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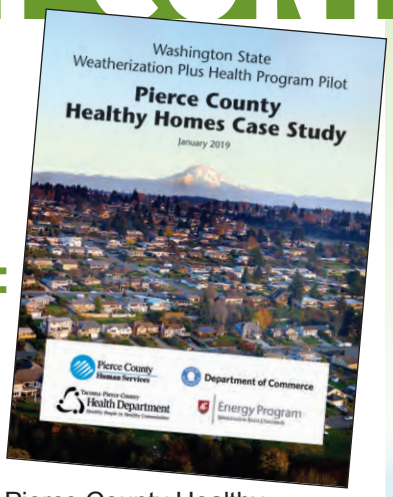








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# EDITORIAL

Healthy indoors magazine
www.healthyindoors.com Vol. 7 No.3, March 2019

# March Healthy Homes Madness?

Ah, it's that time of the year again, when like many of you, I will spend numerous hours in my home glued to the television watching college basketball games. Speaking about those extra indoor hours, we should perhaps also take some time to consider the environmental quality in those spaces.

Based on one's typical average life expectancy, we will likely spend more than 60-years in our indoor environments, with the bulk of that at home. Think about it for a moment. How important does that make the environmental quality of the places where you will spend most of your life?

Accordingly, we have devoted a signiflcant portion of our March Digital Edition to the topic of Healthy Homes. We take a look at a pilot study in the Paciflc Northwest that examines how improving one's indoor living spaces can help provide positive medical outcomes. Columnists Jeff May and Nate Adams both discuss ways we can better address some of the common issues that can adversely affect our indoor environments.

In the past few years there has been a lot of interest in consumer-type air monitoring devices, which has spawned a ton of new, affordable products. David Pariseau shares Part-3 of his technology series about Air Quality Instrumentation with his latest installment on Particle Mass (PM) Estimation in this issue.

Is it possible for you to have a Healthy Home? *The ball is in your court…*

Bob Krell

*Bob Krell*
Founder & Publisher

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# Healthy Indoors Show

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***Last year we ran a live special edition of the Healthy Indoors Show in a video webinar format on the topic of Carbon Monoxide, featuring Bill Spohn, CEO of Tru Tech Tools.***


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Last year we ran a live special edition of the Healthy Indoors Show in a video webinar format on the topic of Carbon Monoxide, featuring Bill Spohn, CEO of Tru Tech Tools.

The 60-minute progrom was well-received by the several hundred online attendees of the event, so we decided to include it for our March installment of our show, to provide this valuable information for the rest of our audience.

### Bill Spohn, P.E.

*Bill is President & CEO of Tru Tech Tools providing advanced tools & test instruments to technicians in the HVACR and Energy Audit Industries. He was previously a Product Marketing Manager at Testo, Inc., and has also served as both a consulting engineer and expert witness to the HVAC/R and related trades for over 30-years.*

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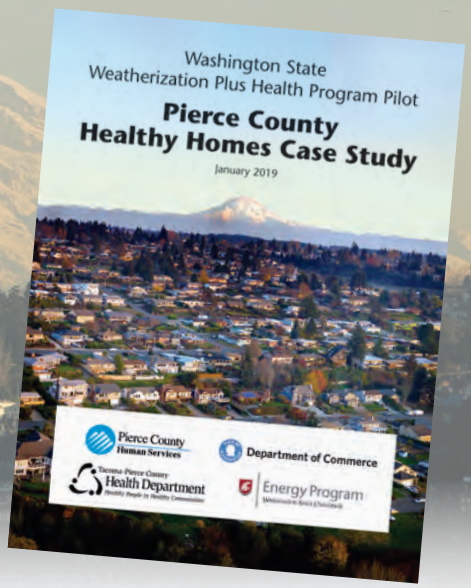
# A Collaborative Pilot to Improve Quality of Life for Asthma and COPD Patients

*By Judy Olsen, Environmental Health Supervisor, Tacoma-Pierce County Health Department*
*Larry Zarker, CEO, Building Performance Institute*




A collaborative healthy homes pilot in Tacoma-Pierce County, Washington yielded some promising outcomes for asthma and chronic obstructive pulmonary disease (COPD) patients. An evaluation of participants in the Pierce County Healthy Homes (PCHH) income-based weatherization program showed positive health beneflts. From the initial 53 households and 78 clients, 65% of clients had improved asthma control and 70% reported an improvement in quality of life.

