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SOLVING INDOOR AIR QUALITY PROBLEMS

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Health Effects of Fungi (Mold) in Residential Construction 1990-2009

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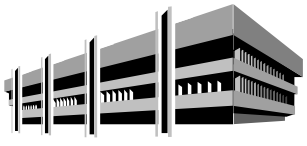
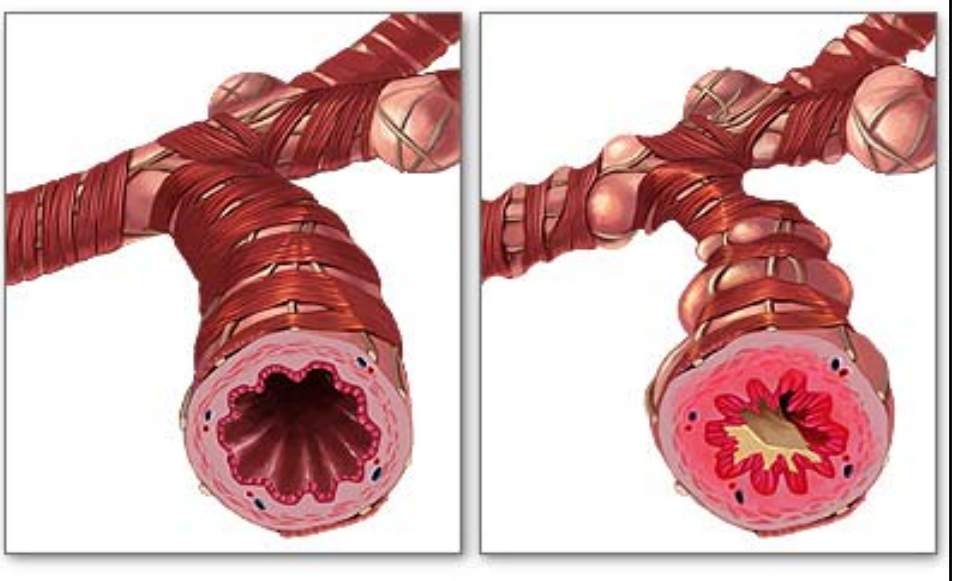
What Health Problems Have Been Related to Fungi?

- Odor Concerns
- Respiratory and Skin Allergies
- Hypersensitivity Reactions/Asthma
- Pathological Manifestations/disease causing



30% of population has Asthma and Allergies

- **20.5 million people have asthma**
- **300% increase from 1982 to 2006**
- **Greater increases among children, minorities and inner-city neighborhoods**
- **No identified cause for increase**



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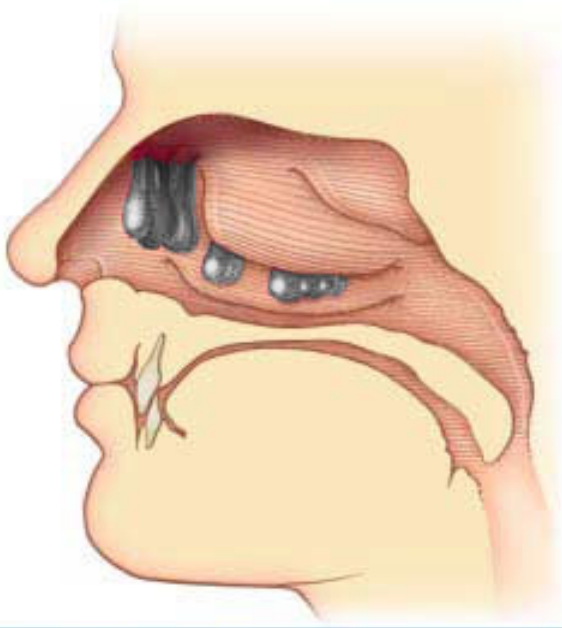
Health Effects of Asthma and Allergies

- 6% of children and 5% of adults have active asthma
- 5,000 deaths per year: 1 death per 2,400 asthmatics/yr), hospitalization (~500,000 per yr: 4 admissions per 100 asthmatics/yr), emergency care (~1,500,000 per year: 12 ER visits per 100 asthmatics/yr)
- For Minnesota, which has 2% of US population this means 100 deaths per year

1999 Mayo Clinic Study of Allergic Fungal Sinusitis

- Studied 210 patients who had been diagnosed with rhino sinusitis (runny nose)
- 96% had positive cultures in nasal secretions
- 101 of 210 patients had surgery to remove nasal polyps – 97% of the polyps removed were caused by fungal infections



1999 Mayo Clinic Study of AFS

- Control Group - Cladosporium (57%) Alternaria (50%), Aspergillus (5S-43%), Geotrichum (29%) and Penicillium (21%)
- Patients - Penicillium (43%), Aspergillus (9S-30%), Candida (21%), and Fusarium (16%)

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What mold related problems are we seeing in residential housing?

