An Opinion on Assessing the Health Effects of Mold

Submitted to IEC on 02/23/2007

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This is an updated excerpt from the original.

INTRODUCTION

I am not a physician, so I am certainly not qualified to comment on the health effects of mold as they may be affecting any individual. However, I am qualified to comment on the quality of the data upon which associations between airborne concentrations of mold spores and potential health effects may reasonably be based. It is my opinion that if one is to conclude that health effects either are or are not associated with airborne mold, those conclusions should be based on an analysis of defensible field data. Furthermore, if such conlcusions are stated, they should include an assessment of the applicability and quality of the field data upon which those conclusions were based.

The US Environmental Protection Agency (EPA) considers the quality of field data to be of paramount importance. EPA has a multi-volume set of guidelines, referred to as Data Quality Objectives (DQO's), which their scientists are expected to follow when collecting field data. Both EPA management and scientists know that if the field data that were collected are of such poor quality that they cannot be interpreted, then the conclusions resulting from an analysis of those data may be meaningless and indefensible. Surprisingly, both the utility and the quality of the field data collected during mold investigations has received little attention within the Indoor Environmental Quality (IEQ) community.

For example, the American College of Occupational and Environmental Medicine (ACOEM) published a guidance document for physicians on the health effects of indoor mold (Adverse Human Health Effects Associated with Molds in the Indoor Environment; 2002; www.acoem.org/guidelines). On page three of that document ACOEM concluded "…indoor airborne levels of microorganisms are only weakly correlated with human disease or building-related symptoms…".

In comparison, the Institute of Medicine (IOM) in publishing *Damp Indoor Spaces and Health* (Institute of Medicine of the National Academies, National Academies Press, Wash, DC, 2004) reached the conclusion that associations between the concentrations of airborne mold and health effects may exist, but that *not enough reliable data were available to confirm whether an association actually existed*. Considering the vast

amount of data on this subject that has been collected, this exposes a serious limitation in the standard approach for assessing associations between airborne concentrations of mold spores and potential health effects. Therefore, it's reasonable to examine the quality of the field data upon which these conclusions were based.

DATA QUALITY

The commonly used samplers for the collection of airborne mold spores are the slit-impaction samplers such as the Air-O-Cell and the Allergenco-D cassettes. This type of sampler was originally developed as a qualitative tool, and used primarily for the enumeration of spore types present in the air. However, as IEQ surveys became popular, these samplers began to be used as quantitative tools, and they are now commonly used to report the concentrations of airborne spores.

In fact, most of the data relating to airborne concentrations of mold were probalby collected using either multi-hole culturable samplers such as the N6 (also an impaction sampler) or slit-impaction samplers. Therefore, any attempt to associate health effects with concentrations of airborne mold has probably been based on data collected using these types of samplers – and this is the problem. In general, the sampling results obtained with these samplers (1) have not been validated, and (2) the results are not reliable at elevated spore concentrations - which is exactly where adverse health effects are most likely to occur.

What if the reported concentrations of airborne mold obtained using these samplers were not accurate? What if the magnitude of these errors varied with spore concentration? [If they were constant, one could simply adjust the data to account for the error]. Would one expect to be able to associate airborne concentrations of mold spores with potential health effects? This is exactly the situation faced by the IEP, the occupant, and the physician when assessing occupant exposures to indoor mold.

For example, what if a reported concentration of 5,000 spores/m^3 using these samplers actually corresponded to an average concentration of 11,000 spores/m^3 in one investigation and 700,000 spores/m^3 in another investigation? If this example reflected the quality of the field data collected during the typical mold investigation, would the conclusions reached by ACOEM still be valid?

