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Inside

Mold: Evaluation of Risk and Decontamination

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On June 14, 2004, the AIC Health & Safety Committee presented a workshop entitled, "Safety in Decontamination: Mold." This workshop was intended as a follow-up to a more general workshop on the decontamination of cultural property, presented at AIC's 2002 annual meeting in Miami.

In recent years, outside of the world of conservation, great attention and concern has been drawn to the effects to both building materials and occupant health with respect to microbiological contamination inside commercial and residential structures. The subject has been highlighted in major magazines and newspapers throughout the country. Additionally, there have been numerous stories about insurance claims related to mold and there has "been a significant increase in liability lawsuits alleging that any number of illnesses have been caused by mold exposure" (Umbrell, C. Mold: Creating a Scientific Consensus on a Hot Topic, *The Synergist*, April 2003).

The term "toxic mold" has been used extensively in the lay literature cited above, though it is a misnomer. A more correct term is microbiological contamination, which includes fungi (and its subset "molds"), bacteria, viruses, dander, mites, and more (ACGIH. Bioaerosols: Assessment and Control, 1999). The distinction between the "toxic" varieties of the organisms and those that cause lesser or no effect is also still being debated (Umbrell, C. Mold: Creating a Scientific Consensus on a Hot Topic, *The Synergist*, April 2003).

Concerns about the presence of mold on collections or in the environments that house collections have also increased in recent years. Many organizations, particularly larger institutions such as the National Archives and

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Interview with FAIC/Kress Fellow Pamela Hatchfield

Ellen J. Pearlstein

Pamela Hatchfield, head of Objects Conservation at the Museum of Fine Arts, Boston, received the Kress Publication award in 1996 and published her book in 2002. Hatchfield was interviewed at the American Institute for Conservation annual meeting in Portland, Oregon, on June 12, 2004, and responded to questions about the process of preparing a book-length manuscript and seeing it through the publication phase. These fellowships, which are administered through FAIC with funds from the Samuel H. Kress Foundation, are awarded competitively for release time from work obligations, permitting awardees to complete publishable manuscripts that contribute to the field of conservation. The guidelines and application form for this fellowship are available in the July 2004 *AIC News*, pages 21–25, and under "publication grants" on the AIC website, http://aic.stanford.edu/faic/grants/index.html.

The first enormous challenge authors face is their identification of subject matter about which they can make a substantive contribution. Initial questions centered on the origin of the idea for Hatchfield's book, *Pollutants in the Museum Environment: Practical Strategies for Problem Solving in Design, Exhibition, and Storage* (London: Archetype Press). Hatchfield's subject grew out of her long-standing interest in the effects of exhibition and storage materials on museum collections. After publishing numerous articles between 1984 and 1996 about the off gassing effects of wood composites used in case construction, she presented a paper entitled, "Mitigating the Effects of Internally Generated Pollutants" at a 1996 Norfolk annual meeting. It was at this

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Records Administration, the Smithsonian Institution, and the Canadian Conservation Institute, have conducted projects, published guidelines, or implemented programs to evaluate and handle mold contamination.

Mold Basics, Health Risks, and Toxicology

Estimates suggest that there are at least a million species of fungi, which are typically divided into yeasts and molds. Yeasts are unicellular organisms and molds are multicellular. Various fungi survive in virtually every environment and different species thrive in different environments or microclimates; there are generally four factors required for growth of any fungi: appropriate temperature, available water, nutrients, and time for growth (reproduction or amplification).

Fungi are present in nearly all indoor and outdoor environments. Generally, fungi concentrations indoors are expected, and the abnormal or elevated presence of fungi can be evaluated with respect to two factors: concentration and the types of organisms present. Ideally, indoor air concentrations should be at levels near or below outdoor levels, the typical source of indoor air. Additionally, the types of fungi detected indoors should be a similar mix of organisms to those detected in the outdoor air.

Dr. David Goldsmith spoke at the workshop about the medical conditions that are associated with exposure to fungi. The toxicological and health risks to trades associated with exposure to fungi are varied, and while some effects are well understood, others are still actively debated. "Excessive exposure to airborne fungal spores and their contents can cause the following affects on human health: irritation, infections, allergies (Ajello, L. et al., Microbes in the Indoor Environment, Pathogen Control Associates, 1998). The most common symptoms of fungal exposure are runny nose, eye irritation, cough, congestion, and aggravation of asthma. Although there is evidence documenting severe health effects of fungi in humans, most of this evidence is derived from ingestion of contaminated foods (i.e., grain and peanut products) or occupational exposures in agricultural settings where inhalation exposures were very high. With the possible exception of remediation to very heavily contaminated indoor environments, such high-level exposures are not expected to occur while performing remedial work" (New York City Department of Health [NYCDOH], 2000: "Guidelines on Assessment and Remediation of Fungi in Indoor Environments" [online]. Available at www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html).

The Institute of Medicine recently published *Damp Indoor Spaces and Health (*Damp Indoor Spaces and Health, A prepublication version of a report by the Institute of Medicine of the National Academy of Sciences, May 25, 2004).

