.; Zhang, Y.; Onishi, T.;
Proceedings of Healthy

er, P. O.; Valbjørn, O.;
in 56 office buildings:
s '95, Milan, Vol. 3, pp.

nger, P. O. 1989. "Air
2000, Sarajevo, August

systems-investigations to
, Vol. 6, pp. 279-284.

tion Review, Vol. 14, No

ons of ventilation ducts".

hangers". Proceedings of

on of ventilation filters".

ation on acceptability of
pp. 49-54.

ntry, The Air Infiltration

to quantify air pollution
l. 12, pp.1-6.

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REDUCTION OF SENSORY POLLUTION BY AIR FILTERS: EFFECT OF TREATMENT TO INHIBIT MICROBIAL GROWTH

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ABSTRACT

Ventilation systems may in some cases be a major contributor to indoor air pollution. Several studies have shown that the pollution mainly originates from the filters. Microbial growth in the filters is seen as a cause for this pollution.

The sensory pollution from a standard glass fiber filter and a glass fiber filter treated to inhibit microbial growth (both EU7) were compared. No clear pattern was found in the influence of the filters on the sensory air quality. The differences between the two tested filters were not significant. Stopping the airflow through the filters led to a substantial increase of perceived air quality of the filters.

INTRODUCTION

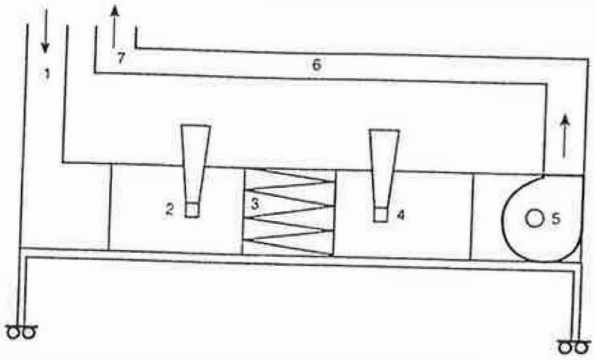
In ventilation and air conditioning systems air filters are used to remove dust, pollen bacteria and other contaminants. However, ventilation systems may in some cases be a major contributor to indoor air pollution. In several studies it was shown that a substantial part of the pollution in the investigated ventilation systems mainly originated from the filters (1,2,3,4,5). Generally, microbial growth in the filters is seen as one of the possible underlying causes.

A measurement section was built in which measures to reduce the pollution from filters can be evaluated. In the measurement section two filters, exposed to the same air, can be simultaneously evaluated. As a first experiment, the sensory pollution loads from a standard glass fiber filter and a commercially available glass fiber filter treated to inhibit microbial growth (both EU7) were compared. Both filters were exposed to a continuous flow of outdoor air for ten months.

METHODS

The set-up of the measurement section is presented in Figure 1. Two filters can simultaneously be exposed to the same outdoor air and be evaluated. To prevent pollution from the ventilator to influence the air quality evaluations, the ventilator was positioned downstream from the measuring points.

Sensory evaluations were made upstream and downstream from the filters. Air from the air handling unit was extracted through glass tubing and led into a glass cone. The glass construction was chosen to minimize sorption effects. To overcome the under pressure in the air handling unit micro ventilators (Micronel 361M) were installed. To be able to deliver air at the same temperature to the panel members regardless the outdoor air temperature, an electrical heating wire on the outside of the glass tubing was added. The heating was supplied outside to prevent any disturbance of the sensory and chemical pollution load of the air sample. With the heating a constant temperature (23°C) of the air supplied via the glass cones was maintained.



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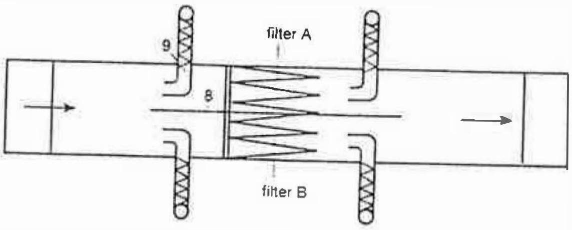

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Legend:

1. outdoor air supply (detachable to enable future additions/modifications)
2/4 measuring position air quality, temperature, humidity
3. filter section; frame 305x610 mm
5. ventilator; 0-1 m^3/s, pressure difference 100 Pa. Wolf type KG 63/9493
6. measuring section for flow measurement
7. exhaust
8. detachable panel, so also filters 610x610 mm can be tested
9. glass tubing + micro ventilator + glass cone + electrical heating

Figure 1 Measurement set-up

Sensory pollution was evaluated using a trained panel (6), comprising of 8 to 12 persons. The panel evaluated the air samples in random order. Before each evaluation the panel members refreshed their senses in the zero-decipol-room (7). Immediately after the (new) filters were installed, a first evaluation by the panel was made.

