AIRBORNE FUNGAL SPORE AND BACTERIA LEVELS IN FINNISH HOMES WITH DIFFERENT VENTILATION SYSTEMS

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Abstract

The fungal spore, bacteria and total particle mass levels were monitored inside and outside apartment buildings with different ventilation systems. First sampling was carried out on completion of the houses before the tenants moved in and later during different seasons. The sampling was performed with a six-stage impactor for spores and bacteria and Nuclepore filters for total particle mass. The results show that mechanical supply and exhaust ventilation decreases indoor levels of fungal spores. The effect is not so evident for bacteria or total particle mass. The effect of occupancy could, however, be seen on indoor bacteria and total particle mass levels.

Introduction

Fungal spore and bacterial counts are important parameters of indoor air hygiene. The sources of spores are mainly outdoors while for bacteria and total particle mass there are sources both indoors and outdoors (4). The aim of this study was to find out indoor air levels of fungal spores, bacteria and total particle mass in certain Finnish homes equipped with different ventilation systems. The effect of occupancy was studied by starting the monitoring before the tenants moved in.

Material and methods

The study homes are situated in Kuopio, the regional center of Eastern Finland with 80 000 inhabitants. The three new apartment buildings are situated side by side, and are identical in construction except for different ventilation systems consisting of: 1) ventilation due to gravity (house B) 2) mechanical exhaust ventilation (house C) and 3) mechanical supply and exhaust ventilation (house D). There are six homes in each house - four 40.5 m^2 flats and two 56.5 m^2 flats. The tenants are young families of 2 - 5 persons.

Sampling apparatus. Fungal spore and bacteria samples were collected with six-stage cascade impactors (1) using malt-extract agar plates for spores and tryptose-yeast-glucose agar plates for bacteria sampling. The sampling time was 15 - 30 minutes with a flow rate of 28 liters/minute and the plates were incubated at 20°C for 7 - 10 days. The fungal spore and bacteria plate counts were transformed to counts of colony forming units per cubic meter. Particles were collected by Nuclepore stacked filter unit samplers for 7 - 8 hours and analyzed gravimetrically. Ventilation rate, temperature and humidity in each of the studied apartment as well as outdoor wheather conditions were monitored by an automatic data collection system reported elsewhere (3).

Sampling. Four two week series of samples were collected in 12 months: the first in the fall of 1985 when the homes were completed, without furniture and tenants; the following three in the winter, spring and fall of 1986, when the homes were inhabited. In most homes the sampling was carried out while the tenants were at work and school. Samples were taken from living or bedroom on the same hour of the day and in the same room in each measurement cycle. Families were allowed to carry out their normal daily activities and to adjust ventilation, temperature and humidity levels as they liked.

Statictical analyses were performed by SPSS-X programs on daily geometric mean values. Pearson correlation coefficients were calculated from log-transformed values. The indoor/outdoor -relationship (I/O) of spore and particle mass concentrations were used instead of indoor concentrations in statistical tests. Differencies between the buildings with different ventilation systems were tested by the Kruskal-Wallis one-way analysis of variance (three independent groups) and by the Mann-Whitney U test (two independent groups). The effect of occupation on the indoor levels was tested by comparing the results in the fall before and after the move-in (falls 1985 and 1986) using the Wilcoxon Signed-Ranks test.

Results

Concentrations. The indoor air fungal spore levels were below 1300 cfu/m^3 (Table 1) and correlated significantly ($p < 0.001$) with outdoor spore levels. The indoor bacteria levels varied between 30 and 2500 cfu/m^3 and did not correlate significantly with outdoor bacteria concentrations. The total particle mass varied between 15 - 130 $\mu g/m^3$ (Table 1). Most of the values (70%) were below 60 $\mu g/m^3$. The correlation between indoor and outdoor particle mass concentration was not significant indicating that indoor particle sources are important.