In 2015, the Washington State Legislature provided additional state funds to expand the Matchmaker Low Income Weatherization Program and focus on healthy homes interventions. This allowed the Washington State Department of Commerce to create the Weatherization Plus Health (Wx+H) Initiative, designed to integrate weatherization, health, and social services so that all Washington state low-income housing is energy efflcient, safe, healthy and durable. PCHH was one of eight local weatherization partnerships to pilot integration approaches in 2016 and 2017.

The inability to assist families with costly environmental health concerns related to their home's structure has been a long-time frustration of the Tacoma-Pierce County Health Department's asthma program. Similarly, Pierce County Human Services' (PCHS) weatherization staff experienced the frustration of being unable to assist with identifled health needs. This pilot project built upon the known successes and challenges of each program. An unexpected positive outcome was the morale boost to staff from both agencies as they were able to provide more meaningful action and interventions.

## How the PCHH Partnership Works

The PCHS weatherization program partnered with the Health Department's Clean Air for Kids asthma program to create the PCHH Wx+H partnership. They developed a braided funding approach in which the Health Department's community health workers (CHWs) and PCHS weatherization auditors deflned priorities and roles. Most referrals came from within the PCHS network of clients obtaining weatherization, energy assistance or early learning services. Other referrals came through the Health Department's healthcare provider referral network. The weatherization auditor conducted an initial pre-audit of referred homes. This included:

- A walk-through for a healthy home assessment
- Information on weatherization services

- Energy conservation education, and
- Discussion of environmental triggers and air quality in the home.

On completion of the pre-audit, potential Wx+H clients received referrals to the Health Department. A CHW then provided 1-3 home visits focused on:

- Asthma or respiratory health management
- Comprehensive assessment of other needs, and
- Development of an asthma action plan.

During the grant period, Health Department and PCHS outreach and auditing staff met weekly to share information and coordinate services. Wx+H work on the homes was scheduled between 1 and 14 months after the initial CHW visit.

***"The Pierce County Healthy Homes Partnership serves as a national model for coupling the asthma action plan with an environmental action plan to produce positive health and quality of life outcomes for patients with asthma or other respiratory conditions," said Tonya Winders, President and CEO of the Allergy & Asthma Network and a founding member of the Healthy Housing Working Group. "The Working Group's mission is to ensure that everyone with allergies or asthma has an Environmental Action Plan," she said.***

## The Healthy Home Assessment

PCHH Wx+H auditors are certifled BPI Healthy Homes Evaluators (HHE) who conduct initial audits which include the use of Air Advice monitors that measure relative humidity, temperature, carbon dioxide, carbon monoxide, particulate matter, and volatile organic compounds. HHEs provide healthy homes education, based on their observations and Air Advice results. This education includes ventilation, moisture management, household cleaning, and other healthy homes measures.

Jennifer Bayeur is a Pierce County HHE who conducts a pre-audit for weatherization applicants. Bayeur began her career in the energy-effIciency world in 2012 and earned her BPI Building Analyst certifIcation in 2015. By 2016 she had the experience and pre-requisites needed to successfully obtain the BPI Quality Control Inspector certifIcation. In June of 2018 she added BPI's Healthy Home Evaluator certifIcation to her resume.

Working with the resident, Bayeur identifles energy saving opportunities and schedules a full energy audit for a future date. At the same time, she completes the Pollution Source Survey and asks if anyone in the home has asthma, COPD, or other respiratory issues.

Bayeur uses this opportunity to provide one-on-one healthy homes education to the resident. "The Healthy Homes Evaluator training really solidifled what I do and allowed me to see how the home and the occupant behaviors affect each other. You have to look not just at the house as a system, but also how the person lives in it." Bayeur explains the BPI HHE certifIcation prepared her to deliver not just energy savings to her clients, but also a better quality of life. She learned how to solicit household information from clients in a non-threatening way, without negative judgement. "I ask people: 'Tell me about your house. What would you change if you could?'"

