

Demonstration of Microorganisms and Dust in Schools and Offices

An Observational Study of Non-Industrial Buildings

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"The sick-building syndrome" (WHO) is reported with increasing intensity in non-industrial places of work, such as schools, kindergartens, and offices, all of which have a heavy load of traffic (people). The construction of these buildings (e.g. flat roofs) often leads to water damage with subsequent microbial growth. Further, reduced cleaning budgets in connection with the wide use of needle-felt carpets, as well as ventilation systems not regularly maintained, will lead to pollution by dust and microorganisms. A systematic registration of dust and microbial parameters has been carried out since 1980 in buildings with indoor climate complaints, in order to elucidate the possible influence of these factors.

Key words: allergy; carpets; dust; indoor climate syndrome; microorganisms; volatiles.

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Organic components in dust, such as mite, mold, animal dander, and pollen acting as specific allergens related to Type I and III allergy are well known (3, 12, 19, 20). Inorganic components in dust acting as etiological factors in industrial pneumoconiosis, such as asbestosis and silicosis are also described (13). The significance, however, of dust and microorganisms and their volatiles as air pollutants in non-industrial places of work has until recently been little investigated (7, 15, 21). An increasing number of people with such a non-industrial occupation complain of the following symptoms: sensation of dry mucous membranes and skin, erythema, mental fatigue, headaches, high frequency of airway infections and cough, hoarseness, wheezing, itching and unspecific hypersensitivity, nausea and dizziness (26).

At a WHO meeting in West Germany in 1982 on indoor climate problems, the following statements were expressed: "The number of case reports describing similar symptoms is now so large that it is reasonable to assume that we

are dealing with a true environmental health problem which is often referred to as "the sick-building syndrome" (26). From field study observations we have noticed that this syndrome is often present in schools and offices which are heavily peopled, use needle-felt carpets, and are so constructed as to cause dust accumulation and microbial pollution, and furthermore have a reduced cleaning budget.

Based on these observations we propose the following hypothesis: Contamination by dust and microorganisms may be an important factor in indoor climate problems since most of the complaints are ascribed to carpeted rooms. These biological factors should be considered together with the physico-chemical factors earlier demonstrated (5).

To elucidate this hypothesis an investigation of the following parameters is being carried out in a number of schools and offices: accumulated dust on carpets/floors, organic macromolecular components of dust, dust-bound molds and airborne molds and bacteria. Further, an etiologi-

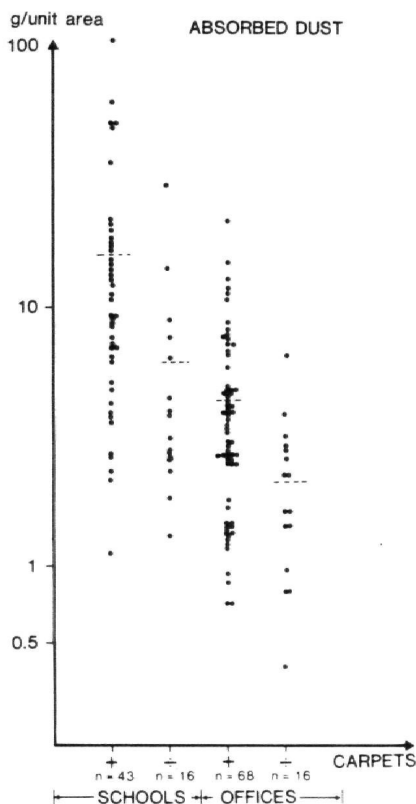


Fig. 1. Individual values of absorbed dust in g/unit area from 143 rooms in schools and offices. Horizontal lines: mean values. Comparison between carpeted rooms (+) and rooms with bare floors (-). $P = 0.001$ (schools), $P = 0.004$ (offices).

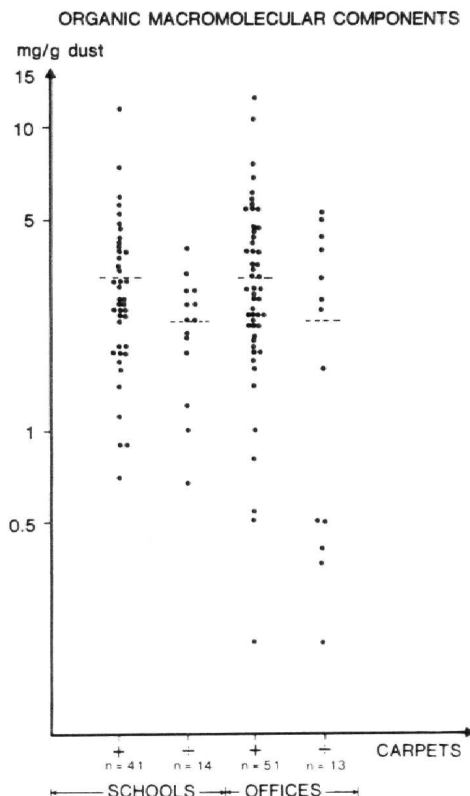


Fig. 2. Individual values of organic macromolecular components in mg/g dust from 112 rooms in schools and offices. Horizontal lines: mean values. Comparison between carpeted rooms (+) and rooms with bare floors (-). $P = 0.054$ (schools), $P = 0.063$ (offices).

cal study of the sick-building syndrome in Copenhagen town halls is being carried out as a multi-disciplinary collaborative study.

