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Dampness in Building and Health (DBH) - Indoor Air Sampling of Viable Mould Spores and Volatile Organic Compounds (VOC/MVOC) in 400 Swedish Homes

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Summary: *The aim for the project is to investigate on the impact of the indoor environment on asthma and allergy in pre-school children in Sweden. Sampling for viable mould spores and volatile organic compounds was included in the sampling plan of the DBH project. Results show that in cases of moisture damages that led to growth of mould fungi inside the building, the samples indoors tend to show both elevated values and different species than found in the reference material. Results of the first analysis of mould and VOC together show that homes in the highest category of mould infestation seem also to have higher VOC load for source groups "dampness" and "MVOC", but not for other groups.*

Keywords: *dampness, mould, voc, mvoc, indoor, dwellings*

1 Introduction

The project "Dampness in buildings and health (DBH)" is a comprehensive and multidisciplinary research project in Sweden. The aim is to find out which pollutants in the air inside dwellings with moisture and indoor air quality problems that might cause health problems, e.g. asthma, allergy and respiratory problems in children.

Norwegian Institute for Air Research (NILU) and Mycoteam A/S provided the sampling equipment and methods for measurement of viable mould spores and volatile organic compounds (VOC/MVOC) and received the samples for analysis after exposure of the media. The sampling was carried out during October 2001 - April 2002, months mostly with a snow cover in Sweden.

2 Methods

In each building viable microorganisms were sampled in the kitchen, living room and the child's bedrom, on two media (MEA and DG18). Reference samples were taken outdoors. Microscopically analyses were conducted after cultivation. Fungi were identified to the level of genera, and recorded as number of colony forming units pr. cubic meter of air (cfu/m^3). Samples were subjectively evaluated into four categories based on fungi amount and composition. One air sample of VOC was taken in each house in the child's bedroom, resulting in 384 VOC samples. Samples were taken in standard Perkin Elmer glass-tubes filled with 200 mg Tenax TA. Sampling rate was 80 ml/min – sampling time about one hour. The tubes were analysed by automated thermo desorption and GCMS detection. Identification of compounds was based on mass-spectra search in commercial available libraries from Wiley and NIST together with NILU's own database for indoor air pollutants.

3 Results

The total numbers of viable mould spores are surprisingly low both outdoors and indoors in the buildings. The indoor and outdoor biota/air differ in mold composition when a qualitative approach is chosen. In cases of moisture damages that led to growth of mould fungi inside the building, the samples indoors tend to show both elevated values and different species compared to the reference material. 379 chemical species were identified. The compounds were grouped according to source into the following groups that are then represented by a sum of concentrations: Total concentration of VOCs, compounds that are known to be present when there is damage from humidity (but not fungal damage) (5), MVOC (compounds that are in the literature reported to be connected with fungal damage) (28), Aromates (20), Organic acids (9), Oxygen containing solvents (19) and Hydrocarbons (58). Benzene as an indicator of traffic pollution was added as a single compound. Results of the first analysis of mould and VOC together show that home in the highest category of mould infestation seem also to have higher VOC load for group "dampness" and for group "MVOC", but not for other groups.

The results will be used for exposure characterization in the DBH study, and are a first step to a simplified method for identification of mould infested indoor environments.

Appendix A

Presentation

Dampness in Buildings and Health (DBH)

Exposure measurements of mould and VOC in 400 Swedish homes.

- The Norwegian project

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Dampness in Buildings and Health (DBH)

Coordinator: Carl-Gustaf Bornehag, Public Health Sciences, Karlstad University, Sweden

Aim

Investigate on the impact of the indoor environment on asthma and allergy in pre-school children in Sweden

Study design

- **Phase I - Cross-Sectional study**:
  - Questionnaire on housing and health sent to all children in Värmland
    - 14 077 children (age 0-6 years)
- **Phase II - Case-Control study**:
  - 198 children with self-reported symptoms were chosen for clinical examinations and 202 ”healthy” children - controls
  - The subject’s homes (400) were examined by a thorough building inspection
  - Exposure measurements include: ventilation rate, moisture, visible mould, temp, dust samples

Dampness in Buildings and Health (DBH)

Assessment of mould in buildings

- Visual examination (direct and indirect signs of damages)
- Moisture measurements
- Sampling
  - Material samples
    - Building materials (bulk samples)
    - Surface samples (tape-lifts, contact agar)
  - Air samples
    - Mould spores (number of viable spores, total number of spores)
    - Particles (dust, mineral fibres etc.)
    - Volatile organic compounds (VOC/MVOC)

DBH - Norwegian participation

Norwegian project (Mycoteam/NILU)

- Sampling of viable mould spores and volatile organic compounds (VOC) in air, with emphasis on microbial VOC (MVOC) included in DBH.
- NILU and Mycoteam provided the sampling equipment and methods and received the samples for analysis after exposure of the media.

Aims

- Establish a set of data on the occurrence of viable mould spores and volatile organic compounds (MVOC/VOC) in the 400 houses.
- Compare levels/types of VOC/MVOC and viable mould spores.

