Microbials and HVAC system operation and maintenance in office buildings

By Tedd Nathanson, P.Eng., ACGIH, ISIAQ*

A Public Works and Government Services Canada (PWGSC) investigation of 95 buildings conducted from 1987 to 1994 has found that problem areas can be grouped into two categories: internally generated contaminants (52 per cent) and heating, ventilating and air conditioning (HVAC) system deficiencies (48 per cent). In the contaminant area, it was found that in 21 per cent of the cases, microbial contamination was the primary contributing factor to poor indoor air quality (IAQ).[1]

Microbial contamination

Microbials or microorganisms, which include fungi, moulds and bacteria, are ubiquitous in the outdoor and indoor environment. The presence of moisture and dust in the indoor environment can, under certain conditions, result in microbial contamination.

In normal building operations, the filtration system is expected to significantly reduce the levels of particulates coming from outdoors, while the building interior should not provide for any growth or amplification sites. Wetted carpet, ceiling tiles and insulation offer suitable environments for microbial proliferation under certain circumstances.

Heating, ventilating and air conditioning (HVAC) systems also offer a number of locations where microbial populations can flourish. The HVAC system can also transport microorganisms from the locus of contamination to the occupied space.[2]

Fungal spores, especially *Cladosporium* and *Alternaria*, are common in outdoor air during the growing season, and the principal fungi that grow on leaves constitute 60-70 per cent of the spores in the air. Species of fungi that have the ability to grow and accumulate indoors, or in air-handling equipment, can be quite different from common plant and leaf fungi. Certain fungi can induce allergies and other health problems in sensitive individuals.[3] Affected individuals manifest symptoms such as fever, shortness of breath, cough, muscle aches, rashes and other general asthma and allergy symptoms.[4]

Microbial sampling protocol

Although inspection will often reveal mould on contaminated surfaces, a microbial source cannot always be detected visually or by its characteristic musty odour. PWGSC, using a federal-provincial IAQ assessment protocol [2], routinely takes airborne and surface samples in order that a mycologist may qualify and quantify the microbial species and interpret the results. The protocol contains guidelines for interpretion of results, even though "safe" limits have not yet been scientifically determined.[3]

In conducting a visual inspection of a building and HVAC system, the following potential microbial reservoirs and amplification sites should be investigated:

- Water towers or evaporative condensers;
- Air intakes, filter systems, cooling/heating fins and coils, spray humidifiers, reservoirs, mixing plenums, ducts, insulation, ceiling air-handling units (AHUs), induction and fan coil units, drain and condensate pans, and sumps that are dirty or wet;
- Mouldy, damp surfaces, and areas of previous flooding or water leaks on ceiling tiles, plaster, gyprock, carpets and window sills/frames, etc;
- Portable humidifiers and water coolers.

Remedial action

Outside air

The on-site investigation begins outdoors at the air intake and continues through the HVAC system to the workplace. The avoidance of stagnant water and dirt through proper design, operation, maintenance and housekeeping is the best defence against microbial proliferation. Keep the building's systems and interior dry and clean!

For the outside air:

- Avoid pollutant entrainment into the air intake from cooling towers and evaporative coolers located close to or upwind of the intake. Rain should not enter the air intake.
- Sanitary and kitchen vents and exhaust from the building or adjacent buildings can also contaminate air intakes. Locate or position the intake properly to avoid this.
- Remove stagnant water, leaves, soil, etc. from the roof near the air intake. Also, bird droppings can harbour infectious fungi.[3]
- Cover the air intake with a screen.

Air filters

In large buildings, it is common to have a 2-stage filtration system — a primary panel or roll filter and a secondary bag filter. Filters not only keep the HVAC system components clean and operating more efficiently, but also filter the incoming and recirculating air. The function of the primary filter is to remove large particles and debris from the air and thus protect and extend the life of the more efficient and expensive bag filters.

For the filtration system:

- Ensure that the filters are well seated in the rack so that there are no gaps. As air flow seeks the path of least resistance, small spaces allow a disproportionate amount of unfiltered air to flow through.
- Ensure that filters are never wet from rain, or from the humidification system. Such conditions indicate an improper design. Wet filters not only encourage microbial growth but they also mat (reducing performance) and even collapse (allowing for bypass).
- Roof-top air-handling units with a single panel filter should have a dust-spot efficiency rating of at least 30 per cent. Replace the oil-coated filter with a pleated one. Large mechanical systems should have 85 per cent efficiency filters. This would remove most spores, as well as dusts that support microbial growth, without decreasing system performance.
- Change panel filters four to six times a year, depending on load. While it is best to replace bag filters according to pressure drop specifications, they should be replaced at least once a year.

HVAC system

The HVAC system itself can be a source of microbial growth and dissemination. In the winter, air is usually humidified by either steam or water spray (air washer); during the summer, air is dehumidified through the process of cooling (air conditioning). Water-spray humidifiers require regular maintenance and water testing. Often, access to parts of the HVAC system is restricted, making inspection and cleaning difficult, if not impossible.