Table 1: Geometric mean (x), geometric standard deviation (s), minimum, maximum and number of observations (n).

	x	s	minimum	maximum	n
Spores cfu/m^3					
indoor	140	5.3	3	1300	62
outdoor	250	9.6	<4	1700	63
Bacteria cfu/m^3					
indoor	330	3.0	30	2500	63
outdoor	60	5.5	<4	1600	63
Total particle mass $\mu g/m^3$					
indoor	38	1.6	15	130	63
outdoor	33	1.8	15	90	63

The effect of different ventilation systems. Statistically significant ($p < 0.05$) differences between the three differently ventilated buildings were observed in I/O -relationships of fungal spore counts during the spring 1985 ($p < 0.05$) and fall 1986 ($p < 0.05$). The differencies applied only to total spore counts and to large spores ($D_p > 2 \mu m$). The highest I/O -values of large spores were in the house C and lowest in the house D ($p < 0.02$) in the spring 1986. In the fall 1986 the I/O -values of large spores in house B were higher than in house C ($p < 0.05$) and house D ($p < 0.03$). The bacteria concentrations and the I/O -relationships of particle mass concentrations did not differ significantly between the research houses.

The effect of occupancy was seen in the airborne bacteria levels ($p < 0.01$) and in the I/O -values of particle mass ($p < 0.01$) (Fig. 2). The I/O -values of spore counts did not change from the fall 1985 to 1986.

Discussion

The indoor and outdoor spore counts were lowest in winter. The high I/O correlation ($p < 0.001$) indicates that there were no remarkable spore sources in the homes. The I/O correlations of bacteria and particle mass concentrations were not significant indicating intramural sources eg. humans for these parameters. In the spring and the fall, when outdoor spore concentrations are highest, the lowest I/O -values were in the house with mechanical supply and exhaust ventilation with air filtration. This shows that concentrations of particles which are mainly outborne can be reduced by air filtration. This is similar to the findings of Pellikka et al. /2/. The effect of

occupancy on indoor air is poorly known. Our results show that the effect of occupancy can be studied with the aid of airborne bacteria levels and total suspended particles, which have remarkable intramural sources, too.

Acknowledgements

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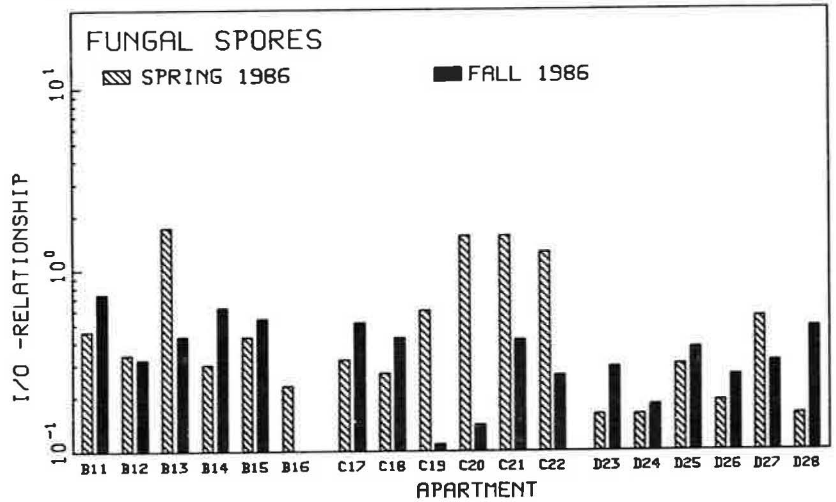

Fig. 1. I/O -values of fungi in each home in the spring and in the fall of 1986.

