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Indoor Air Quality

Fungal Contamination Guidelines: Interpreting the Analysis

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Introduction

Micro-organisms such as fungi, bacteria, viruses and pollen, are natural and ubiquitous components of the outdoor and indoor environment. Fungi, often called "mould", or "mildew", originate on plants, leaves and in soil. Yeasts are also fungi. Over 100,000 species of fungi are known to exist and many have yet to be classified; most produce spores that are designed to be transported through the air.

Microbial evaluation of indoor air started in the late 1950s when secondary [nosocomial] infections of patients were reported. Later, an industrial case of exposure to airborne contaminated cutting fluids [Pontiac fever] and cases of exposure to contaminated cooling towers [legionellosis,1976] and humidifiers [humidifier fever] were documented. In Canada, microbial contamination affects approximately 20% of buildings with indoor air quality problems (8). The first measured case occurred in 1986.

Mould should not grow in indoor environments. However, spores will germinate anywhere where both moisture and nutrients exist. Therefore, strategies to prevent microbial growth must include the avoidance of wet surfaces, keeping relative humidity levels below 70%, effective filtration of particulates, proper HVAC system operation and maintenance, and good housekeeping.

Floods and leaks do occur in buildings and established procedures should be followed to avoid contamination. When areas do become contaminated, often the mould is not visible and odours may be absent. Release of spores can take place months after water has disappeared. Air sampling is undertaken in order to characterize the extent of the problem and to establish

a remediation plan.

Microbials can be measured by a variety of methods; bulk samples, surface samples using a swab or tape, and air-borne samples using a pump. The samples can be inspected microscopically or can be cultured on a nutrient medium, or agar. The identification and numeration of species should be done by an accredited laboratory. The Canadian federal protocol uses a Reuter centrifugal sampler [RCS], Rose-Bengal agar, and a 4-minute sampling time to measure viable air-borne microbials. A spore trap is used to assess non-viable quantities. Swab samples are taken to locate the source of contamination.

Interpretation of Results

There are no regulated exposure thresholds or standards for micro-organisms; several reasons for this will be examined in the following section. Using data collected since 1986 by PWGSC [over 3,000 samples in hundreds of buildings], the Federal-Provincial Advisory Committee on Environmental and Occupational Health in 1993 (1), and 1995 (1) (2), published interpretation guidelines for microbial measurements in building environments. Other cognizant authorities such as the World Health Organization, The American Industrial Hygiene Association [AIHA, 1996] (3), and the American Conference of Governmental Industrial Hygienists [ACGIH, 1999] (4), have referenced these Canadian guidelines.

The basic, common-sense approach to interpretation is as follows;

1. Microbial growth within a building is not acceptable. Moisture intrusion, visible mouldy, wet, or soiled surfaces must be remediated following an established protocol. Good HVAC system design, operation, and maintenance practices should follow current standards to avoid microbial amplification.
2. Fungal quantities, measured as colony-forming-units per cubic meter of air [CFU/m3], should be lower inside compared to outside, and the "mix" [biodiversity] should be similar. Quantities of normal outdoor [phylloplane] species greater than 500 CFU/m3 indoors, indicates poor filtration or housekeeping. Dominance indoors by species of mould that are not predominant outdoors indicates an interior amplification site. This must be located and rectified. If no contaminated site or moisture source is found, then "normal" remediation is recommended; all hard surfaces wiped with a cleaning solution, all fleecy surfaces vacuumed with a HEPA filtered unit. The area should be re-sampled in 3 months.
3. The confirmed presence of a toxigenic fungi [as defined in (5)], indicates that further investigation is necessary. Visual inspection, use of a moisture meter, and air/surface sampling is usually done to locate the source. If none is found, normal remediation is recommended, and the area should be re-sampled in 3 months.
4. Health Canada's protocol for mould recognition and management (2), follows the following phases; assess the magnitude of the health problems, identify problems in the building environment, identification of indoor fungal amplifiers, risk communication, and remedial action. All cases lead towards remediation. New York City guidelines (6) state, "Except in cases of widespread fungal contamination that are linked to illnesses

throughout a building, building-wide evacuation is not indicated".

[Similar guidelines apply to bacterial samples. Bird and bat droppings must be assumed to contain pathogenic fungi and must be removed under hazardous waste conditions.]

Fungal Exposure Regulations

There are no mandatory numerical limits for fungal exposure in any country. Several reasons for this are as follows;