For the HVAC system:

- Ensure access to system components for cleaning and maintenance.[4]
- Ensure that the mixing plenum floor, walls and ceiling are clean. Surfaces lined with acoustic insulation should have an intact, clean outer liner with no exposed fibreglass. Torn surfaces should be patched. The liner should be carefully cleaned with a vacuum incorporating a high efficiency particulate air (HEPA) filter once a year. The central supply duct should also be similarly maintained. Since uncovered fibreglass cannot be effectively cleaned, its use in the HVAC system and in the return plenums is not recommended.[4]

• Examine the humidifier for microbial growth, particulates, or chalky deposits, and note any use of treatment chemicals. The addition of scale and rust inhibitors, deodorants (to mask smell) and biocides are not recommended. The first line of attack is to keep the system clean [5] and to maintain good water quality.[6]
• Monitor the general water quality in humidifier reservoirs and water towers by taking samples and keeping monthly records. Microbial and bacterial growth can be measured using dipsticks containing agar, or by a dye test. Measuring total dissolved solids (TDS) or conductivity will indicate "cycles of concentration" or water purity. It is common to allow two to three cycles of concentration of city water in the humidifier reservoir. Control is achieved by adding a determined quantity of potable water, a process called bleed-off.
• Disinfect hard surfaces contaminated with microbial slime while the building is unoccupied. Use a 10 per cent bleach or dilute hypochlorite solution to wipe the area and flush with clean water.[3] No residue or odour should remain prior to system start-up.
• Inspect cooling/heating coils, fins and tubes for scale, rust and blockage and clean the units yearly, in reverse direction of the air flow.

Moisture incursion due to leaks, spills and blocked and dirty condensate pans and humidifier reservoirs is the most common cause of microbial contamination in the office environment. A preventive maintenance program will reduce the likelihood of HVAC system breakdown. While prevention is the best defence, reduction of the nutrients that support microbial growth through proper filtration, housekeeping and quick corrective action in the event of a water spill is the best way to avoid microbial problems. Fungal spores can be released into the air months after a wet area has dried.

Occupied space

For the office area:
• Keep carpets, ledges, office furnishings, etc. clean. Vacuum carpets with a high performance vacuum cleaner at least once a week.

• There should be no stagnant water in perimeter and ceiling induction, or fan coil units. Condensate pans under cooling coils should have drain lines and sufficient pitch so that water drains completely. Pans should not be internally lined with porous insulation such as fibreglass, as this can become a microbial breeding area.
• Personal portable humidifiers should not be used. The HVAC system should provide acceptable relative humidity in the workplace.
• Do not exceed 60 per cent relative humidity (ASHRAE Standard 55-1992, Thermal Environmental Conditions for Human Occupancy).
• Replace water-damaged furniture or clean with a 10 per cent bleach solution. Discard wet, contaminated particle board, ceiling tiles, fibreglass, etc.
• Extract as much water as possible from wetted carpets, so that they are totally dry within 24 hours. Carpet moisture is a special problem when it penetrates the carpet backing, padding and concrete floor slab. These materials permit downward flow of water by gravity but block the passage of water vapour upward. Thus a dry carpet may still have a wet backing, which can become a microbial amplification site.

Conclusions

Preventative maintenance is probably the single most important factor for controlling microbial contamination in buildings. Keep the HVAC system components and office area clean, free of dust, particulates and stagnant water. Prompt attention to leaks and floods are essential for preventing microbial growth.

If IAQ complaints continue after simple remedial action has been taken, airborne and surface microbial levels should be monitored as part of an assessment process. Air and surface samples, if properly taken, analysed and interpreted, can both quantify the number of colony-forming units present and identify the type (genus and species), so that the source and exposure risk can possibly be determined. It may be prudent to seek expert advice. As a general rule, the indoor microbial load should be lower than outside levels and have the same mix of species.

A number of factors will collectively increase the future importance of microbials in the indoor environment. Heightened public awareness coupled with an older, more susceptible workforce demanding more comfortable accommodation (thus adding complexity to the HVAC system controls and maintenance) will escalate the need for microbial control in office buildings.

The design, commissioning and operation of buildings will have to include considerations that will minimise the potential for accumulation, amplification and dissemination of microbials.

References

1. Nathanson, T. *Indoor Air Quality Building Investigations: 1987-1994 Summary Report*, Public Works and Government Services Canada, Documentation Centre, Ottawa, K1A 0M2, Canada, 1994.
2. *Indoor Air Quality in Office Buildings: A Technical Guide*, Health Canada, Communications Branch, Tunney's Pasture, Ottawa, K1A 0M2, Canada, 1995.
3. *Biological Contaminants in Indoor Environments*, Phillip R. Morey, ed., ASTM, Philadelphia, PA,USA, 1990.
4. *Architectural Design and Indoor Microbial Pollution*, Ruth B. Kundsin, ed., Oxford University Press, New York, 1988.
5. "Guidelines for the Assessment of Bioaerosols in the Indoor Environment", *The American Conference of Governmental Industrial Hygienists*, Cincinnati, Ohio, USA, 1989.
6. Nathanson, T. *Humidification System: Function, Operation and Maintenance*, Public Works and Government Services Canada, Documentation Centre, Ottawa, K1A 0M2, Canada, 1995.

*Tedd Nathanson is senior engineer, Building Air Quality Technology, Real Property Services, Public Works and Government Services Canada, Ottawa. *This paper was presented at the 1996 AIRAH International Conference, Adelaide, South Australia.*