American Industrial Hygiene Association (AIHA)

The Facts about Mold

Introduction

Mold is in the news. People are talking about its potential health and economic impact. But what are the real risks and issues?

The available science is incomplete and sometimes controversial. Although there are several guidance documents available, there is no accepted national standard. Validated methods to measure contamination are still in their infancy, and even when measurement techniques are available, there are no clear benchmarks or standard values to compare the results against. Similar scientific uncertainties exist in the medical diagnosis of some mold-related health effects.

The scientific complexities alone would be a huge challenge, but the truth is that other difficulties dwarf them. The intense public and media attention on this topic often creates emotionally charged circumstances that make scientific judgment and reasoned dialogue difficult. In some instances, building owners tend to ignore or dismiss potentially serious problems. In other instances, building occupants or public officials can react with excessive alarm to perceived potential threats, complicating the scientific component of the evaluation and making risk communication very difficult.

While experts and practitioners disagree on which trend is of more concern, it is clear that both are real and sizable. The biggest obstacle, however, is the amount of money that can be involved in these disputes. As a result, the issue is increasingly clouded by the acrimony and distorted partisanship of mushrooming liability battles in the legal arena.

This brochure represents a consensus statement by a group of experts about important aspects of the "state of the science." The guidance offered is practical information and does not claim to be a definitive or comprehensive position statement. Because it is not comprehensive, it should always be used in conjunction with other existing guidance documents, as well as professional judgment.

Public and occupational health practice is rarely an exact science. Prevention always poses the challenge of making tough and often costly decisions with incomplete information or understanding. For a more complete analysis of the situation, see the AIHA Report of Microbial Growth Task Force, available from www.aiha.org or (301) 283-3064.

The Facts About Mold: For Everyone

What is mold? Molds are forms of fungi found all year round both indoors and outdoors. Outdoors, molds live in the soil, on plants, and on dead or decaying matter. Another common term for mold is mildew. Mold growth is encouraged by warm and humid conditions, although it can grow during cold weather. There are thousands of species of mold and they can be any color. Many times, mold can be detected by a musty odor. Most fungi, including molds, produce microscopic cells called "spores" that spread easily through the air. Live spores act like seeds, forming new mold growths (colonies) with the right conditions. All of us are exposed to fungal spores daily in the air we breathe.

How does mold get into a house or building? Most, if not all, of the mold found indoors comes from outdoor sources. It needs moisture to grow and becomes a problem only where there is water damage, high humidity, or dampness. Common sources of indoor moisture that cause mold problems include flooding, roof and plumbing leaks, damp basements or crawl spaces, or any

moisture condensation on cold surfaces. Bathroom showers and steam from cooking may also create problems if not well ventilated.

How can I prevent mold growth? Con-trolling excess moisture is the key to preventing and stopping indoor mold growth. Keeping susceptible areas in the home clean and dry is very important. Ventilate or use exhaust fans (vented to the outdoors) to remove moisture where it accumulates, particularly in bathrooms, kitchens, and laundry areas. Clothes dryers should be vented to the outside. Repair water leaks promptly, and either dry out and clean or replace water-damaged materials. Materials that stay wet for more than 48 hours are likely to produce mold growth. Lowering humidity indoors helps prevent condensation problems. To lower humidity during humid weather, use air conditioners and dehumidifiers. Proper exterior wall insulation helps prevent condensation from forming inside during cold weather.

Can mold be toxic?Some molds produce toxic substances called mycotoxins. Airborne mycotoxins have not been shown to cause health problems for occupants in residential or commercial buildings. The health effects of breathing mycotoxins are not well understood and are currently under study. In rare cases, high or chronic airborne exposures, typically associated with certain occupations like agricultural work, have been associated with illnesses. More is known about the health effects of consuming moldy foods or feed containing mycotoxins than about the effects of breathing mycotoxins.

What is "black mold"?The news media often refer to "black mold" or "toxic black mold." It is usually associated with Stachybotrys chartarum, a type of greenish-black mold commonly associated with heavy water damage. Not all molds that appear to be black are Stachybotrys. The known health effects from exposure to Stachybotrys are similar to other common molds, but have been inconclusively associated with more severe health effects in some people.