The sensory pollution load of the filters was calculated using the comfort equation (8):

$$G = 0.1\ (C_d - C_u)\ Q \qquad [1]$$

with:

G = sensory pollution load [olf]
C_d = perceived air quality downstream [olf]
C_u = perceived air quality upstream [olf]
Q = airflow rate through filter [l/s]

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Temperature and relative humidity of the incoming (outdoor) air were continuously measured using a thermistor and a capacitive humidity sensor (Vaisala 31 UT). The air temperature in the decipol meters was measured using thermistors. Furthermore, the pressure differences over the filters were measured using electronic pressure difference meters (EMA, 0-100 Pa). The signals from the different sensors were collected using a data logger (Grant Squirrel 1209). Data were stored every 5 minutes.

The airflow rate through both parts of the air handling unit was measured using a Pitot tube. In each subsection, the dynamic pressure was measured at 16 positions, evenly distributed over the area of the cross-section. From the dynamic pressure, the velocity was calculated using the Bernouilli equation. Multiplying each area with the corresponding velocity and summing up these values resulted in the flow rate in each sub section of the air handling unit.

The measurement set-up was located at the laboratory of TNO Building and Construction Research in the outskirts of Delft in the west of the Netherlands. Sensory evaluations were performed during approximately eleven months, from February 1995, when filters were installed, to January 1996. In December 1995 the ventilator was stopped to study the influence of absence of airflow on the sensory pollution load. In January 1996, immediately before panel evaluations, the airflow was started again. Measurements were taken immediately and after one week.

RESULTS

The airflow rate through the filters was 0.62 m^3/s (2232 m^3/hour) (treated filter A) and 0.60 m^3/s (2160 m^3/hour) (untreated filter B), respectively. The face velocity over the filters was 3.3 m/s. To realize similar flow rates in both sub-sections, a grid was installed in the sub-section of the untreated filter, downstream from the positions for the sensory evaluations.
The flow rates led to initial pressure differences over the filter of 65 Pa (treated filter) and 36 Pa (untreated filter), respectively. Apparently, the treated filter had a higher initial resistance.
In the course of the experiment the pressure differences over the filters rose steadily to 80 Pa (treated filter) and 55 Pa (untreated filter) after 11 months.

Figure 2 presents the perceived air quality from the air samples taken upstream and downstream from the filters. Values ranged from 2 to 7.3 decipol for the samples taken downstream from the filters. Values for the differences in perceived air quality over the filters are presented in Figure 3. In some cases a negative value was found (down to -1.3 decipol), implying an improvement of the sensory air quality when the air passed the filter.

From the perceived air quality and the airflow rates through the filters, the pollution loads of the filters were derived (equation [1]). Before the shutting down of the ventilator, the pollution load of the treated (A) and the untreated filter (B) ranged from -56 to 130 olf and -78 to 174 olf, respectively. Directly after restarting the ventilator (day 339), a pollution load of 254 olf for the treated filter and 96 olf for the untreated filter was calculated.

In the heating season (October 1 to May 1 in The Netherlands), the temperature of the unheated supplied air just before the filters varied from approximately 3 to 17°C and the relative humidity varied from approximately 5 to 90 %. During the whole period of the test, these values ranged from approximately 3 to 33°C and from approximately 5 to 100%, respectively.