The report summarizes that molds have been significantly associated with the following maladies: upper respiratory symptoms, cough, wheeze, asthma symptoms in sensitized asthmatic persons, and hypersensitivity pneumonitis (a relatively rare immune-mediated condition) in susceptible persons. Damp indoor environments were also associated with the following conditions: upper respiratory tract symptoms, cough, wheeze, and asthma symptoms in sensitized asthmatic persons.

Some literature suggests that certain illnesses are associated with exposure to specific molds or fungi. The CDC (CDC. 1999. Reports of Members of the CDC External Expert Panel on Acute Idiopathic Pulmonary Hemorrhage in Infants: A Synthesis. December 1999. Available at www.cdc.gov/od/ads) and Institute of Medicine suggest that scientific data may not be sufficiently strong to show a true relationship between specific fungi and environmental exposures.

One particular fungi that has received a lot of attention is Stachybotrys chartarum. The presence of Stachybotrys chartarum was initially implicated in pulmonary hemorrhage and the death of several infants in Cleveland, Ohio, in the mid 90s. Stachybotrys species are most commonly detected in damp environments, both indoors on wet building materials, and outdoors on rotten leaves, moldy hay, or birds' nests (Unknown, Toxic Fungus Suspected in Death of Three Children in Cleveland, *Infectious Diseases in Children*, March 1997).

Previously, Stachybotrys was associated with harmful effects to animals, and reports from as early as the 1920s found gastrointestinal bleeding in animals that ate moldy grain. Stachybotrotoxicosis is known to cause severe reactions in domestic animals, as initially seen in Eastern Europe, and experimentally demonstrated in humans. Some scientists have also posed that the harm caused by exposure to Stachybotrys is caused by compounds that the organism can make, called mycotoxins, or large, nonvolatile, secondary metabolic products made by the fungus. Myctoxins are very difficult to measure in the air and this is likely reflective of the nonvolatile nature of the compounds. In the final analyses of the cases in Cleveland, a combination of factors including environmental tobacco smoke exposure and exposure to damp/water damaged conditions, were determined to have had the strongest association with the medical conditions observed. And ultimately, the CDC concluded that identifying a specific disease-causing fungi was difficult and may not have been as important as recognizing and repairing the circumstances that lead to the excessive moisture, water intrusion, and moldy conditions.

To that end, Dr. Goldsmith emphasized that best defenses in limiting the likelihood of occupational lung diseases and harmful exposures to fungi include good health and safe standard operating procedures (SOPs), a proper evaluation of the hazards at a work site, and, when appropriate, medical monitoring and personal protective equipment suited to the observed hazards.

Evaluating Mold Presence and Exposure Assessment

Denny Ertel and Hilary Kaplan discussed various considerations when evaluating the presence of mold in cultural property. From the perspective of health risks, one should initially consider how the objects became moldy, because the central cause is often related to excessive moisture or humidity. When excess water or moisture is present in combination organic materials that act as food sources, such as drywall or wood, fungi that are normally present in the environment can begin to grow more actively. Water intrusion or relative humidity levels continuously greater than 60 percent or intermittently above 70 percent may contribute to fungal growth (including mold) on indoor surfaces. An evaluation of water intrusion, building leaks, or excessive humidity should be conducted when necessary.

There are several reasons to conduct sampling for microbiological materials, such as fungi. Visual identification of suspect mold growth may be sufficient to proceed with cleanup or repair activities. Sampling for microbiological materials should be conducted as part of a well thought out scientific evaluation. Like sampling for chemical exposures, sampling for microbiological materials should be done as a comprehensive assessment to include evaluation of other conditions like ventilation, moisture, and relative humidity.

Sampling for microbiological materials does not necessarily need to be conducted in all cases. Often the costs of sample collection and analysis can be better spent on addressing causes of water intrusion or excessive humidity. Indoor air samples with contemporaneous outdoor air samples can assist in evaluating whether or not there is mold growth indoors. Sampling for microbiological contamination can also be done to identify types and concentrations of organisms, which can be helpful in determining the potential health impacts or, in rare cases, provide some information about the sources of water intrusion. While bulk, wipe, and wall cavity sampling may be helpful to indicate the presence of mold, they may not provide any information that aids in the characterization of exposures for building occupants.

The primary methods of evaluating fungi are viable and nonviable analyses. These methods can be used to evaluate fungi in the air, on surface wipe or swab samples, and in bulk material samples. Other methods—such as measuring concentrations of microbial volatile organic compounds (MVOCs), mycotoxins, or endotoxins—have some limits, but can provide information in certain cases. Nonviable analytical methods provide basic information about the quantity and type of spores detected. Sampled materials are normally placed on slides and the analyst performs a microscopic identification of the spores and fragments. The analysis is limited as it is difficult to distinguish different types of organisms. This analysis also reports on myceleal fragments (fungal tissues that normally no longer have the capability to reproduce) and pollen. Results of nonviable analyses are usually reported as spores. Analysis of samples by viable methods provides more detailed information about the types of organisms present. These samples are placed and cultured in a controlled environment for up to ten days, and a microscopist then produces an analysis of the organisms present on the plate. Results of viable analyses are usually reported as colony-forming units, which are limited to the growth colonies that the microscopist can identify after the culturing period.