- Number one is below grade wall failures – wet basements
- Number two is inadequate window flashings
- Number three is lack of adequate drainage planes on above grade walls

Below grade wall failures

- Unforgiving wall designs in combination with inadequate landscaping spells disaster.
- Having drain tile and water proofing will not make up for poor wall design and landscaping
- All buildings need a good below grade wall design and adequate landscaping
- Below grade wall designs common in housing from 1990 to 2009 is extremely poor

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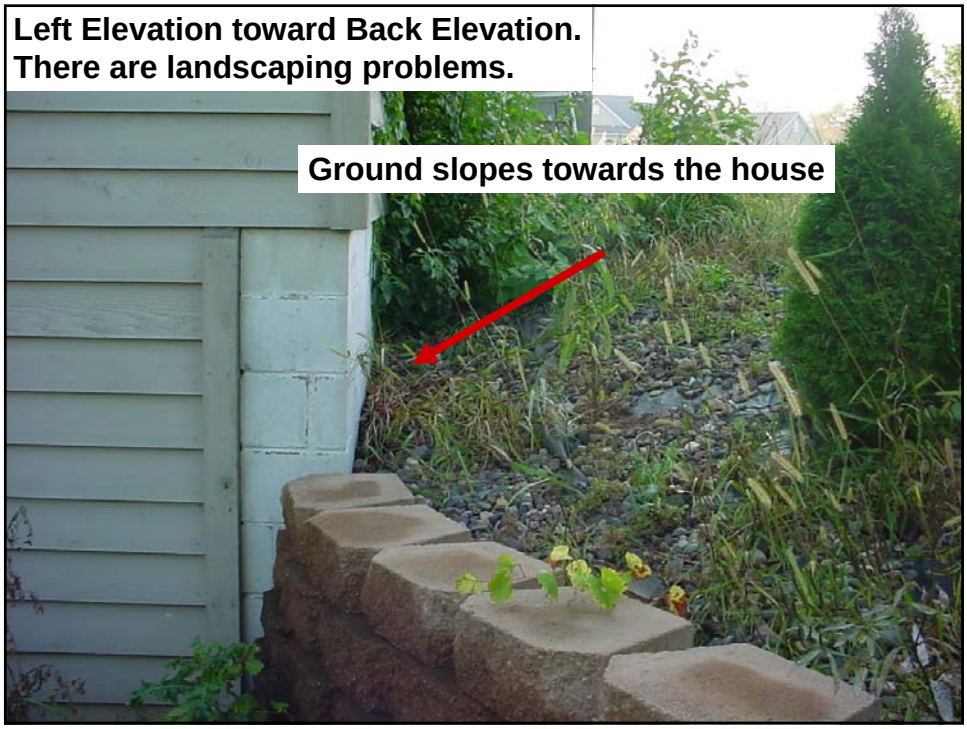
Lake Elmo, Minnesota House – six years old – 40 year old husband died of an asthma attach in this house – two of three children presently living in the house have asthma – Poor widow with three kids

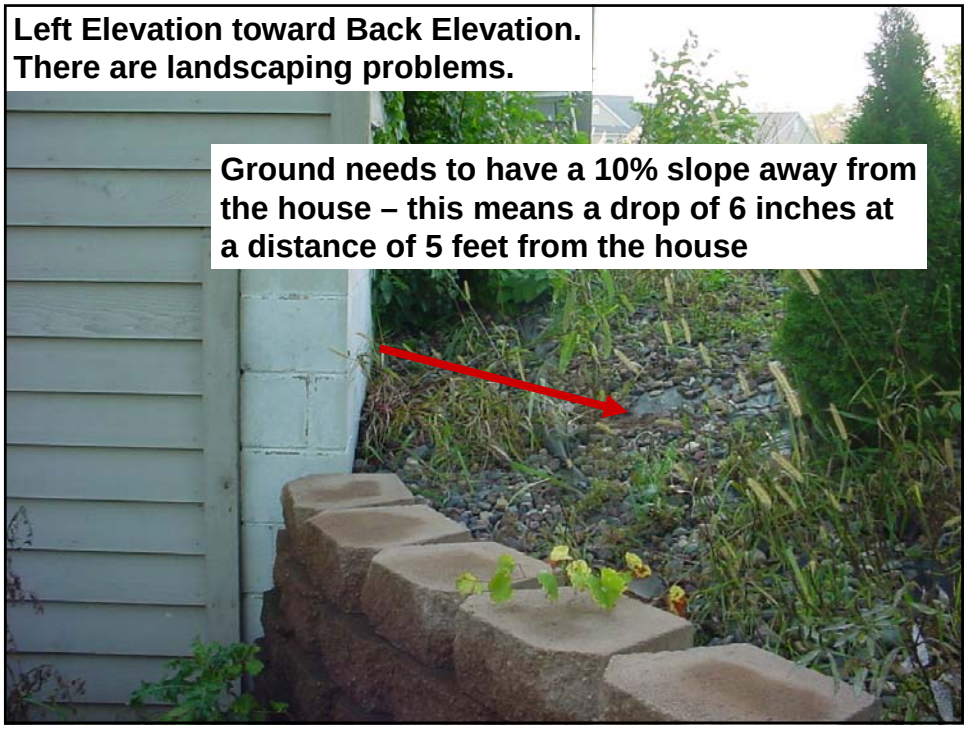
Left Side

Right Side

Left Elevation toward Back Elevation. There are landscaping problems.



Left Elevation toward Back Elevation. There are landscaping problems.