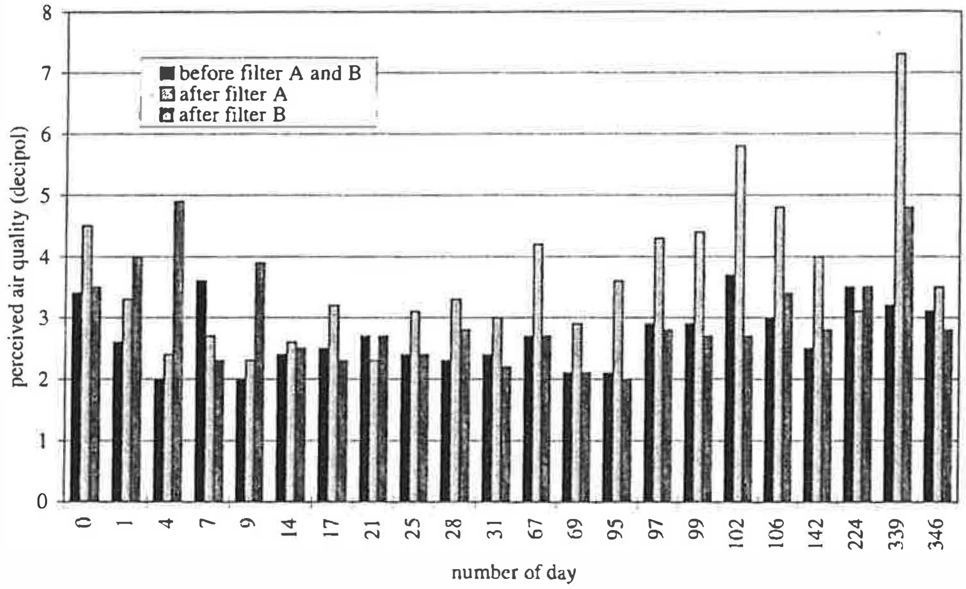

Figure 2 Perceived air quality

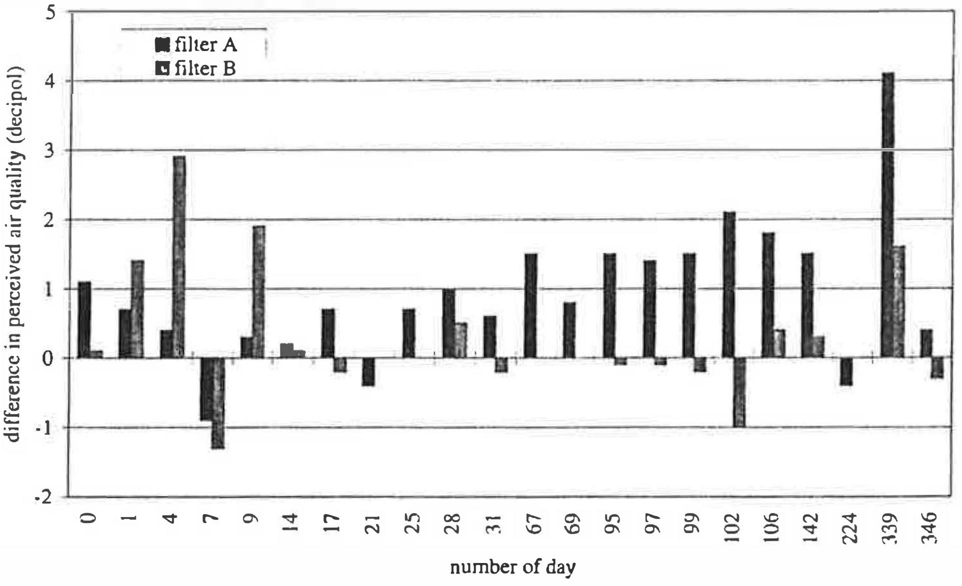

Figure 3 Differences in perceived air quality over the filters.

DISCUSSION

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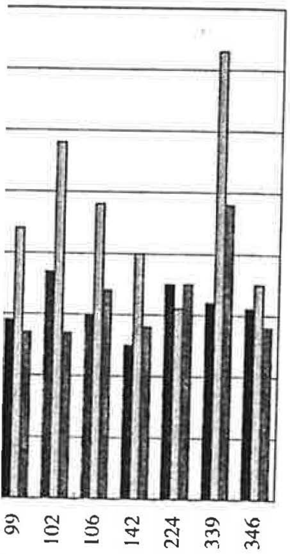

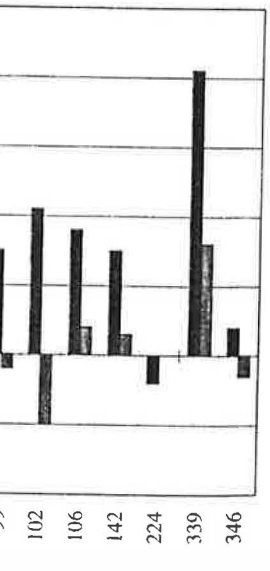

filters.

DISCUSSION

The values for the perceived air quality levels correspond to percentages of dissatisfied of 28 to 55% for the treated filter and 22 to 44 % of the untreated filter. Pasanen et al. (4) found percentages of dissatisfied ranging from 23 to 43% for filters with a loading time of 26 weeks. In a study carried out by Pejtersen (9), values for perceived air quality of the same order of magnitude were found.

No clear pattern can be found in the influence of the filters on the sensory air quality. There is no significant change during the time of exposure. Pasanen et al. (4) found a strong rise in perceived air quality (percentage of dissatisfied) during the first 2 to 4 months. After 4 months, the perceived air quality did not change significantly. Pejtersen (9) also found a rise in perceived air quality in time.