Why are we concerned about mold? Small amounts of mold growth in workplaces or homes (such as mildew on a shower curtain) are not a major concern. But no mold should be allowed to grow and multiply indoors. Large quantities of mold growth may cause nuisance odors and health problems for some people. In addition, mold can damage building materials, finishes, and furnishings and, in some cases, cause structural damage to wood.

How do molds affect people? Most people have no reaction when exposed to molds. Allergic reactions, similar to common pollen or animal allergies, and irritation are the most common health effects for individuals sensitive to molds. Flu-like symptoms and skin rash may occur. Molds may also aggravate asthma. In rare cases, fungal infections from building-associated molds may occur in people with serious immune disease. Most symptoms are temporary and eliminated by correcting the mold problem.

Who is affected by exposure to mold?There is a wide variability in how people are affected by mold exposure. People who may be affected more severely and quickly than others include:

Infants and children

Elderly people

Pregnant women

Individuals with respiratory conditions or allergies and asthma

Persons with weakened immune systems (for example, chemotherapy patients, organ or bone marrow transplant recipients, and people with HIV infections or autoimmune diseases)

Those with special health concerns should consult their doctor if they are concerned about mold exposure. Symptoms that may seem to occur from mold exposure may be due to other causes, such as bacterial or viral infections or other allergies.

What should I do if I see or smell mold in my home? The most important step is to identify and fix the moisture sources causing mold growth. For small mold problems, use detergent and water to wash mold off hard surfaces, and dry completely. Replace moldy porous or absorbent materials (such as ceiling tiles, wallboard, and carpeting). If you do not see mold growth but notice a musty odor, mold may be growing behind water-damaged materials, such as walls, carpeting, or wallpaper. Persons cleaning mold should wear gloves, eye protection, and a dust mask or respirator to protect against breathing airborne spores (an N95 dust mask or respirator may be purchased in hardware stores). If you have health concerns, you should consult your doctor before doing any mold cleanup.

Should I test my home for mold? Probably not. Looking for evidence of water damage and visible mold growth should be your first step. Testing for mold is expensive, and you should have a clear reason for doing so. In addition, there are no standards for "acceptable" levels of mold in the indoor environment. When testing is done, it is usually to compare the levels and types of mold spores found inside the home with those found outdoors. If you know you have a mold problem, it is more important to spend time and resources getting rid of the mold and solving the moisture problem causing the moldy conditions.

Who do I call to deal with extensive mold growth in a building? A professional experienced in mold evaluation and remediation, such as an industrial hygienist, may need to be hired to address extensive mold growth in a building. It is important to correct large mold problems as soon as possible by first fixing the source of the moisture problem and removing contaminated materials, then cleaning the surfaces, and finally drying the area completely. If you use outside contractors or professionals, make sure they have experience cleaning up mold. Check their references, and have them follow the recommendations and guidelines given in the information resources at the end of this brochure.

The Facts About Mold: For the Professional

How should a building be evaluated for mold growth? Check building materials and spaces for visible mold and signs of moisture damage indicating a history of water leaks, high humidity levels, and/or condensation. Any occupant complaints or reported health problems should be noted as well as any musty or moldy odors.

Components of the building's ventilation system should also be inspected. A moisture meter is often helpful in identifying wet or damp building materials. If mold growth or moisture problems are found, the air pressure differentials between the area of growth and surrounding areas should be determined. Potential air pathways from the source should also be characterized to determine its impact on the building and its occupants.

When is sampling necessary in a building evaluation? Sampling may not be necessary. If visible mold is present, then it should be remediated, regardless of what species are present and whether samples are taken. In specific instances, such as cases where health concerns are an issue, litigation is involved, or the source(s) of contamination is unclear, sampling may be considered as part of a building evaluation. Sampling is needed in situations where visible mold is present and there is a need to have the mold identified.

If mold is suspected, but not visibly detectable after an inspection, then sampling may reveal evidence of mold amplification or reservoirs indoors. If mold is being removed and there is a question about how far the colonization extends, then surface or bulk sampling in combination with moisture readings may be useful. Sampling for airborne mold spores can indicate whether the mix of indoor molds is “typical” of the outdoor mix or, conversely, “atypical” or unusual at that time.