Back Elevation at Left Elevation. Cladding goes below grade for 6 feet. Ground does not slope away from the house – needs a 10% slope away from the house

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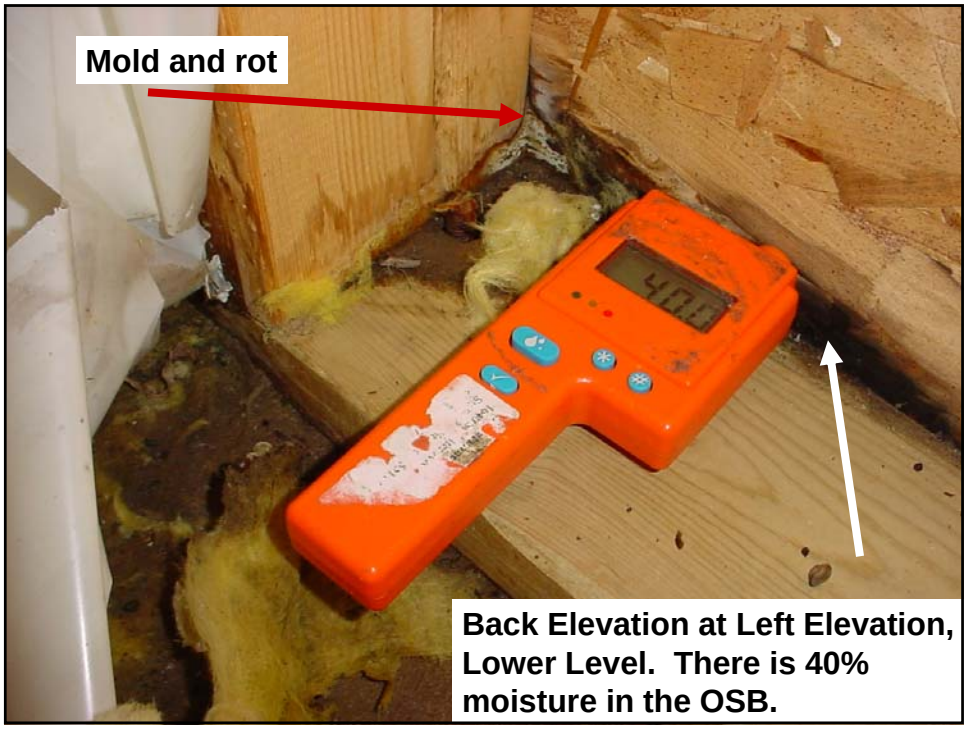
Canadian Mold Guideline – Visible Mold

- Normal is less than 1% of its floor area -visible mold
- 1-3% borderline
- Moldy - Over 3% of its floor area with visible mold.
- This house - 3,000 square feet of floor area
- Normal would be less than 30 square feet of visible mold – moldy over 90 square feet of visible mold
- This house has over 1,000 square feet of visible mold.
- “Fungal Contamination in Public Buildings” by Doctor David Miller Cat. H46-2/04-358E, ISBN 0-662-37432-0.

Lower level Back Elevation near Left Elevation, showing wet concrete blocks and water on the floor.



Back Elevation at Left Elevation, Lower Level. There is 40% moisture in the OSB.

Lower level Back Elevation near Left Elevation, showing mold growing on the fibrous glass behind the poly.

