MOLD IDENTIFICATION AND PREVENTION IN WISCONSIN SCHOOLS

by
Lori A. Rode

A Research Paper

Submitted in Partial Fulfillment of the
Requirements for the
Master of Science Degree in

Risk Control

Approved: 3 Semester Credits

Investigation Advisor

The Graduate College
University of Wisconsin Stout
May, 2002

The Graduate School

University of Wisconsin-Stout

Menomonie, WI 54751

ABSTRACT

Rode	Lori	A.
(Last Name)	**(First)**	**(Initial)**

Mold Identification and Prevention in Wisconsin Schools

(Title)

Risk Control	Elbert Sorrell	May 2002	82
(Graduate Major)	**(Research Advisor)**	**(Month/Year)**	**(No.of Pages)**

American Psychological Association (APA) Publication Manual Fifth Edition

(Name of Style Manual Used in this Study)

Mold is a term commonly used to describe visible fungal growth and forms of microbial contamination. Molds are found both indoors and out and can be beneficial to mankind, while some are toxic with sufficient exposure. Molds can produce a variety of effects ranging from allergic reactions, including headaches, dizziness, sore throats and respiratory difficulties to toxic infections and disease. Buildings housing large groups of

individuals such as schools are currently under scrutiny for mold exposure. Studies of injuries and illnesses due to mold exposure in schools are escalating rendering old and new construction alike to be closed. Specific prevention programs are needed for early mold identification, prompt elimination and remediation. Fifty Wisconsin school buildings were examined for mold susceptibility comprised of a historic questionnaire for water damage and walkthrough inspection. Signs of visual microbial growth, building odor, construction type, relative humidity, indoor and outdoor water sources, site drainage and frequency of HVAC system inspections were documented. The top five mold sources in typical Wisconsin Schools were identified. A comprehensive strategy to limit microbial growth is outlined, including a prevention checklist to deter mold growth, guidelines for remediation if mold is found and framework for management support and accountability for success of a prevention and remediation program.

TABLE OF CONTENTS

CHAPTER THREE: METHOLDOGY

CHAPTER FOUR: RESULTS AND DISCUSSION

CHAPTER FIVE: SUMMARY,CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 1

Statement of the Problem

Introduction

According to the World Health Organization 30% of new and remodeled buildings world wide contain enough pollutants to make workers ill (Brown, 1996). The term, Sick Building Syndrome (SBS) has been recognized by the World Health Organization since 1982. It is estimated there are 30-70 million of new cases reported each year (Hasbach, 1998).

Most contaminated building problems originate from outdoor fungi that grow in the soil. Typically fungal levels are higher outside and concentrations vary according to geographic location, climate conditions, season, and surrounding human activity. Mold is a term commonly used to describe visible fungal growth and forms of microbial contamination.

Mold growth is often the result of water damaged building materials such as wet carpets, wall coverings or wallboards. The building materials may be damaged because of roof or wall leaks, clogged air conditioner drain lines, chronic plumbing leaks, condensation within wall cavities, wet ductwork, and improperly controlled humidification systems. The water damaged materials offer nutrients for

growth and once heavily contaminated it is difficult to successfully decontaminate porous surfaces. If allowed to grow and dissipate, mold can render the building uninhabitable causing substantial property damage in addition to injuries and illnesses (Liberty Mutual, 2001).

Despite the potential for loss, presently there are no established federal or state permissible exposure limits (PELS) in public or private buildings (Skaer, 2002). Buildings housing large groups of individuals such as schools are currently under scrutiny for mold exposure. In a nation of aging schools, many students are warehoused in dank facilities at a time when districts cannot afford renovations, much less new buildings. Although general indoor air quality programs exist, specific mold prevention programs are needed for early identification, prompt elimination and remediation.

Purpose of the Study

The purpose of the study was to provide a comprehensive strategy to resolve problems related to microbial growth in typical Wisconsin school buildings.

Goals of the Study

The study focused on the following objectives:

1. Provide a prevention checklist to deter microbial growth in typical Wisconsin school buildings.

2. Provide guidelines for remediation of existing mold contamination.
3. Provide a framework for management support and accountability for success of a prevention and remediation program.

Background and Significance

Considering most Americans spend 90% of their time indoors where pollutants can be two to five times higher than exposure to external pollutants, indoor air quality is an increasing occupational health problem (Hasbach, 1998). A NIOSH representative said requests for investigation into indoor pollution have jumped from 2 percent of all complaints in 1980 to 35 to 65 percent of all complaints in recent years. At least 41 medical studies on Sick Building Syndrome were completed throughout 1996-1997 (Ferraro, 1997).

Indoor air quality concerns within public schools are also escalating. A 1995 General Accounting Office report said that more than 50% of the country's schools have poor ventilation and significant sources of pollution (Davidson, 1999). Children may be especially susceptible to mold. The same concentration of spores can result in a higher body burden in children than adults because children breathe a greater volume of air relative to their body weight (EPA, 2000). Nearly one school aged child in thirteen have

asthma, the leading cause of school absenteeism due to chronic disease (EPA, 2000).

Is asthma caused by mold? Although there is no direct proof, scientists suggest exposure to allergens such as mold can play a role in triggering reactions (EPA, 2000). Molds can affect health in three primary ways. First people can become infected themselves, that is mold can start growing inside them, usually in their lungs. This health affect however is rare, typically only occurring in those with impaired immune systems such as in cancer or AIDS patients.

Most people have allergic reactions to molds. Symptoms range from headaches, dizziness, sore throats and nausea to respiratory infections and asthmatic reactions. In the Northern Hemisphere, Cladosporium spores are the dominant species, with an estimated 10% of Americans allergic to Cladosporium (Redford, 2002).

Finally people can have toxic reactions to molds. The mycotoxins produced by molds can affect otherwise healthy people. Of the 5000 known species of mold, approximately 50 are cable of creating mycotoxins (Redford, 2002). Symptoms range from bleeding to respiratory illness that sometimes lead to death.

Growth of mold inside buildings depend on a number of interrelated variables, but when ideal conditions are present, germination can occur quickly within 24 to 48 hours.

As buildings such as schools, already have favorable temperature and nutrients for growth, prompt identification, elimination and remediation are necessary to prevent microbial growth.

Limitations

Although indoor air quality research can encompass a broad range of contaminants from complex chemicals to bioaerosols, for purposes of the study the focus is limited to mold exposures only.

The scope of this field work is limited to mold identification at 50 schools equally distributed throughout the various regions within Wisconsin. Although it is reasonable to expect that the representation provides typical findings of Wisconsin school buildings, the validity of the findings is limited by the sampling size.

Assumptions

As the mold susceptibility inspections were initiated by an insurance carrier, there could have been lack of disclosure in an effort to avoid premium increases as a result of finding a problematic building. It is assumed the information secured regarding the history of the buildings and maintenance plans is based on the schools' full disclose of accurate facts.

Definitions

ACGIH American Conference of Governmental Industrial Hygienists (EPA, 2001).

Allergen Substance such as mold that can cause an allergic reaction (EPA, 2001).

APR Air purifying respirator (EPA, 2001).

Aspergillosis Mold ubiquitous in the environment, found in soil, decomposing pant material, household dust, building material ornamental plants, items of food and water (CDC, 2001).

ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRE, 1989).

Cladosporium Mold spores formed in long branching chains made up of barrel-like to lemon shaped formations on surfaces ranging from smooth to highly "warty" (Liberty Mutual, 2001).

EPA Environmental Protection Agency (EPA, 2001).

Fungi A diverse group of organisms that have their own kingdom, separate from plants and animals that produce microscopic spores to reproduce (EPA, 2001).

HEPA High Efficiency Particulate Air Filtration device (EPA, 2001).

HVAC System Heating, Ventilation and Air Conditioning system (Checket-Hanks, 2001).

IAQ Indoor Air Quality (EPA, 2001).

Mold Visible fungal growth found on damp or decaying organic matter or living organisms (Liberty Mutual, 2001).

Mycotoxins Fungal metabolites that have been identified as toxic agents (New York, 2001)

NIOSH The National Institute for Occupational Safety and Health is a federal agency responsible for conducting research and making recommendations for the prevention or work related disease and injury (EPA, 2001).

PAPR Powered Air Purifying Respirator (EPA, 2001).

PEL Permissible Exposure Limits are regulatory limits set by OSHSA on the amount or concentration of a substance in air (OSHA, 2002).

Remediate To fix (EPA, 2001).

Sick Building Syndrome (SBS) A set of varied symptoms and complaints commonly attributed to building design, operation and maintenance (Hasbach, 1998).

Stachybotrys A greenish black mold known to grow on materials with a high cellulose content (New York, 2002).

