Benefits of Applying Moldiness Index Abound

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Despite molds in the indoor environment having been a growing public concern, there have been no standardized, objective methods available to quantify the indoor mold burden in homes. I believe this situation has now been corrected with the development of mold-specific quantitative polymerase chain reaction or MSQPCR, and its application called the Environmental Relative Moldiness Index.

MSQPCR is an objective, standardized DNA-based method of mold analysis developed by U.S. Environmental Protection Agency scientists to identify and quantify molds (US Patent No.6,387,652). In 2006, the Department of Housing and Urban Development (HUD) used this technology to complete the American Healthy Homes Survey (AHHS). Based on this national survey and MSQPCR, analysis of the settled dust in the homes in locations across the United States, a national Environmental Relative Moldiness Index or ERMI^{sm} was developed.

In the AHHS, dust was collected in 1,096 homes by vacuuming two square meters in the living room and bedroom for 5 minutes each with a dust sampler-fitted vacuum. This is approximately 18 square feet in each room. Each sample was then mixed and sieved through a 300-micron pore, nylon mesh screen. The samples were analyzed by an EPA licensed laboratory for 36 indicator species of molds.

What is the ERMI?

The 36 indicator species that make up the ERMI were chosen because they can be found at relatively high concentrations in homes throughout the United States. This is not to say that there are no other species that are unique or important in different climates or locations; rather, these 36 indicator species are common enough to be predictive of the total mold burden. The goal is to measure enough species to allow the laboratory to describe the “relative mold-burden” in homes anywhere in the country.

As shown in Table 1, these 36 species were categorized into two groups. The first group (Group 1) includes 26 species/clusters associated with water-damaged homes. The other group (Group 2) is comprised of 10 common species/clusters not specific to water-damaged homes. In the AHHS, the ERMI was computed for each home by taking the sum of the log-transformed concentrations of each of the Group 1 molds minus the sum of the log-transformed concentrations of the Group 2 molds. (The concentration of the Group 2 species is subtracted from the Group 1 species in order to adjust for variations in cleaning habits.)

ERMI Report

Fungal ID \ Unit	House A Spore E./mg	House B Spore E./mg
Aspergillus flavus/oryzae	ND	ND
Aspergillus fumigatus	ND	1
Aspergillus niger	ND	2

Group 1	*Aspergillus ochraceus*	5	9
	Aspergillus penicillioides	4	730
	*Aspergillus restrictus**	ND	ND
	Aspergillus sclerotiorum	ND	ND
	Aspergillus sydowii	ND	<1
	Aspergillus unquis	ND	8
	Aspergillus versicolor	ND	530
	Aureobasidium pullulans	680	390
	Chaetomium globosum	ND	ND
	Cladosporium sphaerospermum	7	26
	*Eurotium (Asp.) amstelodami**	1	150
	Paecilomyces variotii	ND	ND
	Penicillium brevicompactum	ND	170
	Penicillium corylophilum	ND	74
	*Penicillium crustosum**	ND	29
	Penicillium purpurogenum	ND	ND
	*Penicillium spinulosum**	ND	1
	Penicillium variabile	ND	3
	Scopulariopsis brevicaulis/fusca	ND	ND
	Scopulariopsis chartarum	ND	4
	Stachybotrys chartarum	ND	140
	*Trichoderma viride**	ND	<1
	Wallemia sebi	ND	460
	Sum of Logs (Group 1):	**4.98**	**25.36**
Group 2	*Acremonium strictum*	ND	ND
	Alternaria alternata	2	14
	Aspergillus ustus	ND	58
	Cladosporium cladosporioides 1	11	350
	Cladosporium cladosporioides 2	<1	2
	Cladosporium herbarum	8	100
	Epicoccum nigrum	14	350
	*Mucor amphibiorum**	ND	8
	Penicillium chrysogenum	ND	17
	Rhizopus stolonifer	ND	ND
	Sum of Logs (Group 2):	**3.39**	**12.42**
	ERMI (Group 1 - Group 2):	**1.59**	**12.94**

Table 1: This sample ERMI report shows how measurements of 36 mold species in two houses are compared.