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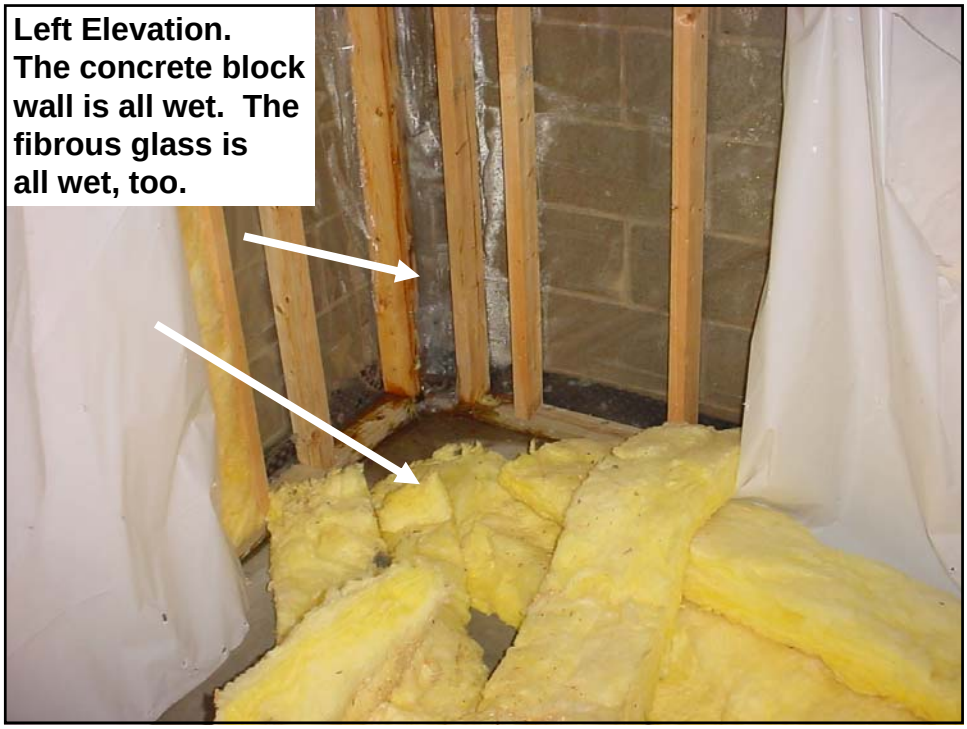
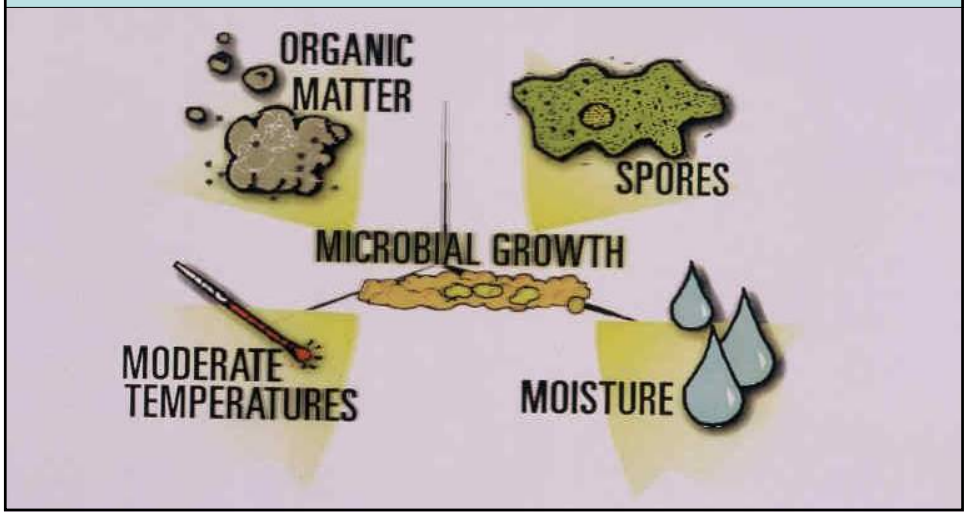
Fungal samples collected in this house show the mold growing here to be primarily Aspergillus and Penicillium

Back Elevation near Right Elevation, Lower Level. Mold is growing on the poly and in the fibrous glass.

Left Elevation. The concrete block wall is all wet. The fibrous glass is all wet, too.



Requirement for Fungal Growth



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Common Fungi

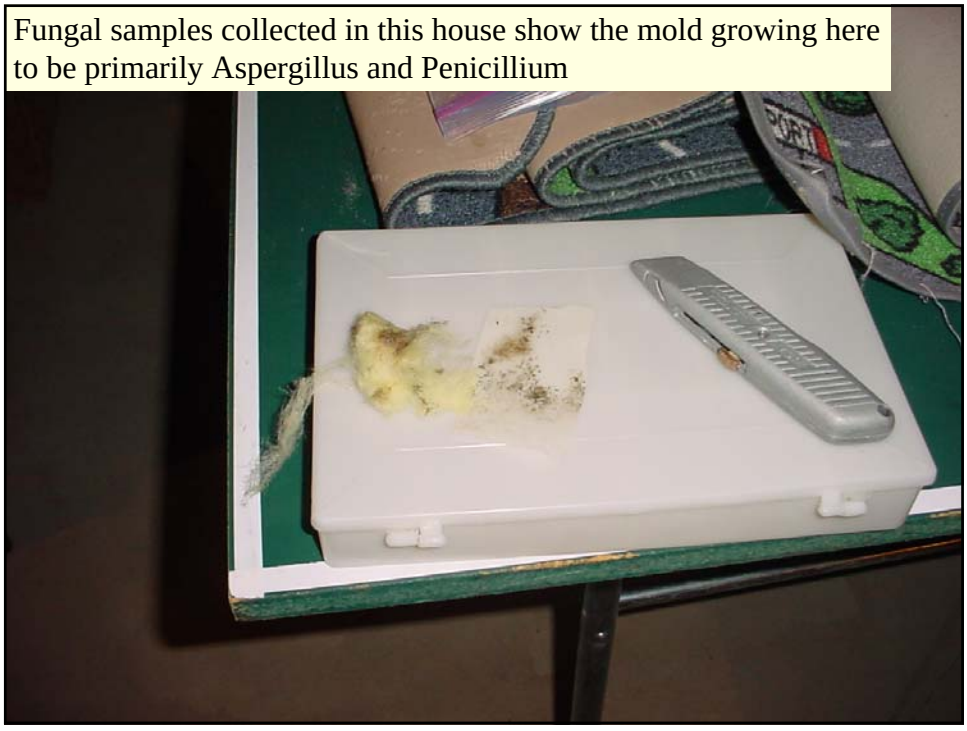
- **Found everywhere**
- **Problems in high concentrations**
- Soil and leaf molds - C*ladosporium,* Alternaria, *Epicoccum,* Basidiomycetes, Paecilomyces, Pithomyces, *and yeasts*

Indicator Fungi

- Indicator species vary from guideline to guideline
- Indicator species are primarily fungi which are not common outdoor airborne fungi.
- Most studies have shown that Penicillium (green to black in color) and Aspergillus species (most are black but can be any color) are the most common fungal species found in fungal infested buildings.