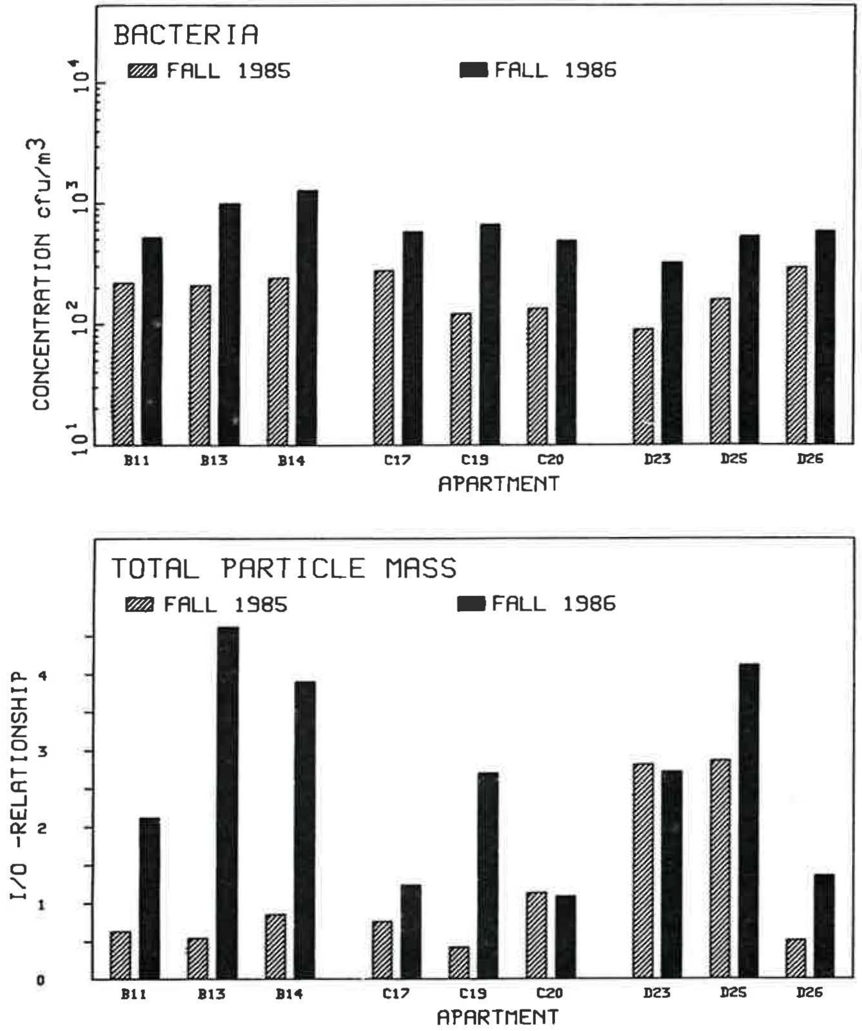

Fig. 2. Indoor bacteria concentrations and I/O -values of particles in each home in the falls 1985 and 1986.

INDOOR MOULD EXPOSURE AND HEALTH EFFECTS

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Abstract

Subjective complaints reported by 33 adult occupants in 13 buildings with interior mould sources, were recorded by a standardized questionnaire, and an interviewer-administated questionnaire completed by a physician. The questionnaire data from these 2 sources was compared, and examined for reporting bias. The patterns of responses were similar, and indicated an overall prevalence rates of 73% for subjective complaints of eye and skin irritation, respiratory symptoms and constitutional symptoms such as headache and fatigue. Microbial analyses identified the interior mould sources as overgrowth of Aspergillus fumigatus and A. flavus. Total airborne fungal levels averaged 343 ± 406 colony forming units (cfu) per m^3, and airborne Aspergillus counts 116 ± 132. Other environmental measurements included indoor relative humidity, ventilation rate, and tests for other air contaminants in the occupied spaces.
All occupants underwent a medical examination including test for nonspecific airway hyperreactivity, pulmonary function tests and a series of laboratory tests in order to reveal predisposing features for adverse health effects in the study population.
Univariate analyses were used to test for association between symptoms and environmental exposures and medical examination variables. Additionally, the effects on symptom prevalences of these factors were evaluated using a multivariate technique. A significant association was present between the duration of exposure, elevated indoor levels of airborne Aspergillus particles, atopic disposition, and some of the reported complaints. These stratified analyses were confirmed by the logistic model that controlled for other known risk factors.

Introduction

Many single family houses and other residential dwellings in Sweden are contaminated with endogenous mould sources. Recent data from nationwide measurement programmes indicate that several tens of thousands of dwellings are contaminated (1). Experience made by various local and regional health authorities have indicated that mould contaminated dwellings are responsible for subjective irritative symptoms of the throat, eyes and skin in healthy occupants, and increased respiratory complaints in sensitive individuals. However, the presence of adverse effects has not yet been objectively validated.

Quite controversial standpoints have been taken as to the type and magnitude of the health risks from indoor exposure to airborne mould particles and their metabolic and decay products. Based on extrapolation from work-related high-dose exposure of mould, immunological and toxico-