VOC's Volatile organic compounds produced through the primary or secondary metabolism of fungi and released into indoor air (Ammann, 2002).

Summary

Indoor air quality is a growing issue that is rendering new and old construction alike to be closed. Illnesses due

to exposures such as microbial contamination are on the rise. Buildings that house large groups of individuals such as schools are under scrutiny. Although general indoor quality programs exist, specific mold prevention programs are needed for early mold identification, prompt elimination and remediation.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

The purpose of this chapter was to examine and evaluate literature, which is relevant to mold identification, prompt elimination and remediation. The literature review is divided into the following subparts:

1. Health effects of mold exposure
2. Relationship between health effects and mold exposure
3. Mold sources and prevention
4. Strategies for assessment
5. Strategies for remediation
6. Summary

Health Effects and Mold

Mold is the visible growth of any 100,000 species of fungus. These organisms are everywhere, indoors and out (Egan, 2002). In nature, they break down dead materials such as leaves and branches by feeding on the cellulose in lumbar, which is why they also grow on the paper covering in drywall and fibre ceiling tiles (McLean, 2001). Molds reproduce by making spores, which, if land on a moist food source can germinate and begin producing a branching network of cells called hyphae. Spore or fragments then become airborne can expose people indoors through inhalation or skin contact

(Ammann, 2002). Molds impact on human health depends on the nature of the species involved, the metabolic products produced by the species, the duration of exposure and the susceptibility of the individuals exposed. Health effects generally fall into three categories: allergy and asthma, infection and toxicity, and irritation and volatile organic compounds (Liberty Mutual, 2001).

Allergy and Asthma

Allergy is the most common exposure to mold. When mold cells are inhaled and land in the respiratory tract, the body's immune system's response to those invading cells can cause allergic illness. The immune system tries to destroy the mold as it would an agent, like a flu virus, that might cause infection. In a relatively small portion of the population (about 10 percent of people in the U.S.), the immune system overreacts and causes the allergic response that results in symptoms such as runny nose, scratchy throat and sneezing. Most of us know this allergic illness as "hay fever" or "allergic rhinitis" (Public Health, 2001).

Allergic reaction range from mild, transitory responses to sever, chronic illnesses. The Institute of Medicine has estimated that one in five Americans suffer from allergic rhinitis. In addition, 14 percent of Americans suffer from

allergy related sinusitis, while 10 to 12 percent have allergy related asthma (Public Health, 2001).

Asthma is a lung disease in which the airways that carry oxygen to the lungs can partially close, causing breathing difficulties. Symptoms can range from mild, such as a dry cough, to life-threatening such as the inability to breathe. Molds can trigger asthma episodes in sensitive asthmatics (Public Health, 2001).

Infection and Toxicity

Unlike allergies, infections from molds that grow in indoor environments is not a common occurrence, except if susceptible populations such as those with compromised immune system by disease or drug treatment.

Very large doses of certain molds, whether inhaled or ingested, can result in poisoning caused by toxins. These toxic fungal metabolites are called mycotoxins. It is not clear whether an individual can receive a high enough exposure to mold growing indoors to experience these toxic effects. However, exposure to certain types of mold, such as aspergillus and stachybotrys have been found to be toxic (CDC, 2002).

Aspergillus fumigatus is a pathogen that is thought to cause infections called aspergillus, which can cause invasive pulmonary infection, usually with fever, cough and chest pain.

If left untreated, aspergillus can disseminate to other organs including infection in the brain, skin and bone (CDC, 2002).

Another toxic mold that has received much attention in the literature is Stachybotrys. Stachybotrys is easy to identify due to its greenish-black coloring and grows on materials with high cellulose content (drywall, wood, paper, ceiling tiles) that are chronically wet or moist. Stachybotrys mold, is listed in the military manual as an agent of biological warfare (American City and Country 2002). Stachybotrys is a toxin producing fungus the can suppress immunity and cause headaches, fatigue, and in large doses, death (Davidson, 1999).

Irritation and Volatile Organic Compounds

A third group of possible health effects from fungal exposure is derived from the volatile compounds (VOC's) produced through fungal metabolism and released into indoor air (Ammann, 2002). Depending on the available oxygen, fungi may engage in aerobic or anaerobic metabolism, producing alcohols, aldehydes and acidic molecules. In sufficient concentrations the compounds can irritate the mucous membrane of the eyes and respiratory systems (Ammann, 2002).

In addition to their own metabolism compounds, the nature of the food source the fungi grows on can result in unhealthy metabolic products. For example, one fungus growing on wallpaper has been found to release the highly toxic gas arsine from arsenic containing pigments (Gravesen, 1994).

The fungal VOC's may also affect the "common chemical sense" that senses pungency and responds to it. This sense is associated with the trigeminal nerve which initiates avoidance reactions such as breath holding, discomfort, paresthesis, or odd sensations such as itching, burning, and crawling skin. Trigeminal nerve stimulation can also cause changes in sensation, swelling of the mucous membrane, constriction of the respiratory smooth muscle, or dilation of surface blood vessels. Decreased attention, disorientation, diminished reflex time and dizziness can also result from such exposures (Otto, 1989).

It is difficult to determine whether the level of VOC's produced by fungi influences the total concentration of VOC's commonly found indoors emitted by building material, paints, plastics and cleaners. However, a summary of study by Miller and coworkers (1988) measured a total VOC concentration approaching the levels at which Otto (1989) found trigeminal-nerve effects. Although no further details of the study were available, it suggests a valid concern for concentrations of fungi produced VOC's .

The Relationship Between Health Effects and Mold

Studies such as the above, suggest mold can make one sick, however scientists actually know very little about the proven health effects from mold exposure (Lexis-Nexis Group, 2002). Stachybotrys and aspergillis are a few documented toxins but scientific evidence is scant on the how people actually become sick from mold (Lexis-Nexis Group, 2002). The point at which individuals react to mold is difficult to determine. Although the most critical type of mold reaction is that which comes from inhalation, there is lack of medical data, on specifics of inhaling low levels of mold spores (Hays, 2001). Furthermore, there are no standard operating procedures for spore collection at a contaminated site. To analyze spores, some methods are better for capturing larger spores, while others are better for smaller. Blood tests on individuals to determine the effects of mold exposure are worthless without a pre-exposure sample for comparison purposes (Hays, 2001).

Presently there are no state or federal agencies that have set an indoor air standard for mold, but in the absence of scientific evidence courts are tending to side with the people who claim they are sickened by mold in buildings (Lexis-Nexis Group, 2002). Some predict toxic mold verdicts will eventually surpass asbestos matter in terms of case volume and value (Cahill, 2001). Laurie Pegler, an attorney

for the Property Loss Research Bureau, a national organization that collects information for insurance companies, said she thinks a medical basis will be established for setting standards (Lexis-Nexis Group, 2002).

California is presently leading the way in adopting standards for this rising concern. Last October, California Governor Gary Davis signed Senate Bill 732, The Toxic Mold Prevention Act of 2001. The bill directs the California Department of Health Services to develop and adopt standards for mold exposure limits for indoor mold environments by July 1, 2003. The bill addresses commercial, industrial and residential buildings (Skaer, 2002). There is no information yet available as to California's progress with this new legislation. New Jersey is proposing a resolution S.R.77 which would require the Commissioner of Health and Senior Services and the Commissioner of Community Affairs to educate residents to identify Stachbotrys mold and to identify cleanup methods for mold infections (Journal of Property Management, 2002).

Mold Sources and Prevention

As it appears that eventually some type of indoor air quality standards will be set, it makes sense to be better educated in regard to mold sources and thus the prevention of them. Although individual sources of mold are countless, most research suggests the primary players in commercial

buildings are poor building design and construction, flooding and water leaks, uncontrolled relative humidity and condensation and poorly maintained HVAC systems.

Building Design and Construction

Forethought in building design and construction can reduce the amplification of fungal contamination. The construction phase is the often the cheapest opportunity to change potential problematic areas that can cause or contribute to microbial growth. The following are several aspects to take into consideration at the design/construction stage (Liberty Mutual, 2001):

1. Provide an effective drainage plane for egress of water that may accidentally enter the building.
2. Control ground water around and under the foundation to eliminate hydrostatic pressure forcing water into the foundation.
3. Grade the site to divert water away from the building.
4. Ensure concrete and mortar have enough time to cure before closing up.
5. Backfill the foundation as soon as possible.
6. During construction make the building weather tight before installing finishing materials.
7. Prevent penetration of surface water, ground water, and capillary water movement through materials with appropriate caulks, coatings and sealants.

