CLASSIFICATION OF DAMPNESS IN HOMES

B. Brunekreef (1), L. de Rijk (1,2),
A.P. Verhoeff (3), R. Samson (4)

(1) Department of Environmental Health,
University of Wageningen,
P.O. Box 238, 6700 AE, Wageningen,
The Netherlands
(2) Department of Air Pollution
University of Wageningen
(3) Municipal Health Service, Amsterdam
(4) Centraalbureau voor Schimmelcultures,
Baarn

A checklist system for classification of home dampness in epidemiological studies was used in 84 homes located in Wageningen, The Netherlands. In addition, inhabitants were asked to answer questions about home dampness, and viable mould spore measurements were made in and out of the homes. There was some relationship between home dampness and the concentration of viable mould propagules indoors, but the associations were generally weak.

INTRODUCTION

The classification of home dampness for epidemiological studies presents several problems. Measurements of mould propagules in the air are highly variable in time and space. Measurement of dust mite allergens in house dust is cumbersome and not very feasible in large scale studies. Recent studies have documented associations between simple dampness characteristics of homes and respiratory morbidity (1-5). In most cases, study subjects reported on the presence of damp spots, mould growths, water damage, basement flooding and the like in their homes, and the relationship between these dampness characteristics and objective measures of home dampness or biological contamination is unclear. This paper discusses a study in which a checklist system, currently in use in the Netherlands to investigate home dampness, was used to classify 84 homes. In an earlier study (6), we found that the results of the classification correlated weakly with indoor viable mould propagule concentrations. However, outdoor measurements were not made at that time. Therefore, we included measurements of viable mould propagules in the air of living rooms, bedrooms and outdoor air using Andersen N6 samplers and (indoor only) open petri dishes.

SUBJECTS AND METHODS

The study was performed in 84 homes, located in Wageningen. The homes were selected from an area where in the past, dampness problems were reported for some homes. In May 1989, all homes were inspected with a checklist system originally developed to assess to what extent a house was infested with house dust mites (7). It has been in use in the Netherlands since the late 60's and it focuses on building characteristics that may give rise to too high a moisture content in parts of the structure, and on observable signs of dampness. Among the characteris-

tics that may give rise to dampness problems are the age of the building (assuming that older homes have more dampness problems - with new tight building practices, it is felt that this assumption should be revised); the state of maintenance (assuming that bad maintenance means better chances for moisture to penetrate the building shell); floor height above ground level (in many parts of the Netherlands, the water table is just below ground level, so that floor height above ground level says something about the chance that moisture rising from the water table through capillary action will penetrate the walls up to floor level); the presence or absence of special construction features to prevent water to rise from the ground); the presence or absence of ventilated basements or crawl spaces; the presence or absence of soil cover in basements or crawl spaces; soil type; the presence or absence of outer cavity walls (which are less penetrable by moisture); the presence and type of heating for each room; the possibilities for ventilating in each room (assuming that well ventilated rooms are drier than poorly ventilated rooms); the access of sunshine to each room (assuming that sunny rooms are drier than rooms to which the sun has no access). Among the observable signs of dampness are the presence of water in the basement or crawl space; the presence of damp stains on indoor walls, wallpaper etc.; the presence of mouldy spots on indoor walls, wallpaper etc.; the presence of mouldy or stale odors; the presence of woodrot in floors and skirting boards; the presence of organisms like silver fish. The system was developed primarily to assess whether conditions would be favorable for the development and survival of house dust mites. For this reason, damp stains and mouldy spots on ceilings and the like, i.e. away from the floor level, were originally not considered to be important, as dust mites do not live on walls and ceilings. However, in later applications, damp stains and mouldy spots on indoor surfaces have been recorded irrespective of their location, to assess dampness in a more general sense. The checklist records each item on a scale from 0-4, and gives equal weight to the building characteristics and to the observable signs of dampness. It results in a score with a range from 0-55, and a score of 20 has been somewhat arbitrarily used to separate (relatively) dry from (relatively) damp homes.

In addition, one adult subject in each home was asked to complete a questionnaire containing simple questions about home dampness as those used in an earlier study (4).