DBH - Norwegian participation

Sources of indoor VOC

- Outside air
- Building materials
- Human activities
- Moisture
- Mould

DBH - Norwegian participation

MVOC

- Are produced by actively growing mould cultures
- Emission composition and amount depend on the species, point in the ”life-cycle”, nutritional status etc.

But:

- Can occure both naturally or are part of synthetic products
- Have highly variable properties (volatile)

Thus:

- Need to study a sufficient number of MVOC components
- Simultaneously look at the emission component composition, emission patterns and emission rates

DBH - Norwegian participation

Methods

Mould (Mycoteam)

- Samples taken in 3 rooms in each house and outdoor (reference samples)
- Viable mould spores sampled on two media (MEA and DG18)
- 3200 air samples microscopically analysed for viable mould spores after cultivation
- Samples subjectively evaluated and grouped into four categories (Mycoindex) based on both the number (cfu/m3) and the types of fungi present in each sample

DBH - Norwegian participation

Methods

VOC/MVOC (NILU)

- 400 air samples taken in the child's bedroom and analysed for MVOC/VOC (384 samples available)
- Samples taken in Tenax TA glass tubes
- Samples analysed by automated thermo desorption and GCMS detection.
- Identification of compounds based on mass-spectra search in commercial available libraries together with NILU's own database for indoor air pollutants
- 50 VOC with highest concentrations in each sample selected (in all over 414 compounds)

DBH - Norwegian participation

Summary of VOC results

- 384 samples gave valid results
- VOCs were grouped according to source:
  - Total VOC load
  - Dampness (5)
  - MVOC (28)
  - Aromatic compounds (20)
  - Organic acids (16)
  - O-containing solvents (9)
  - Alkanes (12)
  - Methylalkanes (32)
  - Dimethylalkanes (14)
  - Benzene

DBH - Norwegian participation

MVOC and dampness-related VOC

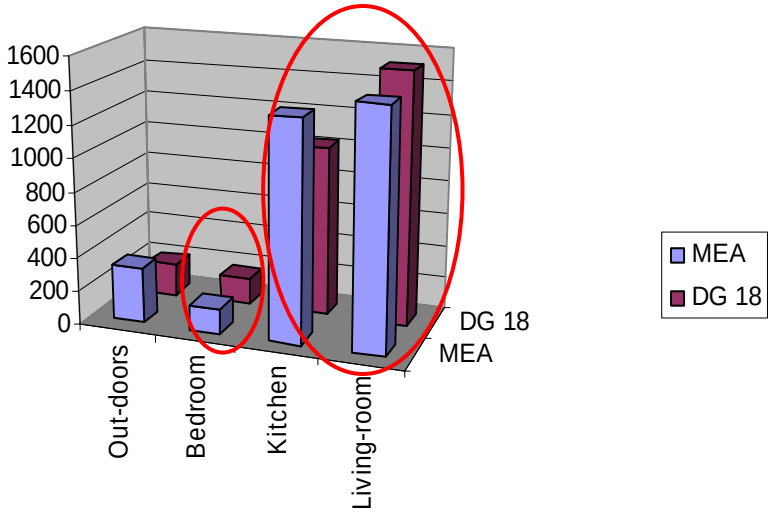
- **Dampness-related VOC:** 5 compounds

  Compounds that are known to be present when there is damage from humidity towards paints and floorings (but not fungal damage)

- **MVOC:** 28 compounds

  Compounds that are in the literature reported to be connected with fungal damage

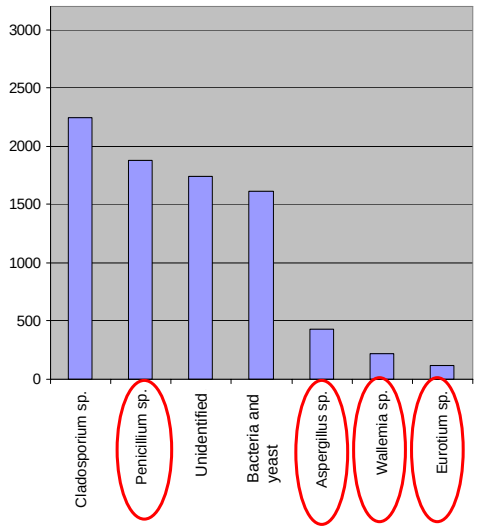
Results - Mould (number of cfu/m3)



Most common moulds

	n
Cladosporium sp	2 245
Penicillium sp.	1 876
Unidentified	1 741
Bacteria / yeast	1 611
Aspergillus sp.	427
Wallemia sp.	216
Eurotium sp.	119

(n = 3 200)



DBH - Norwegian participation

Mycoindex – method

A subjective evaluation of the samples into four categories based on fungi amount and composition.

1. Comparison between outdoor samples and indoor samples (number of cfu/m^3).
2. Dominance of a single genera and/or indicator species are registered.
3. The results from 1 and 2, are evaluated and graded in four levels according to NS 3424.