Professionals experienced with mold issues and familiar with current guidelines must conduct any sampling. If samples are taken, regardless of the purpose, the results should help answer a clear question. Sampling without a specific purpose greatly increases the chances of generating useless data. Note that laboratories vary in experience and proficiency; using an AIHA EMLAP-accredited lab is recommended.

Why is there controversy about the health effects of exposure to mold growth? Not all health effects of molds are controversial. Fungal infections are well known. Fungal allergies are also well known and accepted among medical experts, although the allergens themselves are poorly characterized. Infections and allergies have objective and well-established clinical effects. These effects can be measured and reproducibly demonstrated, and the mechanisms are fully understood. The health effects caused by consuming moldy food or feed that contains mycotoxins are also well known. Regardless of these controversies, mold growth in the built environment is unacceptable from the perspectives of potential adverse health effects and building performance.

Other health effects have been proposed for mold metabolites that are irritants or mycotoxins, and plausible mechanisms exist for health effects due to these mold metabolites. However, the clinical relevance of these mycotoxins and irritants under realistic airborne exposure levels is not fully established. Further, supporting evidence for other health effects is based on case studies rather than controlled studies, nonreproduced studies, or subjective symptoms.

Case studies do indicate the possibility or plausibility of an effect. Unfortunately, such studies cannot address whether an effect is common or widespread among building occupants. Results from nonreproduced studies may be false or are not confirmed by well-designed follow-up studies. In large epidemiological studies, general symptoms have been associated with moisture-damaged and presumably moldy buildings. Many of the reported symptoms are subjective and difficult to quantify. Results are confounded by the fact that the association is general, and mold is not the only possible cause of the symptoms. Neither condition proves that mold is not a cause.

Since much remains unproven, controversy has developed around the presumed health effects attributed to mycotoxins. This controversy is intensified since the health effects are often serious and sometimes are claimed to be permanent. Dampness in buildings is associated with respiratory effects, but the extent to which mold contributes to these effects is unknown. Some health effects from mold exposure remain controversial because of the potentially significant consequences; yet crucial and legitimate scientific questions remain unanswered. Our incomplete knowledge of noninfectious health effects related to mold exposure is due to limited research support and lack of documented health effects in the context of well-defined exposures. Bear in mind that environmental investigations must also be interpreted in context with medical and epidemiological information for infectious diseases from environmental sources. For example, finding Legionella colonization of a water supply serving an immunocompromised population would have potential health significance whether or not there were cases of infection, but finding

mold spores in ambient air has little significance unless people are getting sick from direct exposure.

Why are there no standards for mold exposure? Health hazards from exposure to environmental molds and their metabolites relate to four broad categories of chemical/biological attributes. These materials may be: 1) irritants, 2) allergens, 3) toxins, and rarely 4) pathogens. Different mold species may be more or less hazardous with respect to any or all of these categories. However, risks from exposure to a particular mold species may vary depending on a number of factors. Uncertainty is complicated further by a lack of information on specific human responses to well-defined mold contaminant exposures. In combination, these knowledge gaps make it impossible to set simple exposure standards for molds and related contaminants.

With no standards, how do I interpret my sampling results? A useful method for interpreting microbiological results is to compare the kinds and levels of organisms detected in different environments. Usual comparisons are indoors to outdoors or complaint areas to noncomplaint areas. Specifically, in buildings without mold problems, the qualitative diversity (types) of airborne fungi indoors and outdoors should be similar. Conversely, the dominating presence of one or two kinds of fungi indoors and the absence of the same kind outdoors may indicate a moisture problem and degraded air quality.

Also, the consistent presence of certain fungi such as Stachybotrys chartarum, Aspergillus versicolor, or various Penicillium species over and beyond background concentrations may indicate the occurrence of a moisture problem and a potential atypical exposure. Generally, indoor mold types should be similar and levels should be no greater than outdoor and noncomplaint areas. Analytical results from bulk material or dust samples may also be compared to results of similar samples collected from reasonable comparison areas.

