MOLDS, PESTICIDES, AND OTHER THINGS THAT GO BUMP IN YOUR COLLECTIONS

CHICORA RESEARCH CONTRIBUTION 228

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Michael Trinkley, Ph.D.

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Chicora Foundation, Inc.
PO Box 8664 ▫ 861 Arbutus Drive
Columbia, SC 29202-8664
803/787-6910
Email: chicora1@aol.com

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I want to thank you for being here this morning and especially thank Diana for inviting me. As you no doubt know, I am a pitch hitter, filling in for a speaker who couldn't be here. Although "second string," I hope that my few comments may be useful to some of you fighting very common problems with very limited budgets.

I have always been fascinated with what we do to the world around us, including our archival and museum collections, in order to make things "better." We seem to spend a lot of time "doing what God forget" — eliminating roaches, trying to kill mold, fighting silverfish — things like that. I am convinced that one of the most common phrases in the English language is "it seemed like a good idea at the time." We use all sorts of chemicals in efforts to tame the world around us and it make it free from those things we don't especially like, such as pests, or mold, or even weeds in our lawns. And sometimes, possibly more often than we realize, our efforts backfire, making matters worse, not better.

Curiously, many of our efforts — especially those associated with pest control and mold eradication — seem terribly misdirected. Instead of dealing with root causes, we spend much energy, staff time, and funds, trying to kill things and cleaning up the resulting mess. Let's consider mold first.

I won't spend a lot of time on the biology lesson, but in general mold and mildew are different names for the same thing — a very simply life form that lacks the ability to photosynthesize. Instead mold uses enzymes to digest nutrients from other organic materials — such as building materials and paper. Essentially mold consists of fungi that grow in filamentous forms.

Each vegetative filament of fungus is called a hypha and a large mass of hyphae is called a mycelium. These hyphae are the actively growing, assimilative phase of the fungi and new growth typically occurs as a linear elongation of the hyphae.

The two most common "problem" molds for preservationists are the Ascomycetes and Fungi Imperfecti. The Ascomycetes include over 29,000 species, many of which are disease causing. The Fungi Imperfecti is the second largest subdivision, containing over 17,000 species and are also very aggressive agents of biodeteriation.

Molds reproduce through both sexual and asexual techniques. Those that we are concerned about reproduce almost exclusively through asexual means, forming what are called conidia although they are often mistakenly called "spores." Conidia are typically 5 to 50 μm in diameter (*Aspergillus fumigatus* conidia are among the smallest, measuring about 2.5 μm) and are very easily air borne.

Molds often appear as circular spots, resulting from the outward growth of hyphae, but it is important to understand that just as the mold grows outward, it also grows down, into the substrate, of our paper, book bindings, and leather.

This should be enough biology to awe and astonish your friends at the next cocktail party, so let's talk for a moment about where molds come from. The simple answer is that molds are everywhere. This is particularly important since some people talk about molds as though they are an "infection" coming from some unsterile source. I recall one article where a librarian commented that the source of their mold was "damaged gift books" that "had the chance to affect other books." Mold is ubiquitous and its food sources are intrinsic parts of virtually every institution. The source of this librarian's mold was likely present in the building long before the "gift collection" arrived.

The majority of fungal conidia in the indoor environment come from the outdoors. Consequently, the most common molds are *Cladosporium* and *Alternaria*, with lesser quantities of *Aspergillus* and *Penicillium*. The number of the conidia may reach one million per cubic meter under favorable conditions, although levels of 10,000 to 100,000 per cubic meter are more common. In fact, unless there is an internal mold source, typically levels of mold conidia inside will be less than the levels outside. We also know that new buildings most often have lower mold levels than historic or old buildings.

Mold thrives in a broad range of environmental conditions. Often we read that relative humidities must be 70% or higher, yet we have all seen mold aggressively growing in much lower relative humidities. It's important to understand the concept of water activity, abbreviated "a_w." The technical definition is "surface equilibrium relative humidity," but it's easier to understand if you realize that by their nature, some materials are most moist than others. Dish washing detergents are more moist than bar soap, for example. In other words, water activity is a measure or index of a substance's moisture content. It ranges from 1.0 (the highest) to 0.0 (the lowest). Water has a water activity of 1.0, while talcum powder has a water activity of about 0.5.

