Ritchie C. Shoemaker, MD

King-Teh Lin, PhD

Inside Indoor Air Quality:

Environmental Relative Moldiness Index (ERMI)SM

By King-Teh Lin, PhD, Ritchie C. Shoemaker MD

Concerns about health effects caused by molds growing in the indoor environment of water-damaged buildings (WDB) affect many people. Just picture the questions that accompany thinking about occupying a new living space. Is this musty smell a warning? Can I trust the joints of the flexible duct work attached to the air handler in the crawlspace to be airtight? And what about that bubbling of the paint in the living room ceiling by the chimney? Is this basement play room next to the dirt crawlspace safe for my children?

Mold illness comes from any indoor environment that is damaged by water intrusion and not just by natural disasters. Yet there are been no standardized, objective methods available to quantify the indoor mold burden in homes.

What would you do if you faced the concerns of three actual patients? (1) You are a new home buyer. You have a history of unusual fatigue, cognitive problems and chronic respiratory problems. Your doctor says indoor mold makes you sick. How can you tell if the beautiful home across town is safe? (2) Now make yourself a 55 year old secretary at a large manufacturing site. Your office had visible mold growth; you were proven to be made ill by re-exposure to the office. Your employer assures you the office has been cleaned thoroughly. (3) Now have three sick kids in a riverfront town in Massachusetts. Your children were told they had Lyme disease, but they didn't get better with tons of antibiotics. Another physician says your kids are sick from exposure to WDB.

How do you know if toxigenic molds are in your indoors? Spend a chunk of cash to bring in an industrial hygienist who takes a few air samples? Spend more money on more samples? When do you pay big bucks for mycotoxin testing?

Face it: Human illness that follows exposure to WDB has moved into daily medical practice, in part because confirmation of causation of human illness is backed by intense scientific research (1, 2, 3). Now that physicians can diagnose mold illness using simple tests and treat mold illness effectively, prospective inhabitants of dwellings all want to know: How can I be assured of safety?

Research has come a long way from earlier thoughts that exposure to WDB wasn't confirmed to be dangerous. A recent paper from the CDC on molds in New Orleans states, "Molds, endotoxins and fungal glucans were detected in the environment after Hurricanes Katrina and Rita in New Orleans at concentrations that have been previously associated with health effects (4)." And in the paper's acknowledgments, "We are indebted… to the US Department of Health and Human Services for ensuring the safety of the sampling teams (4)."

We're glad the CDC has caught up with current research on mold illness. Thankfully, that research gives us answers for the questions posed by our three patients. They can do home sampling for fungal DNA. For less than $500 and in less than 10 days, prospective occupiers of new building spaces have a chance to avoid inhabiting risky interior environments by first using the Environmental Relative Mold Index (ERMI). We know that the DNA testing, will not replace either industrial hygienists or careful home inspection as the best way to ensure safety but now no one interested in safety of a building can skip doing an ERMI.

WHY DEVELOP ERMI?

The tests we have used for years to assess mold contamination are flawed. Air samples taken for a few minutes were just a snapshot in time; they didn't actually represent a complete picture of ongoing health risks for occupants. We compared levels of organisms found indoors to outdoors, not distinguishing between genera found. "Mold is mold" was the underlying concept here; we all know that some genera of molds won't cause illness and others do. We tried to establish thresholds for levels of indoor molds but there are so many variables that impact on sampling that reproduction of results is difficult. Spore counts? Not when NIOSH told us that there were toxins on 500 tiny fragments of molds we missed for every spore we found (5). Why not test for mycotoxins alone? Mycotoxin testing has to be thorough, with multiple samples for multiple compounds. Talk about costs!

Thanks to the pioneering work of Dr. Stephen Vesper (6,10) and scientists at the Microbial Exposure Laboratories of the EPA, Cincinnati, we believe the problems involved with indoor testing may be solved. Just look for the DNA! The development of Mold Specific Quantitative Polymerase Chain Reaction (MSQPCR) and its application called the Environmental Relative Moldiness Index (ERMI) has brought the light of illuminating science into the darkness of indoor mold testing. ERMI is an objective, standardized DNA-based method that will identify and quantify molds. The science behind this breakthrough that led to MSQPCR is

Continued on Page 34

Figure 1. The Dust Collector contains a main holder, its caps on both ends & a filter insert.