Comparisons of total bacterial levels indoors versus outdoors may not be as useful as with fungi, since natural bacteria reservoirs exist in both places. Comparisons of the specific types of bacteria present, excluding those of known human origin, can help determine building-related sources.

Does mold remediation always require isolation/containment? Mold remediation should always require some level of isolation of materials or containment. The lower level of containment or isolation involves sealing removed moldy materials in a plastic bag for disposal. Local area or full area containment decisions should be made based on the size of the area of growth and the potential for occupant exposure or building contamination without containment. These decisions should be based on an understanding of the full scope of mold contamination, including visible and hidden mold sources.

Are biocides useful or required in remediation projects? Biocides are disinfectant chemicals used to kill germs. In most mold remediation projects, biocides are not a substitute for thorough cleaning. Biocides are of limited use in remediation of indoor mold contamination for two main reasons:

1) Biocides do not remove allergens that can lead to allergies in sensitive individuals nor do they remove other metabolites from mold that can cause adverse reactions in some people. Even though the application of biocides may kill mold spores, the only way to remove the allergens and other metabolites is through the physical elimination of mold and moldy materials by thorough cleaning or removal.

2) Commonly used biocides do not effectively kill molds. For example, active fungal growth on a surface may produce a spore density of 1 million spores per square inch. Treating this site with a biocide that has an effectiveness of 99.999% would still leave an estimated 10 viable spores per square inch. As such, mold growth may recur if the underlying moisture problem is not resolved.

Biocidal treatments are indicated only when the contaminant is one of the few fungi that are known to cause human infection. This is particularly important in health-care facilities or other places with occupants who have impaired immune systems or who may be more susceptible to infections.

What are the knowledge gaps concerning mold exposure and its health effects? Chief among our knowledge gaps are: (1) defining how mycotoxins affect human health and (2) the health risks associated with mycotoxin, microbial volatile organic compound, allergen, and glucan exposures, particularly the proposed response to Stachybotrys mycotoxins associated with hemosiderosis.

However, the etiology of infectious fungi is relatively well understood. Conversely, mechanisms responsible for allergic sensitization, contact dermatitis, hypersensitivity pneumonitis, and inhalation fevers vary from incompletely characterized to entirely unknown. Predisposing host factors, presumably under genetic control, influence individual susceptibility to environmental exposures. The psychogenic/psychosocial contribution to mold-related illness remains elusive.

The lack of meaningful exposure limits for most indoor air quality contaminants is a major obstacle to establishing regulatory standards for individual exposure to airborne contaminants. The same is certainly true for molds. Until microbiological methods for demonstrating mold concentrations in the environment are standardized and reproducible, epidemiological studies necessary to determine dose-response can only suggest association, not cause and effect, with respect to mold exposures and health effects.

Resources

Listings of indoor air quality consultants can be obtained from AIHA's Consultants Listing, although AIHA does not recommend specific consultants. Additional technical information is included in the following sources:

Field Guide for the Determination of Biological Contaminants in Environmental Samples, 2nd edition (stock #IMOF05-678), American Industrial Hygiene Association (AIHA)

Report of Microbial Growth Task Force (stock #IMOR01-458), AIHA, www.aiha.org

Assessment, Remediation, and Post-Remediation Verification of Mold in Buildings (stock #IAQG04-659), AIHA

Environmental Mold: State of the Science, State of the Art (stock #IMOR03-620), AIHA

Listing of AIHA Laboratory Quality Assurance Program Environmental Microbiology Laboratory Accreditation Program (LQAP EMLAP) accredited laboratories, AIHA, www.aiha.org

Bioaerosols: Assessment and Control, American Conference of Governmental Industrial Hygienists (ACGIH), http://www.acgih.org/www.acgih.org
IICRC S500, Standard and Reference Guide for Professional Water Damage Restoration, Institute of Inspection, Cleaning, and Restoration Certification, www.iicrc.org

Mold Remediation in Schools and Commercial Buildings (EPA 402-K-01-001), Environmental Protection Agency (EPA), www.epa.gov/iaq/molds/index.html

Draft Guideline for Environmental Infection Control in Healthcare Facilities (especially sections I.C.3, I.C.4, I.F, II.C.1, and Appendix B), Centers for Disease Control (CDC), http://www.cdc.gov/ncidod/hip/enviro/env_guide_draft.pdfwww.cdc.gov.