Lower level Back Elevation near Left Elevation, showing mold growing on the fibrous glass behind the poly.

Fungal samples collected in this house show the mold growing here to be primarily Aspergillus and Penicillium



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Bulk Mold Samples

discolored fibrous glass insulation Lower Level	11,200,000 Colony forming units per gram	Cladosporium (46) Aspergillus sydowii (29) Penicillium (11) Oidiodendron (8)
OSB sheathing above sill plate, Lower Level	7,870,000	Oidiodendron (35) Aspergillus sydowii (14) Penicillium (14) Acremonium (7) Aspergillus versicolor (4)

Settled Dust Mold Samples

Settled dust carpet, LL bottom step of stairwell	1,280,000 CFU/sq. ft.	Aspergillus versicolor (39) Sterile mycelium (33) Cladosporium (7) Penicillium (7)
Settled dust from brown couch, Lower Level,	82,500	Penicillium (32) Cladosporium (22) Aspergillus species (17) Alternaria (9)

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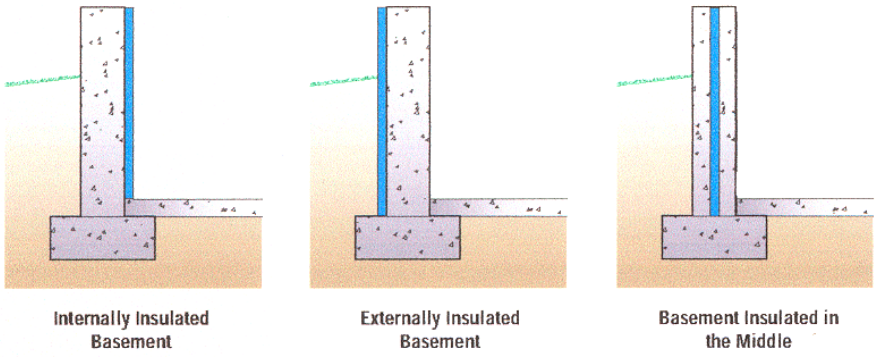
Canadian Settled Dust Mold Guideline

- Canadian Research Technical Series 04-103 January 2004 (www.cmhc.ca)
- Uses ratio of non phylloplane (indicator) to phylloplane fungi (common outdoor)
- Six settled dust samples in this house have the following ratios 5.6, 3.6, 0.14, 0.77, 1.6, and 5.6, with an average ratio of 2.9.
- Normal is a ratio below 0.7 – heavily contaminated is a ratio above 1.5

Conclusions - Moisture problems

- Unfortunately building techniques common in housing built from 1990 to 2009 trap moisture inside walls
- This trapped moisture encourages mold growth in the walls
- The most common material used in construction to trap moisture is polyethylene vapor barriers
- Polyethylene was not used in housing before 1980. Using polyethylene in construction has nothing to do with energy conservation, other more effective building materials can be used in place of poly that do not trap moisture in the walls – this is not a cost issue

Figure 1
Basement insulation locations



Picture Courtesy of Building Science Corporation

Conclusions - Moisture problems

- The foam insulation allows below grade walls to dry to the inside – 100 times better than poly
- Cost difference between foam versus poly and fibrous glass varies but is at most a few hundred dollars to no more than 1 to 2 thousand for a typical 300,000 dollar house
- Building code people presently encourage the poly and fibrous glass – it is not required by the code

RESEARCH HIGHLIGHTS

January 2004

Technical Series 04-103

HOUSE DUST: A USEFUL TOOL TO ASSESS MICROBIAL CONTAMINATION IN HOMES

Introduction

In recent years, there has been increasing concern about indoor air quality in houses. The family home can sometimes become a source of microbial contamination, where molds and bacteria proliferate. Inadequate ventilation and high moisture levels resulting from water damage episodes or excess humidity often cause the proliferation of fungi (molds) and bacteria on visible surfaces or hidden inside structures. In such a context, a good diagnosis of the degree of microbial contamination in homes becomes more important. Unfortunately, assessment tools are few and insufficient. Air sampling, still frequently used, is an incomplete tool, which is not reproducible and can lead to false negative results. On the other hand, surface samples are useful to document the nature of visible fungal contamination but insufficient to obtain a global diagnosis (ACGIH, 1999).

Field experience has led some researchers to promote the use of house dust microbial analysis, as it represents the "memory of a building" providing valuable information on its microbial history. This project was conducted to obtain dust analysis data from homes with no history of moisture damage to compare with water damaged homes. Thanks to an External Research Program grant from CMHC, it was possible to inspect more than fifty healthy homes, and analyse their dust microbial contents. The data from non-moisture damaged homes was added to the researcher's own existing database of hundreds of unhealthy homes to allow comparison of the two data sets, and confirm the validity of the method.

Methods

Healthy home selection

Homes in the Montreal area were recruited by advertising in two newspapers, direct faxing, door-to-door distribution of a brochure, and word of mouth. A selection was made using a telephone questionnaire to eliminate homes that did not meet the microbial health criteria established for this project, including these main conditions: no major water damage during or since the 1998 ice storm, no health problems having appeared or worsened since moving in, at least two years of occupancy, no carpets in the basement, no poorly maintained forced air heating systems with porous insulation in the ductwork, or with humidifiers.