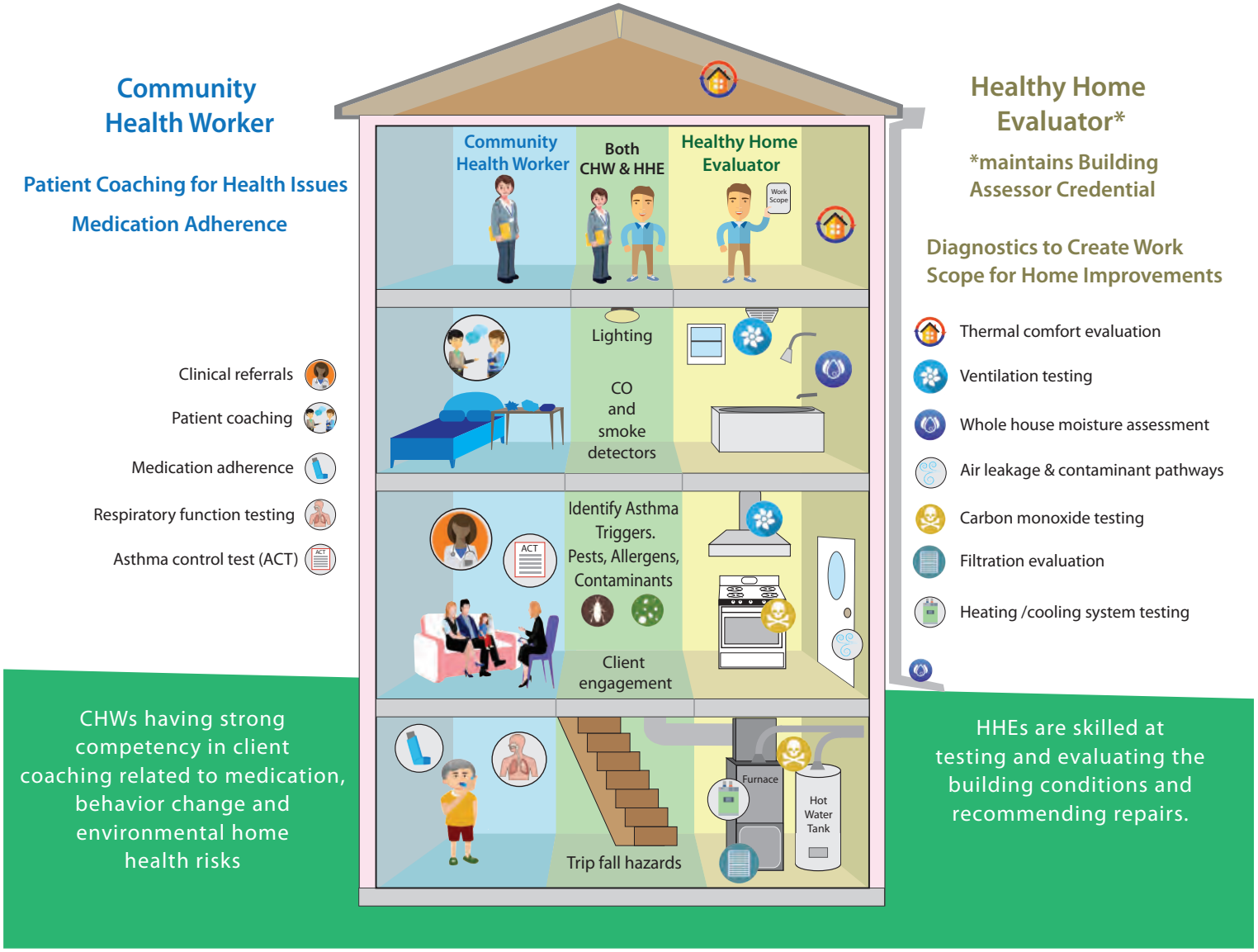
HHEs determine if the household could benefIt from additional "plus health" interventions. This may include structural changes such as carpet removal and plumbing repairs, or household items like HEPA vacuums, allergen bedding covers, and green cleaning kits. Weatherization staff also work with other energy reduction programs to assist clients in comprehensive weatherization (air sealing and insulation), ductless heat pumps, minor and major repairs, and the removal of woodstoves.