For More Information

State or Local Department of Health

Environmental Protection Agency (EPA): http://www.epa.gov/iaqwww.epa.gov/iaq

EPA and FEMA (Federal Emergency Management Agency) Flood Clean-Up Guidelines: http://www.epa.gov/iaq/pubs/flood.htmlwww.epa.gov/iaq/pubs/flood.html and www.fema.gov/hazards/floods/

Centers for Disease Control and Prevention (CDC): www.cdc.gov/nceh/airpollution/mold/default.htm

California Indoor Air Quality Program: www.cal-iaq.org/iaqsheet.htm

New York City Department of Health "Guidelines on Assessment and Remediation of Fungi in Indoor Environments": http://www.nyc.gov/html/doh/html/epi/moldrpt1.shtml

American College of Occupational and Environmental Medicine guideline "Adverse Human Health Effects Associated With Molds in the Indoor Environment": www.acoem.org/guidelines/pdf/mold-10-27-02.pdf

The Facts About Mold: A Glossary

Allergen: A substance that elicits an antibody response and is responsible for producing allergic reactions by inducing formation of IgE. IgE is one of a group of immune system mediators. IgE antibodies, when bound to basophiles in circulation or mast cells in tissue, cause these cells to release chemicals when they come into contact with an allergen. These chemicals can cause injury to surrounding tissue—the visible signs of an allergy. Fungal allergens are proteins found in either the mycelium or spores. Only a few fungal allergens have been characterized, but all fungi are thought to be potentially allergenic.

Biocide/Fungicide: Chemicals that limit the growth of or kill microorganisms such as fungi.

"Black mold": This poorly defined term, which has no scientific meaning (also called "toxic black mold"), has been associated with Stachybotrys chartarum. While only a few molds are truly black, many appear black. Not all molds that appear to be black are Stachybotrys.

Fungi: Neither animals nor plants, fungi are classified in their own kingdom. The fungi kingdom includes a very large group of organisms, including molds, yeasts, mushrooms, and puffballs. There are more than 100,000 accepted fungal species—but current estimates range up to 10 million species. Mycologists (people who study fungi) group fungi into four large groups according to their reproduction method.

Hidden mold: Visible mold growth on building structures that is not easily seen. For example: above drop ceilings, within a wall cavity (the space between the inner and outer structure of a wall), inside air handlers, or within the ducting of a ventilation system. Visible mold within a ventilation duct is in immediate contact with the occupied space. Spores released from such

growths are affected by air movement and relative humidity. Spores of mold growth in wall cavities are released by the air exchange between the wall cavity and occupied space. The rate of spore movement between such spaces is typically slow. Volatile gases produced by visible mold growth in wall cavities are also known to occur and migrate to occupied spaces even through air barriers.

Microbial volatile organic compounds (MVOCs): Chemicals produced by fungi as a result of their metabolism. Some of these chemicals are responsible for the characteristic moldy, musty, or earthy smell of fungi, whether mushrooms or molds. Some MVOCs are considered offensive or annoying. Specific MVOCs are thought to be characteristic of wood rot and mold growth on building materials. The human nose is very sensitive to mold odors, sometimes more so than current analytical instruments.

Mold: A group of organisms that belong to the fungi kingdom (see Fungi). Although the terms mold and fungi have been commonly referred to interchangeably, all molds are fungi, but not all fungi are molds.

Mycotoxin: Compounds produced by "toxigenic fungi" that are toxic to humans or animals. By convention, the term "mycotoxin" excludes mushroom toxins and compounds of low potency or toxicity only in in vitro systems. The ordinary use of the term refers to compounds of importance in agriculture. This includes a small number of very potent compounds such as deoxynivalenol, aflatoxin, fumonisin, ochratoxin, and zearalenone. It also includes the much less common nivalenol, T-2/HT-2 toxins, as well as some other Penicillium and Aspergillus toxins and toxins from S. chartarum and Pithomyces chartarum. The biochemical targets of mycotoxins are usually many but the mechanisms of toxicity, even within families of toxins, are typically different.