Inspection protocol

The building inspections were carried out by inspectors from Groupe Natur'Air-Kiwatin of Montreal. Each site visits lasted a minimum of one hour and a half, and consisted of a comprehensive inspection of both the outside and inside of each house, checking the structures with a moisture detector, conducting a complementary survey with the occupants, taking photographs, and sampling dust.

CMHC SCHL

HOME TO CANADIANS

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63407

Dust sampling
The inspectors used a portable Hoover Portapak vacuum cleaner with disposable paper bags to collect a composite sample of dry settled dust from the occupied rooms. Samples were not taken from the floor to avoid tracked-in dirt and spores brought in from outside on shoe soles, or accumulated dirt and spores in carpets. Dust was sampled higher, for example on bookshelves, kitchen shelves, door frames, etc., where it had deposited from the air at the occupants' breathing level. Depending on the degree of dust accumulation in the house, the total sampling area in the dwelling could be anywhere between 1 and 2 square meters (precisely measured). Vacuuming lasted 5 minutes on each surface. After sampling, the vacuum cleaner bag was removed, sealed with adhesive tape and identified with a number. It was then placed in a tightly sealed plastic bag and brought to the Microvital laboratory where it was kept at 4 degrees C until put in culture, with a maximum delay of 6 days from the time of sampling.

Analysis of dust samples
Samples from healthy houses were analysed at random along with other samples being provided to the lab. The healthy house sample numbers had no distinctive indicators to differentiate them from other samples. Therefore, the healthy house samples were impossible to recognize among the others being analysed. Suitably diluted in sterile water, dust samples were plated on MEA Rose bengal culture dishes for mold and on PYA for bacteria. Duplicates of total bacteria were counted under the dissecting microscope after 48 hours of incubation at room temperature. Duplicates of fungi were counted under the dissecting microscope after 7 to 14 days of incubation at room temperature, depending on their speed of sporulation. The molds were identified to the genus level, and to the species level in some cases.

Results

Fungal counts, extent of water damage and season
The dust from healthy homes, with a mean value of 74 366 colony forming units per gram (cfus/g), contained up to seven times less mold than that of their water damaged counterparts, with a mean value of 482 004 cfus/g. The difference was highly significant (Wilcoxon/Kruskal-Wallis $p<0.0001$). These results statistically confirm the Ontario Wallaceburg study (Miller and al, 1999) where fungal counts from dust sampled in 20 out of 400 homes, with the most extensive water damage episodes, were 10 times higher than fungal counts from the 20 homes without excessive water activity.

Fungal contents of dust from all homes is not significantly influenced by season (two way ANOVA $p>0.05$). Furthermore, there is no interaction between season and the extent of water damage (two way ANOVA $p>0.05$). This confirms that water damage alone makes a significant difference in fungal counts from house dust.

Ratio of non phylloplane to phylloplane fungi in dust related to extent of water damage
Cladosporium and *Alternaria* are the phylloplane fungi (mostly found in air and growing on trees or plants), and *Penicillium* and *Aspergillus* the non phylloplane fungi (mostly from soil) found most frequently in the dust of the inspected homes, whatever their contamination levels. Phylloplane fungi predominate in healthy homes and non-phylloplane fungi predominate in unhealthy homes. Thus, the ratio of non phylloplane to phylloplane fungi for unhealthy homes (1.51) more than doubles that for their healthy counterparts (0.70). The difference is highly significant (ANOVA p 0.00040 for phylloplanes and 0.012 for non phylloplanes).

Bacterial dust counts and extent of water damage
Mean bacterial counts are more than twice as high in unhealthy homes, with 1.45 million cfus/g of dust, compared to healthy homes, with 678 088 cfus/g. However, the standard deviation is too high to confer statistical significance to these data (Wilcoxon/Kruskal-Wallis $p>0.05$).

Many factors can explain these findings, for example the presence of pets, cold water humidifiers or sump pumps with improper maintenance, the season of inspection, etc. Due to insufficient sample size, there were not enough homes with each of these separate characteristics to allow statistical analysis of the bacterial counts in dust. The inspection findings indicate however, that all these factors do have an influence on counts of bacteria in house dust.

Conclusions

This study confirms the reliability of house dust sampling as a complementary diagnosis tool for the assessment of microbial contamination indoors. The fungal contents of house dust can be a good indicator of the extent of water damage and represent the "microbiological memory" of houses. Dust from unhealthy homes can contain up to seven times more mold than that of their healthy counterparts and the fungal distribution often shows a majority of non phylloplane species in these water damaged homes.

However, mold testing is generally not required to determine the presence of mold in houses. The odours and visible signs of moisture and mold are usually all that is required to assess a mold problem. The mold test

results do not influence the remedial actions to be taken in houses. Visual inspections and proper diagnostic of the moisture sources that led to the presence of mold are more useful to homeowners to help them resolve a problem.

