SJWEH Suppl 2008;(4):35–38

Evaluating the success of damp building remediation

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Palomäki E, Reijula K. Evaluating the success of damp building remediation. *SJWEH Suppl.* 2008;(4):35–38.

Despite the notable amount of research, the exact etiology and mechanisms causing the symptoms and diseases associated with dampness and microbial exposure in buildings still remain unresolved. The aim of this report is to present recommendations for remedial actions. It is essential for all stakeholders to commit themselves to the problem-solving and remediation process. Multidisciplinary teamwork and consensus-oriented approaches are needed for a successful process from the beginning. If the follow-up procedure includes microbial sampling, it should not be carried out until the conditions in the building normalize. Microbial sampling does not completely exclude the possibility of a health hazard, and sampling alone cannot be considered a reliable instrument for evaluating the success of damp remediation. Repeated, standardized questionnaires concerning complaints and symptoms are useful tools for follow-up. Some people may still have persistent symptoms and mucosal reactivity once they reoccupy a renovated building, but their problems do not necessarily imply that the renovation was inadequate.

Key terms dampness; mold; quality assurance; symptom.

Despite the notable amount of research, the mechanisms causing the symptoms and diseases associated with dampness and microbial exposure still remain unresolved. The best way for people to protect themselves against symptoms and diseases due to dampness and mold is to avoid such exposure. The best means is to see that damaged structures and contaminated material are removed from the building in question. Sometimes construction professionals choose encapsulation as a remediation method instead of total removal, usually in order to limit the costs involved. In addition the sources of damp problems are sometimes difficult to determine ("hidden mold"), and the remediation can be insufficient. Therefore, the exposure can continue in the building.

After remediation, the management of the facilities in question must face the challenge of how to prove that health hazards no longer exist on the premises. First, no instructions are available on how to inspect the facilities and what measurements should be used after the remediation. Second, it seems that, even after remediation that has been carefully carried out, some employees are not able to return to the facilities without experiencing adverse health effects.

The aim of this paper is to present recommendations for remediation that are based on reported guidelines and our own field experiences, which consist of 12 years working with over 700 cases with various combinations of dampness and other problems with indoor quality.

Common practices

Problems with dampness and mold seem to have existed as long as buildings have been constructed. In *Leviticus,* chapter 14, verses 35–48 (1), the earliest written instructions are given for evaluating microbial contamination in housing environments. The following four aspects can be identified in this scripture: (i) inspection (*Lev* 14:36), (ii) remediation (*Lev* 14:40–42), (iii) evaluation: criteria for failure (*Lev* 14:43–45), (iv) evaluation: criteria for successful remediation (*Lev* 14:48).

Although some practices have remained unchanged since the beginning of their documentation, we also have newer guidelines. The investigation, remediation, and refurbishment and follow-up after remedial actions have been taken in damp buildings have been discussed extensively in the review publication *Damp Indoor Spaces and Health,* edited by the Institute of Medicine of the National Academies (2). In this review, seven guides from six different organizations are presented. The instructions pertain to the investigation of damp buildings,

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the containment of remediation, worker protection, and control of the problem.

The sufficiency of remediation is not covered in one guide (3), while all the others provide quality-assurance principles to ensure that damp remediation is successful.

The New York City Department of Health developed a guide specific for assessing and renovating buildings contaminated with one species of fungi, namely, *Stachybotrys atra (chartarum)* (4). This was the first document on best-practice remediation that provided guidance on selecting the means of containment and worker protection. According to the guide, air monitoring should be used for checking the outcome when the contaminated area is over 30 feet^2 (2.7 m^2) and also for checking the cleanliness of heating, ventilation, and air-conditioning (HVAC) systems. The New York City Department of Health expanded the original scope from *S atra (chartarum)* to molds in general in 2000 (5). These guidelines provide detailed instructions for assessment, containment, and worker protection. According to the guidelines, all areas should be dry and visibly free of microbial contamination and other debris. In addition, air monitoring must be performed if the damaged area is over 100 feet^2 (9 m^2).

The International Society of Indoor Air Quality and Climate (ISIAQ) produced a guideline called *Control of Moisture Problems Affecting Biological Indoor Air Quality* (6). According to this document, in damaged areas, all surfaces should be cleaned until only background fungi and bacteria remain detectable and all materials are dry.

In 1999, the American Conference of Governmental Industrial Hygienists (ACGIH) released a guideline (7) according to which quality assurance after remediation can be carried out visually. In addition, air sampling of microbes should also be carried out if needed.

According to the directions of the United States Environmental Protection Agency (8), a judgment call is needed concerning the remediation process. Sources of water leakage have to be fixed, surfaces have to be dry and free of visible mold, the health condition of reoccupying persons has to be followed, and there should not be an increase in the prevalence of complaints related to indoor air. If air samples have been collected on the premises, careful interpretation of the results is needed.