The data in Table 1 were collected in the living room of a residential property. The six replicate (side-by-side) samples were each collected for 5 minutes using the Bi-Air filter cassette (BA) and the Air-O-Cell slit-impaction cassette (AOC). The average reported *Aspergillus/ Penicillium* (*Asp/Pen*) spore concentrations were 5,400 spores/m^3 for the AOC and 11,300 spores/m^3 for the BA, a BA-to-AOC ratio of 2.1. This difference was statistically significant based on an Analysis of Variance (ANOVA). In this example, about 5,000 spores/m^3 collected with the AOC corresponded to about 11,000 spores/m^3 collected with the BA.

Table 1. *Aspergillus/Penicillium* (*Asp/Pen*) spore (spores/m^3) concentrations (spores/m^3) for six replicate samples collected in a well-mixed room with the BA and AOC samplers during a 66-minute period.

SAMPLER	BA	AOC
Samples	6	6
Minimum	8,000	3,400
Maximum	15,100	7,100
AVERAGE	11,300	5,350

The data in Table 2 are for four replicate samples that were collected during a second residential project. The replicate samples were collected for 60 minutes using the BA and for 5 minutes using the AOC. The AOC samples were collected during the BA sampling period. Clusters of *Asp/Pen* spores were dominant in these samples, whereas single spores or small chains are more typical in field samples, as was the case for the data in Table 1.

Table 2. *Asp/Pen* and *Chaetomium* spore concentrations (spores/m^3) for four replicate BA and AOC samples collected in a residential property.

	Asp/Pen			*Chaetomium*	
ROOM	**BA**	**AOC**	**RATIO**	**BA**	**AOC**
Living Room	365,000	24,500	15	1,800	60
Kitchen	585,400	14,800	40	1,150	0
Bedroom	702,500	4,800	146	300	0
Bathroom	1,406,000	103,200	14	2,700	0
AVERAGE	765,000	36,800	54	1,500	15

The average concentration of *Asp/Pen* spores detected with the BA samples was 765,000 spores/m^3, which substantially exceeded the average concentration detected with the AOC samples of 36,800 spores/m^3. In this particular indoor environment, the average *Asp/Pen* concentration measured with the BA was 54-times that reported for the AOC. The ratios of BA to AOC concentrations ranged from a low of 14 to a high of 146.

Chaetomium was detected in all four BA samples in Table 2, with an average concentration of 1,500 spores/m^3. In comparison, the average concentration for the AOC samples was 15 spores/m^3. Therefore, the average *Chaetomium* concentration was 100-times greater for the BA samples compared to the AOC samples. *Chaetomium*, a toxigenic fungus, was only detected in one of the AOC samples, and that was at the limit of detection. It would not have been reported as a significant contaminant in that particular indoor environment and would not have been considered in the risk assessment, although it was obviously present at elevated concentrations.

These examples raise a concern with the quality of the data upon which the ACOEM and IOM conclusions may have been based. In these two investigations, and many other examples, a reported concentration of 5,000 *Asp/Pen* spores/m^3 corresponded to 11,000 spores/m^3 in one investigation and 700,000 spores/m^3 in the second investigation.

Therefore, the ACOEM and IOM conclusions that indoor airborne levels of microorganisms are only weakly correlated with health effects or building-related symptoms may be based on questionable data.

CONCLUSIONS

The short sampling times and the low spore retention rates of commonly used airborne mold samplers tend to underestimate the average concentrations of contaminant spores. Unfortunately, the degree to which the short-term sample results differ from the true average exposure is usually indeterminate.

Slit- and multi-hole impaction samplers tend to provide the lower bound of exposure and may substantially underestimate the average and maximum exposures – the exposures most closely associated with occpant risk. Therefore, they may not be suitable for performing Occupant Exposure Assessments (assessing the potential risk to the occupant), where the average exposure as well as the maximum (95^{th} percentile exposure, for example) may be of concern.

In my opinion, currently available databases of airborne mold concentrations may be useful for assessing Building-Related Contamination, but their quality is not sufficient for assessing OEP. Any attempt to assess an association between reported health effects and airborne spore concentrations must rely on currently available field data, some of which may be over 100-fold in error.