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Review Article

GENERAL FUNGAL DIVERSITY IN THE INDOOR ENVIRONMENT

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ABSTRACT
Fungi (mold) are present almost everywhere. In an indoor environment hundreds of different kinds of mold are able to grow wherever there is moisture and an organic substrate (food source). They can grow on building and other materials, including: the paper on gypsum wallboard (drywall); ceiling tiles; wood products; paint; wallpaper; carpeting; some furnishings; books/papers; clothes; and other fabrics. Mold can also grow on moist, dirty surfaces such as concrete, fiberglass insulation, and ceramic tiles. It is neither possible nor warranted to eliminate the presence of all indoor fungal spores and fragments; however, mold growth indoors can and should be prevented and removed if present. Water accumulation in indoor environments can lead to mold growth (and other environmental problems), which has been associated with human health effects. Indoor mold growth can be prevented or minimized, however, by actively maintaining, inspecting, and correcting buildings for moisture problems and immediately drying and managing water-damaged materials. In the event that mold growth does occur, this guide is intended to assist those responsible for maintaining facilities in evaluating and correcting this problem.
Removing mold growth and correcting the underlying cause of water accumulation can help to reduce mold exposures and related health symptoms. Prompt remediation of mold-damaged materials and infrastructure repair should be the primary response to mold growth in buildings. The simplest, most expedient remediation that properly and safely removes mold growth from buildings should be used. Extensive mold growth poses more difficult problems that should be addressed on a case-by-case basis in consultation with an appropriate building or environmental health professional. In all situations, the source of water must be identified and corrected or the mold growth will recur. Effective communication with building occupants is an important component of all remedial efforts. Individuals who believe they have mold-related health problems should see their physicians. Individuals who may have an occupationally related illness should be referred to an occupational/environmental physician for evaluation, following any needed initial care. The presence of mold growth, water damage, or musty odors should be addressed quickly. In all instances, any sources of water must be identified and corrected and the extent of water damage and any mold growth determined. Water-damaged materials should be removed or cleaned and dried. For additional information on cleaning water-damaged materials and personal belongings, refer to the EPA document "Mold Remediation in Schools and Commercial Buildings".

INTRODUCTION
Moulds and fungi are found in nature and are necessary for the breakdown of leaves, wood and other plant debris. These micro-organisms can enter a building directly or by their spores being carried in by the air. In a home or building, moulds and fungi are usually found growing on wood, drywall (plaster/gypsum/Sheetrock(R)), upholstery, fabric, wallpaper, drapery, ceiling tiles, and carpeting. The key factor is moisture because moulds and fungi need it to grow. As a result, moulds and fungi are most often found in basements, kitchens and bathrooms. In modern buildings, moisture is present as the result of flooding, leaks in the roof or plumbing, sealed buildings that do not allow excess moisture to escape, sources such as cooking facilities, showers, etc., or excess humidity. Some of the more common types of mould found in buildings and homes include-Stachybotrys chartarum (also known as Stachybotrys atra) Aspergillus sp., Penicillium sp., Fusarium sp., Trichoderma sp., Memnoniella sp., Cladosporum sp., Alternaria sp. Various research works on indoor molds and toxigenic fungi has been carried out (Kuhn and Ghannoum, 2003).

The presence of mould does not always means that health problems will occur. However, for some people the inhalation of the mould, fragments of the moulds, or spores can lead to health problems or make certain health conditions worse. In addition, many of these moulds make "mycotoxins". Mycotoxins are metabolites or by-products from the moulds that have been identified as being toxic to humans. The chemistry of fungal toxins has been reviewed and assessed (Jelinek *et al.,* 1989). These toxins can slowly wear down the immune system and can lead to allergic or respiratory problems. In general, the most commonly reported symptoms include-runny nose or nasal congestion, eye irritation, cough or congestion, aggravation of asthma, fatigue, headaches, and difficulty concentrating. Moulds can also exacerbate (make worse) the symptoms of allergies including wheezing, chest tightness and shortness of breath as well as nasal congestion and eye irritation. People who are immuno-suppressed or recovering from surgery are usually more susceptible to health problems from moulds.

