

# The Complexity of Damp Indoor Environments from Water Intrusion and Human Health<sup>1</sup>

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Water intrusion into homes and buildings leads to the growth of microorganisms. The microorganisms consist of filamentous fungi (molds) and bacteria. The result is a complex indoor environment that has not received adequate scientific/medical research. We as Environmental scientists and physicians need to speak out on this issue. We will briefly review the complexity of this environment along with known health problems consistent with exposure to multiple toxins.

Fungi and bacteria and their by-products cause human illness. These include infections; fungal and bacterial sinusitis; respiratory diseases, skin disease, immunotoxic and neurotoxic effects. Let us now look briefly at each of the components and their known health effects.

**Molds:** Molds begin growing by 48 hours following water intrusion. It is estimated that 50 % of the mold growth is hidden, e.g. wall cavities. The signal molds are *S. chartarum*; *Aspergillus* (11 species); *Penicillium* (10 species); *Fusarium*; *Chaetomium*, *Epicoccum*, and *Memnoniella*. Certain species of these genera are in higher concentrations in the indoor environment as compared to the outdoors.

**Bacteria:** Both gram negative and gram positive bacteria are present. The predominant gram negative organisms are several species of the Actinomycetes (several species of *Streptomyces*) as well as other genera, Mycobacteria and *Nocardia spp.* Human pathogens occur in these groups and in addition *Streptomyces* and *Nocardia* isolated from indoor environments are known to produce toxins that can affect human health. The gram negative bacteria include a variety of genera that do release endotoxins into the air and dust of an infested facility. Finally, the toxins produced by *S. californicus* were shown to act synergistically with trichothecenes *in vitro*

**Particulates:** Colonies of molds and bacteria shed particulates ranging from <0.2 to 9 microns. The particulates can be divided into two general fractions: large and fine. The large particulates consist of spores and hyphae fragments usually collected 2 micron filters. These contain mycotoxins, various secreted enzymes as well as siderophores and hemolysins. The fine particulate matter is less than 2 microns and ranges to nanoparticle size. This fraction is shed at vibrations at 1-20 hertz that are set up by normal human activity (walking, talking, TV etc.). These particulates differ from the larger fraction in that they are up to 320 times more numerous than large particulates and are inhaled deep into

Alveolar spaces with simple diffusion into the blood. The fine particulates also contain the mycotoxins and other mold/bacterial by-products. In addition, the spores of *Streptomyces californicus* and other actinobacter are in this fraction.

**Mycotoxins:** Mycotoxins are present in the indoor environment. The trichothecenes are present in the large and fine particulate matter. Sterigmatocystin, chaetoglobosins, trichodermin, trichodermol, spirocyclic drimanes, ochratoxin A, penicillic acid, verrucosidins, griseofulvin, roquefortine C and others have been demonstrated in bulk and dust samples of homes and office buildings. A recent paper reported trichothecenes and sterigmatocystin in 45 of 62 building material samples. If present, tremorgens are capable of interfering with synaptic transmissions involving glutamate, aspartate, GABA, serotonin) and block complex sphingolipids via inhibition of ceramide synthetase.

**Volatile Organic Compounds (VOCS):** Molds and bacteria release VOCS that include alcohols, aldehydes, organo-sulfides, ammonia and amines. These add to other sources from indoor furnishings, cleaning agents and from outdoor sources. The human health effects have received very little attention.

**Extra Cellular Proteins:** Molds secrete enzymes that allow the organism to digest the substrate upon which they grow. These include lipases, proteinases, metalloproteinases, fibrinolytic enzymes, galactosidases, siderophores, and hemolysins among others. This occurs on building materials as well as in the infectious state. These proteins can act as antigens and/or inflammatory agents producing lung disease and the release of pro inflammatory cytokines. Hemolysins have been implicated in pulmonary hemosiderosis with reference to *S. chartarum*. However, eleven species of *Aspergillus* and 10 species of *Penicillium* found in contaminated homes in Cleveland, Ohio also produce hemolysins. Thus, it is critical to identify all species within a contaminated structure in order to identify potential causes of upper and lower respiratory bleeding in both children and adults.

**Extra Cellular Polysaccharides (EPS):** The cell wall of is a complex structure consisting of polypeptide polysaccharides (EPS), lipids and proteins. Some of the cell wall components are directly associated with tissue colonization and damage, e.g. aspergillosis. Two EPS compounds released into the environment *in vivo* and *in vitro* are the 1, 3-beta-D-glucans and galactomannans. Both are considered biomarkers of exposure to and infection by molds, e.g. *Aspergillus* and *Candida* spp. The glucans are present in the indoor air and dust and promote airway inflammation as shown by broncho alveolar lavage in exposed humans and animals.

**Endotoxins:** Endotoxins released by gram negative bacteria have also been identified in the indoor air and dust of contaminated homes. They can cause: fever; leukopenia, hypoglycemia; hypotension; decreased organ perfusion (brain, ears, kidneys, etc.); activation of C3 complement; bleeding; intra vascular

coagulation, death and late inflammatory responses (endotoxemia). They act by binding to TLR4 (Toll-like receptors), inhibiting IgE mechanisms and initiating pro inflammatory responses. In animals models of neurological disease endotoxins are known to cause the expression of pro inflammatory markers of microglia as well as injury to oligodendrocytes.

**Conclusions:** It is obvious that the indoor environment resulting from water intrusion is complex with several different interactions occurring simultaneously. Although attempts have been made to determine the health effects of exposure to molds and bacteria, additional work is sorely needed.

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**<sup>1</sup>This article can be obtained in its entirety with over 100 references by contacting Dr. Thrasher. E- mail - [toxicologist1@msn.com](mailto:toxicologist1@msn.com)**