"Sick" buildings

- A problem coupled to energy preservation and modern building technology

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Sammanfattning

"Sjuka hus" - Ett problem kopplat till energisparande och modern byggnadsteknologi

Hälso- och komfortproblem sammankopplade med inomhusmiljöer som inte är förorenade av arbetsprocesser ("Sick-building syndrome" eller problemhussyndromet) har ökat påtagligt under det senaste decenniet. Till orsakerna hör förändrade byggnads- och ventilationstekniker, som har framtvingats av tilltagande energikostnader. Det är ett multifaktoriellt tillstånd som påverkas av störningar i inomhusmiljön och färgas av de somatiska och psykiska reaktionerna hos personerna som bor och arbetar i dessa miljöer. Besvären är diffusa och ospecifika men domineras av irritation i ögon och övre luftvägar. Luften brukar uppfattas som "torr" och detta beror inte alltid på låg luftfuktighet. Som regel föreligger inte signifikant förhöjda halter av luftföroreningar, men ventilationsstörningar med luftåterföring och låga luftomsättningstal brukar ofta kunna påvisas, vilket antyder att ökade föroreningshalter ändå kan vara av betydelse. Pågående forskningsaktiviteter är livliga. Inte bara medicinska och hygieniska, utan även tekniska och ekonomiska förhållanden gör det nödvändigt att behandla problematiken med stort allvar.

Summary

Health and comfort problems connected with indoor environments not polluted by industrial processes, the "sick-building syndrome", have been common during the last decade. The increase seems to be coupled with changes in building and ventilation technology necessitated by increasing energy costs. It is a multifactorial condition caused by disturbances of the indoor environments and coloured by the somatic and psychic reactiveness of the individuals living and working in these environments. The complaints are diffuse and non-specific but are dominated by irritation of the eyes and upper respiratory tract. They often include a sensation of "dry air" not always due to a low water content of the air. Significant increases in detectable air pollutants are usually not noted in "sick" houses, but ventilation disturbances, e.g. air recirculation and small air exchange rates, are often observed, indicating that increased levels of air pullutants might indeed be of importance. The present research is extensive. Not only medical and hygienic, but also technical and economic aspects force us to treat the problems seriously.

Key words: Air exchange, air pollution, electrostatic field, humidity, indoor climate, sick building, ventilation

Introduction

During the last century, health and comfort problems coupled to "clean" indoor environments, such as dwellings, offices and day nurseries, have been common in temperate regions. The most accepted names of this type of complaints - sick building syndrome (SBS) and sick building disease - focus their origin to the indoor environment and the building. It seems to be a multifactorial condition caused both by disturbances of the indoor environments and coloured by the somatic and psychic reactiveness of the individuals living and working in these environments. The troubles have increased considerably during the last decade, and they are often connected to new-built houses. There seems to be a connection between this increase and changes in building and ventilation technology introduced to save energy. The complaints are diffuse and nonspecific, but some symptoms appear more often than others. Present research is extensive, and not only medical and hygienic, but also technical and economic aspects enforce us to treat the problems earnestly.

Symptoms

At polls and interview examinations of people living or working in "sick" buildings there are usually registered high frequencies of both general and local symptoms from different parts of the body (*Finnegan et al 1985, Robertson et al 1985*). The picture is dominated by irritation of skin, eyes, and upper respiratory tract, but general symptoms, especially headache and nonspecific tiredness, are also common.

Troubles of this type are non-specific and could occur irrespective of where the affected persons live or work, and the symptoms are usually hard to objectivize at clinical examinations. However, the reactions in exposed groups are often aggressive and not seldom dominated by anxiousness and demands for extensive and expensive reconstruction measures of the localities and buildings inducing the complaints. It is difficult to establish the diagnosis in single cases, but in groups it is often possible to establish a statistical connection between symptoms and specific indoor environments.