- It is not possible to collect all bio-organisms using a single sampling method. The methods used to collect, culture and analyze samples vary greatly. For example, settle plates will collect only large microbials, and centrifugal samplers are also size selective and will miss the larger spores. Microbials may be culturable, nonculturable, and non-viable. Fungal and bacterial fragments can be allergenic. Different agars will support the growth of different fungal species, depending on the agar formulation and moisture availability. Incubation time and temperature also favor selective organisms.
- Collection methods do not reflect actual human exposure. Microbial concentrations in air will vary by several orders of magnitude in one location and between sites. Short "grab" samples [4 minutes for the RCS] cannot represent real exposure values over a work period.
- Information relating both viable and non-viable micro-organisms is presently insufficient to establish dose-response relationships. Very few epidemiological studies have been done. The issue is further complicated be the secondary by-products that many microbial species produce, such as mycotoxins, endotoxins, volatile organic compounds, antigens, -1,3-glucan, etc., that may be more potent that the microbial itself. These "indicator" measurements do not accurately reflect total exposure.
- There is a wide variation in individual susceptibility to microbials and various factors such as genetics, age, personal habits, health, pre-existing conditions, medication, and previous exposure, will affect people's reaction. Furthermore, building occupants are exposed to a large variety of complex and variable chemical and biological mixtures at work, outdoors and at home. Consequently, exposure information is imprecise because agents, other than those identified and measured, will also be present and may be responsible for some of the health responses by exposed persons. Biological markers of exposure to fungi are largely unknown.

Remedial Measures

While prevention and control of microbials are requisite conditions needed to maintain a healthy and comfortable workplace, remediation is necessary if there is an internal source.

Depending on the species type and level of contamination, there are protocols established by Health Canada (2), New York City Department of Health (6), the Canadian Construction Association (10), and other authorities, (4) (7).

The maxim that all building occupants should be protected from microbial exposure during testing and remedial action must be followed. In this regard, the extent of contamination [size] is accounted for by the use of different containment strategies, equipment and methods. Another important related consideration is the isolation of the air distribution system from the remediation area so that microbials are not transported to other zones.

The following general remediation principles apply.

Moisture control is recognized as the primary factor in controlling microbial growth. If porous materials such as fibreglass insulation, carpets, ceiling tiles, and plaster do become contaminated, it is usual to discard these materials. Hard surfaces can be salvaged using a detergent or a 6-10% bleach solution and clean-water rinse. Biocides and antimicrobial agents may be used to decontaminate selective areas such as ducts, water reservoirs, and condensate pans. However, occupants must not be exposed to any residual compound.

Water damage from leaks, floods and plumbing failures should be repaired and remediated within 24 hours. Wet materials should be dried, sewage-contaminated porous materials must be discarded. Water penetration or migration through the building envelope, and condensation within the interior or exterior wall assembly is to be avoided. A moisture meter is useful in detecting non-accessible or hidden wet areas. Do not over-humidify the building during the winter. Dehumidify supply air in summer to 60% maximum during occupied periods and to 70% during downtime.

The HVAC system can be a source of microbial contamination; avoid water vapour reintrainment from roof-top cooling towers and condensers, maintain good filter performance [small systems at 30% efficiency, large systems at 85%]. Avoid stagnant water within the system and clean condensate pans and other wet areas such as drift eliminators, reservoirs, floors, etc., monthly. Wet porous material is to be avoided. There should be no moisture or water vapour in front of the fan as this will carry through into the supply ducts. Insure access to all components for scheduled maintenance and cleaning. Keep a log of all activities.

Conclusions

Air sampling is not an infallible means of determining the existence of fungal contamination and any survey must rely on the skill and experience of the investigator. Information from a large data set has produced practical guidelines on how to interpret measurement results and how to effectively remediate the situation.

As public information on microbial contamination [and other IAQ and environmental issues] increases, research and co-operation between the various disciplines; architecture, engineering, industrial hygiene, mycology, and medicine will evolve to increase our understanding of the issues. The multi-disciplinary aspect of microbial assessment and remediation has been already demonstrated at the Third International Conference on Fungi, Mycotoxins and Bioaerosols, at Saratoga Springs, NY, in 1998, where over 300 participants, many of them medical doctors, presented an extraordinary range of papers (9). Until the magnitude of the population risk is known, it would be prudent, based on current evidence, to remediate indoor sources of microbials.

References

1. Indoor Air Quality in Office Buildings: A Technical Guide, A report of the Federal-Provincial Advisory Committee on Environmental and Occupational Health, Health Canada, 1993, revised 1995.
2. Fungal Contamination in Public Buildings: A Guide to Recognition and Management, Federal-Provincial Advisory Committee on Environmental and Occupational Health, Health Canada, 1995.
3. Field Guide for the Determination of Biological Contaminants in Environmental Samples, American Industrial Hygiene Association, Fairfax, Virginia, 1996.
4. Bioaerosols Assessment and Control, American Conference of Governmental Industrial Hygienists, Cincinnati, OH, 1999.
5. Significance of Fungi in Indoor Air: Report of a Working Group, Health and Welfare Canada working Group on Fungi and Indoor Air, Canadian Public Health Association, 1987.
6. Guidelines on Assessment and Remediation of Fungi in Indoor Environments, New York City Department of Health, 2000.
7. Managing Water Infiltration into Buildings, University of Minnesota, Environmental health and Safety, 1998.
8. Indoor Air Quality Building Investigations, 1987-1994, Summary Report, T. Nathanson, PWGSC, 1995.
9. Bioaerosols, Fungi and Mycotoxins: Health Effects, Assessment, Prevention and Control, edited by Eckart Johanning, Eastern New York Occupational & Environmental Health Centre, Albany, New York, 1999.
10. Mould guidelines for the Canadian Construction Industry, 82-2004, Canadian Construction Association, http://www.cca-acc.com