

EMERGENCY MANAGEMENT

3.8 Emergency Salvage of Moldy Books and Paper

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INTRODUCTION

For most institutions, mold is a familiar problem on a small scale—a moldy book here and there—and unimaginable on a large scale—a collection wide outbreak of active mold. Many institutions have never experienced an active mold outbreak on a collection-wide level. Dealing with such an outbreak can be overwhelming at first—but there are basic and tested methods to help an institution recover.

To best prevent an outbreak and to know how to begin recovery, it is important to understand the basic life-cycle of mold, the steps needed to stop mold growth, the equipment needed to protect staff, and the steps to salvage collections.

MOLD: WHAT IT IS AND HOW IT REPRODUCES

Mold and mildew (mold in early stages) are generic terms for a specific family of fungi, microorganisms that depend on other organisms for sustenance. There are over 100,000 known species of fungi. Because of the great variety of species, mold's patterns of growth and activity in a particular situation can be unpredictable. Nevertheless, some broad generalizations of mold's behavior are still possible.



Active mold growth on raspberries

Mold propagates by disseminating large numbers of spores, which become airborne, travel to new locations, and germinate – under the right conditions. When spores germinate, they sprout hair-like *hyphae* (the “fuzzy” stage) which in turn produce spore sacs that ripen and burst, releasing more spores, which starts the life cycle again.

While it is actively growing and reproducing, mold excretes digestive enzymes that alter, weaken, and stain paper, cloth, or leather. It is important to note that mold can be dangerous to people with allergies and immune problems and, in some cases, can pose a major health hazard.

PRINCIPLES OF PREVENTION

To germinate (become active), spores require a favorable environment: relative humidity, temperature, stagnant air, and a food source. If favorable conditions are not present, the spores remain inactive (dormant), and in this state they can do little damage. However, be aware that mold in its dormant or inactive state can and will reactivate if the environment changes and conditions become favorable.

The most important factor in mold growth is the presence of moisture. This is most commonly found in the air as relative humidity (RH), but can also be the natural moisture content of the object on which the mold is growing. In general, the higher the RH, the more readily mold will grow. If the RH is over 75% for one month or more at 70°F, 2 weeks at 80%, or 4 days for 90%, mold growth is likely (although some species of mold can grow at lower RH). If collections are wet as the result of a water disaster, this increases their susceptibility on both fronts: not only is the RH higher, but the moisture content of the materials has risen as well.

Other factors that will contribute to mold growth in the presence of moisture are high temperatures, stagnant air, and the location of storage. High temperatures, in conjunction with high relative humidity, will increase the rate of germination and growth of mold spores, a cycle which can then occur in as little as 24 hours. Stagnant air allows airborne spores to settle on collections. Due to this same lack of air circulation, these collections may already have increased moisture content. The resulting combination provides spores with a perfect environment for germination. Collections stored in basements or other uncontrolled spaces are most likely to be impacted by a mold outbreak. Basements tend to be damp with poor air circulation, and the likelihood that exterior walls will be cold and condense or leak is high. Collections are also more likely to be stored on the floor where rising damp is less likely to be noticed and can cause serious problems.

Mold spores, active or dormant, are everywhere. We cannot and should not attempt to eliminate all of them. They exist in

every room, on every object in a collection, and on every person entering the building. The only dependable prevention strategies are:

1. Keep the humidity and temperature moderate and steady so the spores remain dormant (below 70°F and below 60% RH) and monitor to ensure the space is remaining within safe levels;
2. Maintain good air circulation in collection storage areas and monitor for stagnant pockets within a space;
3. Do not store collections in known damp spaces or those areas prone to leaks or floods;
4. Keep areas where collections are stored and used as clean as possible. Dust and dirt are a source of spores, both active and dormant, so housing collections in protective enclosures whenever possible helps keep them free of dust. To also keep dust and spore levels low, keep windows closed;
5. Isolate incoming collections to check for mold;
6. Change HVAC (heating, ventilating, and air conditioning) filters according to manufacturer's recommendation and/or switch to HEPA filters if the institution has had several outbreaks in the past.

