that indoor CO_2 concentrations are low, always much smaller than 1000 ppm. Also, first results of a questionnaire (Squinazi, F., Lanfranconi, I. and Giard, A.M. 1994) submitted to the occupants of the offices have shown that they feel well and that no major problem occurs.

CONCLUSION AND IMPLICATIONS

Our study has allowed to characterise indoor air quality in building offices over a long period along with its HVAC installation study. Data that we have obtained give more understanding on how indoor air quality may change over a long period. The HVAC installation of this offices building may be considered as a well working installation giving chance to the occupants to live in spaces where indoor air quality may be regarded as good. The last measurements carried out in March 2002 seems to show that air filters begin to be more and more loaded but their filtration efficiency continues to increase. Measurements are still in progress and will end in June 2002. We also expect to study an other building in 2003.

ACKNOWLEDGEMENTS

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