8. Eliminate sites of water accumulation in cooling and humidification systems by designing and installing drainage components.
9. Eliminate areas of potential water condensation on cold surfaces such as external walls, water pipes and ducts.
10. During construction, test the water supply and fire prevention systems with air before activating.
11. Test and certify waste and vent systems for leakage before closing in wall cavities.

Ventilation for occupant's needs should also be taken into consideration. The amount of outdoor air considered adequate for proper ventilation has varied substantially over time. Currently however, the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE, 1989) recommends the minimum ventilation guidelines represented in figure 1. The quantities listed are in CFM/person, which is cubic feet per minute of outdoor air flow for each person in the area served by the particular ventilation system.

Figure 1. Outdoor Air Ventilation Requirements

Application	CFM
Classroom	15
Music Rooms	15
Libraries	15
Auditoriums	15
Spectator Sport Areas	15
Playing Floors	20
Office Space	20
Conference Rooms	20
Kitchen	50
Cafeteria	20

In addition to building design and ventilation, building materials themselves can affect mold growth. Figure 2 depicts typical construction materials found in school and their susceptibility to microbial growth (Liberty Mutual, 2001):

Figure 2. Building Materials Subject to Mold Growth

Materials	Why it is Susceptible
Lumber	Wood sugars
Gypsum board	Cellulose in sizing material
Paint coatings	Organic filers/pigments
Carpet and textiles	Natural latex and fibers
Air handling system	Cotton fibers
Adhesives	Grain starch fillers
Ceiling tile	Cellulose and starch binders
Concrete and masonry	Dirt and grit

Although the above building materials are necessary in most construction, there are products available to pre-treat some types of materials. In a study by Jennifer Fogel and Jeff Lloyd, (2000), mold performance of construction products with and without borates was analyzed. In the study solid wood, wood composites, and gypsum wallboard were treated with various borate loadings and then analyzed to determine whether boartes used in construction materials would render them resistant to mold growth. The results found that the higher the borate concentration, the lower the ability of the mold fungi to colonize on a given material (Fogel, 2000).

Flooding and Water Leaks

Although eliminating moisture during the building design stage is the best strategy for control, occasionally moisture enters buildings due to leaks, floodings and intrusion. Figure 3 represents guidelines for response to water damage discovered within 24-48 hours (EPA, 2001). As mold growth is likely after 48 hours, guidelines are then dictated within the remediation section of this report.

Figure 3. Guidelines for Response to Water Damage within 24-48 Hours to Prevent Mold Growth

Damaged Material	Actions
Books and papers	• For non-valuable items, discard books and papers. • Photocopy valuable/important items, discard originals. Freeze (in frost-free freezer or meat locker) or freeze dry.
Carpet and backing	• Remove water with water extraction vacuum. • Reduce ambient humidity levels with dehumidifier. • Accelerate drying process with fans.
Ceiling tiles	Discard and replace.
Cellulose insulation	Discard and replace.
Concrete block	• Remove water with water extraction vacuum. • Accelerate drying process with dehumidifiers, fans, and/or heaters.
Fiberglass insulation	Discard and replace.
Hard surface, porous flooring (Linoleum, ceramic tile, vinyl)	• Vacuum or damp wipe with water and mild detergent and allow to dry; scrub if necessary. Check to make sure underflooring is dry; dry underflooring if necessary.
Non-porous, hard surfaces (Plastics, metals)	• Vacuum or damp wipe with water and mild detergent and allow to dry; scrub if necessary.
Upholstered furniture	• Remove water with water extraction vacuum. Accelerate drying process with dehumidifiers, fans, and/or heaters.
Wallboard (Drywall and gypsum board)	• May be dried in place if there is no obvious swelling and the seams are intact. If not, remove, discard, and replace. • Ventilate the wall cavity, if possible.
Window drapes	Follow laundering or cleaning instructions recommended by the manufacturer.
Wood surfaces	• Remove moisture immediately and use dehumidifiers, gentle heat, and fans for drying. (Use caution when applying heat to hardwood floors.) • Treated or finished wood surfaces may be cleaned with mild detergent and clean water and allowed to dry. • Wet paneling should be pried away from wall for drying.

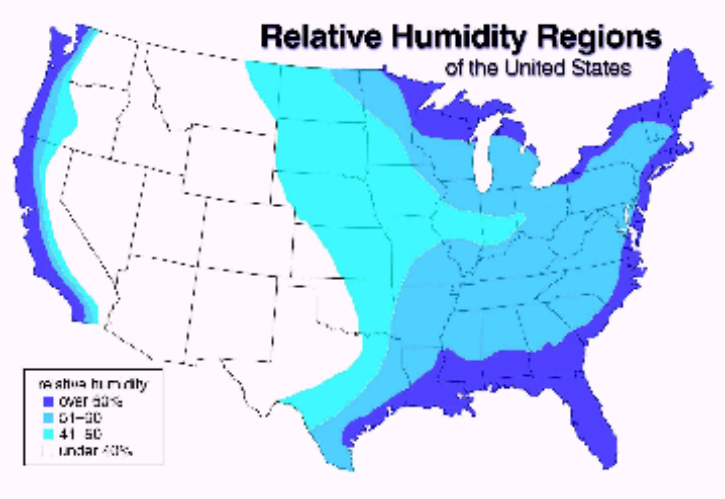
In upwards of 90% of major moisture problems in commercial buildings start with the roof (Lexis-Nexis Group, 2002). Typically commercial buildings have small holes in the roof or sags where water is allowed to collect and will eventually find its way in. Varied sources recommended roof inspections on a yearly basis at minimum for these conditions. In regards to basements, Doug Walkinshaw, Ph.D., who founded the Indoor Air Technology, warns against laying carpet directly onto concrete basement floors. Moisture is drawn through the concrete and becomes trapped beneath the carpet. Either paint the concrete, use tiles or build a continuously ventilated subfloor (Report/Newsmagazine, 2001)

Relative Humidity, Temperature and Condensation

Some forms of moisture however, do not need to find their way into buildings, as they already exist. Relative humidity varies throughout the regions of the United States. Although it is subject to change to some extent as the seasons change, it represents the percentage of humidity in the air (Liberty Mutual, 2001).

Figure 4 depicts relative humidity ranking of within the United Sates (Liberty Mutual, 2001).

Figure 4. USA Relative Humidity



In cases where a state has varied regions, one would refer to relative humidity state by state ranking with specific county ranking. Each county or list of counties will have a number listed near it. The ranking number, 1 through 4, is assigned to each location. (1 = under 40% RH, 2 = 41 - 50% RH, 3 = 51 - 60% RH, 4 = over 60% RH)

For example, the state of Wisconsin is shaded which indicates it has more than one humidity ranking. By referring to the county listing, counties of Douglas, Bayfield, Ashland, Iron, Forest, Florence, Marinette, Burnett, Washburn, Sawyer, Price and Oneida are all listed as 4. Any location residing in these counties are to be listed as 4 which is a relative humidity region over 60%. All other counties would be considered a 3, or 41-51% (Liberty Mutual, 2001).

Excessively high or low relative humidity can produce problems. High humidity can promote the growth of mold an mildew, whereas low humidity can accelerate the release of spores into the air (EPA, 2000). The optimum relative humidity is 30-50%, although anything below 60% is still within a safe range to deter microbial growth (Liberty Mutual 2001). The EPA sets forth recommendations for relative humidity and temperature ranges to control mold growth in figure 5 (EPA, 2000).

Figure 5. Recommended Ranges of Temperature and Relative Humidity

Relative Humidity	Winter Temperature	Summer Temperature
37%	68.5°F-75.5°F	74.0°F-80.0°F
40%	68.0°F-75.0°F	73.5°F-80.0°F
50%	68.5°F-74.5°F	73.0°F-79.0°F
60%	67.5°F-74.0°F	73.0°F-78.5°F

Along with knowledge of the relative humidity, condensation control is critical. Liberty Mutual, (2001) recommends review of the following areas for condensation concerns:

1. Locally ventilate humid areas such as bathrooms, shower rooms, kitchens and laundries to the outside to reduce moisture levels.
2. Dehumidify indoor air by operating the cooling coils in a HVAC system to remove moisture from outdoor or return air.
3. In cold climates, insure appropriate insulation, air barriers and vapor barriers are properly installed on the warm side of the building.
4. In warm climates, insure appropriate insulation, air barriers and vapor barriers are properly installed the external portion of the building.
5. Avoid impermeable wall coverings, use permeable paints and coverings on interior walls.
6. Operate the HVAC system at a slight positive pressure with respect to outdoors and avoid excessive cooling.
7. Provide positive air pressure Inside buildings in high humidity climates to avoid moist air pulled into the wall cavity.