To produce the ERMI scale, the computed ERMI values for all 1096 homes were assembled on a continuum from lowest to highest. The scale ranges from about –10 to about 20, or even higher, as shown in Figure 1. On the left hand side of the scale, the 25 percent of homes with the lowest concentrations of molds in the ERMI analysis have an ERMI value less than – 4. Homes within this low range have the lowest mold burden. The homes in upper quartile have ERMI values of five or higher. Generally homes within this high range are considered to have the highest potential risk of exposure to molds associated with water-damaged indoor environments.

The ERMI scale is not meant as a method of making fine separations, since the standard deviation for any ERMI value is plus or minus 3. For example, the 95% confidence interval for an ERMI of 14 would be from 11 to 17 – i.e., 14 plus or minus 3. So, for example, an ERMI value of 14 is not significantly different from an ERMI value of 15, or an ERMI of two versus zero.

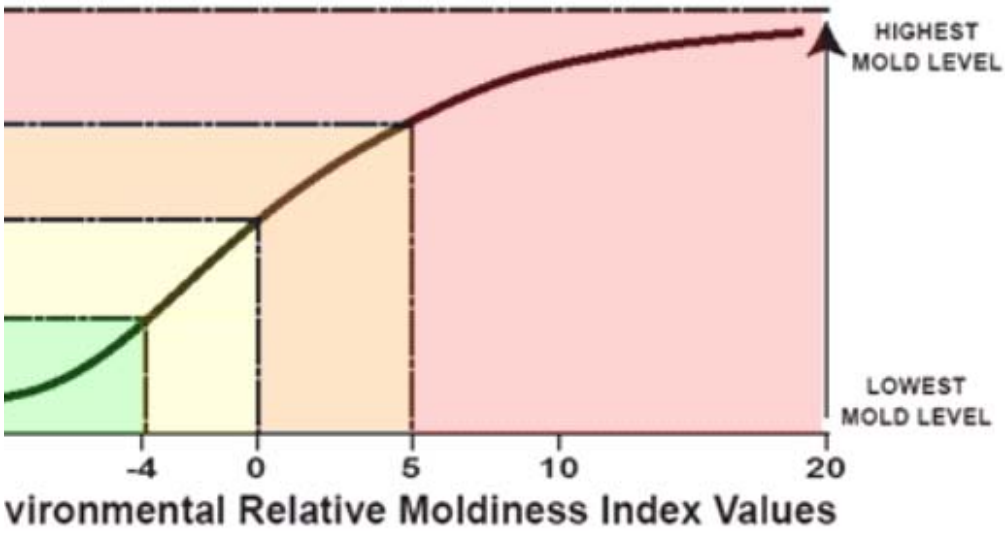

Figure 1: The environmental relative moldiness index, or ERMI, is the application of mold-specific quantitative polymerase chain reaction, or MSQPCR.

Using the ERMI for medical questions

The ERMI scale was derived from the analysis of the settled dust in the common living room plus one bedroom of a home; for proper comparison with the AHHS data, the ERMI samples should be taken in these same areas. However, dust samples can be taken anywhere for analysis and the inspector's expertise should direct that. There is just more uncertainty as one moves away from the locations that were used to build the ERMI scale. Here are some examples of how the ERMI is being used.

"If a person is not feeling well and her/his doctor has determined that sensitivity to mold is an issue to explore, then an ERMI analysis of the patient's home is a good place to start." explained Dr. Ritchie Shoemaker, a Family Practice physician in Maryland who specializes in mold exposures. While the ERMI is a mold index and not a health index, Shoemaker said that whenever the ERMI is elevated, "you may suspect mold trouble". If the ERMI is low and there are people in the home with a typical mold illness, consider repeating the ERMI in different areas. If the ERMI is low and no one is ill, your sense of security increases.

An ERMI analysis might help you to determine if your home is safe for visitors who might have a genetic susceptibility to mold. "If the ERMI value [is above five, which] suggests the home is in the upper 25% of the scale, then an investigation for water damage could be health-saving." Dr. Shoemaker.