Mold growth becomes less likely on material as the water activity falls below 0.7 and on substrates with a water activity of less than 0.5 we know that mold growth is impossible. At times mold grows on substrates with an appropriate water activity level even through the relative humidity is seemingly too low to support growth. More often mold is encouraged by inappropriate HVAC design, inadequate dehumidification, poor building design, a failure to ventilate, unsuitable mixing of the supply air, and a failure to adequately maintain the building envelope.

So, let's sum up what we have so far — mold is everywhere and we encourage it through our inattention. Pretty simple really. Now, beyond this, we tend to make bad matters worse through housekeeping that is typically out of the dark ages. Typical vacuum cleaning results in a 17-fold increase in mold conidia numbers and leave these numbers elevated for at least an hour afterwards. One study found that disturbing surface mold can cause a 3,300 times increase in airborne fungi within 0.3 meter of the source. These are picked up by air currents and dispersed even more widely. In another study poor housekeeping resulted in mold levels of 822 conidia per cubic meter, compared to levels averaging 292 conidia per cubic meter in building with good housekeeping.

On top of the problems mold causes our collections, there is mounting evidence that mold also isn't particularly good for people. The most current research has been summed up with the statement that, "there is consensus that it is harmful to health if fungi grow to such an extent that their spores and volatiles become appreciable contaminants of indoor air."

Inhalation of airborne microorganisms — and their metabolites — may cause a wide range of respiratory symptoms. Mucous membrane irritation, coupled with a dry cough and eye irritation is a common response to continuous exposure. Bronchitis and chronic pulmonary disease, while typically associated with smoking, may also be related to such allergic reactions, although the role of airborne microorganisms hasn't been determined. Allergic rhinitis and asthma, particularly among those who are constitutionally predisposed to allergies, is perhaps one of the most severe responses to mold exposure. Inhalation fever, resulting in influenza-like symptoms, may be caused by fungi, bacteria, mycotoxins, and endotoxins.

Even more potentially toxic are mold glucans — constituents of fungal cell walls — which can cause immune reactions, resulting in mucous membrane irritation, headache, muscular pain, cough, and chest tightness. Mycotoxins are poisonous secondary metabolites of fungi. They are chiefly produced by *Fusarium, Penicillium,* and *Aspergillus* — all of which are common to buildings and collections. Toxicity by inhalation can be 40 times greater than by ingestion. Aflatoxins may cause liver and other cancers, while other mycotoxins can affect other organs or cause immune suppression. There is also a possibility that mycotoxins may play a role in leukemia.

Finally, there is the possibly, although typically remote, of respiratory infection. This is typically associated with *Aspergillus*, but the nature of the infection will depend on the immunological status of the individual.

It's important to understand that while fungi *can* cause these problems and perhaps others, there is relatively little evidence that molds *commonly* cause these diseases. Furthermore, it appears that when these diseases are associated with molds, the affected individuals are often predisposed.

Nevertheless, it would be foolish for institutions to risk exposure by either staff or patrons to serious mold outbreaks. I have read many recommendations that staff use respirators when dealing with mold outbreaks. Unfortunately, this is both good *and* bad advice.

First, the use of mechanical-filters or particulate-removing respirators is good advice only if a HEPA respirator is used. HEPA filters have the ability to remove 99.97% of the particles, including conidia, down to 0.3 microns. Other respirators are unable to achieve this level of filtration and will not adequately protect employees from mold conidia. In addition, if there is a moldy or mildew smell, characteristic of the metabolic volatiles of mold, you will likely want to use a respirator fitted with organic vapor cartridges.

But second, and more importantly, the use of respirators is carefully controlled by OSHA's Respiratory Protection Standard 1910.134. OSHA specifies that workers must be protected by use of engineering controls, with respirators used as a last resort. Typically, respirators are permitted under only five conditions, one of which is during emergencies.

Now assuming that we can justify the use of respirators as an emergency condition, OSHA requires that their use be coupled with a respiratory protection program meeting minimal requirements. Specifically:

- the program must be written and contain detailed operating procedures;
- the program must specify how respirators will be selected;
- the program must establish (and you must implement) a training program;
- the program must train employees in the cleaning, maintenance, and storage of respirators;
- the program must include an inspection component; and finally,
- you must establish medical surveillance of respirator users.