HVAC Systems

As controlling moisture is key, HVAC systems are critical components. When working properly, they can decrease the amount of uncontrolled moisture that is allowed to enter occupied spaces (Turpin, 2001). A properly designed and functioning HVAC system should control temperature and

relative humidity, distribute adequate amounts of outdoor air to meet ventilation needs and isolate and remove odors and contaminants through filtration and exhaust fans. On the other hand, if mold has been allowed to grow and release spores into the classroom air, the HVAC systems acts as a pathway to disperse the spores to other part of the school (EPA, 2002).

The HVAC system includes all heating, cooling, and ventilation equipment serving a school: boilers or furnaces, chillers, cooling towers, air handling units, exhaust fans, ductwork and filters. To decrease the risk of the HVAC system becoming a driving force in moving pollutants along, proper maintenance is the best approach. In that regard, Liberty Mutual, (2001) recommends the following checkpoints:

1. Properly install and maintain air filters of the highest grade compatible with the system. Never run the system without filters in place.
2. Protect air filters from wetting and replace them periodically.
3. Avoid the use of porous materials inside the ductwork, especially in persistent wet areas of the HVAC system. Surfaces within 15 feet of moisture producing equipment such as cooling coils should be smooth and non-absorbent.

4. Closed cell foams with protective non-porous coatings are more easily cleaned and limit fungal growth compared to porous fiberglass interior duct lining.
5. Design cooling coils for minimum carryover of water droplets.
6. Slope drain pans to drain completely.
7. Physically remove growth in drain pans. Clean and sanitize drain pans and cooling coils. In humid climates, these components should be inspected at least monthly.
8. Avoid water spray humidifiers and discourage the use of console humidifiers because these units require frequent maintenance and cleaning to prevent microbial growth.
9. Provide easy access for maintenance and inspection of the HVAC system, especially at coils, filters, dampers, and baffles.
10. Avoid supply duct leaks and supply/exhaust imbalances that bring warm wet air onto cold surfaces.

Before the building is commissioned, test all mechanical systems for operation and for their contribution to building moisture content. It should be noted that most mechanical equipment is designed to operate at some optimum level. When used at levels below or above this optimum level, more moisture or heat may be a byproduct. Oversize cooling coils

may not operate as efficiently, leading to more moisture removed than the condensate pan and drain can handle (Liberty Mutual, 2001).

Strategies for Assessment

Although mold prevention is preferred, if mold growth is suspected, the area should be assessed. Although no standards exist assessment can assist in diagnosing to what extent and type of mold growth is evident. Most the time a visual inspection will suffice, however bulk surface sampling can be utilized if there is a need to determine the particular type of mold. Air sampling can also be utilized for areas not reachable in a visual inspection or bulk/surface sampling, or to determine the concentration of mold spores in comparison to air with no mold contamination (New York, 2001).

Visual Inspection

A visual inspection is the first step in identifying a possible contamination problem. Investigators examine the physical structure including walls, floors, ceiling tiles, carpets, furnishings, material storage, spaces in ventilation ductwork, fan coil units, drain pans, air filters, supply air distribution, humidifiers, sump pumps, and wall cavities.

A moisture meter, can be used to detect building material moisture levels, and is helpful in detecting hidden sources of moisture as well as the extent of past water damage. Investigators search to identify potential sources

of biological agents, evidence of current or past water damage, excess moisture, and as needed, form plans for either more in-depth investigations or control and remediation of noted problems (New York, 2001).

Bulk/Surface Sampling

Bulk samples are portions of wallboard, pieces of duct lining, carpet segments, adhesive-tape lifts, etc. which are tested for the primary purpose of identifying the sources and biological agents that should be remediated.

Bulk samples should be taken from the visibly moldy areas and an equal number taken away from the visible contamination. Decisions can be made later whether to process these, but such samples provide objective data on the extent of contamination or need for remediation beyond that which is visible. Bulk samples are also used to evaluate the effectiveness of remediation efforts (New York, 2001).

A microscopic screen of a bulk or surface sample is a rapid analytical technique for confirming the presence and identity of fungi on a surface if a visual inspection is equivocal. The results are expressed as a percentage range of a fungi type relative to the prevalence and concentration on the sample (New York, 2001).

A trained and experienced individual should conduct the sampling. Bulk samples are normally collected by scraping or cutting material from a moldy surface with a clean tool and

deposited into a clean plastic bag. Surface samples are collected by wiping the contaminated area with a sterile swab or by stripping the contaminated area with clear tape. Use a laboratory accredited by the American Industrial Hygiene Association, Environmental Microbiology Laboratory Accreditation Program- EMLAP, to analyze the samples.

No current available concentration guidelines are generally accepted due to the large variability in surface sampling results and poor correlation with inhalation exposure. In general, remediation is suggested for microbial growth found on materials that are in direct contact with indoor air or subject to disturbances that might release biological particles into building areas (New York, 2001).

Air Monitoring

Air monitoring results can be useful if the presence of mold is suspected in hidden wall cavities or air handling ductwork but cannot be identified by a visual inspection or bulk sampling. Air sampling can also useful if there is evidence from a visual inspection or bulk sampling that there may be contamination and the inspector is trying to determine if there is an airborne pathway by which people can be exposed (New York, 2001).

Although air samples can provide information about a site as it existed during the time tested, the results may not represent conditions at a time in the past or future.

Changes in the kinds, concentrations, and proportions of biological agents in the air can be rapid. Air samples should only be conducted after the formation of a hypotheses about the potential sources of biological agents and the pathway by which people may be exposed to these sources. Even then, results from sampling may be inconclusive and occasionally misleading.

Many investigators collect air samples using both spore traps and agar impactors, sampling outdoor and indoor suspected problem and control locations. Individuals trained in sampling for microbial contaminants should conduct air sampling. A laboratory accredited by the American Industrial Hygiene Association, Environmental Microbiology Laboratory Accreditation Program- EMLAP, should be used to analyze the samples (New York, 2001).

Strategies for Remediation

Once the contamination area is identified, there are several levels of remediation, based on the size of the area impacted by fungal contamination. The objective of remediation is to remove or clean contaminated materials in a way that prevents fungal contamination from leaving the contaminated area and entering a clean area (EPA, 2000).

The following general remediation specifications are recommended for all remediation: (Liberty Mutual, 2001)

- Non-porous (e.g., glass, metals, etc.) and semi-porous (e.g., wood, concrete, etc.) materials that are structurally sound and moldy can be cleaned and reused.
- Cleaning of all mold contaminated surfaces should be done with a detergent solution.
- Ceiling tiles, insulation, wallboard, and other porous materials with more than a small area of contamination should be removed and discarded. There are no special requirements for disposal of mold contaminated materials, however it is recommended to seal the debris before disposal as best as possible.
- Assistance from a professional restoration consultant should be used when restoring porous materials with more than a small area of contamination.
- Materials to be reused should be dry and free from all visible mold.
- The abatement area should be unoccupied and "high risk" persons (i.e. infants, persons recovering from recent surgery, immune-suppressed individuals, or individuals with chronic inflammatory lung disease) should be vacated from adjacent areas inflammatory lung disease) should be vacated from adjacent areas.

In addition to these general guidelines the New York City Department of Health, Bureau of Environmental & Occupational Disease Epidemiology (2001), has set more

descriptive guidelines on remediation of fungi in Indoor Environments:

Level I: Small Isolated Areas

This level includes small isolated areas of 10 ft^2 (3 m^2) or less (e.g., ceiling tiles, small areas on walls, etc.).

Remediation specifications include the following factors:

- Regular building maintenance personnel trained on clean up methods, personal protection, and health hazards can conduct the remediation.
- Personal protective equipment (PPE) including respirators (e.g., N95 disposable respirators), gloves, and eye protection should be worn.
- Although containment of the abatement area is not necessary, dust suppression methods, such as misting mold contaminated surfaces before remediation, are recommended.
- Mold contaminated materials that cannot be cleaned should be removed in a sealed plastic bag. There are no special requirements for disposal of mold contaminated materials.
- The abatement area and other areas used by remedial workers should be cleaned with a damp cloth and/or mop and a detergent solution.

- All areas should be left dry and free from mold contamination and debris.

Level II: Mid-Sized Isolated Areas

This level includes mid-sized isolated areas of 10-30 ft^2 (3-10 m^2) (e.g., individual wallboard panels). Remediation specifications include the following factors:

- Regular building maintenance personnel trained on clean up methods, personal protection, and health hazards can conduct the remediation.
- PPE including respirators (e.g., N95 disposable respirators), gloves, and eye protection should be worn.
- The abatement area should be covered with plastic sheet(s) and sealed with tape before remediation.
- Recommend dust suppression methods, such as misting mold contaminated surfaces before remediation.
- Mold contaminated materials that cannot be cleaned should be removed in a sealed plastic bag. There are no special requirements for disposal of mold contaminated materials.
- The abatement area and other areas used by remedial workers should be HEPA (High Efficiency Particulate Air Filter) vacuumed and cleaned with a damp cloth and/or mop and a detergent solution.