In this paper we present the results from the above-mentioned biological parameters measured in schools and offices with complaints ascribed to the indoor climate.

MATERIAL AND METHODS

The material was obtained from 29 offices (68 carpeted, 16 non-carpeted rooms) and 21

schools (43 carpeted, 16 non-carpeted rooms) consecutively investigated during the period 1981-1984. All institutions were referred to the laboratory for further elucidation of the biological factors in the indoor climate after correction of, e.g. temperature and ventilation, but with resistant complaints about the indoor climate. As a consequence, this is an observational study of a highly selected material. Selection of rooms was made after "a worst case and a best case" strategy, i.e. rooms to which most versus no complaints were ascribed.

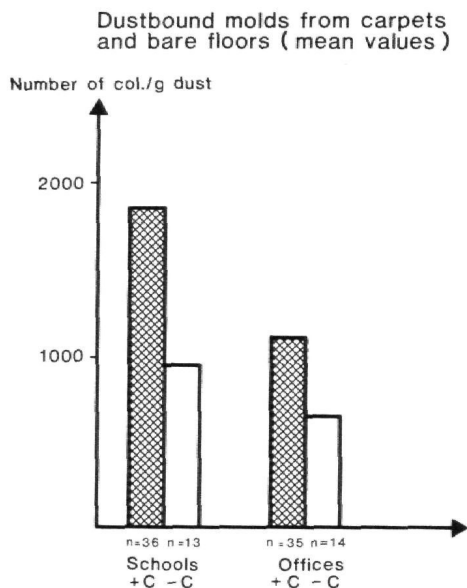


Fig. 3. Mean number of dust-bound molds in col./g dust from 98 rooms in schools and offices. Comparison between carpeted rooms (+) and bare floors (-). $P = 0.002$ (schools), $P = 0.020$ (offices).

The different institutions investigated were schools and kindergartens, banks, a television station, libraries, university and high schools, town halls with tax offices, pay offices and public assistance offices. All these localities were exposed to heavy traffic from people (e.g. children, clients, students) often entering from outside. The carpets, mainly the needle felt type, were made of synthetic material, mainly polypropylene, polyamide (nylon) or mixtures of such materials. The hard floors were either wooden, or covered with vinyl or linoleum.

Sampling procedure

Dust sampling was performed according to the procedure described in (23). No extra cleaning was done in the rooms and no changes made prior to sampling. The analyses were usually carried out the day before the normal cleaning

procedure. All samplings were taken during normal activity, and by the same technician.

The results were given in g dust/area unit. Determination of the organic macromolecular dust components (potential antigenic agents) was done as described by Løwenstein (11) and expressed in mg organic macromolecular dust components/g dust.

The microbial content of the dust was determined by cultivation, and quantitatively expressed in total colony count/g dust. The molds were further identified to genus level after standard taxonomic criteria (7). Microbial airborne particles were collected as described in Gravesen et al. (7).

The parameters studied in carpeted and non-carpeted rooms were compared statistically by means of a Mann Whitney U-test. The level of significance used was 5%.

RESULTS

Fig. 1 shows the results from the vacuum-cleaned floors of schools and offices. The rooms with carpets have significantly higher levels of dust than bare floors ($P = 0.001$ (schools), $P = 0.004$ (offices)).

Fig. 2 shows the amount of organic macromolecular components. The amount was found higher in dust from carpets than in dust from bare floors, both from schools and offices ($P = 0.054$ (schools), $P = 0.063$ (offices)).

Fig. 3 gives the colony count of molds. The microfungi count from schools and offices is significantly higher in dust from carpets than in dust from bare floors ($P = 0.002$ (schools), $P = 0.020$ (offices)).

According to previous observations (7), the mean levels of microorganisms (both microfungi and bacteria) are higher above carpets than above bare floors, although the difference is not statistically significant ($P = 0.250$ for airborne molds in schools and $P = 0.085$ in offices; $P = 0.290$ for airborne bacteria in schools and $P = 0.155$ in offices). Thus, for all parameters studied, the counts are higher in carpeted rooms than in rooms without carpets.

Table 1 shows the percentage distribution of different genera of microfungi in air and dust

from schools and offices. The genera are represented by the normal ubiquitous fungal flora. In the two types of institutions the dominating genus is *Penicillium*, both in dust and air, ranging from 66 % to 81 %. *Aspergillus* ranks third in the airborne microfungal flora. *Fusarium* is frequently found in the dust samples.