(The standard defines the quality or condition for building parameters on a scale from 0 to 3, where 0 is best and 3 is worst)

DBH - Norwegian participation

Mycoindex: Categories

0 **No signs of unnatural occurrence of mould spores in the indoor environment**. The values indoors are lower than outdoors and no species that indicate moisture damage are recorded.

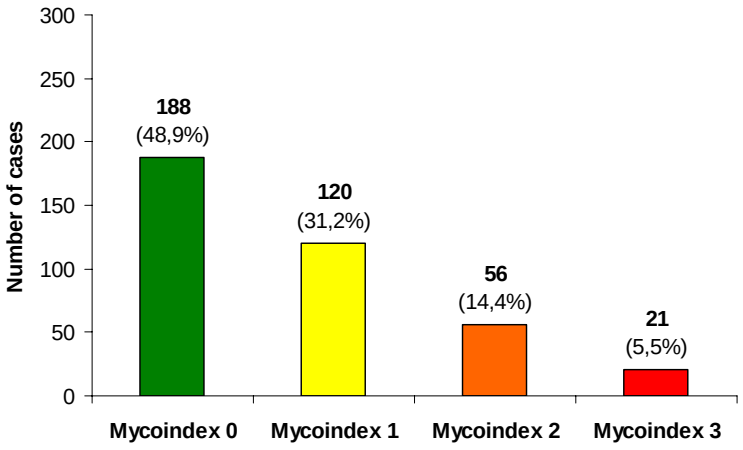
1 **Small signs of unnatural occurrence of mould spores**. The values indoors are slightly raised compared to outdoor values and/or species that indicate moisture damage are recorded.

2 **Moderate signs of unnatural occurrence of mould spores**. The values indoors are clearly raised compared to outdoor values and/or clear occurrence of species that indicates moisture damages are recorded.

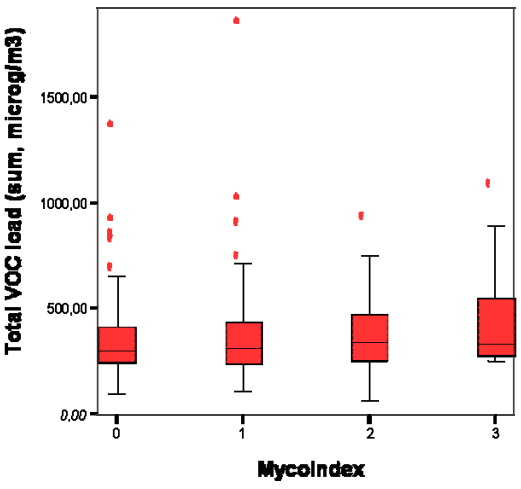
3 **Clear signs of unnatural occurrence of mould spores**. The values are significantly raised compared to outdoor values and/or very clear dominance of species that indicate moisture damages are recorded.

DBH - Norwegian participation

Results of Mycoindex categorisation (n=385 houses)



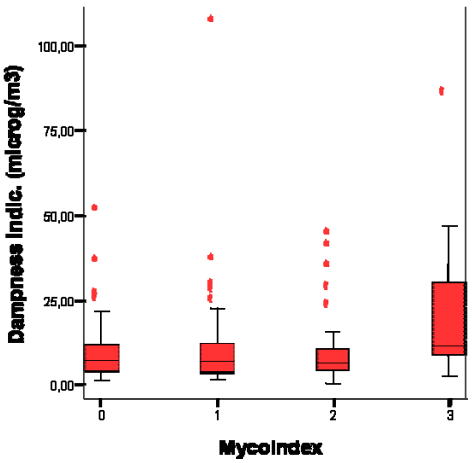
Results: Mycoindex vs total VOC load



SPSS
One-way ANOVA test
(95% CI)

No significant difference between groups.

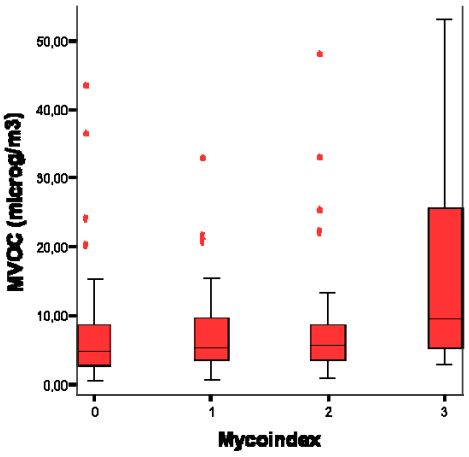
Results: Mycoindex vs dampness-related VOC



SPSS
One-way ANOVA test
(95% CI)

Significant difference between groups, group 3 significantly higher concentration.

Results: Mycoindex vs MVOC



SPSS
One-way ANOVA test
(95% CI)

Significant difference between groups, group 3 significantly higher concentration.

DBH - Norwegian participation

Conclusions

1. A classification method for indication of probability of mould damage in buildings has been improved
2. Database of VOC profiles, MVOC characterisation of indoor environment has been established
3. Results indicate higher MVOC and dampness-related VOC loads in domestic homes with Mycoindex grade 3
4. Further investigations are needed

End