The genetic property to produce mycotoxins is particular to given species. Some species including Fusarium graminearum and S. chartarum have genetic subpopulations called chemotypes that produce different mixtures of compounds. In the case of F. graminearum, these chemotypes are distributed by continent. In the case of S. chartarum, both chemotypes occur together.

Remediate: To fix a problem. Related to mold contamination, remediation includes fixing the water/moisture problem and the cleaning, removal, and/or replacement of damaged or contaminated materials.

Spore: General term for a reproductive structure in fungi, bacteria, and some plants. In fungi, the spore is the structure that may be used for dissemination and may be resistant to adverse environmental conditions.

Stachybotrys: Genus that includes approximately 10 species and occurs mainly on dead plant materials. Of these, Stachybotrys chartarum is the most common. This species is widespread and typically grows on straw. In the indoor environment, it is commonly found on cellulosic materials including paper, canvas, and jute that are wetted to a water activity > 0.98. This is a toxigenic mold. There are two chemotypes of this species that produce trichothecenes plus spirolactones or atranones plus spirolactones; these toxins have been demonstrated on mold-damaged building materials. The closely related species Memnoniella echinata occurs on the same materials but does not produce potent trichothecenes. Both chemotypes of S. chartarum and M. echinata typically occur together on samples of very wet cellulosic materials with M. echinata being more important in warmer climates. This fungus does not cause invasive disease. Antigens to S. chartarum have been identified.

“Toxic mold”: This has no scientific meaning, since the mold itself is not toxic. The metabolic byproducts of some molds may be toxic (see Mycotoxin).

Toxigenic fungi: Fungi that can produce mycotoxins (see Mycotoxin).

Common Indoor Fungi

Alternaria: A genus comprised of approximately 50 species, most of which are saprophytes or plant pathogens. Alternaria alternata is an extremely common saprophyte found worldwide on plants, wood, wood pulp, textiles, and food. A. alternata grows on the surfaces of leaves (phylloplane) and occurs in outdoor air at modest levels, peaking in July or August depending on the location (reaching perhaps 500 spores/m3). The allergens of A. alternata can induce reactions at very low concentrations in sensitized individuals. Phylloplane strains of A. alternata that are found in air do not produce AAL toxin. Some produce the phytotoxin (a compound toxic to plants) alternariol and related metabolites.

Aspergillus: The asexual stage of a number of ascomycetes. Species of Aspergillus are distributed worldwide, although they are more common in warmer climates. These species grow on a vast array of organic materials. There are 182 accepted species, although only 40 occur with any frequency. Species of Aspergillus include several of considerable economic importance: A. flavus is the main producer of the potent carcinogen aflatoxin and A. fumigatus is an important cause of the invasive disease aspergillosis. Several species are common on building materials, including A. versicolor. A. fumigatus is common in outdoor air in some regions during the fall, occurring on composting materials.

Cladosporium: A genus comprised of approximately 500 species, most of which are saprophytes or plant pathogens; perhaps 20 are common. Cladosporium sphaerospermum, C. cladosporoioides, and C. herbarum are the most common species. All are found on plants, wood, wood pulp, textiles, and food. Of the three, C. sphaerospermum is the species typically found on building materials. The other two are phylloplane species that occur in outdoor air at high levels, peaking in June, July, or August depending on the location (reaching perhaps 10,000 spores/m3). C. herbarum produces a wide variety of allergens, and approximately 10 percent of the population is sensitized to Cladosporium. Phylloplane strains of Cladosporium do not produce metabolites with material toxicity.

Penicillium: The asexual stage of a number of ascomycetes. The species of Penicillium are found worldwide but are more common in temperate climates. These species grow on a vast array of organic materials. There are 225 accepted species, although only 70 occur with any frequency. Species of Penicillium include several of considerable economic importance: P. verrucosum produces ochratoxin on cereals and P. chrysogenum produces penicillin. Many Penicillium species cause damage in damp building materials, including the toxigenic species P. aurantiogriseum.

This brochure is a joint effort by the following AIHA technical committees:

Biosafety and Environmental Microbiology

Environmental Microbiology Laboratory Accreditation (EMLAC)

Indoor Environmental Quality (IEQ)