Biological Contamination in the HVAC System

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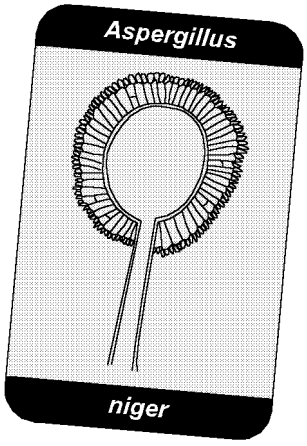
The heating, ventilating, and air-conditioning system (HVAC) in a building is very similar to the respiratory system in a human body. The HVAC system provides conditioned air to building oc-cupants and is essential to the comfort of building occupants, and necessary to the operation of the building. The respiratory system delivers oxygenated air to the blood stream in a human body and is essential to the survival of humans. The importance of these two systems is clearly significant to humans.

To provide sound attenuation and to conserve energy, the HVAC system, including the air handling unit and the air-duct, is often insulated with fiberglass and other insulation materials. Some air-ducts are insulated internally or externally. There are also air-ducts made of glass fiberboard. Internal insulation materials with a rough porous surface will trap particles and particulates from the air stream. Materials trapped include pollen grains, plant matter (including decayed leaves, plant hairs, or fern spores), fungal spores, insect parts, skin flakes, paper fibers, and other organic matter. These materials are often hygroscopic and can absorb moisture from the air. With sufficient moisture content in the accumulated dust, fungal spores germinate and grow. During the cooling season, condensation from cooling coils and water in the drain pans allow fungi and bacteria to proliferate.

The HVAC systems are designed for cooling during hot months and for heating during cold months. During the cooling cycle, warm air is cooled by passing through the cooling coils. Excessive moisture in the warm air is condensed into liquid water when passing through the cooling coils. Air discharged from the cooling coils often has elevated relative humidity. Therefore, the cooling coils, condensate drainage pan, and adjacent areas are primary amplification sites for fungal and bacterial growth. Humidifiers in certain systems also provide moisture for microbial growth. Several cases of excessive fungal and bacterial growth and reported illnesses were associated with cold water humidifiers in the HVAC system. Humidifiers were found to have bacterial growth and endotoxin levels. As with many IAQ problems, it is difficult to directly link environmental data with actual illnesses.

Biological Contaminants in the HVAC System

Various biocontaminants may be found in the HVAC system. The primary biocontaminants are fungi and bacteria. Secondary biocontaminants may include mites, insects, or nematodes. Many fungi and bacteria are saprophytes and very adaptable to the environment as long as there are organic nutrients and sufficient moisture. Secondary contaminants are often the result of fungal growth. Fungal contaminants produce allergens; mycotoxins; beta-1,3-glucans; and fungal volatile organic chemicals (VOCs). Bacterial contaminants may produce allergenic proteins, toxins (endotoxins in particular), and bacterial VOCs. Occu-pants in buildings with a contaminated HVAC system occasionally report musty odors. These odors can often be traced to microbial amplification in the system. Some bacteria, such as *Pseudomonas aeruginosa*, may cause opportunistic infections. These bio-contaminants can produce adverse health effects in exposed building occupants.



Moisture-loving fungi, such as *Acremonium* spp., *Aureobasidium pullulans, Exophiala* spp., *Phoma* spp., *Sporobolomyces* spp., *Rhodotorula* spp., and yeasts, are common inhabitants of cooling coils and drain pans. In addition, Gram-negative bacteria and endotoxins at elevated levels have been detected and reported from drain pans and contaminated humidifiers. A second group of fungi can be found thriving in insulated ductwork downstream and adjacent to cooling coils. They are mostly *Cladosporium* spp. (primarily *C. cladosporioides), Penicillium* spp. (primarily *P. corylophilum),* and occasionally, *Aspergillus* spp. These fungi grow well at a moderately high water activity near 0.85 and 0.90 (water activity measures available water in substrates for microbial growth; the highest water activity is 1.0). Gram-negative bacteria are seldom detected in large numbers with these fungi.

Besides fungi and bacteria, signs of mites and insects have been observed among fungal growth on a few occasions. Intact fungal spores have been seen in insect and mite fecal

pellets, suggesting that insects and mites fed on fungal spores. In one instance, nematodes and a nematode-trapping fungus, *Harposporium anguillae*, were recovered from slime in a drainage pan in the HVAC system of a large building. Endotoxin (produced by Gram-negative bacteria) exposures were associated with cases of sick building syndrome in an office. The source of endotoxins in that instance was identified to be contaminated humidifiers and ventilation ducts.

