

Evaluation Of Indoor Air Levels Of A Mold Enzyme As An Indicator Of Building Moisture Damage And Occupant Airway Symptoms

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1. INTRODUCTION

Indoor mold contamination is an important health issue and exposure to elevated levels of airborne molds may cause a number of unspecific symptoms such as swollen nose, airways irritation, fatigue and headache [1, 2]. At high levels there is also a risk for hypersensitivity pneumonitis and sarcoidosis. In view of this, methods to detect mold damage in buildings are important, both for preventive purposes and for surveillance in connection with flooding or other water damage [3].

Conventional methods to detect the presence of mold growth indoors are visual inspection and sampling of air or surfaces with subsequent microscopic evaluation or cultivation on agar plates. The determination of mold cell wall constituents such as ergosterol and β -glucan has also been used [4]. These techniques are cumbersome and time consuming. The activity of the enzyme N-acetyl- β -D-hexosaminidase (NAHA) showed a good correlation to fungal biomass on surface samples [5] and to total fungal spores in air samples. [6]. Fluorometric detection of the NAHA activity is sensitive and rapid, and can be performed on site.

To assess whether NAHA activity could be used for the detection of mold damage in buildings, NAHA activity was determined in air samples in buildings with and without mold damage. Questions were posed on the presence of subjective symptoms among the inhabitants in the buildings.

2. MATERIAL AND METHODS

2.1 Buildings

The buildings examined were detached or semi-detached family homes and a few apartment buildings. The buildings were collected through advertising for buildings without problems, personal information on mold damage obtained during the investigation, and new buildings before being turned over to the owners. A breakdown of the different categories is shown in Table 1.

Table 1. Number of buildings in each category investigated

Category	number
Delivery ready	19
Advertised for non-problem	37
Known mold problems	30

2.2 Air sampling

For the air samples, a high-efficiency, wet concentrating sampler was used (OMNI 3000, Sceptor industries, MO, USA). The sampler was run for 10 minutes with a sampling volume of 300 L/min. During sampling, 10 mL sterile water from a liquid capsule rotates inside a glass cylinder and the air passes through the water which traps the particles. At the end of sampling, the water is pumped back to the capsule and used for analysis.

2.3 Enzyme analysis

Two mL of the water from the OMNI capsule was filtered through a membrane filter (Millipore, Millex.GP, 0,22 μm) and 2.5 mL of a fluorogenic enzyme substrate (Mycometer ApS) was added to the filter. The reaction time was around 60 minutes (the exact time was determined by the room temperature). The filters were then flushed with 2 ml of an alkaline buffer (the developer) which was collected in a cuvette and the fluorescence was read in a fluorometer (Picofluor, Turner Designs, Sunnyvale, CA, USA) as units and the NAHA activity was expressed as mold enzyme units (MEU)/ m^3 .

2.4 Symptoms

The inhabitants in all buildings examined were asked open questions regarding the presence of building related symptoms. Those similar to symptom profiles as earlier reported [1, 3] were recorded.

3. RESULTS

The amounts of mold enzyme in the different building categories are reported in Table 2.

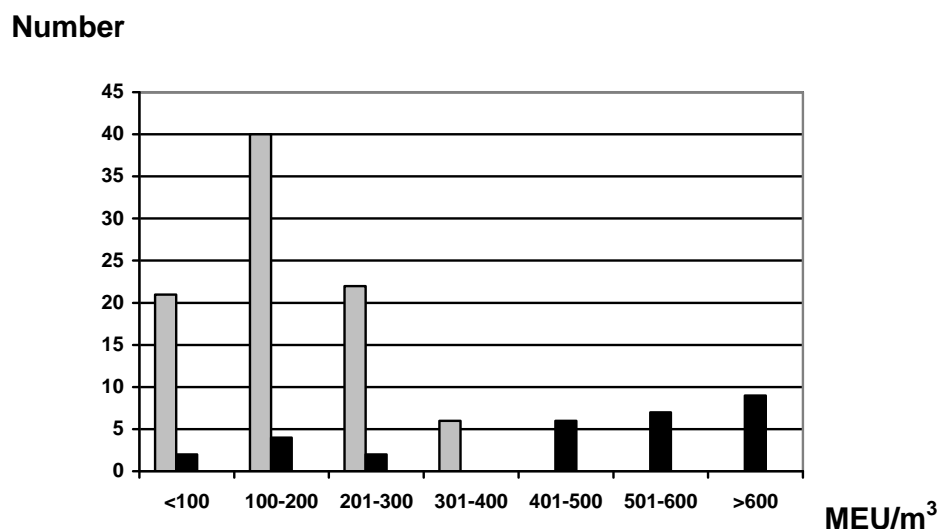
Table 2. Mold enzyme (MEU/m³) in different categories of buildings

Category	No. rooms	Median	Range
Delivery ready	22	132	70-305
Advertised for non-problem	57	147	27-581
Known mold problems	43	265	43-944

Rooms in buildings with known mold damage had higher levels of enzymes as compared to those with no mold problems (t-test $p < 0.001$, ANOVA $p < 0.001$).

In buildings with known mold damage, there was a significant relation between the distance to the site of damage and measured enzyme values. ($r = 0.500$, $p = 0.01$, Spearman's test). This demonstrates that mold from a site with damage may not always spread into rooms further away. For this reason, the highest measured value was considered the most relevant for identifying mold damaged buildings. Figure 1 illustrates the distribution of mold enzyme levels in rooms in buildings without mold damage and the highest value in buildings with mold damage.

Figure 1. Mold enzyme in buildings without (grey) and with mold damage (black bars)



The majority of rooms measured in buildings without mold damage had values less than 300 MEU/m³. The distribution of the highest value recorded in buildings with known mold damage was different. In 22 out of 30 buildings (73%) the amount of mold enzyme exceeded 400 MEU/m³.

In buildings where symptoms were reported the mold enzyme levels exceeded 400 MEU/m³ in all buildings except one.

4. COMMENTS

The major result from the study is that mold values exceeding 400 MEU/m³ were highly related to the presence of mold damage and subjective symptoms. There are some methodological issues to consider. The analysis of airborne samples comprised the determination of a mold enzyme - N-acetyl- β -D-hexosaminidase (NAHA) as a measure of mold biomass. A relationship between NAHA and the amount of mold biomass has previously been demonstrated in different environments such as gypsum boards, or in air samples [5, 6]. Activity due to this enzyme was found in all 50 randomly selected mold species in connection with mold damage in houses (unpublished).

The results are based on one measurement only. Non-systematic repeated measures within the project as well as experience from other studies [7] suggest, however, that levels in a room vary relatively little within a year, particularly in buildings with high levels of mold enzymes.

Some of the buildings with known mold damage had low enzyme values in spite of the presence of mold damage, verified by inspection. It is reasonable that some locations of mold damage will not give rise to an increased exposure in an adjacent room, even if close to the damage. In such cases a low mold enzyme value would represent a false negative result. From an application point of view this means that determinations of airborne mold enzymes are of value particularly in cases where high levels are measured. When high levels are recorded the risk for a false positive is very small. High values also correlated well with the presence of symptoms.

In summary, the results from this investigation suggest that values of mold enzyme exceeding 400 MEU/m³, using the technique employed, with high likelihood indicate the presence of mold damage or symptoms due to indoor exposure.

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