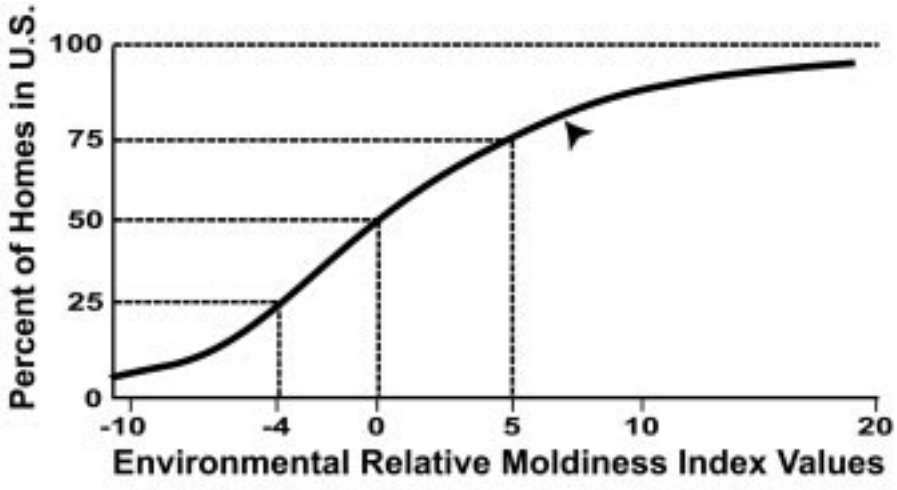
now patented (US Patent No.6,387,652). In 2006, the Department of Housing and Urban Development (HUD) used this technology to complete the American Healthy Homes Survey (AHHS). Based on this national survey and MSQPCR analysis of the settled dust in these homes, a national Environmental Relative Moldiness Index (ERMI) was developed.

In the American Healthy Homes Survey, dust was collected in a nationally representative sampling of 1096 homes by vacuuming an area three feet by six feet in the living room and bedroom for 5 minutes, each with a dust sampler-fitted vacuum (Figure 1). The settled dust is collected in a special in-hose device that is sent to a reference laboratory. At the lab, the individual samples are evaluated for quality and reliability against internal standards. Each satisfactory sample is then mixed and sieved through a 300 micron screen. The samples are each analyzed for DNA of 36 species of molds that can distinguish between molds found in WDB from molds found in non-WDB. ERMI doesn't measure DNA of all fungi, just those that describe the "relative mold burden" that has validity anywhere in the country.

WHAT IS THE ERMI

These 36 species were divided into 26 species/clusters associated with WDB (Group 1) and 10 common species/clusters not associated with WDB, called Group 2. The number calculated as the ERMI is actually the sum of the logs of the concentrations of the DNA of the different species. The "mold index" is the difference between Group 1 and Group 2. The laboratory will report the concentration of the 36 species in your sample (Table 1).

The computed ERMI values are graphed from lowest to highest (Figure 2). The scale ranges from -10 to 20. On the y-axis, the percentage of homes that fall into different ERMI percentages is shown. For example, an ERMI of 14 is in the top 25 % of homes for relative mold burden. An ERMI of -6 would be in the lowest 25% of homes. Each value is plus or minus three.



Group 1

Fungal ID \ Unit	House A	House B
	Spore E./mg	Spore E./mg
Aspergillus flavus/oryzae	ND	<1
Aspergillus fumigatus	<1	1
Aspergillus niger	<1	ND
Aspergillus ochraceus	ND	11
Aspergillus penicillioides	81	4600
*Aspergillus restrictus**	ND	ND
Aspergillus sclerotiorum	ND	13
Aspergillus sydowii	ND	ND
Aspergillus unquis	ND	ND
Aspergillus versicolor	ND	56
Aureobasidium pullulans	610	450
Chaetomium globosum	1	5
Cladosporium sphaerospermum	<1	24
*Eurotium (Asp.) amstelodami**	16	3600
Paecilomyces variotii	ND	ND
Penicillium brevicompactum	19	34
Penicillium corylophilum	ND	ND
*Penicillium crustosum**	ND	ND
Penicillium purpurogenum	ND	1
*Penicillium spinulosum**	ND	ND
Penicillium variabile	ND	6
Scopulariopsis brevicaulis/fusca	3	43
Scopulariopsis chartarum	ND	3
Stachybotrys chartarum	ND	1
*Trichoderma viride**	ND	3
Wallemia sebi	8	2400
Sum of Logs (Group 1):	**8.56**	**24.13**

