Quality assessment in building investigations

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ABSTRACT
IAQ investigators have a responsibility to give correct advice to the client. In cases with mould growth, the question of people's health is often involved. Economical aspects can also be considerable due to the high costs of necessary actions during and after the remediation process. These aspects make it important for the decision-maker to have a good description of the situation based on a thorough survey, including reliable background data on different aspects (e.g. building construction and materials, moisture and mould growth).

The quality assessment model systematically uses four different categories when describing visible symptoms, measurements and analyses of samples and consequences of problems where mould might be present. The system makes it easier to interpret the reports and pinpoint possible weak parts in order to make the right decision.

An example is given where the quality assessment discovered insufficient background information that led to an incorrect evaluation and treatment.

INDEX TERMS
IAQ assessment; Mould; Building survey; Remedial measure

INTRODUCTION

In our line of work, as mycologists and consultants on biological problems in buildings, we have during the last 15 years repeatedly experienced that actions taken by different decision makers are often based on insufficient information and understanding of the reason and extension of the problem. This is especially prevalent in cases where water damages and mould growth is involved. When you make a decision to do something with the building based on insufficient or wrong background data the risk of prescribing the wrong action is great. Even more serious, taking the wrong turn can lead to even further deterioration of the problem. In many cases the problem often remains in spite of a costly rehabilitation process. There is of course also the risk of spending a lot of money on actions that are not at all necessary.

Due to what appears to be thorough information in a single measurement or a single observation, one is often led to draw quick conclusions, even if other equally important information is lacking. During the past years there have been numerous cases where the results from a single measurement of viable mould spore sampling (cfu/m^3), a suspicious smell or a high moisture measurement/content is the only information that is used as background for further actions. The results have in some cases been proven to be insufficient or, in worst case, both expensive and ineffective.

In order to establish a tool to ensure a proper handling of mould damages, we have designed a quality assessment tool; *Mould Analysis, Survey and Remediation Quality Assessment* (MOULD Q-CHECK) for evaluation of actions taken in this multidisciplinary process. Our experience in using this procedure is that it makes it both easier to pinpoint weak

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elements in a survey or process, and that it gives a good pedagogical tool for the involved personnel (decision makers or occupants) in order to explain where to focus further work.

METHODS

To ensure that sufficient information is available, the known facts in a case can systematically be evaluated. This is done by checking if crucial facts are lacking, and furthermore the value of the information, i.e. its relevance and extension. By grading the information into five groups, it is possible to pinpoint possible weak parts in a survey.

The Norwegian standard of building survey NS 3424 (Norse standard 3424) is a general framework on how to make a thorough building survey, regardless of what construction and material that has been used. We have used the general idea of dividing the observations and evaluations into four levels; e.g. 0 = no signs, 1 = small signs, 2 = moderate signs and 3 = extensive signs of a damages or observations.

In the case of MOULD Q-CHECK, the available pieces of information in a case are placed in one of following categories: 0 = lacking information, 1 = limited information, 2 = moderate information and 3 = comprehensive information. Furthermore, in cases where the information has no relevance for the actual case, this is marked as 'N' (*N*o relevance).

It is possible to incorporate various factors depending on the problem. The following main subjects have to be examined:

A. Building related information
    a. Building (time of construction, former and present use, type of ventilation etc.)
    b. Construction (crawl spaces, flat roof, attics, etc.)
    c. Materials (gypsum, fibre boards, wood, paper, paint etc.)
B. Damage related information
    a. Source and extension of humidity, including humidity measurements
    b. Occurrence of micro-organisms and extension of established damage, including sampling (material samples, tape lifts, viable spores, total counts, spore trap, etc.)
C. Indoor Air
    a. Exposure to occupied rooms
    b. Influences on the extension of exposure
D. Health of occupants
    a. Self-reported symptoms (headache, fatigue, discomfort, time and place of symptoms, etc.)
    b. Any medically diagnosed cases (allergy testing, asthma, etc.)

The evaluation of this information has to be described in a well-documented survey, which forms the basis for further actions. If essential information is clearly lacking or is insufficient, this must be provided in order to be able to make the future construction/rehabilitation work on a proper basis.

When the remediation work starts, the activities such as treatment, efficiency of enclosure, safety measurements and removal/cleaning of infested materials have to be evaluated in the same way as the basis information. This leads to an ongoing control of the process. By a comprehensive documentation, it is possible to ensure a complete quality control of the work.

RESULTS

Practical Case—Complaints of Condensation in a School Building

This school building is a three-storied brick building, constructed in 1930. The ventilation is mechanical but not balanced. It has concrete flooring between the stories and the investigated room has painted outer walls and the floors are sleeper plate.

During wintertime there have been repeated complaints about condensation and mould growth on the inside of outer walls in a storage room close to the gymnasium. Moisture had accumulated on the windows and painted walls during sub-zero conditions outdoors. The school owners (governmental agency) had concluded that the condensation was caused by a combination of low air supply and bad air circulation in the room. The solution was to install an air hatch in the window and door to increase the circulation. We were asked to perform air sampling/clearance control in the storage room to document/evaluate the effectiveness of the remediation process performed by a company two weeks earlier (cleaning of suspected mould growth, disinfecting and painting). No documentation on the extent of the former mould growth or moisture measurements had been performed. The situation at this stage was as shown in Table 1.

