DUSTY, DRY AIR AND SICK BUILDING SYNDROME

T.S. Burt

Dept of Energy Technology
Royal Institute of Technology,
100 44 Stockholm, Sweden

ABSTRACT

This investigation was carried out on a mechanically ventilated office building with a high prevalence of occupant symptoms. The commonest complaints were of dry air, stuffy air and noise. Occupant symptoms, however, were most strongly associated with reports of dusty air and static electricity. Allergic and asthmatic people suffered the most. Cleaning standards were high, and upgrading the air filters failed to give improvements in occupant symptoms. Air flows to the rooms were adequate, but air movements in the rooms were poor. Remedial measures should focus on improving air distribution, rather than increasing air flows.

KEYWORDS

Sick building syndrome, dry air, dusty air.

INTRODUCTION

Reports of both sick building syndrome (SBS) and dusty air come predominantly from mechanically ventilated buildings (Hodgson 1997). Many investigators have found an association between perceived dusty air and symptoms (Skåret et al 1995). Wallace et al (1993) reported that perceived dust was associated with nasal congestion, throat symptoms, dizziness and dry skin. Gyntelberg et al (1994) reported that the qualitative properties of dust are important to SBS: gram-negative bacteria were associated with general symptoms (headache, fatigue, dizziness, concentration problems); dust particles were associated with mucous membrane symptoms (nose and throat); dust carrying volatile organic compounds, histamine or potentially allergenic material was associated with some general symptoms.

This report concerns part of a broad-based study on a ten-storey office building in Stockholm. The building had a mechanical supply and exhaust ventilation system, with no humidification and no air recirculation. Complaints of dry air were more prevalent than complaints of dusty air, but the complaints of dusty air were more strongly associated with SBS symptoms. The source of the dust appeared to be the ventilation system.

METHOD

Self-administered questionnaires were given to the occupants, and measurements were made of their offices while they filled out the questionnaire. The questionnaire consisted of questions relating to the indoor environment, plus a set of symptoms taken from a questionnaire frequently used in Scandinavia for building studies and recommended as a standard (Andersson et al 1988). The response scale for the symptoms was a five-point scale of combined frequency and intensity, ranging from 1 (little/seldom) to 5 (a lot/frequently). The ratings for all the symptoms were added up to give each occupant a "sick building score", so that high scores indicate a high prevalence of SBS symptoms. Such scoring methods are commonly used in epidemiological studies (Hodgson 1997). The occupants' scores were then compared with their personal factors and their perceptions of the physical environment, which were also marked on five-point scales.

Measurements were made of air temperature, humidity, air speed and air flow. There were no particle measurements, as visual inspection and discussions with building management indicated that cleaning and maintenance standards were high, filters had been upgraded, and dust was not suspected as a problem. In addition, measurements of particle size and number are complex (Morawska et al 1996), and the number of methods used for measuring particles are almost as numerous as the studies (Rivers 1982). It was only when the results were analysed that the problems with dust became apparent.

RESULTS

Over 70% of the occupants reported two or more symptoms. Comparisons with the literature show prevalences covering a wide range. Blom et al in Norway (1993), using the same questionnaire, found 14% of respondents reporting general symptoms. In a building with a recognised problem (Hanssen et al 1987), 35% of respondents had nasal and eye symptoms. Symptom prevalence in this building therefore appears to be high. The average SBS score for all respondents was 18,0. For personal factors such as allergy, all ratings above 1 were counted. For the physical factors, all ratings above 2 were counted. For example, if an occupant marked dry air as 2, this was considered a minor problem and disregarded (including ratings of 2 gives very high prevalences). Table 1 shows the prevalence of the occupants' perceptions of their physical environment, and how their perceptions were related to their SBS symptoms. The results for personal factors are shown in Table 2. In both tables, SBS scores for a factor are compared with SBS scores for the rest of the study population. The factors are ranked in order of decreasing differences between their SBS scores, so that factors at the top of the list have a strong association with SBS symptoms and factors at the bottom have a weak association. Females had more symptoms than males, and generally reported greater dissatisfaction with their working environment, Table 3.

Table 1. Prevalence of physical factors and their association with sick building symptoms.

Factor (Prevalence, %)	Average SBS scores		Factor (Prevalence, %)
Dry air (71)	21	8	Air not dry (29)
Static (18)	32	15	No static (82)
Stuffy (64)	22	10	Not stuffy (36)
Poor air quality (62)	22	10	Good air quality (38)
Ventilation noise (21)	26	15	No ventilation noise (79)
Dust (27)	23	16	No dust (73)
Noise (39)	21	15	Not noisy (61)
Moist air (9)	22	17	Air not moist (91)
Supply temp >20°C (66)	17	16	Supply temp ≤ 20°C (34)
RH desk >50% (35)	17	17	RH desk ≤ 50% (65)
Desk temp >24°C (68)	17	18	Desk temp ≤ 24°C (32)
Draughts (9)	16	17	Not draughty (91)
RH supply air ≤50% (34)	19	16	RH supply air >50% (66)
Tobacco smoke (18)	13	19	No tobacco smoke (82)

Table 2. Prevalence of personal factors and their association with sick building symptoms.