Viable mould propagules were measured in the living room, one bedroom, and in the outdoor air immediately next to the study homes using Andersen N6 samplers with dichloran 18% glycerol agar (DG18) as discussed in (8). Also, open petri dishes with DG18 were used to collect settling propagules in the living room and one bedroom. After colony counting, fungal spores and/or mycelium were transferred from the culture plates of the N6 measurements in the living room and outdoors in/near 18, randomly selected homes onto appropriate media for identification up to species level, by the Centraalbureau voor Schimmelcultures, Baarn, The Netherlands.

RESULTS

The mean dampness scores as estimated from the checklist are given in Table 1. Full checklist data were obtained in 83 homes. The measurement period was characterized by unusually warm and dry weather, and under those circumstances, virtually no homes were found to be damp upon

inspection. In an earlier study conducted in the fall of 1987 in 45 Amsterdam homes, a mean dampness score of 18.7 (entire home) was found, and 13 homes were found to exceed a score of 20 (6).

In 35 homes of 74 that had information on this item, resident subjects reported that damp stains had been present at least sometime in the past two years. In 19 homes of 78 that had information on this item, resident subjects reported that mould stains had been present on indoor surfaces at least sometime in the past two years. In the Amsterdam study (6), it was also found that relatively more homes were classified as 'damp' by the inhabitants than by the checklist system.

Table 1. Dampness scores for four rooms separately, and for the entire home, as estimated with a checklist system in 83 homes located in Wageningen, The Netherlands

Location	Dampness score Mean	range	Dry (<20)	Damp (>20)
Living room	11.0	7.0 - 16.9	83	0
Bedroom	11.4	6.0 - 23.2	80	3
Kitchen	10.7	6.5 - 19.2	83	0
Bathroom	12.3	6.0 - 22.8	80	3
Entire home	11.5	7.1 - 22.1	82	1

Table 2 lists the results of the viable mould propagule measurements. Relatively high mean concentrations 1600 - 2100 colony forming units (CFU) /m^3 were found. With the open petri dishes, an average of 27 CFU were found in the living rooms (range 2 - 528) and of 21 CFU in the bedrooms (range 1 - 206).
The concentration distributions were highly right skewed, so that geometric means were more than twice as low as arithmetic means. Over all indoor concentrations were not much different from outdoor concentrations. However, whereas ln-transformed indoor concentrations in bedroom and living room were well correlated (r = 0.72), indoor concentrations were not well correlated with outdoor concentrations (r = 0.13 and 0.19 respectively for living room and bedroom concentrations).

Table 2. Mean viable mould propagule concentrations in CFU/m^3 as measured in and out of 84 homes located in Wageningen, The Netherlands, in May 1989

Location	Mean	Range	Geometric mean	GSD
Living room	2064	104 - 43200	806	3.09
Bedroom	1795	72 - 24000	822	3.23
Outdoors	1597	125 - 22400	882	2.49

Also, the species distribution was rather different outdoors from indoors (Table 3). Notably, Penicillium and Aspergillus were higher indoors than outdoors, and there was not much correlation between indoor and outdoor concentrations. Cladosporium concentrations were higher outdoors than indoors, but this was mostly so for C. herbarum. For Cladosporium in general, and for C. herbarum, the correlation between indoor and outdoor concentrations was significant.

Table 3. Geometric mean viable mould propagule concentrations for some major species in CFU/m³ as measured in and out of 18 homes located in Wageningen, The Netherlands, in May 1989

Species	Living room	Outdoors	r[a]	p[b]
Penicillium	154	65	0.16	0.06
aurantiogriseum	2	4	0.07	
brevicompactum	15	6	0.35	
glabrum	6	2	0.04	
olsonii	8	3	-0.16	
Aspergillus	24	8	-0.18	0.11
penicillioides	6	2	0.26	
versicolor	4	2	-0.23	
Cladosporium	245	501	0.57*	<0.05
cladosporioides	65	72	0.19	
herbarum	59	224	0.58*	

a Pearson correlation between indoor and outdoor concentration
b significance of T-test on differences between indoor and outdoor concentrations
* $p < 0.05$

Geometric mean concentrations of viable mould propagules as measured with Andersen N6 samplers and with the open petri dishes were marginally higher in homes where damp stains or mould were reported by the inhabitants. Correlations between dampness scores and concentrations of viable mould propagules were generally positive but weak, with values between 0.17 and 0.28 for concentrations measured in the rooms to which the dampness scores applied. Figure 1 shows the scatter of viable mould propagule concentrations in the living rooms in relationship to the dampness scores for the living room.