PRINCIPLES OF SALVAGE

If efforts to prevent an outbreak have not been successful—or if there has been a disaster involving water—it will be necessary to act to prevent the loss of collections. The following are the basic principles that will guide any salvage effort, large or small.

- **Reduce the humidity:** As noted above, moisture initiates mold growth. Reducing the humidity below 55% is essential to stopping most mold growth.
- **Do not turn up the heat:** If the RH is high and cannot be controlled, or if there has been a flood that has not been dried out, additional heat will cause the mold to grow faster.
- **Dry or freeze collections, especially if wet:** Mold will normally grow on wet materials in about 48 hours (sometimes sooner) and will grow rapidly thereafter. If you know you cannot treat or attend to affected material within 48 hours, it is best to freeze it. This will kill any active mold and will inhibit further growth until you have a chance to clean or dry the material.
- **Consider the health risks:** Exposure to mold can lead to a debilitating allergy even among people not prone to allergies. Some molds are also toxic. Everyone who works with moldy objects must be properly protected. Gloves, goggles, and masks are the bare minimum. Exposure to mold will sensitize exposed individual's systems, and the resulting sensitivity will lead to an allergy. This allergy, if care is not taken with protection or health concerns, will lead to severe mold-related health problems.
- **Avoid quick and easy cures:** Quick cures such as spraying Lysol on objects or cleaning them with bleach may cause additional or unforeseen damage; they are also often ineffective. In the past, mold-infested collections were

often treated with fumigants. Ethylene oxide (ETO) and thymol will kill active mold and mold spores but are known carcinogens; other chemicals that have been used are less effective. Any of these chemicals can have adverse effects on both collections and people, and none will prevent regrowth. For some collections, it will even make them more susceptible.



Personal Protective equipment worn by staff members cleaning up after a mold outbreak. Photograph courtesy of Julie Mosbo.

SALVAGE IN PRACTICE

The actions recommended below are basic stabilization techniques to be undertaken in-house for small to moderate outbreaks. The complexities of dealing with a large number – typically over 100 books or 10 document boxes – of moldy (or wet) materials will usually require outside assistance (see <https://pinboard.in/u:NEDCC>) and experience in working with vendors. In all cases, a conservator or preservation professional should be consulted if any questions arise or if further treatment of collections is necessary.

NOTE: the following steps are numbered for convenience. The process may not always be carried out in exactly this order, and some of these activities will occur simultaneously.

1. Isolate the affected items, collection, or area. Individual items should be quarantined by moving them to a clean area—separate from the rest of the collection—that has a relative humidity below 55%. To avoid spreading any spores during the move, items should be sealed in plastic bags for the transfer. Once in quarantine, bags should be removed from the items to prevent creating microclimates (within the bags) that encourage mold growth.

In the case of a large mold outbreak it may be impractical to move whole collections; the area in which they are housed should be quarantined and sealed off from the rest

of the building to the extent this is possible (including isolating air circulation from the affected area).

2. Determine the cause of the mold growth. You need to know what is causing the problem so that additional outbreaks can be avoided.

Look first for an obvious source of moisture, such as a water leak. If there is no obvious source of moisture, use a monitoring instrument to measure the relative humidity in the affected area. If the humidity is elevated, there might be a problem with the HVAC system, or the area might be subject to higher humidity for another reason: shelves placed against an unsealed outside wall, poor air circulation, or accumulations of dust and dirt that might provide a food source for mold.

Initiate repairs or resolve the problem as soon as possible. If the problem cannot be resolved quickly, salvage the collections and develop a strategy for frequent monitoring of the area for additional mold growth.

3. Take steps to modify the environment so that it is no longer conducive to mold growth.

Mop up and/or use a wet-dry vacuum to remove any standing water. Bring in dehumidifiers, but be sure that a mechanism is in place to drain them periodically so they do not overflow. The size of dehumidifier needed will be determined by the square footage of the space. Be sure air circulation is isolated in that space to prevent a small dehumidifier trying to lower the RH for an entire building. To help select the right dehumidifier, see http://www.energystar.gov/index.cfm?c=dehumid.pr_basics_dehumidifiers.