Group 2

Fungal ID \ Unit	House A	House B
	Spore E./mg	Spore E./mg
Acremonium strictum	ND	1
Alternaria alternata	ND	ND
Aspergillus ustus	ND	1
Cladosporium cladosporioides 1	31	140
Cladosporium cladosporioides 2	1	4
Cladosporium herbarum	87	13
Epicoccum nigrum	37	570
*Mucor amphibiorum**	2	22
Penicillium chrysogenum	1	ND
Rhizopus stolonifer	<1	<1
Sum of Logs (Group 2):	**5.3**	**7.96**
ERMI (Group 1 - Group 2):	**3.26**	**16.17**

USING THE ERMI

The ERMI scale was derived from the analysis of the settled dust in the common living room plus bedroom of a home. Even if most of a water-intrusion problem in a home comes from the basement, we won't suggest sampling the molds in the basement first, as all the national standards are derived from sleeping areas and living areas.

So what should our patients do? The ERMI costs several hundred dollars, providing information that is potentially

Continued on Page 35

far better than limited testing done by an expert whose time can be a large part of the bill. Each of our patients did home samples. The beautiful home across town had a bargain price tag because of its multiple problems with the roof flashing by the chimney. An ERMI of 18 saved the patient a mountain of trouble. The secretary found an ERMI of 0.02. She has done well after remediation. The Massachusetts Mom 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.

Make no mistake; presence of health effects shown by a protocol that evaluates health will always trump an ERMI. ERMI is a mold index, not a health index. If the ERMI is elevated, you have 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. If you are not ill, an ERMI helps determine if your home is safe for visitors and loved ones who might have a different genetic susceptibility to mold exposure than you do. If the ERMI value suggests the home is in the upper 25% of the scale (i.e. ERMI above 5), then an investigation for water damage could be health-saving.

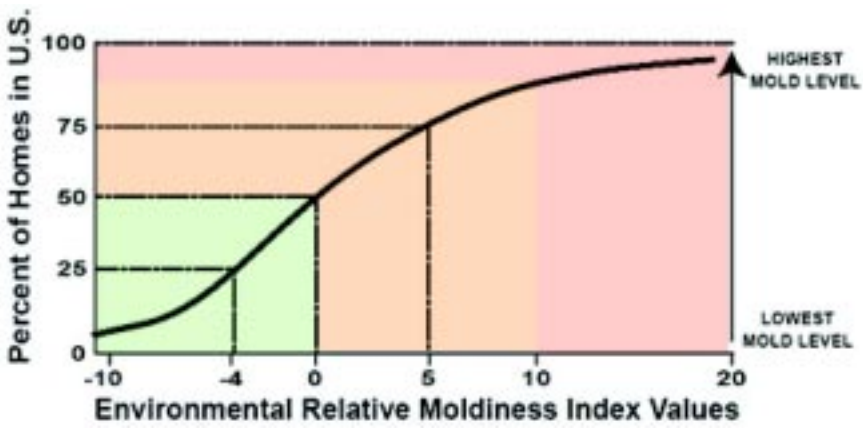
The Institute of Medicine's report (8) on dampness and health expressed the opinion that there was scientific evidence linking molds and damp environments with respiratory symptoms. The cut-off for literature to be considered by the IOM was 2003; the pace of mold illness research has long ago outstripped the earlier IOM recommendations. ERMI isn't discussed in the IOM.

ERMI is useful in clinical studies

In a recent paper (7), ERMI values were correlated with laboratory assays, symptoms, neurotoxicological studies and measurement of brain metabolites, lactate (indicating capillary hypoperfusion) and ratios of glutamate to glutamine (indicating the balance of excitation versus inhibition of neurotransmission). There was a clear association between an elevated ERMI and elevated levels of lactate measured by magnetic resonance spectroscopy (MRS), in hippocampus (memory) and frontal lobes (acquisition), together with reduction of normal ratios of glutamate to glutamine. An elevated ERMI was closely linked to brain fog, memory deficits and abnormalities in executive cognitive function.

Do high levels of mold, therefore, translate in genetically susceptible patients into inflammation that reduces blood flow in particular parts of the brain such that the brain doesn't work? Yes! Even better, (i) following treatment abnormal brain metabolites are reduced and (ii) the benefit of treatment maintained with re-occupancy of the home provided the post-remediation ERMI is less than 2. Relapse occurs if the ERMI is higher.

