



Microbiologics in the Workplace

Indoor environments present a complex challenge when trying to determine the role of microbiologic organisms in causing workplace symptoms and disease.

Occupational health study has been focused on chemical, physical agent and even biomechanical (ergonomics) exposures. Researchers have tried to identify the chemical culprits for diseases and symptoms in a wide spectrum of indoor settings. The failure to identify specific chemicals at levels capable of causing disease in office buildings resulted in clinicians and scientists exploring other issues such as humidity, temperature, and organizational and individual psychosocial factors.

More recently, exposure to microbiological agents has taken center stage in the indoor air quality (IAQ) arena. Fungi, which include molds, bacteria and viruses, increasingly are being studied as potential culprits for the myriad symptoms and complaints that have been reported by inhabitants of sick buildings. A number of workers' compensation and third-party lawsuits have arisen over whether exposure to these small living things produces not only annoying symptoms, but also far more serious illnesses, some of which are potentially fatal.

Historical evidence of microbiologic-related disease from molds dates to the Plague of Athens in 430 B.C. In 1960, approximately 100,000 turkeys died from a toxin produced by the commonly found mold *Aspergillus*.

One of the most notorious incidents that helped drive recent interest occurred in 1976, when a mysterious dis-

ease broke out at an American Legion convention in Philadelphia. It was subsequently named Legionnaires' disease.

Since then, IAQ concern has centered on molds, the toxins they produce and specific bacteria such as *Legionella pneumophila*, the gram-negative bacteria responsible for Legionnaires' disease.

Mixed Environment

Microbiologically, the indoor environment reflects contaminants from the outside as well as building-specific agents. Pollens from trees, grasses and other plants, insects fragments and excreta are known or suspected producers of allergies and asthma and are brought inside buildings through doors, HVAC systems and general infiltration. The indoor environment contains dust mites and the potential for exposure to animal danders, food and vegetative debris. Housekeeping and a variety of other building-related factors will impact the exposure potential for many of these agents.

There are a variety of molds found in outdoor and indoor environments. Typically, the outdoor levels will exceed those found indoors. As might be expected, the levels of molds will vary by geographic location and weather (e.g., higher with periods of rain). Species of various molds frequently identified in the outdoors, homes and buildings include those of *Penicillium*, *Cladospo-*

rium and *Aspergillus*. The relative amounts of each fungi species in outdoor air vs. indoor air, however, are not frequently found to be the same.

Legionella and various fungal species will grow substantially under the right conditions (i.e., nutrient source and water). *Legionella* frequently is found in water supplies but also hot tubs and even aerosols from industrial applications. Most of us are familiar with the smell of mold and mildew in damp basements. Molds will grow in humid environments, especially where standing water exists, such as flat roofs, damp filters or condensate collection trays. Water damage from leaking roofs or pipes may provide growth opportunities for various fungal species.

The growth rates and extent of growth is related to the temperature as well as factors such as humidity and nutrient availability.

Health Effects

In addition to Legionnaires' disease, various types of microbiologics may produce health problems ranging from the common cold passed from worker to worker to allergies, asthma and humidifier lung (hypersensitivity pneumonitis).

The presence of *Stachybotrys* species such as *S. atra* and *S. chartarum* have created concern due to the disease that has been associated with extensive exposure to these molds and the toxins they and other molds produce, known as mycotoxins. Probably the most recognized mycotoxin is aflatoxin, a known carcinogen produced by *Aspergillus* species.

The reported health effects of mycotoxicosis include:

- Immunosuppression
- Dermatotoxicity
- Myelosuppression
- Estrogenicity
- Hepatotoxicity
- Mutagenicity

Fungi increasingly are being studied as potential culprits for the symptoms reported by inhabitants of sick buildings.