## CHW and HHE Ongoing Collaboration

When HHEs identify a household member with asthma or COPD, they make a referral to the Health Department's Community Health Workers (CHW). Sometimes a CHW is the client's flrst contact with the program after receiving a referral from the healthcare system. While the client works with the HHE and contractors to make weatherization and health improvements to the home, a CHW meets separately with the family to talk about managing their respiratory disease. CHWs are trusted members of the community, trained to provide health education and to support residents in making behavior change. They coordinate with the healthcare provider to review respiratory medications, make sure provider instructions are clear, and ensure each client has an asthma action plan.

Elodia Andres-Cornelio has four children with asthma and has worked as an Asthma CHW for three years. CHWs spend an average of 90 minutes at each visit talking with families to understand their needs. Andres-Cornelio tells a story of one Wx+H client who struggled with her 10-year old

# HEALTHY HOMES




*CHW and HHE collaboration help to improve health and quality of life outcomes for asthma and COPD patients in the PCHH Partnership. Graphic courtesy of Joe Medosch.*

son's asthma. "He has some developmental disability and the mother was very focused on his learning and development but did not have an asthma action plan at school. That was shocking to me, because he could have really had a problem and the school would not know what to do," she said. Andres-Cornelio contacted the healthcare provider to get an asthma action plan for school and taught the mother how to use safer cleaning products. According to Andres-Cornelio, "She was spraying freshener on the carpet in her son's room to cover up odors and using pine scented cleaners. I showed her how to use baking soda, vinegar, and safe products and we talked about opening windows and using fans to help with odors."

The HHE and CHW share observations and recommendations with each other, which allows for reinforcement of educational messages. Follow-up assessments showed 86% of households reported taking two or more actions to reduce environmental triggers or improve medical management. This behavior change success is likely due to CHW training in motivational interviewing, as well as the fact that clients hear health messages multiple times. Andres-Cornelio provides an example of this message reinforcement, "…the weatherization auditor had talked to a client about his Air Advice results and suggested he open his windows and use green cleaning because his results showed he was using a lot of strong cleaning products. When I went to visit, he had not stopped using them,

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*Elodia Andres-Cornelio spends time talking with a mother of four about her asthma symptoms.*

so I explained how these things were affecting his child's asthma." Andres-Cornelio reinforced the HHE's messages and the client allowed her to replace some of his cleaning products with a green cleaning kit.

CHWs help families identify and problem-solve for potential barriers, as well as refer households to other resources such as food and furniture banks, early learning, behavioral health and legal services. Households in the pilot project received anywhere from one to four educational visits with a CHW, depending on individual needs and willingness to continue with the program. The CHWs noticed that many deferrals were the result of client hoarding disorder. They are currently developing an alternative pathway for these clients that will result in increased services and more CHW visits prior to the start of weatherization work, in the hope of decreasing these deferrals.

## Some Key Outcomes from the Pilot

The results are not comprehensive but yield insights into the potential for collaborative CHW and Wx+H interventions to in‡uence positive health outcomes. Here are some of the outcomes:

- 86% of households with follow-up home assessments reported taking two or more actions to reduce environmental triggers or improve medical management.
- 65% of clients had improved asthma control and 70% of asthma patients reported an improvement in quality of life.
- The greatest areas of improvement for asthma patients were:
  - Symptoms (coughing and chest tightness)
  - Sleep (better sleep for patients and caregivers)
  - Anxiety, frustration and worry

***"I did like how they assessed both of my children's asthma and they checked the medicine that was in my cupboard. . . They explained to me that there was two different types of asthma and they showed me pictures and stuff …They did more than the doctors did. She told me things to do, clean my windows and stuff like this and vacuum rugs and stuff like that.***

***We have noticed a big change inside our home since the work was done. We have been doing what the (Community Health) Worker recommended and we've noticed our electrical bill is not high anymore.***

***My daughter's asthma has improved because I now know the right stuff to put in the nebulizer and they put it all out on paper which is something the doctors didn't do.***

***Seniors like myself, that are just living out of an SSI paycheck…that sometimes have to pick if they eat or pay to have a roof over them. After the weatherization work, my winter bills dropped from $300 a month to $90-150.***

***…Now I have air conditioning in my mobile home…But when I go out to drive on a hot day…in my pickup without air conditioning, I start wheezing quite a bit. As long as I'm in the house, it's fine.***

## Healthy Home Working Group (HHWG)

The HHWG is an umbrella organization dedicated to improving the quality of life for those impacted by asthma and other respiratory conditions. The HHWG is a collaboration of medical and building performance leaders including:

- Allergy and Asthma Network
- American Lung Association
- Asthma and Allergy Foundation of America
- American College of Asthma, Allergy and Immunology
- Association of Asthma Educators
- Green & Healthy Homes Initiative
- HomeLab
- Building Performance Institute

HHWG creates awareness and provides educational resources on the home's environment and its impact on health.

