Indoor Air Quality Assessments: Mould

Daniel Fong
National Collaborating Centre for Environmental Health
Indoor air quality workshop
CIPHI National Education Conference
Winnipeg, MB | June 23, 2013
Outline

Introduction
- What is Mould?
- Sources
- Health effects

Sampling and Interpretation
- Sampling methods
- Interpreting results (example lab reports)

Management
- Education
- Remediation - see resources
Introduction
What is Mould?

- Moulds are multi-cellular spore-forming filamentous organisms
  - Ubiquitous, outdoor and indoor
  - >100,000 reported species, few hundred are relevant to human exposure
  - Saprophytes (live off dead organic matter), parasites, symbionts

- Growth requires…
  - $O_2$
  - Organic carbon source
  - Temperature (ideal = 18-32°C)
  - Time
  - Moisture (e.g., RH >60%)
    - most important and only factor that can be controlled indoor

Kathie Hodge
http://www.flickr.com/photos/cornellfungi/5613739709/
Sources

- Walls, floors and ceilings, wallpaper
- Insulation, carpet,
- Furniture, mattress
- Paper, cardboard
- Food, oil
- HVAC
- Dust
- Plants
- Soil
- Other biodegradable organic materials, even in small amounts or parts of seemingly inorganic substances (e.g., residue/condensation on glass, plastics, caulking)

Concentrations are generally higher outdoor vs. indoor
Health Effects

• Irritation
  – Eyes, skin
  – Upper RT
    • Nose, throat irritation
  – Lower RT
    • Cough, wheezing, shortness of breath

• Infection (opportunistic)

• Immunological reactions
  – Asthma symptoms
  – Hypersensitivity pneumonitis (inflammation of alveoli)
  – Allergic rhinitis, sinusitis, dermatitis

Vulnerable populations:
immunocompromised (HIV/AIDS), immunosuppressed (transplant, chemotherapy patient);
those with allergies, chronic underlying respiratory disease (COPD, asthma); infants, elderly
Sampling & Interpretation
Many factors affecting the composition of mould in the air…

- Growth + distribution
- Note outdoor and indoor conditions
- A few examples…
  - Climate
    - temperature, season, time of day,
  - Aerosolization
    - Wind, rain, anthropogenic activity, turbulence
  - Indoor pets, plants, etc.
Sampling methods

- **‘Non-culturable’ (air)**
  - spore traps

- **Culturable (air)**
  - Anderson, biocassettes

- **Direct microscopic examination (qualitative)**
  - Tape, swab, bulk
Non-culturable Fungi Air Sampling

- Spore traps (e.g., air-o-cells)

- Sampled fungi (viable/non-viable) are analyzed under microscope

- Can provide...
  - ID to genus level
  - Concentration (spores/m³)
  - Genus-level comparison between samples

EMLab P&K
http://www.emlab.com/m/store/003-2022-01_Lg.jpg
Culturable Fungi Air Sampling

Andersen, biocassettes, RCS, etc.

Sampled fungi are collected onto growth media; subsequently enumerated and isolated for ID

Used for determining species and viability of fungi in the air

- Can provide...
  - ID genus + species (e.g., Aspergillus, Penicillium)
  - Concentration (CFU/m³)
  - Species-level comparison between samples

EMLab P&K
http://www.emlab.com/m/store/012-3347-00_Lg.jpg
Surface Sampling

Surface sampling (tape lift, bulk, swab)

Sampled fungi (viable/non-viable) are analyzed under microscope

Used to verify presence/absence of mould on surfaces

• Can provide...
  – relative level of mould on a surface (qualitative, genus level)
  – information on whether viable fragments or spores are present
  – information on background debris
Interpreting Results – Compare Indoor vs. Outdoor (control)

Anaylze lab results…

• ‘Expected’ moulds and levels between…
  – Suspect areas…
    • indoor air
    • surfaces
  – ‘Control’/baseline areas…
    • outdoor air
    • non-suspect areas/rooms

• Any potential indicators of indoor mould/dampness?
  – further investigation?