Methodology to Prevent Fungal Contamination

Moulds can grow almost everywhere and on any substance providing moisture is present. Thus, the best method of prevention is to reduce the amount of moisture. Keep the relative humidity between 30% and 50%. To accomplish this goal, prevention measures include-Vent showers and other moisture generating sources directly to the outside; Control humidity with air conditioners and/or dehumidifiers; Use exhaust fans when cooking, dishwashing, or laundering (especially in the food service or laundry areas) or when cleaning large areas; Insulate cold surfaces to prevent condensation on piping, windows, exterior walls, roofs and floors where possible; Keep the building and the heating, ventilation and air conditioning (HVAC) systems in good repair; Clean up any floods or spills immediately (within 24-48 hours). See below for more information on cleaning, etc.; for floors and carpets, remove spots or stains immediately. Reduce the amount of water used when cleaning carpets as much as possible; do not install carpet around fountains, sinks, bathtubs/showers or directly on top of concrete floors that are prone to leaks or frequent condensation. It is important to remember that when using air conditioners and dehumidifiers to keep them in good condition. Empty any water collectors regularly so this water does not contribute to the moisture problem! If you use humidifiers, ensure that they are cleaned regularly. Pasanen, (2001) performed assessment of fungi in indoor environments. This study has been utilized as a basis for removing fungal contamination and keeps the indoor environment sterilized.

A visual inspection is the most reliable method of identifying mould problems. The most common signs of water damage will be discoloration and staining. Moulds will most often appear as dark spots, stains or patches. If you find a suspicious spot, you can do a check to see if it is mould or fungi by dabbing the spot with a small amount of chlorine bleach. If the colour changes or disappears, the stain is "likely organic and probably mould". While conducting the inspection, be sure to look at, in, or under the following places-ceiling tiles ,walls including wallpaper, and condition of drywall (Sheetrock (R) [USG], gypsum wall board),floors, window sills ,insulation, carpet, furniture (condition of fabric, upholstery, etc.), if possible, look behind duct work and walls (a mirror will help) , condition of any cardboard or paper present

Also look for "standing water" - puddles of water around and under sinks, tubs, drip pans for dehumidifiers, air conditioners, and refrigerators that can be contributing to the moisture in the building and provide conditions where mould can grow. Surface sampling can be done by scraping or swiping suspected spots if needed for medical evaluation but this should be done by a trained professional. Air monitoring is also possible, but it is not considered routine. Monitoring devices are available which can measure the moisture level of drywall, wood, etc. These devices will help indicate whether or not moisture levels exists that would promote the growth of mould. The evaluation of three portable samplers for monitoring airborne fungi has been carried out which is important for fungal expulsion and removal from a particular area (Mehta *et al.,* 1996).

Methods of Sterilization and Disinfection

In general, once mould has been discovered, it is recommended that porous materials such as dry wall, ceiling tiles, fabric or carpet be thrown out and replaced rather than cleaned whenever possible. Non-

porous materials such as metal, glass, hard plastic and semi-porous materials such as wood and concrete can be cleaned and reused (if structurally sound).How to clean the mould depends of the size or extent of the damage.

For small areas (less than 30 square feet)

Use a disposable respirator as well as glove and eye protection. A high-efficiency particulate air filter (HEPA) respirator will provide a higher level of protection. It is not necessary to vacate the building, but persons who work close by or those who are immune-suppressed, those with chronic lung problems (such as asthma, allergies, etc) or those recovering from surgery may wish to work in a different section or area on those days (Cornet *et al.,* 1999). Dust suppression methods such as misting the surface lightly before cleaning is recommended. Clean the area with water and detergent. Area should be dry and free of any visible contamination when the work is completed.

For larger areas or areas of high contamination

While large remediation projects should be done by trained professionals, some good work practices include: Persons working in this situation have appropriate training in disposal and removal the biological contamination. Wear a high-efficiency particulate air filter (HEPA) respirator plus appropriate glove and eye protection. Wear disposable protective clothes such as coveralls, head cover and shoes. Isolate the area from the rest of the working space with plastic sheeting and by sealing ventilation ducts and other openings. Use an exhaust fan with a HEPA filter to create a negative pressure in the space. It is not necessary to vacate the building, but persons who work close by or those who are immune-suppressed, those with chronic lung problems (such as asthma, allergies, etc.) or those recovering from surgery may wish to work in a different section or area on those days. Discarded materials should be sealed in plastic bags for disposal. HEPA vacuum or wipe the sides of the bags before carrying outside of the sealed area. The contained area, as well as the entrance to it, should be HEPA vacuumed and cleaned with a detergent solution. Efficacy of prevention by high-efficiency particulate air filtration or laminar airflow against *aspergillus* airborne contamination during hospital renovation has been one of the great scientific researches carried out by Cornet *et al.,* (1999).