A document of the American Industrial Hygiene Association (AIHA) (9) differs from all the other guidelines. It is the only one that reviews other guidelines by identifying common grounds, disagreements, strengths and weaknesses in the evidence, and gaps in the knowledge of each document. The AIHA recommends that the documenting of successful intervention with respect to moisture source, containment, cleaning, removal, completeness, final surface dusting, and the use of high-efficiency particulate air (HEPA) vacuuming should be arranged for all premises that have been investigated.

Reversibility of symptoms

The remediation of a problem building can be carried out so that the prevalence of perceived complaints and symptoms decreases among people who occupy the building (10, 11). Problematic buildings that have repetitively undergone remediation are in the minority among all the buildings that have undergone this process. There is a lack of scientific publications on the successful remediation of problem buildings. Moreover, the perceived complaints and symptoms related to indoor air after remediation have been described in only a few articles (12, 13).

The symptoms caused by water damage and mold can remain much longer than has earlier been thought (14). The belief that all irritation symptoms disappear after microbial exposure has been terminated seems to be too optimistic. In follow-up studies, an increase in the prevalence of symptoms related to indoor air existed even 5 years after the exposure had been eliminated (12). Increased nasal histamine reactivity, measured as mucosal swelling, was observed among teachers 6 years after an obviously successful renovation of a school environment (15).

Principles for the quality assurance of damp remediation

Because the precise etiology and mechanisms causing the symptoms and diseases associated with dampness and microbial exposure are still not known, the causative agent cannot be identified and directly measured in problem environments. Therefore, the quality assurance for damp remediation in a building cannot be based on findings from monitoring the harmful substance. On the other hand, there is a difference in the results of air monitoring samples between insufficiently renovated buildings and healthy premises. The differences are more related to the character of species rather than to the quantity of microbial growth (16–18).

It is essential that, in the very beginning of the inspection process, all parties define and set realistic goals for assessing the remediation. Goals should be set for a single aspect or for all of the following three aspects: (i) well-being of persons occupying the premises and the change in their perceived complaints—the goals in this respect could be evidence of a change in

absenteeism, sick leaves or perceived symptoms related to indoor air, (ii) the monitoring of indoor-air quality with the use of different sampling methods, (iii) the remediation process, in which all problematic deviations have been corrected, should be clearly monitored and documented.

If goals are not set as early as possible, the target may become unrealistic, usually due to the needs of the occupants. If such a situation develops, the risk of conflict increases significantly. The remediation process can reach a successful end if the goals are the result of a common consensus. Without a defined target, the process may be never-ending, especially if new demands appear during the remediation process.

The quality assurance of damp remediation should not only be assessed with the use of air sampling, but also ensured by an evaluation of the quality and documentation of all actions in every phase of the remediation process, which is presented in table 1.

Table 1. The remediation process.

Process	Type of action
1. Dampness inspections and surveys	Technical inspections Sample analysis Assessment of the problem (character, scale) Agreement on controlling actions, follow-up procedures and goals Risk communication
2. Planning of the remediation	Designing construction and heating, ventilation, and air-conditioning operations Planning of construction site and contamination protection Communication
3. Implementation of the remediation	Removal of the cause and all the contaminated material Handling of demolition material Contamination protection and negative pressurization
4. Clean-up after the remediation	High-efficiency particulate air (HEPA) vacuuming Cleaning with a moist or oiled cloth the next day Treatment of movable property
5. Follow-up	Accomplishing the agreed control and follow-up Actions (concerning people, building, sampling) Communication

Concluding remarks

It is essential that all stakeholders commit themselves to the problem-solving and remediation process. Multidisciplinary teamwork and consensus-oriented approaches are needed from the beginning for all actions if the process is to be successful. The quality assurance and completeness of damp remediation should not be assessed only by using air sampling. Instead the sampling strategy, the follow-up procedure, and the criteria for evaluation should be set in the beginning of the process, and they should be accepted by all parties. If the evaluation of the remediation is carried out after the process, it should nevertheless cover all the phases of the remediation process. This procedure can help guide the renovation process, and unnecessary costs can be avoided.

If the follow-up procedure includes microbial sampling, it should not be carried out until the conditions of the building have normalized. Usually such conditions have not been reached until about 2 months after the remediation has been completed. In addition, microbial sampling does not completely exclude the possibility of a health hazard, and sampling alone cannot be considered a reliable instrument for evaluating the success of damp remediation.

Repeated, standardized questionnaires are useful tools for following perceived complaints and symptoms related to indoor air (19, 20). Some people may have persistent symptoms and mucosal reactivity when they reoccupy a renovated building. Such an occurrence does not necessarily imply that the renovation was inadequate (21).

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