No sampling method is perfect. Air samples, for instance, measure the microbial contents of air only at the precise time of sampling, with frequent risks of false negative results. The microbial contents of dust is a better indicator of the house's microbiological memory, however, in some cases it might not correspond with the inspection data in the field. Mold testing may be required to document a case i.e. for litigation, but it is rarely warranted simply to identify the presence of mold, determine the remediation measures, or to resolve the moisture conditions to avoid mold growth. Sound judgment is to be used on a case-by-case basis to choose the most appropriate diagnostic method(s) and avoid unnecessary sampling.

Project manager: Ken Ruest

Research report: *House Dust: an Efficient and Affordble Tool to Assess Residential Microbial Contamination*

Research consultant: Laboratoire MICROVITAL Inc.

Housing Research at CMHC

This project was funded (or partially funded) by Canada Mortgage and Housing Corporation (CMHC) under the terms of the External Research Program (ERP), an annual research grant competition. The views expressed are the personal views of the author(s) and do not represent the official views of CMHC. For more information on the ERP, please visit the CMHC web site, www.cmhc.ca, or contact the Project Officer, Responsive Programs at (613) 748-2300 ext. 3061; by email at erp@cmhc.ca, or by regular mail: Project Officer, Responsive Programs, External Research Program, Policy and Research Division, Canada Mortgage and Housing Corporation, 700 Montreal Road, Ottawa, ON K1A 0P7.

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Mold Questions and Answers

Questions and Answers on *Stachybotrys chartarum* and other molds

Questions and Answers

Summary

Questions and Answers

1. QUESTION: I heard about "toxic molds" that grow in homes and other buildings. Should I be concerned about a serious health risk to me and my family?

ANSWER: The term "toxic mold" is not accurate. While certain molds are toxigenic, meaning they can produce toxins (specifically mycotoxins), the molds themselves are not toxic, or poisonous. Hazards presented by molds that may produce mycotoxins should be considered the same as other common molds which can grow in your house. There is always a little mold everywhere - in the air and on many surfaces. There are very few reports that toxigenic molds found inside homes can cause unique or rare health conditions such as pulmonary hemorrhage or memory loss. These case reports are rare, and a causal link between the presence of the toxigenic mold and these conditions has not been proven. A common-sense approach should be used for any mold contamination existing inside buildings and homes. The common health concerns from molds include hay fever-

like allergic symptoms. Certain individuals with chronic respiratory disease (chronic obstructive pulmonary disorder, asthma) may experience difficulty breathing. Individuals with immune suppression may be at increased risk for infection from molds. If you or your family members have these conditions, a qualified medical clinician should be consulted for diagnosis and treatment. For the most part, one should take routine measures to prevent mold growth in the home.

2. **QUESTION:** How common is mold, including *Stachybotrys chartarum* (also known by its synonym *Stachybotrys atra*) in buildings?

   ANSWER: Molds are very common in buildings and homes and will grow anywhere indoors where there is moisture. The most common indoor molds are *Cladosporium*, *Penicillium*, *Aspergillus*, and *Alternaria*. We do not have precise information about how often *Stachybotrys chartarum* is found in buildings and homes. While it is less common than other mold species, it is not rare.

3. **QUESTION:** How do molds get in the indoor environment and how do they grow?

   ANSWER: Mold spores occur in the indoor and outdoor environments. Mold spores may enter your house from the outside through open doorways, windows, and heating, ventilation, and air conditioning systems with outdoor air intakes. Spores in the air outside also attach themselves to people and animals, making clothing, shoes, bags, and pets convenient vehicles for carrying mold indoors. When mold spores drop on places where there is excessive moisture, such as where leakage may have occurred in roofs, pipes, walls, plant pots, or where there has been flooding, they will grow. Many building materials provide suitable nutrients that encourage mold to grow. Wet cellulose materials, including paper and paper products, cardboard, ceiling tiles, wood, and wood products, are particularly conducive for the growth of some molds. Other materials such as dust, paints, wallpaper, insulation materials, drywall, carpet, fabric, and upholstery, commonly support mold growth.

4. **QUESTION:** What is *Stachybotrys chartarum* (*Stachybotrys atra*)?

   ANSWER: *Stachybotrys chartarum* (also known by its synonym *Stachybotrys atra*) is a greenish-black mold. It can grow on material with a high cellulose and low nitrogen content, such as fiberboard, gypsum board, paper, dust, and lint. Growth occurs when there is moisture from water damage, excessive humidity, water leaks, condensation, water infiltration, or flooding. Constant moisture is required for its growth. It is not necessary, however, to determine what type of mold you may have. All molds should be treated the same with respect to potential health risks and removal.

5. **QUESTION:** Are there any circumstances where people should vacate a home or other building because of mold?

   ANSWER: These decisions have to be made individually. If you believe you are ill because of exposure to mold in a building, you should consult your physician to determine the appropriate action to take.

6. **QUESTION:** Who are the people who are most at risk for health problems associated with exposure to mold?

   ANSWER: People with allergies may be more sensitive to molds. People with immune suppression or underlying lung disease are more susceptible to fungal infections.

7. **QUESTION:** How do you know if you have a mold problem?

ANSWER: Large mold infestations can usually be seen or smelled.

8. **QUESTION:** Does *Stachybotrys chartarum* (*Stachybotrys atra*) cause acute idiopathic pulmonary hemorrhage among infants?