Factor (Prevalence, %)	Average SBS scores		Factor (Prevalence, %)
Eczema (15)	38	15	No eczema (85)
Hay fever (11)	37	16	No hay fever (89)
Allergy (21)	32	14	No allergy (79)
Asthma (11)	32	16	No asthma (89)
Confusion (20)	31	15	No confusion (80)
Vision problems (44)	27	11	No vision problems (56)
Memory lapses (21)	30	15	No memory lapses (79)
Stomach upset (20)	30	15	No stomach upset (80)
Depression (15)	28	16	No depression (85)
Muscle tension (42)	25	13	No muscle tension (58)
Underemployed (11)	27	16	Not underemployed (89)
Dizzy (22)	26	16	Not dizzy (78)
Doctor seen (26)	26	16	Doctor not seen (74)
Lack of control (20)	25	15	Control OK (80)
Smoker (29)	23	13 1)	Non-smoker (52)
Work related (67)	22	12	Not work related (33)
Time pressure (58)	22	12	No time pressure (42)
Fast pace (72)	20	11	Acceptable pace (28)
Evening type (22)	25	18 2)	Morning type (36)
Too much work (91)	18	11	Acceptable work load (9)
Age < 40 (37)	21	15	Age ≥ 40 (63)
Female (70)	19	14	Male (30)
Demanding work (70)	19	14	Work not demanding (30)
VDU work (54)	19	15	VDU ≤ 4 h/day (46)

1) Ex-smoker (19) = 16

2) Neither (42) = 12

Table 3. Prevalence of factors affecting males and females. (Average SBS scores 13,6 and 19,0 respectively).

	Males, %	Females, %
Dust (>2)	6	35
Static (>2)	18	18
Dry air (>2)	53	78
Stuffy air (>2)	47	68
Draughty (>2)	0	13
Asthma (>1)	6	13
Hay fever (>1)	12	10
Eczema (>1)	6	18
Allergy (>1)	24	18
Work with VDU > 4 h/day	35	60
Smoker	24	30
Evening type	29	18

In Table 1, the average scores are mostly a little below the overall average of 18. The exception is those factors relating to air quality: people who considered the air quality to be good had the lowest scores. The scores are still not zero, however; a score of 10 represents e.g. two symptoms experienced at maximum frequency/intensity. The most prevalent physical factors were that the air felt dry, stuffy and was generally of poor quality. The strongest association with symptoms, however, was with static electricity, dust and ventilation noise. Ventilation acoustics have been dealt with separately (Burt 1998). The personal factors in Table 2 show a similar picture: most scores in the right-hand column are a little below 18, apart from some factors related to the occupants' work, and the strongest association with symptoms is with some of the least prevalent factors. Because the figures in the right-hand columns in Tables 1 and 2 are mostly similar, a good idea of SBS associations can be had from the figures in the left-hand columns alone.

DISCUSSION

The strongest association with SBS symptoms was with allergic-type symptoms. Females perceived their environment to be worse than men did, with more reporting the air to be dusty, dry, stuffy and draughty. In addition, females had a higher prevalence of asthma and eczema. Studies in Great Britain found that females usually have poorer jobs, worse accommodation, less control and greater body awareness than men (Burge et al 1990). More females than males worked with VDUs, which are thought to contribute to problems of posture, skin symptoms and eye symptoms. Table 2 shows, however, that VDU work had only a slight association with SBS symptoms.

The physical factors having the strongest association with symptoms were static electricity and dust. Hanssen et al (1984, 1987) suggested that static electricity increases the deposition of particles on skin and mucous membranes, and that static electricity could be contributing to the feelings of dry air. The average relative humidity for all the rooms was reasonably high at 48%, and only one room had a value below 30%. So the problems of static electricity and dry air probably cannot be dealt with by humidifying the air further.

Mechanically ventilated buildings are usually dustier than those with natural ventilation, which suggests that dust is produced by supply ventilation systems. If so, then improving floor cleaning routines is unlikely to have any effect on symptoms: by the time the dust has reached the floor, it has been suspended in the air long enough to have been respired. This is borne out by studies that have found symptoms to be unaffected by cleaning routines (Kildesø et al 1996), and by the experience in this building with a high standard of cleaning.

Skåret et al (1995) reported that even low dust concentrations were associated with both SBS and dryness of the air. Most particles in the outdoor air are smaller than 0,5 µm aerodynamic diameter and therefore respirable (Drangsholt 1996). The efficiency of fibrous filters is low for this size range (Ensor et al 1994). Also, fine particles are generated indoors, e.g. by friction against clothes. Therefore upgrading the filters is unlikely to provide an improvement in dustiness. The filters in this building have been upgraded several times since it was first occupied in 1980, yet the occupants still find dustiness a problem. Other studies have also found that upgrading filters failed to provide an improvement (Blom et al 1995, Niu et al 1996).

There have been many recommendations for increasing ventilation, but if mechanical ventilation systems are responsible for much of the dust in "sick" buildings, then increasing air flows is likely to make the situation worse. Measurements in this building showed that the air flows to the rooms were adequate (> 12 L/s per person). However, the measured air speeds in the rooms were very low, indicating little air movement in the rooms. The lack of air movement may be contributing to the perceptions of dryness. Effective remedial measures will consist of ensuring good distribution of the supplied air, rather than increasing ventilation flows. Improvements in air distribution can be obtained by lowering the supply air temperature. Most rooms had air temperatures higher than 24°C, so reducing the supply air temperatures should improve both air movements and thermal comfort. Blom et al (1995) found that reducing room temperatures from 24°C to 22°C led to a decease in perceptions of dryness, and that the air quality was more acceptable with displacement ventilation because it gave better air distribution. Further improvements may be achieved by filtering the air *downstream* from the supply fans. This option is usually not pursued because of its cost. But experience with mechanical ventilation systems and "sick" buildings suggests that new strategies are needed for dealing with the dryness and dustiness in the indoor air.

ACKNOWLEDGEMENTS

This study was supported by the Swedish Council for Building Research, Project No. 960673-8.

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