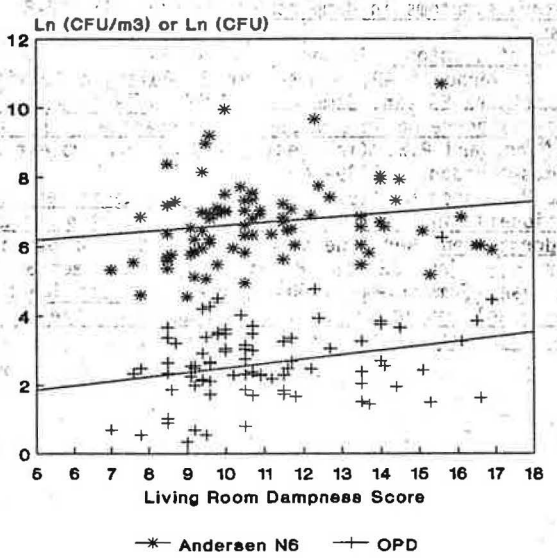
DISCUSSION

Compared to other studies (6) in which the checklist system has been used, the homes in this study were relatively dry. During the study, the weather was unseasonably warm and dry, and this may have affected the results, as some items in the checklist system apply to the actual presence of signs of dampness in the home.

In indoor as well as outdoor air, relatively high concentrations of

viable mould propagules were found. This is probably related to the month of measurement (May 1989).

Figure 1. Relationships between home dampness and viable moulds



For individual homes, there was not much correlation between indoor and outdoor concentrations, however, and indoors, the predominating species were different from those outdoors (Table 3). However, for Cladosporium, some significant correltations between indoor and outdoor concentrations were found, suggesting that for Cladosporium, outdoor air was the major source of the propagules found indoors.

The correlations between home dampness and indoor viable mould concentrations were positive but low, and figure 1 shows that there was much scatter. This is in line with our earlier work (6). At present, the association between checklist results and the dust mite allergen content of house dust is being investigated. Also, separate checklists for detection of dust mite and mould problems are being developed.

REFERENCES

1. Andrae S, Axelson O, Bjorksten B, Fredriksson M, Kjellman N-IM (1988) Symptoms of bronchial hyperreactivity and asthma in relation to environmental factors. Arch Dis Childhd 63: 473-8
2. Brunekreef B, Dockery DW, Speizer FE, Ware JH, Spengler JD, Ferris BG jr (1989) Home dampness and respiratory morbidity in children. Am Rev Resp Dis 140: 1363-1367
3. Martin CJ, Platt SD, Hunt SM (1987) Housing conditions and ill health. Br Med J 294: 1125-7
4. Waegemaekers M, Van Wageningen N, Brunekreef B, Boleij JSM (1989) Respiratory symptoms in damp homes. Allergy 44: 192-8
5. Strachan DP (1988) Damp housing and childhood asthma: validation of reporting of symptoms. Br Med J 297: 1223-6
6. Fischer P, Verhoeff AP, Brunekreef B, Boleij JSM, Wijnen JH van, Reenen-Hoekstra ES van, Samson RA (1988) Relationships between home dampness, airborne mould propagules and guanine levels in housedust. In: R. Perry and P.W. Kirk (eds), Indoor and ambient air quality, Selper Ltd, London, p. 439-445
7. Varekamp H, Leupen MJ (1970) Onderzoekingen over het verband tussen de vochtigheid van woningen en chronische klachten van de luchtwegen bij minderjarigen. Ned T Geneesk 114: 352-355 (in Dutch)
8. Verhoeff AP, Wijnen JH van, Boleij JSM, Brunekreef B, Reenen-Hoekstra ES van, Samson RA (1990) Enumeration and identification of airborne viable mould propagules in houses - a field comparison of selected techniques. Allergy 45: (in press)