If you don't have a written respiratory program you have no business using respirators in your institution. I can't stress this to you enough — either play by the rules or get out of the game. Size of institution, number of employees, or annual budget does not offer any exemption.

Another bit of advice I see a lot is to use a Rainbow™ vacuum to remove mold. Or sometimes you'll here of filling a wet-dry vacuum half full of Lysol™. The theory is that the liquid traps the mold conidia. This is another great example of "it seemed like a good idea at the time." The problem is, these vacuums — whether brand name or put together in your shop — aren't very good. They trap relatively little and allow a great deal to be expelled. When they are used to vacuum mold, you create a bioaerosol that is dispersed throughout the immediate area. Even if the chemical solution kills the conidia, it is still dispersed, it is still respirable, and now it is also coated with a toxic chemical. But, "it seemed like a good idea at the time" and "boy was it cheap."

Like respirators, the only vacuum appropriate for mold is a HEPA vac. Relatively small, light-weight models are available for around $500 or $600. When you add to this the cost of a respiratory protection plan, training, fit-testing, and medical surveillance of your employees, mold outbreaks begin to cost some real money.

So maybe we're coming at mold from the wrong direction. Rather than spending a lot of time and energy worrying about how we're going to clean it up, we'd do well to think about why we have it. Of course there will be times when we have to clean up mold, but as much as possible my advice is to focus on prevention.

Instead of accepting mold as inevitable, institutions must begin to understand why they have mold and treat the root causes. In many cases mold is simply a symptom of uncaring administrators, deferred maintenance, and lax preservation efforts. In terms of better understanding moisture problems, an excellent place to start is the ASTM book, *Moisture Control in Buildings*, edited by Heinz R. Trechsel. Two other excellent sources are the National Institute of Building Sciences' *Bugs, Mold & Rot* and *Bugs, Mold, & Rot II*.

Let's turn for a few minutes to pesticides — another topic that frequently results in the synopsis, "it seemed like a good idea at the time." Many librarians and archivists feel relatively secure from pesticides, believing that all the really toxic stuff was reserved for natural history collections in museums. You shouldn't be so trusting.

One of my favorite memories is of an archives in a large southern city which routinely treated its gift collections by piling them in a carrel — which happened to be just off the main reading room and by the archivist's desk — and then setting off about three or four roach bombs. You could stand outside the room and watch the fumes swell up like a fog and then begin to slip under the door and out into the open room. I asked the archivist if this didn't bother him, only to be told that "its only a few (cough) roach bombs." Of course those bombs were primarily pyrethroids in a petroleum distillate. The pyrethroids, of course, are surprising safe, although extraordinarily high doses may cause incoordination, tremor, salivation, vomiting, diarrhea, and irritability. Fortunately, these are few systemic poisonings of humans since the chemical rapidly biodegrades in the presence of liver enzymes and most pyrethroid metabolites are quickly excreted by the kidneys. In terms of the collection, they were probably more at risk from the petroleum distillates, which can cause extensive staining, dissolve adhesives, and run inks.

I also recall another institution that routinely used what it called, quite seriously, "bug-a-boo" in all of its collections. This product was a blue powder, which I saw employees dump in records boxes without respirators, gloves, or other protection. I also saw users sorting through records by just blowing off the blue powder and then handling the materials, again without gloves. Well, it turned out that this "bug-a-boo" was sodium fluoride. This was widely used in the earlier part of this century for control of insects, so you should be on the lookout for it. And you should be particularly careful, since sodium fluoride has a very high inherent toxicity. Toxic effects are multiple and all may threaten life. It can inhibit the creation of critical intracellular enzymes, it can have a corrosive effect on the gastrointestinal lining, it can reduce the extracellular level of magnesium and calcium, there can be toxic actions on the brain, as well as cardiac arrhythmias.

A study on the exposure levels to indoor pesticides was conducted by North Carolina State University. One very interesting finding was that even relatively nonpersistent pesticides will remain within structures protected from direct sunlight and with limited ventilation for several weeks. Furthermore, while the pesticide may be applied at floor level, it tends to migrate upward, with residue levels at chest height being about equal to those at floor levels by the seventh day. Another study found that pesticides tend to migrate from room to room, remaining in the air for considerable periods of time.

