AIR FILTERS - CAN THEY BE USED FOR AIR QUALITY CONTROL

Gunnar Graeffe
Tampere University of Technology, Tampere, FINLAND

Abstract

The air impurities can be removed with different kinds of air filters. If the impurity to be removed is known, which is often the case e.g. in industry, the proper device or action can be chosen. Indoors, in dwellings and offices, the problem is more indistinct. There is a variety of different pollutants, mostly in small amounts and concentrations. The filters are selective and they can remove only certain groups of pollutants.

There are many commercial air cleaning devices available, mostly intended to the filtration of particles (dust, smoke, fume etc.). Cleaning devices for gases e.g. volatile chemical compounds are few. When used indoors the devices quite often function unsatisfactory due to noise level, effective air flow, flow resistance, cleaning and maintenance, odor, ozone production and so forth. In many cases filtration of air or the use of air cleaning devices is argumented but the main effort is as much as possible to eliminate the sources generating indoor air pollution.

Introduction

The requirements usually for the houses are:

- healthy
- economical
- comfortable
- aestethic
- energy saving.

Some of these requirements are contradictory. Indoor environment is complex. Good indoor environment and healthy building (1) consist of many factors:

- thermal environment
- draught
- humidity
- light
- color
- noise
- indoor pollution
  - particulate matter
  - gases, chemical compounds
- electromagnetic fields.

With air cleaners we can affect some of the factors. Firstly we should analyze what we mean with good and healthy air. Usually the quality of air is judged by its chemical composition. In industrial environments we have established threshold limits for single chemical compounds which are usually products of the production processes. The limit values are often compromises between detectability and the acceptable risk. Thus the limits are quite high. When measuring chemical compounds we can be happy if we can measure concentrations down to 10^{-9}. There are exeptions, though. In the case of radon or radiactivity generally we can actually measure each disintegrating atom.

In dwellings, schools and offices the situation is different. The observed concentrations of chemical pollutants are far below the limits established for industrial use (2, 3). We still have problems and health effects. Generally we assume that outdoor air is good or at least better than indoor air. But we know that at least in industrialized world outdoor air is quite badly polluted and it often causes serious health effects.

Removal of the source

The most effective and chiefly also the most inexpensive way to prevent indoor air pollution is the removal of the source. Those actions which have been made e.g. in the case of formaldehyde have been succesful. By proper construction the radon entry to the houses can be eliminated. For smoking some countries have restritions in official buildings. All materials and systems are polluting or in some cases absorbing pollution. The idea of Fanger to introduce a new unit olf is due to that (4, 5). In the air there are thousands of different pollutants in small amounts. The way of studying one component at the time does not solve the problem. With the new unit olf it is strongly emphasized that when we build our houses and dwellings we should pay attention to what we do and what kind of materials and systems we use. There are many other factors than just human beings which are polluting indoor air.

Air cleaners

In the following we shall concentrate on some aspects of air cleaners mostly removing particulate matter. There are some methods (chemical sorption, vapor ventilation, combustion and scrubbing) and devices to remove chemical compounds. Methods are selective; they can remove one group of impurity but others come through. Usually also large installations are needed; for small houses devices with absorbents are used but results are not yet too succesful. There are problems with the cost of maintenance, efficiency, air flow resistance, pollution holding capacity and so forth. In a HVAC system fibrous media filters, renewable media filters and electronic air cleaners to remove particulate matter are used. Efficiency, air flow resistance and dust holding capasity determine the quality of the system (6). More than 90 % of particulate matter can be removed from the incoming air. Special attention should be paid to maintenance of the system.

Cleaning efficiency

$$E = (1 - \frac{c}{c_o}) \qquad (1)$$

is an important quantity when cleaners are considered. Here c_o and c are the concentrations of impurity before and after the cleaner. Even more important quantity for room air cleaners is the effective flow rate Q_{eff}

$$Q_r E = Q_{eff} \qquad (2)$$

where Q_r is the recirculation rate.