Bring in fans to circulate the air and open the windows (unless the humidity is higher outside). Your goal should be to reduce the relative humidity to 55% or lower and to bring the temperature below 70°F. Get a monitoring instrument that can measure the relative humidity and temperature accurately, and record the measurements in a log several times a day or use a data logger. Do not rely on your own impression of climate conditions.

From this point on, DO NOT DO THIS YOURSELF! Call in the professionals.

4. Implement safety precautions for staff and others working with moldy items.

All molds are potentially dangerous to people so if collections will be salvaged in-house, everyone working with the affected materials must wear disposable nitrile gloves, protective clothing (disposable Tyvek® is best), goggles, and a protective N95 or N100 mask. If staff members are already fit-tested and have a doctor's

approval for use, wear a respirator with a HEPA (high efficiency particulate) filter.

Note: Not everyone can wear a respirator as they make breathing difficult for people with asthma, heart conditions, or people who are pregnant.

5. Deactivate any active mold growth.

The goal in deactivation is to make the mold go dormant – the stage that it appears dry and powdery rather than soft and fuzzy. Once deactivated, it is possible to remove the mold residue more easily.

If the items are small in number, place them in the freezer compartment of a home refrigerator, in a chest freezer, or in a commercial freezer wrapped in freezer or waxed paper, labeled, dated, and taped shut to prevent contamination and aid identification.

Note: It is a good idea to make arrangements for commercial freezer storage before an emergency arises since there may be restrictions on storing moldy items in a freezer that normally holds foodstuffs.

For wet materials, see NEDCC leaflet [3.6 Emergency Salvage of Wet Books and Paper](#).

6. Clean the affected items.

Do not try to clean active mold (soft and fuzzy), see step 5, or any friable materials such as pastels, charcoal drawings or flaking paints.

Remove inactive mold outdoors rather than in an enclosed space whenever possible. Be sure to wear protective gear (see step 4). If you work indoors, use a fume hood with a filter that traps mold or in front of a fan evacuating air out a window. Close off the room from other areas of the building (including blocking the air circulation vents). This is similar to creating negative air pressure.

The simplest method of removing inactive mold is to vacuum using a variable speed vacuum on low with a HEPA filter to trap the mold spores. A normal vacuum will simply exhaust the spores out into the air. Do not vacuum fragile items directly, since the strength of the suction can easily cause damage to weakened materials. Paper and textiles can be vacuumed through a fiberglass window screen held down with weights. Move the vacuum nozzle in a straight up and down, not side-to-side, motion. A brush attachment completely covered on the outside with cheesecloth should be used for books to guard against loss of detached pieces. Again, only move in an up and down motion. When disposing of cheesecloth, screening, vacuum bags, or filters, seal them in plastic trash bags and remove them from the building.



HEPA vacuum with variable speed settings

It is also acceptable to clean off mold with a soft brush, but this must be done carefully. Once moldy material is deactivated, take a soft, wide brush (such as a watercolor brush) and lightly brush the mold off the surface of the item into a vacuum nozzle. Use a light touch to prevent the mold from being permanently embedded into the fibers of the paper or textile.

7. Thoroughly clean (and dry, if wet) the space where the mold outbreak occurred.

Cleaning may be done in-house or by a company hired to provide cleaning and/or dehumidification. If working in-house, wipe shelves down with a bleach, Lysol, or similar solution. Allow all cleaned surfaces to dry completely before returning any materials. If a musty odor lingers in the room, the culprit may be carpets and pads that have also become moldy. These will need to be replaced. If the odor is not coming from carpeting or furnishings, the odor may be temporary. If the odor lingers, the problem that initiated the mold may not be repaired. It is also a good idea to have the HVAC system components (heat-exchange coils, ductwork, etc.) cleaned and disinfected if they were the cause of the problem.