- Leave all areas dry and free from mold contamination and debris.

Level III: Large Isolated Areas

This level includes large isolated areas of 30-100 ft^2 (10-30 m^2) (e.g., several wallboard panels). Remediation specifications include the following factors:

- Project management should be provided by a safety and health professional with experience performing microbial investigations.
- Personnel trained in the handling of hazardous materials should conduct decontamination.
- PPE including respirators (e.g., N95 disposable respirators), gloves, and eye protection should be worn.
- The abatement area should be covered with plastic sheet(s) and sealed with tape before remediation.
- Recommend dust suppression methods, such as misting mold contaminated surfaces before remediation.
- Mold contaminated materials that cannot be cleaned should be removed in a sealed plastic bag. There are no special requirements for disposal of mold contaminated materials.
- The abatement area and other areas used by remedial workers should be HEPA vacuumed and

cleaned with a damp cloth and/or mop and a detergent solution.

- Leave all areas dry and free from mold contamination and debris.

Level IV remediation procedures should be followed if the abatement procedures are expected to generate a large accumulation of dust or the visible concentration of fungi is heavy.

Level IV: Extensive Contamination

This level includes extensive contamination greater than 100 contiguous ft^2 (30.48 m^2) in any area. Remediation specifications include the following factors:

- Decontamination should be conducted by personnel trained in hazardous material handling. They should be equipped with full-face respirators with high efficiency particulate air (HEPA) cartridges, disposable protective clothing from head to toe, and gloves.
- The abatement area should be provided with containment including:
    - Thorough isolation of the abatement area (including all openings, such as ventilation ducts/grills, etc.) from occupied spaces with plastic sheeting sealed with duct tape.

    - Establish a negative pressure via the use of an exhaust fan with a HEPA filter.
    - Airlocks and decontamination room.
- Vacating people from spaces adjacent to the abatement area is unnecessary but is recommended for "high risk persons" (i.e. infants, persons recovering from recent surgery, immunesuppressed individuals, or individuals with chronic inflammatory lung disease).
- Mold contaminated materials that cannot be cleaned should be removed in a sealed plastic bag. The outside of the bag should be cleaned with a cloth and a detergent solution or HEPA vacuumed in the decontamination chamber before transport to uncontaminated areas of the building. There are no special requirements for the disposal of mold contaminated materials.
- The containment area and decontamination chamber should be HEPA vacuumed and cleaned with a damp cloth and/or mop with a detergent solution before removal of the isolation barriers.
- Air monitoring for mold concentrations should be conducted before occupancy to ensure the area is safe to reoccupy.

Level V: Remediation of HVAC Systems

Small Isolated Area of Contamination Less Than 10 ft^2 (3 m^2) in an HVAC System:

Remediation specifications include the following factors:

- Regular building maintenance personnel trained on clean up methods, personal protection, and health hazards can conduct the remediation.
- PPE including respirators (e.g., N95 disposable respirators), gloves, and eye protection should be worn.
- Shut down the HVAC system before proceeding with remedial activities.
- The abatement area should be covered with plastic sheet(s) and sealed with duct tape before remediation.
- Dust suppression methods, such as misting mold contaminated surfaces before remediation, are recommended.
- Leave all areas dry and free from mold contamination and debris.
- The abatement area and other areas used by remedial workers should be HEPA vacuumed and cleaned with a damp cloth and/or mop and a detergent solution.
- HVAC manufacturer's recommended biocides should be used for cleaning of HVAC components, such as cooling coils, condensation pans, etc.

Areas of Contamination Greater Than 10 ft^2 (3m^2) in the HVAC System

Remediation specifications include the following factors:

- Project management should be provided by a safety and health professional with experience performing microbial investigations.
- Decontamination should be conducted by personnel trained in the hazardous materials handling. They should be equipped with:
  - Respiratory protection (e.g., N95 disposable respirators).
  - Gloves and eye protection.
  - If contamination is greater than 30 ft^2 (10 m^2), full-face respirators with HEPA cartridges and disposable protective clothing from head to toe should be worn.
- Shut down the HVAC system before proceeding with remedial activities.
- The abatement area should be provided with containment including:
  - Thorough isolation of the abatement area from others areas of the HVAC system with plastic sheeting sealed with duct tape.

    - Establish a negative pressure via the use of an exhaust fan with a HEPA filter.
    - Airlocks and decontamination room if contamination is greater than 30 ft^2 (10 m^2).
- Remove contaminated growth supporting materials, such as paper on the interior lined ducts and filters. Other contaminated materials that cannot be cleaned should be removed in sealed plastic bags. When a decontamination chamber is present, the outside of the bags should be cleaned with a damp cloth and a detergent solution or HEPA vacuumed before their transport to uncontaminated areas of the building. There are no special requirements for disposal of mold contaminated materials.
- The contained area and decontamination room should be HEPA vacuumed and cleaned with a damp cloth and/or mop and a detergent solution before removal of the isolation barriers.
- Leave all areas dry and free from mold contamination and debris.
- HVAC manufacturer's recommended biocides should be used for cleaning of HVAC components, such as cooling coils, condensation pans, etc.
- Air monitoring should be conducted before re-occupancy with the HVAC system in operation.

EPA Guideline Grid

The EPA, (2001) presents similar guidelines based on contaminated areas in figure 6, but breaks down the actions by material type affected:

Figure 6. Guidelines for Remediating Building Materials with Mold Growth

(Small-Total Surface Area Affected Less that 10 square feet)

Damaged Material	Method/PPE/Containment
Books and papers	• Method: High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Carpet and backing -	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Concrete block	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Hard surface, porous flooring (Linoleum, ceramic tile, vinyl)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Non-porous, hard surfaces(Plastics, metals)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.

Upholstered furniture	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles. • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Wallboard (Drywall and gypsum board)	• High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Wood surfaces	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles . • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.

Medium-Total Surface Area Affected Between 10 & 100(ft2)

Books and papers	• Method: High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional judgement. Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.
Carpet and backing-	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.
Concrete block	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.

Hard surface, porous flooring (Linoleum, ceramic tile, vinyl)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.
Non-porous, hard surfaces (Plastics, metals)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.
Upholstered furniture	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry &covering flap; maintain are under negative pressure with HEPA filtered fan unit Block supply & return air vents.
Wallboard (Drywall and gypsum board)	• High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents.
Wood surfaces	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.

Large-Total Surface Area Affected Greater Than 100 (ft2)or Potential for Increased Occupant Exposure During Remediation

Books and papers	• Method: High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.
Carpet and backing	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.
Concrete block	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.
Hard surface, porous flooring (Linoleum, ceramic tile, vinyl)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.
Non-porous, hard surfaces (Plastics, metals)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply / return air vents within contaminated area.

Upholstered furniture	• Method: Wet vacuum or steam cleaning and damp wipe surfaces with plain water or detergent solution. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply / return air vents within contaminated area.
Wallboard (Drywall and gypsum board)	• High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply / return air vents within contaminated area.
Wood surfaces	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.

Summary

Mold can be found almost anywhere and can grow on any organic substance as long as moisture and oxygen are present. The health of individuals can be compromised when mold spores or fragments of spores become airborne and are inhaled or skin contact made. Although allergic reactions involving the sinuses or asthma are the most common, some individuals react with severe infections that have proven toxic. Certain types of mold can also produce toxins and volatile organic compounds (VOC's) that can add to overall poor indoor air quality.

For scientists part of the challenge is figuring out why mold exposure seems to make some people severely sick while others only experience mild symptoms. There is little medical data on low exposures to mold spores and no standard operating procedures for mold spore collection or analysis.

There has been much investigation however into the sources of mold, and thus prevention. In commercial buildings it can began in building design and construction or occur as a result of flooding or water leaks. In addition high humidify and uncontrolled temperature and condensation as well as poorly maintained HVAC systems are often players in the foundation that supports mold growth.

Once mold growth is suspected, the area should be assessed by means of a visual inspection, bulk/surface sampling and/or air monitoring. This helps to isolate the type of mold growth and the concentrations within a given area.

Once mold growth is isolated, remediation is specified by its size, from small isolated area 10 square feet or less to extensive contamination in excess of 100 contiguous square feet. Remedation specifications are also outlined for mold growth when found in isolated areas of the HVAC systems under an over 10 square feet.

