Causes of Poor Air Quality in Swedish Schools

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Summary: *This literature survey distinguishes between building and other factors influencing air quality. It does not identify building factors sufficient to account for occupant complaints. It concludes that buildings are often blamed for adverse health effects without sufficient grounds. The risk is there will be too much focusing on the wrong underlying problem when remedying so-called sick buildings. The study shows the importance of ensuring that factors independent of the school building, including the choices of environments and activities, are important for the indoor environment.*

Keywords: *school environment, SBS, measurements, questionnaire, furnishing and materials*
Category: *Sick Building Syndrome (SBS)*

1 Introduction

During recent decades, poor air quality has become so widespread in Swedish schools that health problems regularly affect occupants. “Symptoms include irritation of eye, nose and throat, dry mucous membranes, skin rashes, tiredness, headache and nausea. World Health Organisation guidelines state that if 20% of a building’s occupants report health probems, the building can be classified as a *sick building*” [1] Resultant costs can be considerable at both local and national government levels, including absenteeism and rehabilitation as well as building alterations, and even demolition and rebuilding. This study aims to show factors contributing to health problems in Swedish schools. It includes literature surveys, particle measurements (bacterium and fungus) in a gym, day nurseries and stables, and documenting of indoor air quality in buildings and during various activities.

Atmospheric pollutant particles are often carriers of health-negative substances such as allergens and Colony Forming Units (CFU) where bacteria are included. CFU in cleanrooms, rooms with increased cleanness requirements, originate from people and these CFU do not normally occur in suspension, but are transported on particles that are their conveyers. Most CFU are found on particles in the size range 10 µm [2, 3]. Indoor air quality is strongly related to airborne particle concentration, size distribution, and chemical or biological composition. Ordinary indoor activities, including walking and housekeeping, can cause particle resuspension. Such activites may also generate new particles through abrasive wear of surfaces [4]. Particle pollutants consist often of substances from natural cycles, for example dust, pollen, fungus and bacteria. Fungus, inclusive of moulds, is disseminated through small spores and these can be airborne and thereby enter buildings during ventilation, through ventilation systems, with clothing, equipment, daily intake of goods and such. The fungi's plentiful occurrence makes people unavoidably exposed to them. Of the approximately 100,000 species that exist approximately 30 are to be considered to be allergy inducing. The common species in Sweden belong to the families Cladosporium and Alternaria. Of little importance are Penicillium and Aspergillus. Inhalation of spores from fungus can cause atopic allergy, but this is usually no indoor problem. Exposure to high concentrations of fungus happens primarily from the air outdoors during the summer half-year [5].

Bacteria are a group of microorganisms that propagate through division. In order to be transported in air bacteria usually require a dead particle of certain size as means of transportation. Bacteria of different types occur normally on people's skin and a normal sized person carries approximately 0,5 kg bacteria. The number is estimated to about 10^{14} pcs. The bacterial flora comprizes normally resident species that normally do not constitute any threat for people. This is a necessary component for the skin's total function. From the ambient environment, new bacteria are continually transferred, that normally are competed out by the resident organisms. Man is in himself a major particle-spreader. Quite naturally, hundred of thousands of particles are emitted each minute, of all sizes from microscopically small particles to millimetre large flakes and long hairs [3, 6]. The particle's size and weight decide how long it remains airborne. In rooms with ventilation, where people are in motion, particles of the size some micrometer remain less airborne.

A person inhales approximately 10,000 litres of air per day and night. This means that we inhale large quantities of our own skin flora, other people's skin flora, the skin flora from animals and other dust from the environment, through both direct and indirect contacts [7]. Humans play a central role in indoor environmental issues whether they are issues related to air quality or comfort evaluation. In studying any indoor environment problem, the most important thing is therefore to clarify the relationship between the human body and the surrounding environment [8]. The results of this study support the hypothesis that among adolescent school children, an independent association exists between moulds in floor dust and building related symtoms. Similar associations were not found for observed extent of moisture and mould growth in the buildings [9].
Results show that different accommodation habits influence the indoor environment and that one cannot find connections between parameters that describe the patient's asthma disease and the indoor environment. On the other hand, one has demonstrated indirect links between different parameters in the indoor environment and between different symptoms of the patients and their families. The hypothesis that the homes of mould-allergics contain more moulds than homes of persons subject to experiment has not been confirmed. It shows clearly that those patients with higher sensibility scores than the median value have twice as many contacts with animals and animal owners in their homes than those with a low score.
These visits contribute to a considerable increase content of allergen in the room and in the report it is stressed the importance of taking into consideration people's total environment [10]. The knowledge is useful when it comes to the occurrence of allergens from mite and domestic animals in rooms, schools and offices. A number of studies demonstrate that significant allergens occur also in environments where animal or mites do not occur. The allergen is carried with persons from home to school and offices so that the concentrations, also in these environments, become sufficient in order to maintain bronchial reaction. Despite extensive research it cannot be confirmed that for example the building material should be injurious to health [7, 11].