## BPI Healthy Home Evaluator (HHE) certifIcation

The BPI HHE builds on a prerequisite foundation of one of four BPI building diagnostic certifIcations. As a more advanced certifIcation, it positions technicians to conduct environmental risk assessments to identify factors in the home that could compromise the health of occupants. The HHE is designed to "Help Break the Link Between Unhealthy Houses and Unhealthy Families."

## BPI Healthy Housing Principles (HHP) Reference Guide and CertifIcate Exam

Designed for CHWs and others who need to know the principles of healthy housing but may not be trained to conduct diagnostic testing or maneuver through crawl spaces or attics, the HHP focuses on the eight "Keep It" principles (dry, clean, pest-free, safe, contaminant-free, ventilated, maintained, and thermally controlled). Modeled after BPI's widely used Building Science Principles, the new HHP reference guide and exam will be available in May 2019.


- Fewer impacts and interruptions for caregivers
- 97% of asthma patients and caregivers reported that asthma had some negative impact on their quality of life. This dropped to 50% after the intervention.
- One year after initial services were provided, study participants reported four fewer Urgent Care visits, flfteen fewer Emergency Room visits and six fewer hospital admissions.

## Client Reactions to the PCHH Partnership

Clients shared appreciation of the Healthy Homes program during phone follow-ups. Their comments ranged from gratitude for the CHW's medication review done by the CHW to the healthy home suggestions and interventions the HHE recommended.

## Summary and Conclusions

Washington State University's Energy Program conducted a comprehensive case study of the PCHH as part of its ongoing work with Commerce to evaluate and learn from the Weatherization Plus Health Initiative. Vince Schueler, WSU EP lead researcher for Wx+H noted that "One of the reasons we focused on PCHH for a case study was because the model was a strong example of potential partnership between public health and local weatherization agencies, and because the Health Department was committed to collecting client data needed to tell the story."

The completed case study found that despite a complex client mix and small sample sizes, it was possible to detect evidence of improved health outcomes, improved Quality of Life and lower use of medical services. This case study also highlights the challenges and opportunities of providing integrated weatherization, healthy homes and home visit services to low income weatherization clients. Evaluators noted the importance of cross training, "CHWs must have the skills to address multiple health conditions including asthma, COPD, mental health and co-morbid conditions. Weatherization program staff also needs additional training and support to work with these clients."

The partnership works on continual quality improvement, modifying processes and protocols as they learn and grow. An internal evaluation revealed the importance of four areas in a new weatherization plus health partnership; deflning roles and processes, avoiding duplication and flnding synergy, communications, and training.

**Training:**

- Early cross-training and job shadowing is critical.
- Motivational Interviewing skills for all CHWs and auditors.

**Roles and Processes:**

- Be clear about the requirements and needs of each program for both staff and client.
- Deflne program limitations, such as income or documentation requirements for clients.
- Determine work and process ‡ow.
- Decide on evaluation details up front-energy and health outcomes, timeframes, and responsibilities.

**Look for synergy/avoid duplication:**

- Decide which aspects of the home and household each partner will evaluate.
- Ensure consistent health messages and determine which ones need reinforcement.
- Determine who will order and deliver supplies to the client.

**Communication:**

- Choose how frequently the team will meet and whether in person or by phone.
- Identify how the CHW and auditor will communicate and share client information.
- Ensure all communication is HIPAA compliant. Create a terminology and acronym dictionary to avoid confusion or miscommunication.

Although CHWs are not available in every location, other possible health partnerships include public health nurses, health insurance providers, health educators, AmeriCorps and Vista volunteers, or nursing student interns. Weatherization and health partners working together provide a greater outcome than the sum of the two parts. Bayeur describes the PCHH partnership to clients as a “Great big community hug.” With consistent communication, they can reinforce messages and provide timely support to address client barriers, ensuring healthier and happier households.