Bottom line is various quick fixes do not usually eradicate the root causes. The best advice is to put forth the necessary resources for mold prevention.

CHAPTER 3

Methodology

Introduction

The purpose of this study was to provide a comprehensive strategy to resolve problems related to microbial growth in typical Wisconsin school buildings. The objectives were to provide a prevention checklist to deter microbial growth in typical Wisconsin school buildings, provide guidelines for remediation of existing mold contamination and provide framework for management support and accountability for success of a mold prevention and remediation program.

The methods and procedures used to analyze the unique problems associated with mold within typical Wisconsin school buildings are explained under the headings of a) review of literature, b) data collection techniques, and c) method analysis.

Literature Review

Chapter two documents this study's review of literature as it relates to mold in general buildings. To secure specific data on mold within schools, historical case studies were reviewed to determine the causes and concerns in individual settings. Studies were found in newspapers, periodicals, journals, and school publications. The focus on information gathered was to determine common trends of mold

sources unique to school buildings, prevention activities, maintenance procedures and remediation strategies in place.

Data Collection Techniques

In addition to the review of past case studies, 50 school districts were randomly selected for purposes of a mold evaluation. All participating schools were policyholders of Liberty Mutual Insurance Companies and agreed to the inspection as part of the loss control services program. The schools were equally distributed within the five regions within Wisconsin, southeast, central, southwest, northwest and northeast.

Each school district participated in a building tour led by either the Building and Grounds Supervisor or the Principle. The tour included observations in classrooms, hallways, cafeterias, locker rooms, kitchens and furnace rooms for visual microbial growth and/or water intrusion. In addition, a history of the building was secured on the topics noted below:

- Building age
- Number of students & employees
- Floor plan style/level of compartimentation
- Wall construction
- Roof/floor construction
- Relative humidity region

- History of water damage & remediation techniques,
- History of mold growth
- History of occupants reporting of health problems,
- Interior finish susceptible to water damage
- Indoor water vapor sources
- Outdoor water sources
- Site drainage
- Frequency of HVAC/condensation pan inspections

Method of Analysis and Summary

At the conclusion of the case study reviews and mold susceptibility survey/tours the top five mold sources were identified within a typical Wisconsin school. These findings set the foundation in which to build a comprehensive prevention program for mold identification, prompt elimination and remediation.

CHAPTER 4

Results and Discussion

Introduction

The case study review and mold susceptibility surveys revealed a number of issues regarding mold prevention and remediation.

- Of the 50 schools sampled, most were over 50 yrs old.
- Of the 50 schools sampled, most buildings housed over 300 students and faculty.
- Of the 50 schools sampled all buildings were highly compartmentalized, with interior finishes susceptible to water damage.
- Of the 50 schools sampled, all buildings had some type of indoor water vapor sources such as kitchens and locker rooms.
- Of the 50 buildings sampled, none monitored relative humidity.
- Of the 50 buildings sampled, most had some history of water intrusion.
- Of the 50 buildings sampled, most building's HVAC systems were inspected on a annual basis only.
- of the 50 buildings sampled, most were aware of mold findings that have caused illnesses or building to be closed.

- Of the 50 buildings sampled, most did not have a specific mold prevention or remediation program in place.
- Of the 50 buildings sampled, none had a mold coordinator, or an individual knowledge in current mold issues.

Based on these findings it is clear that despite the high susceptibility to mold contamination, specific mold prevention and remeditaiton programs are lacking. In an effort to tailor a comprehensive program, the top five leading sources of mold within the typical Wisconsin School were identified in figure 7:

Figure 7. Top Five Mold Sources in Wisconsin Schools

1. Water intrusion due to roof leaks
2. Water intrusion due to pipe condensation and pipe breaks.
3. Water intrusion due to cracking foundation
4. Dirty ductwork in HVAC systems
5. Malfunctioning exhaust fans in areas with high relative humidity

Goal # 1

Goal # 1 was to provide a prevention checklist to deter microbial growth in typical Wisconsin school buildings. Figure 8 is proactive prevention checklist adapted from the ACGIH Bioaerosol's Assessment and Control (Macher, 1999), to be used to identify possible mold sources. The checklist was modified to include sources of mold unique to schools as determined by the literature review, case studies and school tours. Figure 9 was developed as a follow up form for any positive responses indicated upon completion of the prevention checklist.

Figure 8. Monthly Mold Prevention Checklist

Date:	Inspector Name:	
Source	**What To Look For**	**Yes/No**
Roof	Small holes, sags, weather damage blocked rain gutters, animal infestation	YES NO
Site Drainage	Proper water drainage, erosion, blocked storm sewers	YES NO
Building Exterior	Water intrusion, sprinklers hitting building, crawl space obstructions	YES NO
HVAC Outdoor Intakes	Blockages due to debris, animal infestation	YES NO
Filters	Dampness, microbial growth, gaps between housing & filter	YES NO
Supply ductwork and diffusers	Blockages due to debris, animal infestation, microbial growth, rust	YES NO
Windows	Caulking failures	YES NO
Basements	Evidence of wicking thru walls/floors	YES NO
Plumbing	Evidence of condensation, wet insulation, leaks	YES NO
HVAC systems	Clean filters, Clean drain pans, cooling coils, dampers and baffles.	YES NO
Ceiling tiles	Stains & discoloration	YES NO
Carpet	Musty smell, dirt buildup, moisture	YES NO
Wall coverings	Musty smell, dirt buildup, moisture	YES NO
Kitchens, locker-room, laundries & pools	Humidity levels above 60%, malfunctioning exhaust fans	YES NO
Humidifiers/Air conditioners	Microbial growth in water reservoirs, leaks	YES NO

Figure 9. Follow up to Mold Inspection Checklist

Date: **Inspector:**
Area of Concern:
Detail of Problem:
Corrective Action:
Anticipated Cost:
Anticipated Completion Date:
Person Accountable:
Actual Completion Date:
Follow up Inspection Date:
Follow up Inspection Findings:

Goal #2

Goal #2 was to provide guidelines for remediation of existing mold and contamination. Figure 10, suggests recommendation for water damage cleanup if caught within 24-48 hours (EPA, 2001):

Figure 10. Guidelines for Response to Water Damage within 24-48 Hours to Prevent Mold Growth

Damaged Material	Actions
Books and papers	• For non-valuable items, discard books and papers. • Photocopy valuable/important items, discard originals. • Freeze (in frost-free freezer or meat locker) or freeze-dry.
Carpet and backing -	• Remove water with water extraction vacuum. • Reduce ambient humidity levels with dehumidifier. • Accelerate drying process with fans.
Ceiling tiles	• Discard and replace.
Cellulose insulation	• Discard and replace.
Concrete block	• Remove water with water extraction vacuum. • Accelerate drying process with dehumidifiers, fans, and/or heaters.
Fiberglass insulation	• Discard and replace.
Hard surface, porous flooring (Linoleum, ceramic tile, vinyl)	• Vacuum or damp wipe with water and mild detergent and allow to dry; scrub if necessary. • Check to make sure underflooring is dry; dry underflooring if necessary.
Non-porous, hard surfaces(Plastics, metals)	• Vacuum or damp wipe with water and mild detergent and allow to dry; scrub if necessary.
Upholstered furniture	• Remove water with water extraction vacuum. • Accelerate drying process with dehumidifiers, fans, and/or heaters.
Wallboard (Drywall and gypsum board)	• May be dried in place if there is no obvious swelling and the seams are intact. If not, remove, discard, and replace. • Ventilate the wall cavity, if possible.
Window drapes	• Follow laundering or cleaning instructions recommended by the manufacturer.
Wood surfaces	• Remove moisture immediately and use dehumidifiers, gentle heat, and fans for drying. (Use caution when applying heat to hardwood floors.) • Treated or finished wood surfaces may be cleaned with mild detergent and clean water and allowed to dry. • Wet paneling should be pried away from wall for drying.

If water damage was not caught within 24-48 hours or mold contamination is found, the suspected area should be assessed by means of a visual inspection, bulk/surface sampling or air monitoring, depending on its location and accessibility. Remediation of the suspected area should follow based on the size of the area affected. The EPA (2001) remediation recommendations as noted in figure 11 were preferred as they were easier to follow than those previously reviewed by the New York City Department of Health, Environment and Occupational Disease.

Figure 11. Guidelines for Remediating Building Materials with Mold Growth

(Small-Total Surface Area Affected Less that 10 square feet)

Damaged Material	Method/PPE/Containment
Books and papers	• Method: High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Carpet and backing -	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Concrete block	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.