2 Method

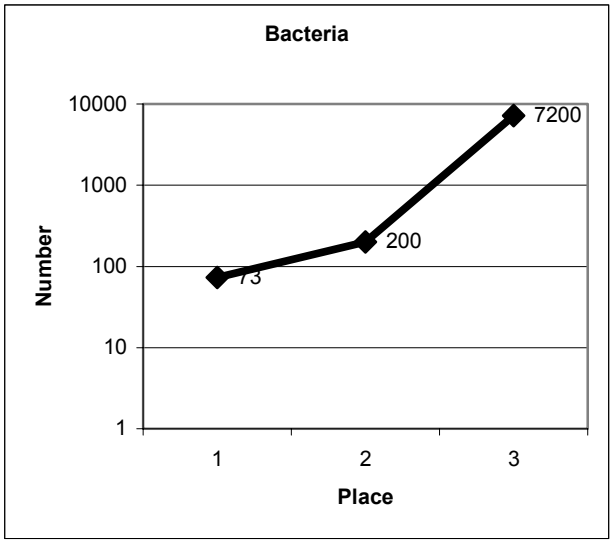
This literature survey distinguishes between building and other factors influencing the indoor-air-quality (IAQ). The question is if the result in doctoral thesis report [6] still is relevant today. This report is complemented by a literature survey regarding the period after 1994. The results in this report are based on the results from the doctoral thesis report [6] and compared with the results from the new literature survey.

3 Result

The conclusion is that the results from the licentiate thesis report still are relevant. The licentiate thesis report [6] explains the following. The results from interviews from 200 municipal organisations showed that the presence of indoor air problems in buildings usually emerged through diffuse complaints from occupants, with much uncertainty about the nature of the problem for the building owner. Adequate remediation thus becomes difficult, and with resources used on an uncertain basis (to retrofit the building without the real need) the chance of economic wastefulness is high. Where people complain about the indoor-air-quality (IAQ) in a building thought to give rise to health problems, the combination of allergies and contacts with both domestic animals and smoking occur in all cases. The material that is presented is statistically incomplete since the number of interviewed persons is limited and a control group is missing.
The result indicates however connections between good user- habits and inconvenience problems, where in all cases there are contacts with health-affecting environments that give susceptible persons risk for health effects. As well as results from measurements, air measurements has been implemented, as results from interviews indicate that there very likely exist problems within other areas than the building structure one complains about. An important factor for the quality of indoor air is the treatment of the building by users. Choices of furnishing, presence of domestic animals, smoking, quality of the cleaning, wet room use and such are crucial aspects that influence the indoor-air-quality. It is also important what type of activity that is carried out in the building and how many people and animals there are in the building. It is surely well known that, for example, furred animals are afflicted with vermin. An important point is the complexity of the problem, the combination of sensitive and allergic people that come in contact with animals and smokers. This applies as well to direct as indirect contacts. Concerned persons often get problems through these contacts and this cannot be solved technically, but must be taken into consideration on an individual level.
Results from measurements show that the environment and the activities people cause buildings influence the indoor air microbiological quality. Environments with animals are strongly microbial producing and give high concentrations of both micro-fungus and bacteria. In a study of measurements the following results occurred. Measurements showed that microorganisms were influenced by both environment and activity. Indirect contact with animals, such as from stables or pets at home was important.

Fig. 1 and 2 show results from measurements (bacterium and fungus) in Indoor air gym, day nurseries and stables,

- Fig. 1, A calm activity during measurements (logarithmic introduce) and
- Fig. 2, Increased activity during measurements.



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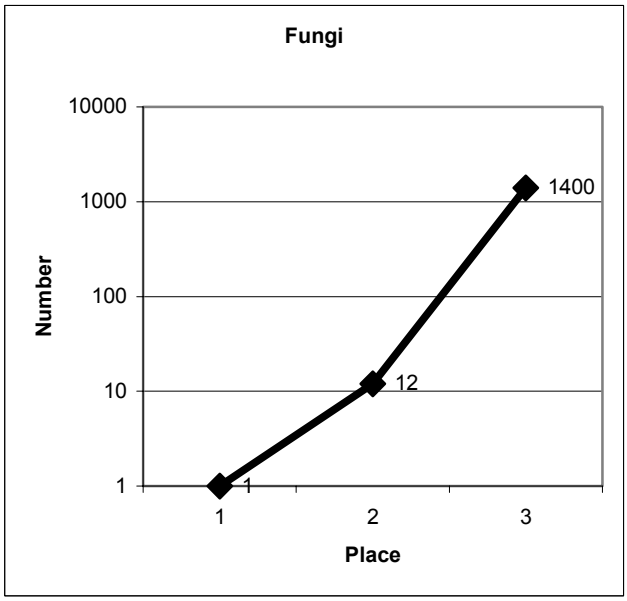