There is also evidence that at least some active ingredients produce volatile by-products. For example, chlorpyrifos breaks down into disulfides, trisulfides, and tetrasulfides, as well as ethyl mercaptan — all products with low odor thresholds. This probably accounts for the bad smell associated with some chlorpyrifos treatments, even though chlorpyrifos itself is odorless. At times these by-products can be detrimental.

In addition to the active ingredient, we should always be aware of the carrier, as I mentioned a few minutes ago. Many contain C8 and C9 aromatic hydrocarbons which are upwards of 10,000 times more volatile than the active ingredients! The petroleum based solvents consist of xylene, methyl ethyl benzene, and a host of related compounds — none of which we really want to be exposed to in an concentrations.

Most of us are familiar with the toxicity of fumigants such as ethylene oxide, but routinely allow pesticides in our facility, and often in very close contact to collections, without a second thought. In fact, I'm always surprised how few staff have any idea what pesticides are being used in their institutions, or even when the pesticides are being applied. Probably far too many of us have a naive belief that government pesticide regulations will protect us from unscrupulous, ignorant, or untrained pest control operators.

In fact, FIFRA, the Federal Insecticide, Fungicide, and Rodenticide Act, began in 1947 as a labeling law and did not deal with actual pesticide use or regulate the pest control industry. It wasn't until 1972 that the act was amended to deal with pesticide use. It requires that the individual applying the pesticide in your institution to operate under the supervision of an individual who is licensed. In general, this means that the applicator be able to reach his or her supervisor by phone if there is a problem. In other words, the individual applying the pesticide doesn't have to know much of anything about it. I recall one situation when an applicator, for a very large and nationally recognized company, applied granular diazinon — a pesticide typically used for control of crawling insects — while claiming it was a rodenticide intended for the control of rats.

This should be more than enough reason for you to begin to take a much firmer hand in the application of pesticides in your facility. My advice is that all institutions allow the use of pesticides only when there is a documented pest problem. This is, in effect, a modified IPM approach. Avoid the monthly spraying or preventative approach. Not only is this costly, but there is good evidence that it helps the pests we seek to control build a resistance to the most commonly used pesticides. If you have a pest, ensure that your pest control operator can identify the problem and selects an appropriate pesticide. FIFRA establishes certain labeling requirements and one of these is that the label must indicate for which pests the pesticide is appropriate. Use of a pesticide for non-listed pests is not allowed.

In addition, I recommend that a staff member escort your pest control operator throughout the building. I recommend that the pest control operator be required to specifically describe, in writing, where pesticide was applied (in what rooms and where in those rooms), how it was applied (crack and crevice, bait, behind plumbing pipes), the concentration or dilution (1%, for example), and the amount (a quarter of a gallon, 3 ounces, whatever).

Finally, institutions should demand not only a specimen label for the pesticide being used, but also the material safety data sheet. These can not only help ensure that the pesticide is being applied correctly, in the right amounts, to appropriate places, but it can also help you evaluate its risk to both collections and people. If there is any sign of pesticide poisoning, the MSDS will provide important information to the treating physician. Beyond these concerns, these demands will also clearly indicate to the pest control company that you intend to be an active player in the health and safety of your institution.

For those interested in learning more about pesticides, I can recommend two excellent books. The first is *Basic Guide to Pesticides: Their Characteristics and Hazards* by Shirley A. Biggs. Although published by the Rachel Carson Council, this is a very authoritative publication which can be relied on. The other, published by the EPA, is *Recognition and Management of Pesticide Poisonings*. While primarily useful to pest control operators and physicians, it offers exceptional information on a wide variety of common pesticides. Finally, if you aren't very familiar with material safety data sheets, there are lots of training aids. Although many are little more than comic books for the marginally literate, some, such as *Pocket Guide to MSDSs and Labels,* offer excellent introductions. For those a little more advanced, the *NIOSH Pocket Guide to Chemical Hazards* is indispensable.

I hope that I have touched on at least a few issues of use to you this morning. I understand that we'll now have an open question and discussion session, so if there are issues I didn't cover, or perhaps failed to cover in enough detail, I would be happy to go to greater detail.