Hard surface, porous flooring (Linoleum, ceramic tile, vinyl)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Non-porous, hard surfaces(Plastics, metals)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Upholstered furniture	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles. • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Wallboard (Drywall and gypsum board)	• High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.
Wood surfaces	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: N-95 respirator, gloves and goggles . • Containment: None required but recommended to dispose of contents of the HEPA vacuum in well-sealed plastic bags.

Medium-Total Surface Area Affected Between 10 & 100(ft2)

Books and papers	• Method: High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional Judgement. Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.
Carpet and backing-	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply/return air vents within contaminated area.

Concrete block	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.
Hard surface, porous flooring (Linoleum, ceramic tile, vinyl)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.
Non-porous, hard surfaces (Plastics, metals)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.
Upholstered furniture	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry &covering flap; maintain are under negative pressure with HEPA filtered fan unit Block supply & return air vents.
Wallboard (Drywall and gypsum board)	• High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents.

Wood surfaces	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Limited or full depending on professional judgement .Limited = gloves N-95 respirator or half face respirator with HEPA filter, disposable overalls, goggles/eye protection. Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use polyethylene sheeting ceiling to floor around affected area with slit entry and covering flap; maintain are under negative pressure with HEPA filtered fan unit. Block supply and return air vents within contaminated area.

Large-Total Surface Area Affected Greater Than 100 (ft2) or Potential for Increased Occupant Exposure During Remediation

Books and papers	• Method: High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.
Carpet and backing	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.
Concrete block	• Method: Wet vacuum or steam cleaning and High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.
Hard surface, porous flooring (Linoleum, ceramic tile, vinyl)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.

Non-porous, hard surfaces (Plastics, metals)	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply / return air vents within contaminated area.
Upholstered furniture	• Method: Wet vacuum or steam cleaning and damp wipe surfaces with plain water or detergent solution. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply / return air vents within contaminated area.
Wallboard (Drywall and gypsum board)	• High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply / return air vents within contaminated area.
Wood surfaces	• Method: Wet vacuum or steam cleaning. Damp wipe surfaces with plain water or detergent solution High -efficiency articulate air (HEPA) vacuum after the material has been thoroughly dried. Discard water damaged materials and seal in plastic bags while inside containment area. • PPE: Full = gloves, disposable full body clothing, head gear, foot coverings, full face respirator with HEPA filter. • Containment: Use two layers of fire retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA filtered exhausted fan unit outside of building. Block supply and return air vents within contaminated area.

Goal #3

Goal # 3 was to provide a framework for management support and accountability for success of a prevention and remediation program. The 8 step approach noted in figure 12 was adapted and modified from the EPA Tools For Schools, (2000):

Figure 12 Management Framework for Mold Prevention and Remediation Program

1. Secure top administrative support
2. Appoint a mold coordinator
3. Train mold quality coordinator
4. Perform monthly inspections with mold checklist
5. Recommend repairs with cost estimates, completion dates and accountability
6. Gain consensus and approval
7. Conduct follow-up inspections
8. Communicate results

Summary

The case study review and mold susceptibility surveys showed a discrepancy between the high mold susceptibility in Wisconsin schools and a prevention and remeditaion programs in place to address them. In an effort to tailor a comprehensive program the five top leading sources of mold were identified as roof leaks, pipe leaks and pipe condensation, cracking foundations, dirty HVAC systems, and malfunctioning exhaust fans.

With this in mind a comprehensive program was established with checklist for early mold identification and prevention follow-up procedures. In addition to prevention, checklist were provided for remediation including early water intrusion guidelines and remediation for actual mold growth found on building materials.

Finally, a framework for management support and accountability for success of a prevention and remediation program was set forth including securing top administrative support, appointing a mold coordinator, training the mold coordinator and job duties of the mold coordinator.

CHAPTER 5:

Summary, Conclusions and Recommendations

Summary

Every day, students and teachers are exposed to mold in schools that can affect their overall health. Many school districts already overwhelmed by budgetary constraints, lack the proper resources in order to take corrective steps. Although there are no state or federal government standards in place, the simplest solution to prevent mold contamination is through proper building maintenance, prompt repair of water damaged areas and remediation of contaminated materials.

Restatement of the Problem

In a nation of aging schools, many students are warehoused in dank facilities at a time when districts cannot afford renovations, much less new buildings. Although general indoor air quality programs exist, specific mold prevention programs are needed for early identification, prompt elimination and remediation. The purpose of the study was to provide a comprehensive strategy to resolve problems related to microbial growth in typical Wisconsin school buildings.

Methods and Procedures

To secure specific data on mold within schools, historical case studies were reviewed to determine the causes and concerns in individual settings. The focus on information gathered was to determine common trends of mold sources unique to school buildings, prevention activities, maintenance procedures and remediation results.

In addition to the review of past case studies, 50 school districts were randomly selected for purposes of a mold evaluation. Each school district participated in a building tour led by either the Building and Grounds Supervisor or the Principle. The tour included observations in classrooms, hallways, cafeterias, locker rooms, kitchens and furnace rooms for visual microbial growth and/or water intrusion and a history of maintenance procedures.

Major Findings

The major findings of the study were as follows:

1. The top five mold sources within a typical Wisconsin school were:
    - water intrusion due to roof leaks
    - water intrusion due to pipe condensation and pipe breaks
    - water intrusion due to cracking foundation
    - dirty ductwork in HVAC systems

- malfunctioning exhaust fans in areas with high relative humidity

2. Despite the high susceptibility to mold contamination in Wisconsin schools specific mold prevention and remediation programs were lacking.
3. Although many general indoor air quality programs exist, they are often too lengthy and technical to be put in use without the assistance of a consultant.

Conclusions

The major conclusions of the study are as follows:

1. There was evidence of mold contamination in Wisconsin schools that could cause injuries and illnesses.
2. There was a need to "repackage" present IAQ programs to focus on specially on mold and therefore provide a useable tool for practical use.
3. There is a need for structure and accountability for a successful mold prevention and remediation program.

Recommendations Related to This Study

The recommendations of the study are as follows:

1. With knowledge of the leading five causes of mold in a typical school, it is recommended that schools utilize the monthly mold prevention checklist for early identification and prompt elimination. It is recommended that:

- The checklist be completed by the same individual who could make month to month comparisons and spot potential areas of concern.
- If areas of concern are noted it is recommended the follow up checklist be utilized to ensure the problem is identified.
- Document the corrective action outlined, and note person held accountable
- Once corrective action is taken it is recommended the area be re-inspected to ensure the corrective action was successful.

2. If water damage occurs or actual mold contamination is found, it is recommended that:
    - The water intrusion guidelines be followed if caught within 24-48 hours.
    - The mold contamination remediation guidelines be followed if found beyond 48 hours.
    - No shortcuts to these procedures are acceptable as they allow for the potential of mold to continue to grow and dissipate throughout the building.

- Once the forms are introduced to a given school, it is recommended they are customized to the individual building's construction or problematic areas.

3. Mold management within schools will not just happen, it requires leadership. To provide the management support and accountability for a successful prevention and remediation program it is recommended that:
    - Leadership begins with support from the highest levels of administration with the authority to ensure that the school staff has the proper resources to carry out the proposed corrections.
    - It is recommended that a mold coordinator be appointed. In larger school districts, the coordinator may be at the district level, such as a health and safety officer, or the facilities manager. In smaller school systems the mold coordinator may be the principal or the building and grounds supervisor.
    - Once the mold coordinator position is appointed, he or she must be trained. If no formal classes are available, a thorough literature review is recommended.

- A designated mold coordinator should be enabled to make decisions about what materials to bring into the school, how those materials are used, how the school building and ventilation systems are operated, how they are maintained, and how to respond to problems.
- It is recommended the coordinator automatically receives notice of all complaints or claims involving mold exposure.
- Good communication is critical. Administration and school boards should include the coordinator in the monthly meeting agenda for updates, concerns and communication of successes of the program.

