Moisture indicator microbes

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Healthy buildings, sick buildings?

- The concepts ’sick buildings’ and ’SBS’ (sick building syndrome) were introduced in the 70’ies
- The occupants had symptoms in certain buildings, and were symptom-free in other surroundings
- Causes were unknown
- Are the buildings sick/ill or the patients?

Mouldy buildings

- Moisture and mould damage as a potential cause of ill health and irritation symptoms was introduced in late 80'ies and early 90'ies
- Is mould growth normal or unusual in a building?
- Moulds are everywhere
- What is normal, what is not normal?

What is moisture damage

- Water damage, water leaks, roof or pipeline leaks, sue water or rain water leaks, flooding, soil humidity (capillar moisture)
- Condensation of moisture on cold surfaces, walls, window panes
- Relative humidity (RH) is usually very low during the winter in Nordic countries
- Can mould survive in building structures when the air is extemely dry?

Humidity vs. water activity

- Humidity in the air is strongly correlated with the temperature (RH)
- The same water content in the air results high RH in low temperature and low RH in high temperatures
- Leads to water condensation when the temperature decreases
- Water activity a_w = RH in construction materials
- In the construction, the water activity may be high although the RH in the air is low (especially concrete, ceramic tiles etc.)

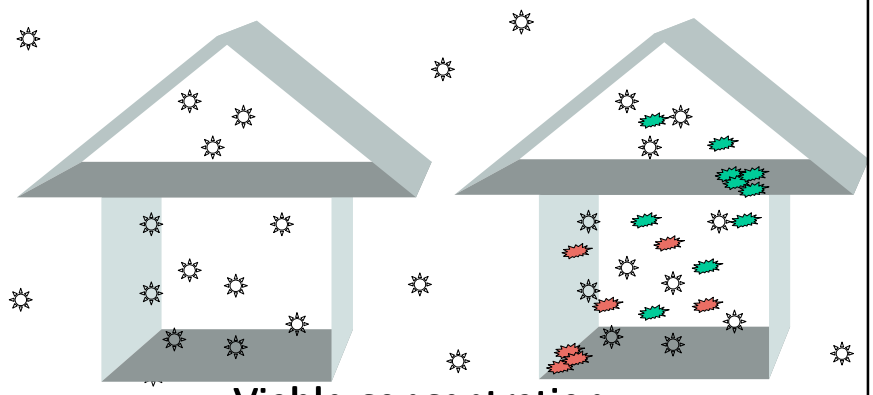
Mould, mildew, fungi, yeast

- What is mould damage?
- Mould spores can be found everywhere in construction materials and on surfaces
- How much is normal and what is abnormal?
- Visible mould growth
- Hyphae and spores
- Is mould odour also mould damage in a building?

’Normal’ and ’abnormal’ microbial flora in a building

- Sampling of ’normal’ / non-complaint buildings in Finnish housing stock
- Small amounts of spores are considered normal on surfaces and in construction
- Low concentrations in the winter, high during seasons when the ground is not covered with snow
- No outdoor sources

How does the indoor air of a moisture-damaged house differ from normal?



Viable concentration

usually < 100 cfu/m³ ☼ often > 100 cfu/m³

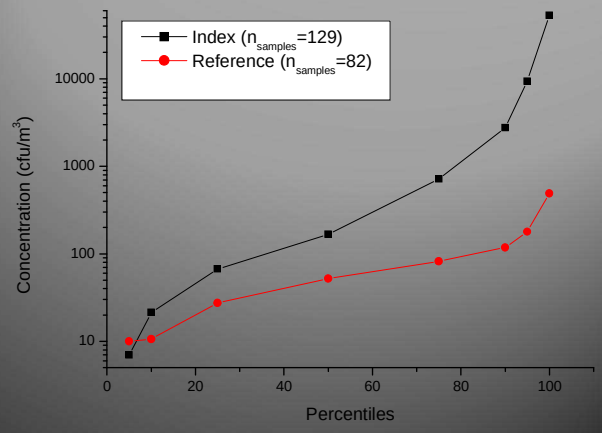
Indoor air concentrations

- Only viable spores are counted
- Sampling with the s.c. Andersen sampler (six stage impactor)
- Sampling time ca. 10 min
- Sampling on plates
- Incubation for 7 – 10 days
- The s.c. normal concentrations were introduced in early 90'ies (500 cfu/m^3)
- Later new reference values 100 cfu/m^3 for winter time, 50 cfu/m^3 for office buildings and 20 cfu/m^3 for school buildings