Recommendations

There are several approaches to address concerns of biocontamination in the HVAC system.

1. Upgrade filtration efficiency of the system. A mechanical engineer should be consulted regarding pressure drop from higher filtration efficiency. Filters should be replaced or cleaned according to the manufacturer's recommendations.
2. Clean and maintain regularly the cooling coil and drainage pan, preferably quarterly or twice a year. The frequency should be decided upon depending on the age, operation, uses, and history of the system.
3. Maintain insulation in the air handling unit and the ductwork to minimize conditions for the amplification and accumulation of biocontaminants. The maintenance should include upgrading filters, making sure that filters are installed properly and do not allow bypass, changing filters on a timelybasis, inspecting cooling coils and drainage pans, and cleaning the insulation materials when necessary.
4. Consider cleaning the HVAC system when there are obvious signs of microbial growth and/or heavy dust accumulation. Consult a competent environmental professional for an evaluation.
5. Design the HVAC system so that the air stream does not contact internal insulation with a rough porous surface.
6. Inspect and maintain humidifiers regularly. Avoid installing and using cold water humidifiers.
7. Place outside air intakes away from street level, cooling towers, and loading dock areas. Air intakes should be cleaned to remove litter and dirt.

Microbial contamination in buildings and its impact on indoor air quality (IAQ) are well documented. Several recent articles suggest that as much as one third of IAQ problems may be microbe-related. Microbial contamination was the primary IAQ concern in approximately 29% of more than 150 office buildings studied by the State of Minnesota. It is important to note that no environmental and clinical correlation was established in

the Minnesota studies. The etiologic agents, whether allergens, mycotoxins, endotoxins, or microbial VOCs, that were responsible for IAQ complaints were not identified. However, complaints of poor IAQ in the buildings involved disappeared, subsided, or were greatly reduced after biocontamination was abated.

Porous materials are commonly used for acoustical and thermal insulation inside the HVAC system. Microbial growth and amplification are known to occur in soft, porous insulation materials. Poorly maintained humidifiers, cooling coils and drainage pans provide a wet environment for microbial amplification. Many biocontaminants have been identified in HVAC systems. They can cause adverse health effects to building occupants. As outlined above, steps can be taken to prevent these problems.

CONSTITUENTS OF CONCERN

Dr. Yang tells *IN*VIRONMENT Professional that a list of common constituents of concern does not exist because current thinking and concepts of microbial issues change frequently. Also, there is usually mixed growth of various molds and bacteria together in a wet and damp environment. An actively growing mold may provide or release various bio-active agents, such as allergens, mycotoxins, microbial volatile organic compounds, and glucan. People with differing levels of immunity may suffer varying reactions different to these agents. Dr. Yang's suggestion to building operators, managers, and occupants is not to allow microbial growth and amplification to occur in the building; if you can prevent colonization and growth, then you do not need to worry about the various health effects caused by microbes.

The following microbes may be associated with the HVAC system, including cooling towers.

1. *Legionella pneumophila*, a common waterborne bacterium, may be detected in cooling tower water or the building potable water system (particularly hot water). It is known to cause Legionnaire's disease and pontiac fever.

2. *Pseudomonas aeruginosa*, a common waterborne bacterium, may cause opportunistic infection. It grows in water, from potable water to stagnant water.

3. *Cladosporium cladosporioides*,
a common mold found outdoors, is a common colonizer of a dirty HVAC system, particularly just downstream from cooling coils. Spores of *Cladosporium* are potentially allergenic and *Clado- sporium* has been associated with hypersensitivity pneumonitis.

4. *Penicillium corylyphilum* is another common colonizer of a dirty HVAC system. Spores of *Penicillium* are potentially allergenic.

5. *Endotoxin* is a cell wall component of Gram-negative bacteria, which is common and abundant in any water. It is released into the environment when bacteria grow, divide, or die. *Endotoxin* is known to cause various adverse health effects related to the respiratory system.

Dr. Yang does not list *Stachybotrys chartarum* as a constituent of concern here because it does not normally grow in the HVAC system. It grows on wet paper products.

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