Underlying environmental components

A lot of different environmental components have been discussed as possible complaint-releasing factors (Table). Many of them induce troubles at high exposure levels, but generalizations from such observations are risky. For instance, formaldehyde was often considered to be an all-embracing explanation to SBS during the 1970's and early 1980's, but now we know that airborne formaldehyde concentrations often are low in premises coupled to SBS *(Robertson et al 1985)*. However, ventilation problems in a wide sense are common in "sick" buildings. Sometimes other things, such as electrostatic phenomena induced by isolating flooring materials *(Norbäck and Torgen 1987)*, video terminals *(Lindén and Rolfsen 1981)* etc., also could contribute to the occurrence of complaints.

Table I. Examples of environmental factors as possible causes to sick building syndrome

Chemical emanations from
carbonless copying paper
chipboard (formaldehyde)
copying machines (ozone)
moisture damages in building (moulds, etc)
polymeric building materials
spirit pens
Electro-physical phenomena coupled to
airborne ions
electrostatic fields
Unsuitable indoor climate conditions, especially with respect to
relative humidity
temperature
Ventilation problems, especially coupled to
air recirculation
slow air exchange rates

Ventilation and humidity

A connection between SBS and type of ventilation system in the buildings has been observed *(Burge et al 1987)*. Ventilation problems with uneven temperature, draught and noise from air inlets and outlets, often combined with air recirculation and small air exchange rates, are common in "sick" buildings.

The subjective symptoms associated with SBS often include a sensation of "dry air", and the air is often actively humidified in order to prevent the complaints. However, "sick" houses are rather characterized by moisture in building elements *(Samuelson 1984, Göthe et al 1990)* than by dryness, and humidification of indoor air is often ineffective to prevent the discomforts.

We have studied the correlation between the subjective sensation of "dry air" and the relative humidity in indoor environments on 32 men and 76 women working at four large offices *(Göthe et al 1987)*. The temperatures and relative humidities at their work places were measured with an Assman psychrometer. At the same time, the subjective judgement of temperature and humidity was recorded on visual analogue rating scales *(Maxwell 1978)*. This method is well established in behavioural sciences and is suited for semiquantification of subjective evaluations.

The mean score for the evaluation of temperature did not differ significantly between men and women. On a group basis, however, women experienced a more intense sensation of "dry air" than men. At the current temperature and humidity conditions, the females demonstrated a weak but paradoxical tendency to increasing sensation of "dry air" with increasing relative humidity.

It is obvious that the sensation of "dry air" in "sick" buildings often depends on other conditions than low water contents of the air. When there is a high frequency of complaints due to "dry air" in centrally heated indoor environments, the primary routine measure ought not to be humidification of the air.

Air recirculation

It is probably not a by chance phenomenon that the SBS "boom" during the last decade occurred parallelly to increasing energy costs and introduction of energy-conservating ventilation technologies characterized by air recirculation and small air exchange rates. In the Scandinavian countries during winter time, up to 80% of the exhaust air could be recirculated in office buildings. In addition, non-intentional air recirculation could occur due to unappropriate locations of air inlets and outlets.

There are both technical and medical-hygienic needs of accurate and workable methods to measure the real air recirculation in buildings. However, measurements of airflows in recirculation ducts and valves are often difficult to perform. There are great error possibilities in such measurements due to turbulence phenomena and varying flow velocities in central and peripheral parts of the ducts.

It is, however, possible to measure the air recirculation according to quite another principle as demonstrated in the skeleton sketch on next side *(Göthe et al 1988)*.

Q_1 - Q_5 represent airflows in different parts of a ventilation system, and C_1 - C_3 represent the concentrations of a suitable tracer at corresponding locations. The air recirculation is represented by the quotient Q_2/Q_3, and this quotient is equivalent to the quotient (C_3-C_1/C_2-C_1). Thus, a quotient between flows is identical with a quotient between differences in tracer concentrations, and it is possible to estimate the air recirculation by analysis of the tracer concentration at three well-defined points before and after the mixing point.