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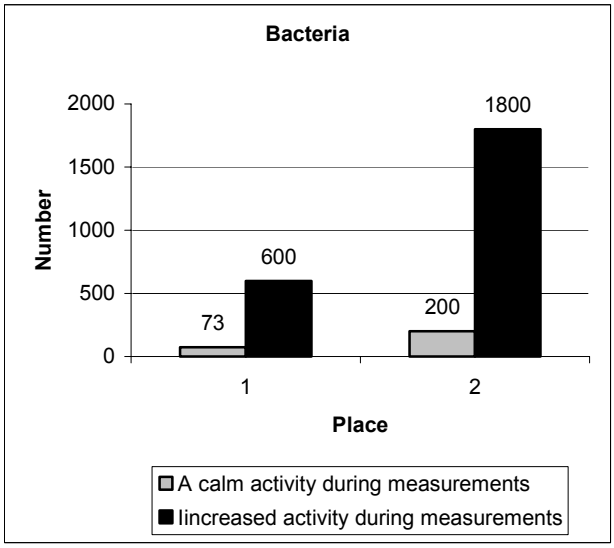
Fig. 1. A calm activity during measurements: (logarithmic introduce, numbers of micro-organisms/m^3 air). Place: 1 -Gym, 2 - Day nurseries and 3 -Stables



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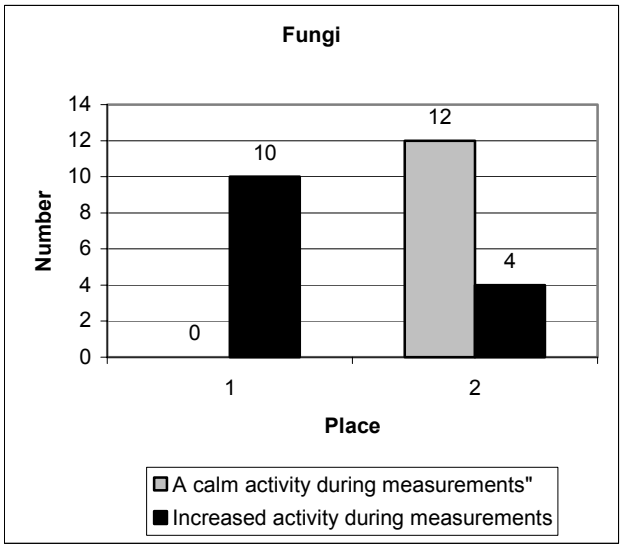


b)

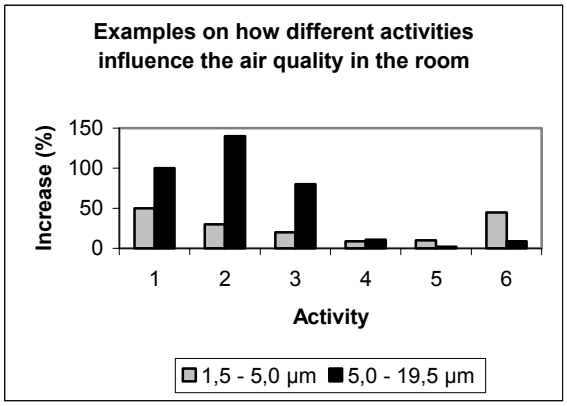
Fig. 2. Comparison, calm activity and increased activity during measurements: (numbers of micro-organisms/m^3 air). Place, 1: Gym, 2: Day nurseries

Arts, Figure 1 and 2:

- Bacteria: Grampositive coccuses, grampositive sporecreating spells, grampositive non-sporecreating spells.
- Microfungus: Penicillium sp, Cladosporium sp, Botrytis sp, Phoma sp, Trichoderma sp and Ulocladium sp. (sp=the micro-organisms are not species defined but only family specified).

Explanation of the above result is the following. The microfungus are allocated into buildings from outdoor air where they are a part of natural cycles. Moreover, micro-fungus occurrence is influenced by animals. Bacteria of different types occur normally on the human skin. People emit large quantities of particles for example, in the form of skin particles. On above all skin flakes there exist bacteria in varying quantities and these bacteria are collected at air measurements. Also the fur on animals is a large disseminating area for bacteria. This means that people as well as animals are disseminating areas for bacteria, which should be considered in the management of the indoor environment.

It is also important that as many particles as possible are at rest and not airborne when the cleaning is implemented in order to make the cleaning effective. At inspections it turned out that apparent differences occurred regarding cleanability where the lower particle number was measured against the higher. In Fig. 3 are shown examples on how different activities influence the air quality in the room [12].



Activity

1. Walking in the room
2. Sitting down in a sofa
3. Making the bed
4. Vacuuming, central suction
5. Vacuuming, with filters
6. Vacuuming, without filter

Fig. 3. Shows dust whirl up at different activities, particle size in micrometer [12].

Important results of the licentiate thesis report indicated

- that microbial levels in indoor air varied greatly between the environments where measurements were carried out,
- that activity was important for the indoor-air-quality.

The conclusion is that there is a risk that there will be too much focusing on the wrong underlying problems when remedying so-called sick buildings. The study shows the importance of ensuring that factors independent of the school building, including the choices of environments and activies, are important for the indoor-air-quality.

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