- Nephrotoxicity
- Teratogenicity
- Neurotoxicity
- Carcinogenicity

While such effects have been associated with mycotoxin exposure, the strength of the associations, occurrence in human populations, quality of the studies and applicability to airborne workplace exposures remain to be clarified. Tobacco, meats, spices, seeds, nuts, cereals and grains, milk and dairy products, and fruits and vegetables have been shown to contain mycotoxins, demonstrating their ubiquity within the environment. The chart below lists some pathology associated with specific fungal agents.

disorder occurring over several weeks. The clinical picture has been reported as being similar to radiation poisoning:

- Bone marrow effects
- Fever
- Nausea/vomiting
- Leukopenia (low white cell count)
- Diarrhea
- Bleeding
- Abdominal pain
- Sepsis

The toxicity has been related to a *Stachybotrys* mycotoxin such as *Trichothecenes*. The disorder starts with three to nine days of nausea, vomiting, mucous membrane and skin irritation, abdominal pain, headache and generalized weakness. At 10 to 14 days, the pa-

bacteria survives principally in water, but to a lesser extent in soil. One study found that 64 percent of a hospital's water supply was contaminated with *L. pneumophila* and that 14 percent of the hospital-acquired pneumonias was found to be a *Legionella* infection. Legionnaires' has been traced to drinking water, bathing, whirlpools, hot tubs and cleaning medication nebulizers. In immunocompromised individuals, the elderly and persons with underlying diseases such as cancer, the attack rate is much greater than in the general population.

One hypothesis for SBS symptoms concerns the role of microbiologic "off-gassing" in the production of sensory irritation. Specifically, certain microbial volatile organic compounds (MVOCs), which include alcohols, terpenes, ketones, esters, aromatic compounds, amines, sulfur-containing compounds and possibly aldehydes, are produced during active microorganism growth. MVOCs are occasionally released into the air but at very low concentrations. A 1999 study by Koppi *et al* examined sensory irritation in mice but failed to show a substantial association with exposure to MVOCs.

Until the precise role of various workplace microbiologic agents in the production of SBS symptoms and specific building-related illness is clearly elucidated, occupational health and safety professionals need to use good judgment in addressing complaints and investigating specific diagnosed conditions. Individuals with allergic rhinitis and asthma will need to be evaluated for causative agents and exposures to symptom triggers.

It is important to remember that the most common indoor producers and aggravators of these conditions include dust, dust mites, molds and possible cockroach fragments and excreta. Inspection, periodic maintenance and appropriate remediation of water leaks, humid environments, and dirt, dust and contamination may help to reduce complaints from building occupants and, it is hoped, have an impact on the risk of building-related illnesses. OH

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Fungal Agents and Their Health Effects

Agent	Pathology
• <i>Aspergillus flavus/parasiticus</i>	Hepatotoxic, hepatocellular
• <i>Fusarium sporotrichioides</i>	Skin lesions, internal/external hemorrhaging
• <i>Aspergillus, Penicillium species</i>	Chronic interstitial nephropathy
• <i>Claviceps purpurea</i>	Convulsion, gangrene
• <i>Fusarium moniliforme</i>	Esophageal cancer
• <i>Fusarium sporotrichiella</i>	Deforming arthritis
• <i>Phoma sorghina</i>	Thrombocytopenia
• <i>Penicillium citreoviride</i>	Cardiac beri-beri
• <i>Pithocyces charitarum</i>	Toxic photosensitization

Various molds and their toxins have been implicated in sick building syndrome (SBS) and specific building-related illnesses. Studies of symptoms and complaints in what have been identified as "sick" buildings frequently identify cold- and flu-like symptoms, sore throats, mucous membrane irritation, headaches, diarrhea and fatigue.

Attempts to relate these complaints to fungal airborne exposures have run into a variety of problems. These consist of lack of specific illness association, inability to demonstrate differences in exposure between controls and study subjects, and inadequate study design. Many studies are, in fact, case reports or case series, or cross-sectional studies. The use of case reports/series and cross-sectional studies severely limit the ability to draw causal conclusions.

True stachybotryotoxicosis, first associated with the ingestion of highly contaminated foodstuffs, especially in Russia, has been described as a severe

patient may feel better, but bone marrow damage evidenced by leukopenia, anemia and thrombocytopenia may be found. Depending on the severity of disorder, at three to four weeks coagulation difficulties, bone marrow failure, infection and sepsis are reported. After four weeks an increased white blood cell count will accompany recovery.

In the early 1990s, Centers for Disease Control investigators reported a cluster of 10 infants from Cleveland, Ohio, with acute idiopathic pulmonary hemorrhage, also termed pulmonary hemosiderosis. One infant died. The potential role of *Stachybotrys* was evaluated. An initial association was later felt to be unfounded as the statistical association was potentially inflated, and there were sampling technique and other concerns.

The annual number of Legionnaires' disease cases, on the other hand, is probably not fully appreciated. It is estimated that 10,000 to 25,000 cases occur in the United States each year. The