Problems in interpretation

- In the summer, high concentrations in indoor air in non-damaged buildings (outdoor concentrations even higher)
- Health problems were reported in moisture damage buildins although concentrations were below 500 cfu/m^3 during winter
- In some problem buildings, the flora and variety of moulds were different from outdoor air
- The concentrations of viable spores in indoor air did not correlate with health effects

Cumulative distributions of concentration of viable fungi in residences



Hyvärinen 2002

Introduction of the 'concept moisture indicator microbes'

- In 'normal' buildings, the spores in indoor air correlate with those in outdoor air
- Normally concentrations higher outdoors than indoors
- In Finland, typical outdoor microbes are *Cladosporium, Geotrichum* and *Botrytis*, indoors *Penicillium, Aspergillus* and yeast
- In warm climate, Alternaria often dominant outdoors

In moisture problem houses

- The variety of microbes in inroor air is larger than outdoors
- Several species found only indoors
- When the concentration on spores is higher indoors than outdoors, there is a source inside of the building
- Are these 'unusual fungi' different or the same in different countries

Moisture indicator microbes

- The list of indicator microbes was intruduced in an international conference held in Baarns, NL in mid 90'ies
- The list is based on water activity of the growth media, building material
- Succession of microbes over time
- Primary, sedondary and tertiary microbes
- Primary phase, lower water activity
- Tertiary phase, high water activity microbes

Primary phase microbes

- Use sugars and carbon hydrate as substrate
- E.g. *Penicillium* sp., *Aspergillus*
- Xerophilic molds, a_w =0.65–0,9, yeast a_w =0.88 – 0.99
- Fungal growth starts rapidly when moisture conditions are optimal in the material
- Some moulds, e.g. *Penicillium* tolerate fluctuating moisture conditions

Secondary phase microbes

- Use starch and longer carbon hydrates as substrate
- *Aspergillus versicolor, Ulocladium, Geomyces, Wallemia* etc.

Tertiary phase microbes

- Use cellulose as substrate
- Slowly growing
- E.g. *Stachybotrys, Chaetomium, Fusarium, Phialophora*
- Rot fungi, e.g. *Serpula lacrymans*
- *Streptomycetes,* other actinobacteria

- Often primary, secondary and tertiary microbes found simultaneously
- In sue water and soil humidity cases, tertiary phase microbes may grow also in the early phase of the water damage

Lists of indicator microbes vary over time

- Preliminary list in the Finnish Guide Book* -97:
  - *Stachybotrys, Phialophora, Fusarium,* actinobacteria

Next version in 2003*:

Exophila *Ulocladium*
Stachybotrys *Aspergillus versicolor*
Chaetomium *Trichoderma*
Phialophora
Aspergillus fumigatus
Fusarium ***Yeast***
Eurotium
Wallemia

- **aktinobakterier**

  - ***The Ministry of Social Affairs and Health**

Moisture indicator microbes

- Correlate with the damage of the building
- Do they correlate also with health risks?

- Moisture damage microbes are considered weak allergens and opportunistic microbes seldom causing infection in otherwise healthy persons
- Are moisture indicator microbes a real risk or are they only a surrogate of exposure?

Health effects

- Higher prevalence of respiratory irritation and non-specific symptoms
- Higher occurrence of common respiratory infections, e.g. sinusitis
- Increased incidence of asthma and allergies
- May grow on skin or in sinuses, but very seldom cause invasive infections in otherwise healthy individuals
- Health impact of individual moulds species can't be distinguished as the exposure almost always includes several mould genera

Health effects is modified by

- The duration of exposure
- Simultaneous other eaxposures, such as RH, temperature, chemicals, dusts ect. modify the effect
- Target population, e.g. children vs adults
- Previous diseases
- Habits, pets, smoking etc.
- Often primary phase microbes have mainly irritative effect, secondary phase microbes are allergenic and tertiary phase microbes are toxic

Experimental studies

- On animals, in vitro on cell cultures
- Ex vivo tissues, trachea, blood cells etc.
- In human beings
- Mould species studied one by one
- Combinations (e.g. Penicillium, Aspergillus or Stachybotrys alone or with Streptomycetes) potentiate the effect (synergism)
- Toxins and toxin producing microbes are in the focus of research (e.g. the next presentation!)

Conclusions

- Moisture indicator microbes indicate the damage of the building
- Not all indicator microbes are equally harmful to human health
- Not all harmful moulds are indicator moulds
- Are indicator lists needed after all?
- Mould growth in a building may be a risk to the building and to occupants
- The duration of exposure is essential
- The succession of microbes (primary -> secondary -> tertiary) may lead to severe health outcomes
- The damage should be remediated!

Thank you!

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