ANSWER: To date, a possible association between acute idiopathic pulmonary hemorrhage among infants and *Stachybotrys chartarum* (*Stachybotrys atra*) has not been proved. Further studies are needed to determine what causes acute idiopathic hemorrhage.

9. **QUESTION:** What if my child has acute idiopathic pulmonary hemorrhage?

ANSWER: Parents should ensure that their children get proper prompt medical treatment.

10. **QUESTION:** What are the potential health effects of mold in buildings and homes?

ANSWER: Mold exposure does not always present a health problem indoors. However some people are sensitive to molds. These people may experience symptoms such as nasal stuffiness, eye irritation, wheezing, or skin irritation when exposed to molds. Some people may have more severe reactions to molds. Severe reactions may occur among workers exposed to large amounts of molds in occupational settings, such as farmers working around moldy hay. Severe reactions may include fever and shortness of breath. Immunocompromised persons and persons with chronic lung diseases like COPD are at increased risk for opportunistic infections and may develop mold infections in their lungs.

11. **QUESTION:** How do you get the molds out of buildings, including homes, schools, and places of employment?

ANSWER: In most cases mold can be removed from hard surfaces by a thorough cleaning with commercial products, soap and water, or a weak bleach solution (1 cup of bleach in 1 gallon of water). Absorbent or porous materials like ceiling tiles, drywall, and carpet may have to be thrown away if they become moldy. If you have an extensive amount of mold and you do not think you can manage the cleanup on your own, you may want to contact a professional who has experience in cleaning mold in buildings and homes. It is important to properly clean and dry the area as you can still have an allergic reaction to parts of the dead mold and mold contamination may recur if there is still a source of moisture.

12. **QUESTION:** What should people to do if they determine they have *Stachybotrys chartarum* (*Stachybotrys atra*) in their buildings or homes?

ANSWER: Mold growing in homes and buildings, whether it is *Stachybotrys chartarum* (*Stachybotrys atra*) or other molds, indicates that there is a problem with water or moisture. This is the first problem that needs to be addressed. Mold can be cleaned off hard surfaces with a weak bleach solution. Mold in or under carpets typically requires that the carpets be removed. Once mold starts to grow in insulation or wallboard, the only way to deal with the problem is by removal and replacement. We do not believe that one needs to take any different precautions with *Stachybotrys chartarum* (*Stachybotrys atra*), than with other molds. In areas where flooding has occurred, prompt drying out of materials and cleaning of walls and other flood-damaged items with commercial products, soap and water, or a weak bleach solution (1 cup of bleach in 1 gallon of water) is necessary to prevent mold growth. Never mix bleach with ammonia. If a home has been

flooded, it also may be contaminated with sewage. (See: After a Hurricane or Flood: Cleanup of Flood Water.) Moldy items should be removed from living areas.

13. QUESTION: How do you keep mold out of buildings and homes?

ANSWER: As part of routine building maintenance, buildings should be inspected for evidence of water damage and visible mold. The conditions causing mold (such as water leaks, condensation, infiltration, or flooding) should be corrected to prevent mold from growing.

Specific Recommendations:

- Keep humidity level in house between 40% and 60%.
- Use air conditioner or a dehumidifier during humid months.
- Be sure the home has adequate ventilation, including exhaust fans in kitchen and bathrooms.
- Use mold inhibitors which can be added to paints.
- Clean bathroom with mold-killing products.
- Do not carpet bathrooms.
- Remove and replace flooded carpets.

14. QUESTION: I found mold growing in my home; how do I test the mold?

ANSWER: Generally, it is not necessary to identify the species of mold growing in a residence, and CDC does not recommend routine sampling for molds. Current evidence indicates that allergies are the type of diseases most often associated with molds. Since the reaction of individuals can vary greatly either because of the person's susceptibility or type and amount of mold present, sampling and culturing are not reliable in determining your health risk. If you are susceptible to mold and mold is seen or smelled, there is a potential health risk; therefore, no matter what type of mold is present, you should arrange for its removal. Furthermore, reliable sampling for mold can be expensive, and standards for judging what is and what is not an acceptable or tolerable quantity of mold have not been established.

15. QUESTION: A qualified environmental lab took samples of the mold in my home and gave me the results. Can CDC interpret these results?

ANSWER: Standards for judging what is an acceptable, tolerable or normal quantity of mold have not been established. If you do decide to pay for environmental sampling for molds, before the work starts, you should ask the consultants who will do the work to establish criteria for interpreting the test results. They should tell you in advance what they will do or what recommendations they will make based on the sampling results. The results of samples taken in your unique situation cannot be interpreted without physical inspection of the contaminated area or without considering the building's characteristics and the factors that led to the present condition.

Summary:

In summary, *Stachybotrys chartarum* (*Stachybotrys atra*) and other molds may cause health symptoms that are nonspecific. At present there is no test that proves an association between *Stachybotrys chartarum* (*Stachybotrys atra*) and particular health symptoms. Individuals with persistent symptoms should see their physician. However, if *Stachybotrys chartarum* (*Stachybotrys atra*) or other molds are found in a building, prudent practice recommends that they be removed.

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