Table 1 Short summary of information at the start of the investigation

Subject	Evaluation	Comments
A. Building related information		
I. Building	1	Based on some general knowledge
II. Construction	1	Based on assumptions
III. Material	2	Based on visible signs
B. Damage related information		
I. Source and extension of humidity, including humidity measurements	1	Based on guessing
II. Occurring micro-organisms and extension of established damage, including sampling	0	Lacking
C. Indoor air		
I. Exposure to occupied rooms	0	Lacking
II. Influences on adjoining areas	0	Lacking
D. Health		
I. Self-reported symptoms	0	Lacking
II. Diagnosed cases	0	Lacking

Due to the owner's limitation of the costs, no building survey was done. The preliminary investigation was restricted to a brief visual control with air-sampling and tape lifts. The analysis showed no signs of visual mould growth on the surfaces but small amounts of mould spores were detected in settled dust in the room. No obvious cause for any humidity problem was observed at this stage. However, the results of the air analysis (Table 2) showed a clear indication of a negative influence on the IAQ and that mould spores were transported into the air in the area. Especially the presence of *Penicillium* sp. and *Aspergillus versicolor* in dominating numbers gave clear indications that something was not normal.

Table 2 Results from measurements of viable mould spores showing a negative influence on the IAQ in the area (sample of 100 l using Micro Bio2 on MEA and DG18 media, positive hole correlation factor used)

Place	Media	cfu/m^3	Species (%)
Outdoor	MEA	220	*Cladosporium* sp. (65%), Yeast (30%), Unidentified (sterile) (5%)
Outdoor	DG18	30	*Cladosporium* sp. (50%), *Penicillium* sp. (50%)
Storage room	MEA	852	*Penicillium* sp. (37%), *Aspergillus versicolor* (31%), *Cladosporium* sp. (28%) Yeast (3%), Unidentified (sterile) (1%)
Storage room	DG18	1107	*Penicillium* sp. (42%), *Aspergillus versicolor* (31%), *Cladosporium* sp. (26%) *Aspergillus* sp. (1%)
Adjoining room	MEA	522	*Penicillium* sp. (44%), *Aspergillus versicolor* (27%), *Cladosporium* sp. (17%) Yeast (8%), Unidentified (sterile) (4%)
Adjoining room	DG18	498	*Penicillium* sp. (50%), *Aspergillus versicolor* (26%), *Cladosporium* sp. (20%) Unidentified (sterile) (4%)

On the basis of these measurements it was concluded that the probable cause of the negative influence on the IAQ was improper cleaning after the remediation process and that mould spores from settled dust was the reason for this. A new cleaning of the room and another control was recommended. It was also noted the possibility of transportation of mould spores from hidden growth in the floor.

Due to remaining condensation problems, the owner wanted a follow-up investigation. This time an investigation of the whole part of the building was carried out. The moisture on the windows was still present and circulation through the air hatch was estimated to be minimal by using smoke tubes. By moving a cupboard in a corner, an old ventilation shaft was detected in the floor. An air-current was detected from this ventilation shaft into the room, which had high levels of relative humidity and higher temperature than the room. This shaft came from a swimming hall in the room underneath. A new evaluation of the situation gave some changes in the available information concerning the case, as shown in Table 3.

Table 3 Evaluation of the case after a more thorough building survey

Subject	Evaluation	Comments
A. Building related information		
I. Building	3	Based on survey
II. Construction	3	Based on survey
III. Material	3	Based on survey
B. Damage related information		
I. Source and extension of humidity, including humidity measurements	3	Based on survey
I. Occurring micro-organisms and extension of established damage, including sampling	3	Based on sampling
C. Indoor air		
I. Exposure to occupied rooms	3	Based on sampling
II. Influences on adjoining areas	3	Based on sampling
D. Health		
I. Self-reported symptoms	3	Based on interview
II. Diagnosed cases	0	No investigation

The ventilation shaft was cleaned and sealed, so no more air with high relative humidity and mould fungi could enter the room. The ventilation of the swimming hall was solved by installing a ventilation fan in a window.

The earlier installed solution with an air hatch in the window and door in the room could now function as planned, and the problems were solved. This case shows how the assumption that poor ventilation in the room had caused the moisture problem was actually wrong, and that relatively obvious signs of the problem was overlooked. The ventilation shaft that caused the IAQ problem by transporting moisture and mould spores to the room was overseen until a more focused building survey was carried out.

DISCUSSION

A complete survey of indoor air-complaints can be extensive and hard to carry out due to the involvement of people with different backgrounds and the need for a multidisciplinary approach. Due to practical and economical reasons, this work often is reduced to a minimum—still with the expectation of identifying the problems and suggesting the correct solutions. This leads to a great danger of misinterpretation of the situation due to restricted information.

The challenge of handling the information can be solved by separating relevant facts from less important information by a trained building investigator. Our experience is that exact knowledge of all possible information usually is neither possible nor necessary. The most cost-effective way in most cases of moisture problems in buildings is to clarify the fundamental facts regarding the building, moisture levels, microbiology and indoor air conditions. This gives the possibility to focus further on the relevant facts and ignore irrelevant assumptions.

By continuing the critical evaluation throughout the remediation process, it is possibly to detect new and relevant information. This process also ensures the revelation of insufficient information and information without relevance to the case. In this way the focus can be kept on the crucial factors.

CONCLUSION

A problem with IAQ because of mould growth in a building is a multidisciplinary process. It is easy to make the wrong decisions on what to do based on small amounts of information or results from single measurements alone (a single material sample, cfu/m^3, total counts, moisture levels, etc.). The different aspects of the building physics, use of the building, recorded health complaints must also be considered through a building survey.

It is our experience that the use of MOULD Q-CHECK gives the possibility for a good evaluation and documentation in each individual case of mould damage and IAQ assessment. The method makes it possible to custom-make the process for every specific situation and it is a good tool in ensuring both a healthy indoor air environment and a good economy by avoiding unnecessary actions.

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