He tells of "a Massachusetts mother who found that her home was terribly contaminated, even without visible mold, musty smells or abnormal air sampling from two prior mold inspectors. She says to this day that ERMI saved her children's lives. Maybe that is too much credit, but the truth is that her family only now is well."

The Institute of Medicine's 2004 report "dampness Indoor spaces and health" expressed the opinion that there was sufficient evidence of an association between molds or other agents in damp indoor environments with asthma symptoms in sensitized people. Each person varies so much genetically that a level of mold burden for one person may cause asthma symptoms but not affect another person at all. Medical questions should always be left to the medical professionals. The ERMI value is just one more piece of information that a physician might use to help in a diagnosis.

For example, a study conducted of asthmatic children in Cleveland by CASE Medical School used ERMI testing to document the mold burden in each home. After remediation of the water damage and

mold, the children experienced a significant reduction in their need for medical intervention for their asthma. In a prospective study of atopic infants, measuring the mold burden with MSQPCR was found to be a better predictor for development of wheeze/rhinitis than the visual home inspection for mold.

Using the ERMI to locate mold problems

Derrick A. Denis, a Council-Certified Indoor Environmental Consultant in Arizona suggests that one should, "Consider what is your mold-related question and which of the sampling methodologies and analyses will most accurately answer your question." He uses MSQPCR as one more tool in his mold inspection "toolbox" of sampling methodologies for indoor air quality investigations. "Each of the sampling methods available has strengths and weaknesses, as well as costs," he said. "An ERMI analysis can give a homebuyer a warning that there was an historic unknown or undisclosed water problem with mold growth in the home, or the ERMI can provide peace of mind that the relative mold burden in the home does not indicate a history of water intrusion."

"Some caution in the use of ERMI is necessary because of conditions that can affect the outcome of sampling," advised Greg Boothe, a Certified Industrial Hygienist in Tennessee, who uses ERMI as an effective screening tool to direct further investigation in both residential and commercial settings. "Investigators must consider the condition and activities related to the sampling surfaces in areas selected for ERMI analysis," according to Mr. Boothe. New carpet and carpet that has recently been professionally cleaned may not reflect the true historical burden of mold in the building.

Gil Cormier, a certified industrial hygienist in Connecticut, has used the ERMI for evaluating carpeting in schools. "We were able to use the ERMI to evaluate carpeting and compare rooms with suspected moisture problems with rooms with no known moisture problems," he said.

Advantages of ERMI

Traditional air sampling has never been standardized; thus, interpretations of the results are always problematic. The major problem with traditional air samples are that they are necessarily of a short duration. Often, air samples are only taken for a few minutes because the recovery source, whether a Petri dish or a sticky slide, is quickly over-loaded. However, air samples can be useful and, if properly taken, they can also be analyzed by MSQPCR.

Air samples can be useful, especially in hospitals or in an effort to pin-point the location of a hidden mold problem, as Steven Vesper and others note in a 2004 paper published in the Journal of Hospital Infection. In order to take air samples for MSQPCR analysis, the collection medium is a 25 or 37 mm diameter polycarbonate filter with either 0.45 or 0.8 micron pore size. The flow rate can range from 2 to 16 liters per minute. The holder for the filter can be a button- sampler, cassette, or any other holder suitable for the filter. Sampling can be accomplished using either a personal or area sampling pump. The great thing about MSQPCR analysis is that the filter cannot be overloaded, meaning air samples can be taken for prolonged periods such as many hours or even days. But the best part is that you don't have to wait days to weeks for your results. However, there is no ERMI scale for air samples.

Sampling for the ERMI?

Sampling dust for the ERMI analysis is fairly simple. Start by locating the most commonly used area in the living room. Using a tape measure and masking tape, mark a 3-foot by 6-foot sampling area on the floor. If the sample location cannot accommodate a sample area of these dimensions, adjust the dimensions accordingly. Record these dimensions and note where you took the sample for later comparison, if necessary. Next, do the same in the main bedroom.