When installing a room air cleaner the effective flow rate should be grater than ventilation rate and the natural removal A of the impurity. We can estimate the effect of a room air cleaner with a simple expression (7)

$$\frac{c}{c_1} = \frac{Q_o + A}{Q_o + A + Q_{eff}}$$

where c and c_1 are the concentrations with and without a cleaner and Q_o the ventilation rate. If for example the room is 50 m^3 and ventilation rate 0,5 l/h with a cleaner of Q_{eff} = 100 m^3/h, one should get a reduction of 80 % in impurity concentration. Theoretically we can remove impurities considerably with air cleaners. In practice the situation is different. In a test of 16 different air cleaners (8), both mechanical and electronic filters, only 2 were qualified acceptable when effective flow rate and noise level were considered. None was qualified good. In a field study in restaurants Kimmel (9) obtained a reduction of 20 - 50 % in particles by using electrostatic presipitators. In laboratory conditions Olander et al (10) made an extensive study on how air cleaners effect on tobacco smoke. Cleaners widely sold in Scandinavia, covering mechanical and electrostatic filters as well as ion generators, were studied. Some of the devices had gas cleaning unit as well. Experiments showed that particles can be removed with quite high efficiency. For gases which were also measured (NH_3, NO_x, $(CH_2)_x$, HCHO) the efficiency was quite low. None effect on carbon monoxide was found. Ion generators had minor effect both on particles as well as on gases.

Room air cleaners can remove also radioactive products. It has been demonstrated that air filtes can remove considerably radon daughter products (11, 12) and decrease somewhat the dose. In the recent study (13) even a better result was obtained by using positive ion generator and a ceiling fan. It has been argumented that room air cleaners give relief for allergic and asthmatic persons. In a study by Vilkka et al (12) no positive correlation was found among adults suffering from asthma when electronic room air cleaners were used.

Conclusions

With air cleaners we can reduce considerably the pollution concentration of incoming air. Special attention should be paid to cleaning and maintenance of the system.

There are many room air cleaners available commercially. Some of them are badly operating. Problems which occur are low effective flow rate, sound level, ozone emission, maintenance, installing odors and so forth. When installing a room air cleaner one should consider consider especially the effective flow rate, the space where the cleaner will be used and the ventilation rate.

Standard procedures to test the devices are needed. With properly installed room air cleaner one can remove certain pollutants considerably. But we have to realize that the most effective way of preventing indoor air pollution is to remove the source which emits air pollutants indoors.

References

1. Det sunda huset, report from a Nordic Seminarium, March 1987. Byggforskningsrådet G20:1987.

2. J. Keskinen, V. Kulmala, G. Graeffe, J. Hautanen and K. Janka, Continuous monitoring of air impurities in dwellings , Proc. 4thb Intern. Conference on Indoor Air Quality and Climate. Vol. 2 (1987) 242 - 246.

3. Jan A.J. Stolawijk, The Determination of Health effects of Indoor air Pollution, Proc. 4th Intern. Conference on Indoor Air Quality. Vol. 4 (1987) 3 - 8.

4. P.O. Fanger, Energy and Building 12 (1988) 1 - 6.

5. P.O. Fanger, J. Lauridsen, P. Bluyssen and G. Klausen, Energy and Building 12 (1988) 7 - 19.

6. D.J. Moschandreas, Indoor Air Pollution Controls, Proc. 4th Intern. Conference on Indoor Air Quality and Climate, Vol. 4 (1987) 91 - 103.

7. Matti Lehtimäki, Risto Laitinen, Raimo Viiki, Report C:29, (in Finnish), Occupational Safety Engineering lab., Tampere, Finland (1986).

8. Matti Lehtimäki, Experiences of the studies on room air cleaners, Proc. 1987 Symposium of the Nordic Association for contamination control, (1987) 101 - 104.

9. Jyrki Kimmel, Performance of Electrostatic Precipitators in Restaurants, Proc. 4th Intern. Conference on Indoor ai Quality and Climate. Vol. 3 (1987) 226 - 230.

10. Lars Olander, Johan Johansson and Rolf Johansson, Luftrenares effekt på tobaksrök, Arbete och hälsa.

11. M. Rajala, K. Janka, M. Lehtimäki, V. Kulmala and G. Graeffe, Health Physics 50 (1986) 447 - 455.

12. Niels Jonassen and Bent Jenssen, Radon Daughter Levels in Indoor Air Effects of Filtration and Circulation. Progress report no XII, Laboratory of Applied Physics I. Technical University of Denmark, May 1987.

13. Edward F. Maher, Stephen Rudnick and Dade W. Moeller, Health Physics 53 (1987) 351 - 356.

14. Vesa Vilkka, Tari Haahtela, Sinikka Mönkäre, Paula Kuusisto and Pentti Tukiainen, Air Cleaners in the treatment of adult asthma. DUODECIM 102 (1986) 313 - 319.