For filter A, there is a weak trend of higher differences in perceived air quality over the filter in the course of the experiment. For filter B, the highest differences, and thus emissions from the filter, were observed at the start of the experiment. It should be noted however that differences were small with values between -1 and +2 decipol in general. Standard deviations for the sensory evaluations laid around 1 decipol.

No clear differences between the perceived air quality caused by a treated and an untreated filter were found. The highest values for the sensory pollution were found for the treated filter. However, an analysis of variance showed no significant difference between the two filters.
The high values for filter A, despite the treatment to inhibit microbial growth, might be explained by a limited range where the treatment is effective. On the outer layer of the pollution on a filter microbial growth might still occur, depending on the dust load. However, no micro-biological measurements were performed to confirm this theory.

The maximum values for the sensory pollution load found in this study were 254 olf (treated filter) and 174 olf (untreated filter), respectively. Bluyssen (2) found values for the pollution load of used filters ranging from 15 olf at 13.6 l/s to 149 olf at 101 l/s. Pejtersen (9) found pollution loads of 164 olf after 18 weeks.

It seems that results can be dependent on the specific moment in time when evaluations take place. Examples are the evaluations on days 21 and 25 and days 102 and 106, respectively.

Shutting down the ventilator had a distinctive influence on the perceived air quality. Directly after the restart of the ventilator in January 1996, higher decipol values, especially for the treated filter, were found than during the previous ten months. After one week of continuous airflow through the filters, the decipol values were back to the levels found before the shut down of the ventilator. In several other investigations (1, 2, 4) filters were taken out of the air handling units. In this way an artificial stop of the airflow through the filter was created. This might have led to higher perceived air qualities at the test.
The high values for perceived air quality after restarting the ventilator confirms the statement from Ruden (10) that a continuous airflow through the filters has a negative impact on microbial growth. This might lead to lower emissions. Maintaining a continuous airflow through the filters is a simple measure that also can be used in existing HVAC-systems. However, since a continuous flow through the filters will lead to higher energy consumption,

it should be investigated further which minimal airflow through the filters is needed to reduce the perceived air quality from filters.

Another point of investigation is the use of the comfort equation ([1]) to calculate pollution loads of ventilation systems and its components. Several studies showed that when the airflow is increased, the pollution load of the polluting filter increased proportionally (2, 11). Remarkable is however, that in these studies the perceived air quality levels before and after the filters did not change significantly with the airflow.

ACKNOWLEDGEMENTS

The study reported above has been made possible by grants of the Dutch Ministry of Housing, Planning and Environment.

REFERENCES

1. Hujanen, M. Seppanen, O., Pasanen, P., 1991. Odor emission from the used filters of air-handling units. Healthy Buildings- IAQ '91, Washington D.C., USA, pp. 329-333.
2. Bluyssen, P.M., 1993. Do filters clean or pollute the air. Air infiltration Review, vol. 14, no. 2, pp. 9-13.
3. Finke, U., 1993, Verunreinigungsquellen in Klimaanlagen, Ki Klima Kälte Heizung 10/1993, pp.392-395.
4. Pasanen, P.O., Teijonsalo, J., Seppänen, O., Ruuskanen, J., Kalliokoski, P., 1994, Increase in perceived Odor Emission with Loading of Ventilation filters, Indoor Air, no.4, pp.106-113.
5. Pejtersen, J., 1994. Pollution sources in ventilation systems, Ph.D. Thesis, Technical University of Denmark.
6. Bluyssen, P.M., 1990, Air quality evaluated by a trained panel, Ph.D. Thesis, Copenhagen, Laboratory of Heating and Air conditioning, Technical University of Denmark.
7. Bluyssen, P.M., 1994, The zero-decipol room: a room for training persons to evaluate perceived air quality in decipol, Healthy Buildings '94, Budapest, Hungary, vol.2, pp.509-514.
8. Fanger, P.O., 1989, The new comfort equation for indoor air quality, ASHRAE Journal, October 1989, pp.33-38.
9. Pejtersen, J., 1996, Sensory pollution and microbial contamination of ventilation filters, Indoor Air, no.6, pp. 239 -248.
10. Ruden, H.K., Botzenhart, K., 1974, Untersuchungen zur Frage des Wachtums abgeschiedener Mikroorganismen auf Glasfaser-Feinstaub- und Glasfaser-Hochleistungsschwebstoff Filtern, Gesundheits Ingenieur, 95, pp. 318-321.
11. Torkki, J. Hotokainen, O Seppänen, Olfactory emissions of used filters, Healthy Buildings'95, Milano, 1995, vol.2, pp.941-946.

KEY WORDS

filter, perceived air quality, HVAC system, emissions, chamber study

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EFFECT OF PAR
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Laboratory of Heating,

ABSTRACT

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INTRODUCTION

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