Do results indicate dampness + mould growth indoors?
Interpreting Results – Potential indicators

**Level**

* spores/m³, CFU/m³, # hyphal fragments/m³: **Indoor > outdoor**

**Diversity**

* Mould (genus/species) ID’ed in indoor sample are **dissimilar** to those in outdoor sample
* presence of a genus/species in indoor **but NOT** outdoor sample

**Dominance**

* mould that are dominant in indoor sample are **dissimilar** to those in outdoor sample
Interpreting Results – Potential indicators

These are not commonly found in indoor air:

- Rusts, smuts (plant pathogens/fungi)
- Pollen, insect parts
- Hydrophilic fungi

• Typical hydrophilic fungi
  - Stachybotrys
  - Fusarium
  - Chaetomium
  - Trichoderma
  - Ulocladium
  - Alternaria
  - Acremonium
  - Actinomycetes
  - Epicoccum
  - Rhizopus…
<table>
<thead>
<tr>
<th>Moisture level</th>
<th>Category of microorganism</th>
</tr>
</thead>
</table>
| High ($a_w > 0.90$; ERH, $> 90\%$) | Tertiary colonizers (hydrophilic)  
  *Alternaria alternata*  
  *Aspergillus fumigatus*  
  *Epicoccum spp.*  
  *Exophiala spp.*  
  *Fusarium moniliforme*  
  *Mucor plumbeus*  
  *Phoma herbarum*  
  *Phialophora spp.*  
  *Rhizopus spp.*  
  *Stachybotrys chartarum (S. atra)*  
  *Trichoderma spp.*  
  *Ulocladium consortiale*  
  *Rhodotorula spp.*  
  *Sporobolomyces spp.*  
  *Actinobacteria (or Actinomycetes)* |
| Intermediate ($a_w 0.80–0.90$; ERH, $80–90\%$) | Secondary colonizers  
  *Aspergillus flavus*  
  *Aspergillus versicolor*  
  *Cladosporium cladosporioides*  
  *Cladosporium herbarum*  
  *Cladosporium sphaerospermum*  
  *Mucor circinelloides*  
  *Rhizopus oryzae* |
| Low ($a_w < 0.80$; ERH, $< 80\%$) | Primary colonizers (xerophilic)  
  *Alternaria citri*  
  *Aspergillus (Eurotium) amstelodami* |
Interpreting Results

Toxigenic/Pathogenic mould

- Aspergillus fumigatus, A. versicolor, A. niger
- Penicillium chrysogenum
- Fusarium
- Stachybotrys
- Trichoderma
- Chaetomium…

• Presence in multiple indoor air samples may support the need for further investigation or remediation
Let’s look at some example lab reports and briefly go over them
  • Non-culturable air
  • Culturable air
  • Surface
Interpreting Results

• Results should not be interpreted in isolation.
  – Needs qualitative risk assessment
    • Information gathering + building history
      » Complainants, tenants, employees, OHS, managers, maintenance staff (building, custodial, engineer)

• Visual/Field inspection for mould growth and dampness
• Professional judgement (may involve a team)
• Assessment and remediation needs to consider individual site-specific conditions and objectives
Interpreting Results

• Consider:
  – Adequacy of other information to assess for mould growth and dampness
    • What is the need for and reasons for sampling?
  – Sampling method and protocol
    • What are the pros, cons, limitations?
  – Objective of sampling
    • What will be the use of lab results?
    • Do results indicate need for further investigation, remediation, etc.?
    • Testing cannot tell you whether human health effects will occur.
Interpreting Results

• **Visible mould** or dampness is ‘unacceptable’ from hygiene perspective
  – sample only if visual inspection unclear or suspect hidden mould (e.g., in crawlspace)

• If sampling results indicate hidden mould…
  – Is there a reasonable **exposure pathway**?
Management
Education

• Inform on…
  – health effects
  – vulnerable populations
  – potential need for professional assessment/remediation
  – preventing moisture/mould issues
Remediation

• Many resources and guidelines available
  – see additional resources
NCCEH Evidence Reviews:


<table>
<thead>
<tr>
<th>EMLab P&amp;K</th>
<th>Mold &amp; Bacteria Consulting Laboratories (MBL)</th>
</tr>
</thead>
</table>
| • Sampling Overview  
• Sample lab reports  
• An index of some commonly encountered fungal genera  
• Glossary  
| • Results Interpretation  
  - [http://www.moldbacteria.com/category/results-interpretation](http://www.moldbacteria.com/category/results-interpretation) |
Guidelines


Books