Fungi are generally evaluated with respect to two factors: concentration and the types of organisms present. Indoor concentrations should be at levels near or below outdoor levels. Indoor levels in excess of outdoor levels suggest an indoor source of fungi or bacteria contamination. Surface and bulk samples may indicate the presence of fungi, recognizing that there is a background or "normal" level of fungi. Samples from suspect areas should be compared to control samples from areas that have not been affected by fungi growth.

As there are no specific regulatory standards for allowable concentrations of mold or fungi, guidelines provided by the ACGIH, AIHA, and other consensus standard setting organizations are often considered.

The Canadian Conservation Institute has published *Technical Bulletin 26, Mould Prevention and Collection Recovery: Guidelines for Heritage Collections*, which cites specific numeric guidelines for concentrations of viable fungi in the air. These guidelines are based on a 1995 document published by Health Canada, which relies on references from the early 1990s. These guidelines should also be used with caution, as outdoor concentrations in the United States differ dramatically from those represented in Canada, especially during certain times of the year.

Remediation Activities

Remediation activities were addressed by Hilary Kaplan, Christine del Re, and various participants, via descriptions of protocol choices and case studies. In cases of excessive fungal growth, elimination of water intrusion, and repair of water damaged materials, remediation of fungus-contaminated environments may be warranted to reduce the likelihood of fungal growth or amplification and to reduce health impacts related to fungal exposure. Initial effort should be aimed at reducing water sources, or regrowth of fungi remains a possibility.

Removal of visible mold was discussed in terms of the use of appropriate cleaning techniques for particular types of materials or surfaces. For example, solid surfaces can often be cleaned using cleaning solutions, which may contain antimicrobial compounds or fungicides. Fungicides, when applied correctly, will kill a significant portion of fungi, but will rarely kill all fungi present, and will not eliminate spore pieces or fragments. Colonized porous materials, such as fabrics, paper, or items made of treated or untreated skins, can be cleaned using a variety of techniques, including various methods of brushing and aspiration, but their efficacy beyond surface remediation remains unclear.

If the decision is made to remove or clean fungal growth, a plan of action should be organized that addresses the questions about what control techniques and what personal protective equipment (PPE) will be used. The decisions about which controls and PPE to use are determined by the degree of contamination and other factors, such as who will be potentially exposed to the mold during remediation activities (i.e., conservation staff, other staff, the public, etc.).

Engineering controls often include the use of ventilation systems or isolation. Ventilation may consist of specific

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equipment brought into an area where mold is being remediated that will draw the air from the area and typically exhaust it outdoors. In projects with significant quantities of mold, this equipment is often equipped with High-Efficiency Particulate Air (HEPA) filters. In projects with small objects that are contaminated with fungi, laboratory hoods may be considered for providing ventilation, assuming that the hoods are both ventilated to the outside air and have been evaluated to ensure their ability to effectively capture fairly large particles associated with mold.

PPE, such as respiratory protection, gloves, and other protective clothing, should also be considered and implemented when appropriate. Some guidelines have been suggested by agencies such as Health Canada and the New York City Department of Health. These sources recommend different levels of PPE based on the surface area of mold present, and are summarized in the CCI technical bulletin 26. However, when using these guidelines in a conservation project, one should also consider other factors, such as manner of disturbance and the aggressiveness of treatment, as many cultural objects will be treated differently than traditional building materials.

Degrees of Contamination and the Effectiveness of Decontamination

Following repair and remediation activities it is unlikely that even the best efforts at decontamination will have rendered cultural property "free" of all fungi. Sampling, as described above, can be conducted to evaluate the degree of residual contamination. Sampling methods can include visual inspection of a material, collecting physical "bulk" samples of a material, collecting wipe samples from the surfaces of materials, collecting air samples in close proximity of a material, or combinations of these methods. The sampling methods for the initial evaluation and an evaluation following a decontamination effort are essentially the same.

Testing for the effectiveness or degree of removal following a decontamination effort is neither a well-regulated activity nor an exact science. Like evaluating risk prior to remediation, evaluating the effectiveness of decontamination will require relative comparisons of air samples to outside air samples, surface samples to "clean" surfaces samples, or other control samples. A judgment of how clean an object needs to be should be considered before conducting a remediation effort, and sampling procedures employed before and after treatment should designed accordingly.

Goals for decontamination should be determined following a thorough assessment. Deciding what level of contamination is acceptable involves consideration of the cultural property in question, intended purpose, likely audience, and which types of treatment methods are acceptable. Following this assessment, those responsible should consider which types of risks to those handling the material are acceptable. Clearly an item that will be permanently sealed in a plastic case should be treated differently than an item that will be handled routinely and extensively by children. Organizational managers, risk managers, lawyers, medical staff, and health and safety personnel may need to play a role in the decision of acceptable risk.

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