8. Return materials to the affected area.

Return materials only after the area has been thoroughly cleaned, dried, and the cause of the mold outbreak has been identified and dealt with.

9. Monitor conditions.

Take daily readings of temperature and relative humidity, and be sure that the climate is moderate. It is particularly important to keep humidity below 55% and temperature below 70°F to ensure that mold will not reappear.

Regularly check problem areas and collections to guarantee that there is no new mold growth. Be sure to

examine the gutters of books and inside the spines as these are common problem areas.

WORKING WITH MOLD REMEDIATION VENDORS

An institution will need outside assistance under certain circumstances:

- If a large portion of the collection is affected by the mold outbreak
- If the infesting mold is known to be a health hazard
- If the HVAC system and the building are also infected with mold

Particularly in the case of a hazardous mold or an infected HVAC system, it is essential to make sure that the building is safe for occupancy by staff. There are a number of companies experienced in working with cultural collections that can assist institutions with recovery. See the NEDCC Delicious page for vendors experienced in working with collection materials.

Several disaster recovery companies also specialize in dehumidifying and cleaning buildings as well as the remediation of collections. In the case of a severe infestation of mold and/or an infestation that poses health risks to staff, companies specializing in indoor air quality can help to ensure that the building is safe for occupancy. Only as a last resort should fumigation of the affected area be performed. Due to the potential for damage, fumigants should not be used directly on or in the presence of collections unless there is no other choice.

Most of the disaster recovery companies that provide drying services will also clean surface mold off of collections. For materials of high artifactual value, conservators and regional conservation centers should be contacted. Be sure that the company you choose is familiar with the requirements of cultural collections. If you are not sure how to choose a service provider, always contact a conservator or preservation professional for advice.

CONCLUSION

Spores, active or dormant, are ubiquitous. Because it is impossible to get rid of all the spores, controlling the environment in which a spore must either thrive or become dormant is key to your preservation strategy.

To be proactive in preventing mold growth:

- keep the RH below 60% (or, better, below 50%);
- use protective enclosures;
- practice meticulous housekeeping;
- monitor RH and temperature; and
- keep a watchful eye.

In keeping with controlling storage environments from the outset, protecting collections from water incidents in the first place should be among the highest priorities for any institution.

If a mold outbreak does occur, do not panic. Remember, you have numerous opportunities and strategies to regain control. Follow the basic salvage steps listed above to identify the problem, isolate materials, stabilize the environment, protect staff, deactivate and clean the mold, and clean the space. By

being proactive and knowing how to safely and properly react to a mold outbreak, you will be better able to protect your collections.

RESOURCES

Canadian Conservation Institute. "Mould Outbreak – An Immediate Response." *Canadian Conservation Institute*. Accessed December 17, 2012. <http://www.cci-icc.gc.ca/caringfor-prendresoindes/articles/mould-moisissures/index-eng.aspx>.

Dadson, Emma. *Salvage*. London: The British Library Preservation Advisory Centre, 2012. <http://www.bl.uk/blpac/pdf/salvage.pdf>.

Environmental Protection Agency. "Molds and Moisture." *Environmental Protection Agency*. (December 4, 2012). <http://www.epa.gov/mold/index.html>.

Image Permanence Institute. *Climate Notes Newsletter*, no. 9 (September 2010). <https://www.imagepermanenceinstitute.org/environmental/climate-notes-newsletter>.

National Park Service. "Mold: Prevention of Growth in Museum Collections." *National Park Service ConservOGRAM*, no. 3/4 (August 2007). <http://www.nps.gov/museum/publications/conservogram/03-04.pdf>.

Reidell, Sarah, and April Smith. "Breaking the Mold." Presentation at the Texas Library Association Conference, San Antonio, TX, March 29, 2001. <http://www.gslis.utexas.edu/~pcs/pdf/Mold.pdf>.

Ritzenthaler, Mary Lynn. *Preserving Archives & Manuscripts*. Chicago: Society of American Archivists, 2010.

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