If the contamination is in the Heating, Ventilation and Air Conditioning (HVAC) system

Small amounts of contamination can be cleaned as above for small surface areas. Large scale contaminations should be handled by trained professionals. The HVAC system should be turned off during cleaning. All areas should be dried before the system is turned on again. Biocide products are available for various HVAC components such as condensation pans and cooling coils. Check with the manufacture for specifications and for handling instructions. The work area should be HEPA vacuumed and cleaned with a detergent solution.

Precautions during Disinfection

The use of chemical disinfectants such as chlorine for remedial purposes is not recommended. The use of chemical disinfectants can pose health concerns for people in occupied spaces of the building. Vacuuming may increase exposure to mould and spores by making them airborne. Central vacuums that exhaust to the outside, or those equipped with high-efficiency particulate air filters (HEPA) will minimize this exposure. No special requirements are necessary for the disposal of mouldy materials although it is recommended that the materials be sealed in plastic bags if possible**.** Khan *et al.,* (2001) recommended various precautions against biological and chemical terrorism due to fungi and bacteria directed at food and water supplies. This introduction of fungal contaminants in food and water is also due to air borne spores.

It is however not possible to completely remove fungi/molds from the air because the spores are continuously dispersed from time to time. However, seasonal variation in fungal species in the air can be seen due to sporulation period and dehiscence at a particular season for specific fungus e.g. *Aspergillus niger* spores are mostly isolated from the air during summer season whereas *Trichoderma spp* has its maximum sporulation in the winter months.

We can also find out that many soil borne fungi grow and reproduce in soil but after sporulation the spores disperse through wind and are hence scattered in various indoor and outdoor environments. Thus, along with air borne fungal flora, soil borne fungi can also be isolated from the air. The fungal spores being prevalent in all indoor places also create havoc in the hospitals. Fungal infections have recently emerged as a growing threat to human health, especially in people whose immune systems are compromised in some way as in cancer patients, diabetes patients etc. Clinicians are particularly concerned that the increasing use of antifungal drugs will lead to drug-resistant fungi, especially in settings such as hospitals where hospital-acquired infections are a growing problem. The two most prevalent fungal infections in hospitals are caused by *Candida* and *Aspergillus* species. The prevention of fungal infections in hospitals should be a priority but in practice few preventive measures are deployed. Diagnosis and treatment remain difficult at best. Invasive fungal infections are an increasingly important consideration in the medical care of critically ill patients and in patients with immunosuppressant. Relationship between environmental fungal contamination and the incidence of invasive aspergillosis in hematology patients in the hospital environment has been performed via research (Alberti *et al.*, 2009).

CONCLUSION

New methods may increase the rate and accuracy of the diagnosis of invasive fungal infections and the use of scoring systems that consider the risk factors for the development of invasive fungal infections may allow earlier therapy, a critical component of the successful treatment of these serious infections. A concern is the emergence of more resistant fungi; better selection of at risk patients for antifungal prophylaxis will reduce indiscriminate drug use and reduce the rate of fungal evolution. The FDA advised that a high index of suspicion should be maintained for invasive fungal infections in symptomatic patients. If possible, the decision to initiate empiric antifungal therapy should be made in conjunction with an infectious diseases specialist. An infectious disease consultation is also recommended when determining the duration of antifungal therapy and whether anti-TNF therapy should be resumed on recovery, particularly for patients who reside in regions of endemic mycoses. Voriconazole, an antifungal agent was compared with another antifungal compound Amphotericin B for carrying out Empirical Antifungal Therapy in hospital infected immunocompromised patients suffering from Neutropenia and Persistent Fever (Walsh *et al.*, 2002).

The increase in the frequency of fungal infections over the past decade is significant among human population due to high amount of indoor fungal spores which are not destroyed by sterilization facilities. This increase has particularly occurred among patients in hospitals, where the rate of fungal bloodstream infection has increased throughout the decade. This increased frequency of infection has been accompanied by significant excess mortality. The fact that the lack of hand washing by patient care providers in intensive care units has been linked to hand carriage of strains of various fungi. Also in other public places and homes hand washing and sanitization is ignored by people. Recent researches have however provided new and more effective strategies for the prophylaxis of endogenous infections and prevention of transmission in all the indoor environments viz. homes, buildings, public places and especially the hospital setting.

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