Then take the protective caps off the holder as shown in Figure 2 and insert the filter into the holder and attach it to the vacuum cleaner hose. Vacuum for 5 minutes in each area, pull out the sampler and

cap it. As a rule-of-thumb, the filter should be generally about half full when you are finished. If there is very little dust, you will want to vacuum for a longer time or over a larger surface area and note this on the chain-of-custody form. Send each of the samples in a sealed bag for an ERMI analysis to an EPA-licensed ERMI laboratory. Your results can be ready in as little as 24 hours.

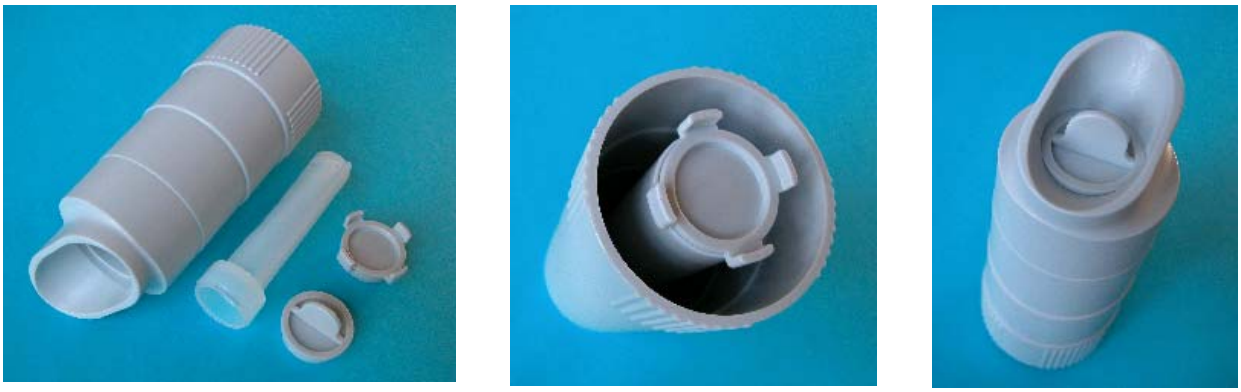

Figure 2: The dust collector contains a main holder, the caps on either end, and a filter insert.

If the ERMI value is high, then you may want to analyze other areas in order to help find the water damage that is the source of the mold. A basement, if there is one, can be a common source of water-damage molds and a sample can be taken there. However, once it is clear that there is water-damage in the environment, other devices like infra-red cameras or moisture meters or even mold-sniffing dogs may help to locate the problem.

When evaluating buildings other than homes, the difficulty is deciding where to take samples. It may be that multiple samples will be required. The experienced inspector will look at the HVAC system and make an educated guess about where to sample. One should take dust samples of an area equivalent to that used in the home investigation. Collecting dust from other available surface areas such as a shelf, cabinet, etc with available settled dust can be an alternative, if no appropriate floor surface is available.

Since no ERMI scale has been developed for other types of buildings, one can only relate the analysis back to the home ERMI. Thus an office with an ERMI of 14 would be like saying the office environment would be equivalent to a home in the top 25% of homes in the United Sates for relative mold burden. Additional samples, even air samples, may help pin-point the mold's location.

Another time to use the ERMI is before and after remediation. After fixing the water problem and removing the mold contaminated materials, it is important that the entire home be thoroughly cleaned. You can then repeat the ERMI sampling and analysis to ensure "post abatement verification". There should be a significant reduction in the ERMI value. However, it may take some weeks to months before the ERMI returns to pre-water-damaged mold levels.

No sampling can replace the wisdom of experience in finding and dealing with mold problems in buildings and ERMI can be a helpful tool. As further research documents the ERMI's applications, it can improve lives.

Summary

We know that all indoor environments contain some mold, but *not* all contain the same molds and definitely not at the same concentrations. Identification and accurate quantitation of indoor molds to the species level is now available using a DNA-based analysis, MSQPCR. This automated analysis provides rapid, reproducible results that can be reliably interpreted. For patients, prospective homebuyers, industrial hygienists and remediators alike, ERMI shows great promise to help us all.

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