References

Ammann, H. (2002, Janaury/February). Indoor Mold Contamination - A Threat to Health? *Journal of Environmental Health.*

American City and Country, (2002, February). Toxic Molds Can Create Liability Problems. *American City and Country 117, 3.*

ASHRE. (1989). Ventilation for Acceptable Indoor Air Quality. *American Society of Heating, Refrigeration, and Air Conditioning Engineers, Standard 62-1989*

Anderson, J. (1997 September). Reactions to Carpet Emissions: A Case Series. *Journal of Nutritional & Environmental Medicine 7 .*

Baillieu, A (1995, April). Sick Buildings Get Clean Bill of Health. *The Guardian 8-9 .*

Baldwin, C. Bell, I. (1998, October). Increased Cardiopulmonary Disease Risk In A Community Based Sample With Chemical Odor Intolerance: Implications For Women's Health and Health Care Utilization. *Archives of Environmental Health 53, 347.*

Bayer, C (1996, January). Molds, Fungi, Cause Sick Building Syndrome. *Occupational Health and Safety, 65, 1.*

Boykin, J. Sauer, R. (1996, April). Sick Building Syndrome and the Modern Office Building. *Real Estate Issues 21, 21-27.*

Brown, K. (1996, October). Sick Days at Work. *Environmental Health Prospectives 104, 10.*

Brown, R. (1998, February). A Plague on our Houses. *Buildings 92, 22.*

Cahill, S. (2001, December). For Some Lawyers, Mold is Gold. *ABA Journal 87, 12.*

CDC, (2000, December). Aspergillosis Technical Information. *Center for Disease Control Division of Bacterial and Mycotic Disease.*

CDC, (2002 March). Molds in the Environment. *Center for Disease Control Division of Bacterial and Mycotic Disease.*

Checket-Hanks, B. (2001, December). Allergies, Asthma, and the Role of the HVAC. *Air Conditioning Heating and Refrigeration News.*

Chih-Shan L. Hsu, C. (1997, June). Indoor Pollution and Sick Building Syndrome Symptoms Among Workers In Day Care Centers. *Archives of Environmental Health 52, 200-208.*

Cole, D. Frank, J. (1996, September). Research Responses to Outbreaks of Concern About Local Environments. *Archives of Environmental Health 51, 352.*

Daley, B (1997 June). School Air: A Failing Grade; Poor Quality Results in Illness. *Boston Globe, 07431791.*

Davidson, J. and Mulvill, K. (1999, May). Sick Schools. *Good Housekeeping 228, 5.*

Egan, M. (2002). The Fungus That Ate Sacramento. *Forbes 169, 2.*

EPA (1989). Radon Measurements in Schools: An interim Report. *Environmental Protection Agency, 315876.*

EPA (2000, August). Indoor Air Quality Tools for Schools. *Environmental Protection Agency.*

EPA (2001, April). Mold Remediation in Schools and Commercial Buildings. *Environmental Protection Agency.*

EPA (2002, February). Indoor Air Pollution: An Introduction for Health Professional. *Environmental Protection Agency.*

Ferraro, S. (1997 August). Indoor Ills Mysterious ' Sick Building Syndrome' Continues to Fell Some Office Workers. *Chicago Tribune 10856706.*

Flannery, W, (1997, September). Lab's Mission is to Treat Air in Sick Buildings. *St. Louis Post 8734.*

Fogel, J. and Lloyd, J. (2000). Mold Performance of Some Construction Products With and Without Borates. *Forest Products Journal 52, 2.*

Fox, R. Shires, D. (1996, December). Environmentally Induced Dysfunction: The Camp Hill Medical Center Experience. *Journal of Nutritional & Environmental Medicine 6, 351-358.*

Frazer, T. (1998, April). RM's Can Curb Indoor-air Problems. *National Underwriter 102, 17.*

Gravesen, S. (1994). Descriptions of Some Common Fungi. *Microfungi 141.*

Greene, R. Williams, P. (1996 October) Indoor Air Quality Investigation Protocols *Journal Of Environmental Health 59, 6-9.*

Grubb, D. Diamantes, T. (1998, March, April). Is Your School Sick? Five Threats to Healthy Schools. *Clearing House 71, 4.*

Hasbach, A (1998). Is Your Workplace a Threat to Your Health? *Consulting-Specifying Engineer 08925040, 28-33.*

Hays, D. (2001, November). Mold Risks, Damages Hard to Quantify. *National Underwriter.*

Horswell, C. (1997, June). Sick Schools/Indoor Air Troubles/Variety of Pollutants Put Students at Risk. *Houston Chronicle, 2.*

Howe, P. (1998, February). Asbestos a Problem in Buildings of Era. *Boston*

Institute of Medicine, (1993). Indoor Allergens: Assessing and Controlling Adverse Health Effects. *Committee on Health Effects and Indoor Allergens.*

Johnson, D. (1998 July). A Cure for Sick Buildings? *The Futurist, 32, 12-13.*

Jones, T. Teeters, K. (1996, August). Sick Buildings and the Bottom Line. *Cornell Hotel and Restaurant Administration Quarterly 37, 4.*

Journal of Property Management (2002). States to Set Mold Standards. *Journal of Property Management.*

Katz, D. (1997, February). Indoor-air Peril Growing Ripe for Risk Assessment. *National Underwriter 101, 5.*

Lax, M. Grant, W. (1998, September). Recognizing Occupational Disease: Taking An Effective Occupational History. *American Family Physician 58, 935.*

Lexis-Nexis, (2002 February). Science May Be Lacking, But Mold Claims Keep Coming. *Alliance of American Insurers Mold Observer.*

Liberty Mutual, (2001). TB 39 and LP 6106W Fungi and Mold in Indoor Environments. *Liberty Mutual Research Center for Safety and Health Technical Bulletins.*

Macher, J. (1999). Bioaerosols: Assessment and Control. *ACGIH.*

Marshall, P. (1996, January). Addressing Indoor Air Quality Concerns. *Occupational Hazards 58, 1.*

McLean, C. (2001, December). Silent Scourge. *Report/News Magazine Alberta Edition 28,23.*

McMillian, L. (1995, April). Indoor Air Pollution Advise on SBS & VOC's. *Facilities Design and Management 14, 4.*

Menzies, D. Pasztor, J. (1997, October). Effects of a New Ventilation System on Health and Well-being of Office Workers. *Archives of Environmental Health 52, 360-368.*

Mikatavage, M. Rose, V. Funkhouse, E. Oestenstad, K. (1995, November). Beyond Air quality - Factors that Affect Prevalence Estimates of Sick Building. *American Industrial Hygiene 56, 11.*

Miller, L. (1998). Fungi and Fungal Products in Some Canadian Homes. *International Biodeterioration 24.*

Mills, D. (1998, January). SBS: Real or Phantom Risk? *Canadian Underwriter 65, 1.*

New York, (2001, August). Facts About Mold. *New York City Department of Health, Environmental and Occupational Disease Epidemiology.*

Odom, D. Barr, C. (1996, November). Emotions in the Air: When Sick Building Syndrome Strikes. *Risk Management 43, 11.*

Oliver, C. Shackleton, B. (1998, October). The Indoor Air We Breathe: A Public Health Problem of the 90's. *Public Health Reports 113, 398-412.*

OSHA, (2002) Occupational Safety and Health Administration U.S. Department of Labor. www.osha.gov.

Otto, D. and Molhave, L. (1989). Neurobehavioral and Sensory Effects of Controlled Exposure to a Complex Mixture of Volatile Organic Compounds. *Neurotoxicology and Teratology 12.*

Ouellette, J. (2001, September). Medical Conditions Associated with Indoor Air Quality (IAQ) Problems. *Wisconsin Council of Safety 10th Annual Autumn Safety and Health Conference/Exposition.*

Pape, W. (1998, June). Healthy, Wealthy, and Wise. *Goldhirsh Group Inc. 20, 9.*

Perera, E. (1997, October). Researchers Bring Fresh Air to Sick Buildings. *The Safety and Health Practitioner 15, 10.*

Pilkington, E. (1995, May). Work Till You Drop: Headache, Lethargy, Sore Throat: All Over the World, Office

Staff are Suffering From the Effects of Poor Working Environments. *The Guardian T.002.*

Public Health in North Carolina. (2001, August). Mold and Human Health. *North Carolina Department of Health and Human Services.*

Redford, G. (2002, January). Keeping Mold in Check at Home. *National Wildlife. 40, 1.*

Report/News Magazine. (2001, December). Microbiological Self-Defence. *Report/News magazine Alberta Edition 28, 23.*

Rylander, R. (1997, August). Airborne and Airway Disease in a Day Care Center Before and After Renovation. *Archives of Environmental Health 52, 281.*

Saunders, B. (1997, September). Office hours: The Low Down: Sick Building Syndrome. *The Guardian 139.*

Skaer, M. (2002, January). Questions, Fears Surround Toxic Mold Protection Act. *Air Conditioning, Heating and Refrigeration News. 215, 5.*

Spicer, C. (1997, March). IAQ's Economic and Productivity Issues. *Engineered Systems 14, 34.*

Strauss, S. (1996, February). New Software Helps Designers Cure Sick Buildings. *Chicago Tribune 5.C.*

Turpin, J. (2001, December) Interoperability Becomes a Bigger HVAC Issue. *Air Conditioning, Heating and Refrigeration News.*

Ziem, G. McTamney, J. (1997, March) Profile of Patients with Chemical Injury and Sensitivity *Environmental Health Prospectives Supplements 105, 417-420.*