DISCUSSION

Environmental factors

One notable point in this study is the higher microbial and dust levels from carpeted versus non-carpeted rooms. The same tendency was demonstrated in Colldahl's study of airborne microorganisms, as well as for accumulated dust and organic macromolecular components (4). This is in agreement with our previous observations on airborne microorganisms from schools and offices (7). The range, however, is very wide in such a dynamic parameter which is dependent on factors present during the sam-

pling procedure, for instance, activity of people, ventilation rates, and especially water damage.

The higher levels of dust and microorganisms could be explained by the fact that carpets act as reservoirs for the large amount of dust and dirt brought in by people. The carpets also act as "cultivation media" for common microbial organisms in the case of water damage, either accidentally or on purpose, e.g. to prevent static electricity. During the growth of microorganisms in carpets, not only the microbial particles but also a long row of volatile organic components are released as intermediate or end products of the microbial metabolism (6, 10, 17).

From a microbiological point of view, it is logical that carpets are more contaminated than bare floors. In this investigation we noticed that most of the carpets were more than 5 years old. Carpets stay moist longer after wetting than bare floors. Furthermore, since dust particles are not removed as easily from carpets as from bare floors, there will be a higher accumulation of especially fine dust particles. Washing floors is a much more efficient way of disinfecting than vacuum-cleaning or shampooing carpets. A bare floor is exposed to the main natural disinfectant, visible light, whereas a carpet is impenetrable.

As a consequence of the above-mentioned factors, it could be anticipated that the components of carpet dust should differ in nature from floor dust. This difference is demonstrated in the greater amount of macromolecular components found per gramme carpet dust versus floor dust.

Another remarkable point in this material is that complaints always referred to the carpeted rooms ("worst case rooms"), whereas no one complained about the rooms with bare floors, e.g. the music-room or the physics laboratory in schools.

Clinical factors

An investigation of two schools (one from 1930 with hard floors and one from 1975 with carpets) showed significantly more teachers suffered from headache and irritation of the

Table 1

Frequency of airborne and dust-bound microfungal genera in schools and offices recorded by means of a BIAP slit sampler. (Air: $n = 143$) (Dust: $n = 98$)

Presence of moldgenera			
Air		Dust	
Schools			
Penicillium	81 %	Penicillium	81 %
Cladosporium	64 %	Fusarium	74 %
Aspergillus	52 %	Alternaria	56 %
Alternaria	29 %	Cladosporium	52 %
Rhodotorula	24 %	Mucor	40 %
Trichosporon	24 %	Trichosporon	30 %
Arthrinium	19 %	Chaetomium	25 %
Mucor	17 %	Trichoderma	21 %
Offices			
Penicillium	66 %	Penicillium	78 %
Cladosporium	57 %	Alternaria	76 %
Aspergillus	52 %	Aspergillus	55 %
Yeasts	24 %	Cladosporium	45 %
Trichosporon	15 %	Fusarium	45 %
Alternaria	13 %	Trichosporon	45 %
Rhodotorula	13 %	Yeasts	33 %
Paecilomyces	9 %	Mucor	29 %

mucous membranes in the nose, pharynx and rhino-pharynx, in the school with carpets (22). Ibsen et al. (9) demonstrated a more frequent occurrence of specific allergy (asthma and rhinitis) in schools with carpets compared to schools with hard floors. More than a third of the pupils participating in the indoor environment investigation had complaints which they connected with the indoor environment.

Recently, a report has been issued from the Danish Health Authorities on whether carpeting in schools has any influence on asthmatic children with regard to their symptoms and consumption of medicine. In this report it is shown that children with severe asthma who live in renovated homes without carpets get a worsening of symptoms when they attend schools with carpeting (2).

Our findings are reasonably consistent with the findings of Holmberg, who found a higher prevalence of subjective symptoms in buildings with mold damage than in buildings without (8). Likewise, the Danish Building Research Institute showed a higher prevalence of headache and upper airway symptoms among persons living in dwellings with moisture or visible mold growth (24).

Human and animal studies (1, 14, 16) have shown the existence of several sensory organs in the upper and lower airways as well as in the nose and eyes. In these organs, irritative gasses and vapours as well as dust particles may elicit a feeling of mucosal irritation. The most important sensory organ related to this is Nervus trigeminus (14).

We are thus dealing with at least three different modes of exposure: The mechanical influence, with the possibility of irritation of skin and mucosa, the antigen exposure, with possible subsequent immunological reactions, and the possible toxic reactions from the organic volatile compounds developed from the growing microorganisms.

This investigation has not been carried out as a planned case/control study but as long term observational study. No confounding factors have been taken into consideration, but in the epidemiological Copenhagen Town Hall study (25) a total evaluation of all possible factors

considered of importance in indoor climate problems is made. However, as all parameters measured show a higher level in carpeted rooms i.e. rooms with most complaints, our findings support the hypothesis that dust and microorganisms may be an important factor in indoor climate problems.

It is thus recommendable to avoid carpets in rooms used by large numbers of people coming in from the street and instead leave the floors bare, thus preventing needle-felt carpets acting as dust reservoirs or cultivation media, with subsequent release of particles and volatiles.

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