As a rule, carbon dioxide is a suitable tracer. It is

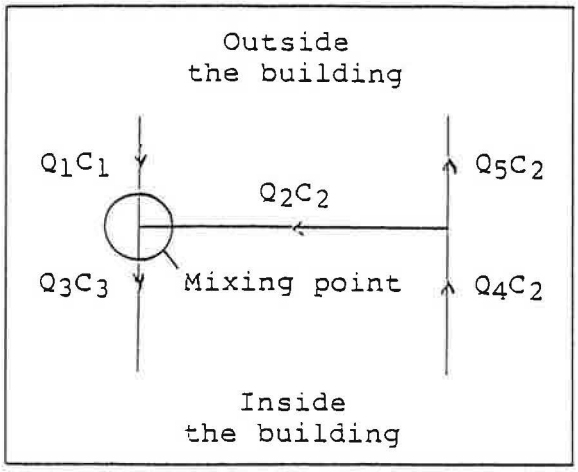

Figure 1.

spontaneously emitted indoors from exhaled air and different indoor activities, and the differences in CO_2-concentrations in outlet and inlet air are usually large enough for estimations of the recirculation quotient. The accuracy of the method is excellent when the CO_2-concentrations are determined with a sensitive instrument, such as an IR spectrophotometer. However, detector tubes for CO_2-analysis obtainable on the market today are not usable in this situation *(Ancker et al 1989)*.

Electrostatic phenomena

From a theoretical point of view, it seems reasonable that airborne particles could accelerate in the electrostatic field around electrostatically charged individuals *(Ancker et al 1984, Göthe et al 1989)*. Particles moving in such electrostatic fields ought to impact especially on protruding parts of the body, especially on the nose and the area around the eyes indicating that combination of large field strength and high concentration of airborne dust might induce irritation in these areas. Perhaps, the occurrence of discomforts in persons working with video terminals *(Lindén and Rolfsen 1981)* and in persons moving on electrically isolating flooring materials, such as wall-to-wall carpets *(Norbäck and Torgen 1987)*, sometimes could be influenced by such phenomena.

It has been demonstrated that exposure to inert dust in connection with handling of paper could result in itching and redness of exposed skin, and that persons with a low itch threshold are especially sensitive in this respect *(Göthe et al 1981, Norbäck et al 1983)*. It is not known to what extent electrostatic phenomena contributes to such effects, but it seems reasonable that electrostatic fields might have some influence. It has, however, been difficult to directly connect the complaints to measured potential differences in clean and well-ventilated offices *(Ancker et al 1984, Göthe et al 1989)*.

Psycho-social factors

SBS sometimes explodes in epidemic outbreaks, and it is often accompanied by emotional stress and aggressive attitudes anchored to the group rather than to single individuals. Correlations between SBS and social conditions, such as marital status and educational attainment level, have been observed *(Boxer 1985)*. However, it seems to be an oversimplification to apprehend the complaints as a pure psycho-social phenomenon. It is a multifactorial condition with its origin both in disturbances of the indoor environment and in the somatic and psychic reactiveness of the individuals living and working in this environment. The observations that SBS is more common among women than among men *(Raman et al 1984; Burge et al 1987)*, and that workplaces with a high prevalence of such complaints often are dominated by female employers could, at least partly, depend on sex-linked differencies in the sensitivity of skin and mocous membranes to irritating components of the indoor environment.

Conclusion

Significant elevations of detectable air pollutants are usually not observed in "sick" houses *(Robertson et al 1985)*, and it is obvious that the subjective sensation of "dry air" often depends on other conditions than a low relative humidity. Thus, active humidification of the air is seldom a reasonable treatment. However, ventilation disturbances characterized by small air exchange rates and air recirculation are often observed indicating that increased levels of air pollutants, anyhow, might be of importance. Many environmental factors, such as air recirculation, have hitherto been difficult to measure, but workable and accurate methods now begin to appear. With that, we have got instruments for further investigations of cause-effect relationships.

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