In a study conducted on homes of asthmatic children by Case Western Reserve, remediating water-damaged, moldy homes significantly reduced the asthmatic child's need for medical intervention (9). In a prospective study of atopic infants (6), measuring the mold burden with MSQPCR was a better predictor for development of wheeze/rhinitis than the home inspection.



Air samples can be useful to pin-point the location of a hidden mold problem. In order to take air samples for MSQPCR analysis, the polycarbonate filter is useful with either 0.45 or 0.8 micron pore size. The flow rates range from 2 to 16 liter/minute. The holder for the filter can be a button sampler or cassette. In MSQPCR analysis, the filter cannot be overloaded, meaning air samples can be taken for prolonged periods. However, there is no ERMI scale for air samples; dust is preferred.

What do we do with the ERMI kit?

Help is always just a few clicks away at www.mycometrics.com. First, locate 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. Record what these dimensions were and where you took them for later comparison. Next, do the same in the main bedroom.

Take off the protective caps of the sampler. Insert the filter into the dust sampler and place the sampler inside the vacuum hose. Use a separate dust sampler for each area sampled. Vacuum for 5 minutes, pull out the sampler and cap it. Send in a sealed bag for an ERMI analysis at an EPA-licensed ERMI laboratory. You should ask for a repeat ERMI, taken in the same spots as before remediation to assure clearance.

No sampling can replace the skill of the experienced mold inspector in investigating mold problems. ERMI is a helpful tool. As further research refines the use and application of ERMI we will have greater ability to direct use of ERMI testing.

Summary:

Identification and accurate quantitation of indoor molds to the species level is now available, using DNA analysis, the

Continued on Page 36

MSQPCR. This automated analysis provides for rapid, reproducible results that can be reliably interpreted. For patients, prospective home-buyers, industrial hygienists and remediators alike, ERMI shows great promise for the future.

Conflicts of interest: Dr. Lin is an employee of Mycometrics. Dr. Shoemaker has none.

References

1. Shoemaker R, Rash JM, Simon E. In: Bioaerosols, Fungi, Bacteria, Mycotoxins and Human Health; ed. by E Johanning MD 2005. Toxicology and Health Effects pp 66-77.

2. Shoemaker R, House D. Neurotoxicology and Teratology 2005; 27; 29-46.

3. Shoemaker R, House D. Neurotoxicology and Teratology 2006; 28; 573-588.

4. Rao C, Brown C, et.al. Applied and Environmental Micro 2007; 73(5); 1630-1634.

5. Gorny R, Schemchel D, et.al. Applied and Environmental Micro 2002; 68(7); 3522-3531.

6. Vesper SJ *et al., J. Occup. Environ. Med.* 2006; **48**, 852-858..

7. Shoemaker R, Maizel M. IACFS meetings 1/14/07, Fort Lauderdale, Florida.

8. Institute of Medicine, National Academies of Science. Damp Indoor Spaces and Health. The National Academies Press. 2004; p. 355.

9. C.M. Kercsmar *et al., Environ. Health Perspect.* **114**,1574 (2006.

10. Vesper SJ *et al., J Exposure Anal. Environ. Epidemiol.* 2007; 17; 88-94.

Ritchie C. Shoemaker, MD is a Family Practice physician from Pocomoke, MD. He writes from his experience of diagnosing and treating the world's largest series of 5500 patients with acute and chronic illness caused by exposure to biotoxins made by molds, spirochetes, dinoflagellates, and blue-green algae. His practice experience is the foundation that enables him to challenge much of what we hear about chronic illnesses from agencies and academics that don't treat the illnesses. For more information, contact Ritchie C. Shoemaker, MD, 500 Market St, Suite 102 Pocomoke, Md 21851.

King-Teh Lin, PhD is Laboratory Director at Mycometrics, LLC, Monmouth Junction, NJ. He earned his PhD in Molecular Genetic and Microbiology from Robert Wood Johnson Medical School. Soon after his postdoctoral fellowship, he continued on at the same University as a faculty, up till recruited by P&K Microbiology Services as a Director of R&D, where he was the first to commercialize the EPA-licensed mold QPCR technology and invented a new DNA testing for wood decay fungi. He has analyzed more than 10,000 PCR samples for both fungi and Legionella. His works have been published in many leading peer-reviewed Journals. In 2005, he established Mycometrics, LLC.

For more information, contact King-Teh Lin at kingteh@mycometrics.com