## Resources

Washington State Weatherization Plus Health Pilot: Pierce County Healthy Homes Case Study, January 2019
http://www.commerce.wa.gov/wp-content/uploads/2019/02/Pierce-County-Healthy-Homes-Case-Study-Jan-31-2019-flnal-1.pdf

Washington State Weatherization Plus Health Pilot: Implementation and Lessons Learned, July 2018
http://www.commerce.wa.gov/wp-content/ uploads/2018/08/WxHSummaryReport1.pdf

## About the Authors

***Judy Olsen*** *is an Environmental Health Supervisor for the Healthy Homes, Clean Air for Kids, and Air Quality programs at Tacoma-Pierce County Health Department. Judy has been with the health department for over 15 years. She is a Registered Environmental Health Specialist and Certified Asthma Educator, leading staff in the program areas of asthma, lead, smoke-free housing, and general indoor and outdoor air quality. Judy is a subject matter expert in asthma and environmental triggers. She has presented on this topic at multiple local and national conferences, including the American Public Health Association and the National Environmental Health Association. Judy led the health department’s team of Community Health Workers as part of Pierce County’s pilot Weatherization Plus Health project.*

***Larry Zarker*** *is the CEO of the Building Performance Institute, the professional standards setting and credentialing organization for both the weatherization and home performance contracting industries. He oversees BPI’s national network of over 12,000 certified professionals and BPI GoldStar contracting companies. He was instrumental in moving BPI toward the new Healthy Home Evaluator certification. Prior to BPI, he worked for nearly twenty years with the NAHB Research Center and was the Vice President of Marketing for over a decade, serving both the new home and remodeling sectors with innovative product development and research.*

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# The Spore-Trap Trap

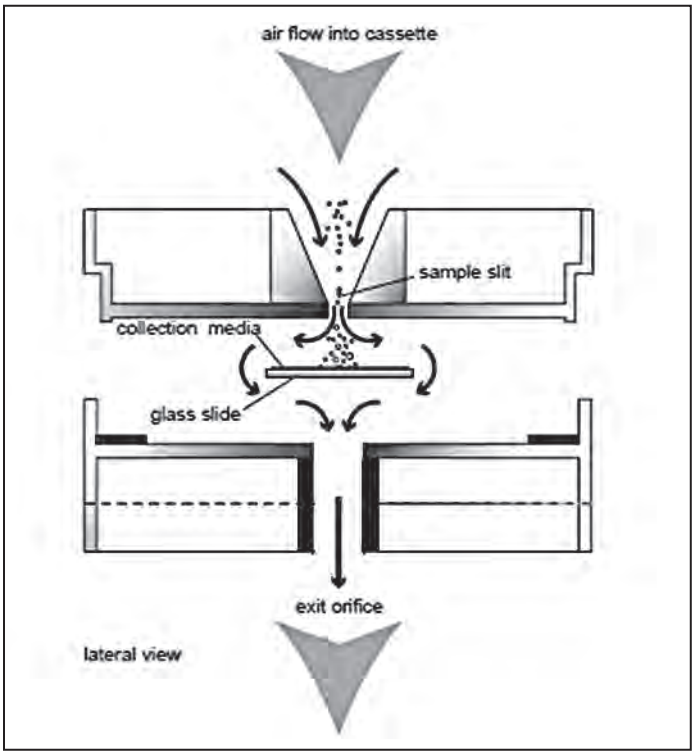
*By Jack Springston, CIH, CSP, FAIHA*

Those of you who know me know that, for years now, I have had issues with the ongoing proliferation of certifIcates and certifIcations in the indoor air quality (IAQ) and mold profession. By last count, the American Council for Accredited CertifIcation (ACAC) has 12 different contractor and investigator certifIcations related to IAQ, and another 8 certifIcations related to mold and moisture control. In addition to ACAC, there are a multitude of other groups and organizations who also issue their own somewhat dubious certifIcations related to IAQ and mold. You say you want to be a "Certifled Formaldehyde Sampler" and do testing in homes with laminate ‡ooring? No problem, just step right up, pay us a bunch of money, take one of our training classes, and, wham, now you are certifled! With the enactment of the New York State mold regulations, for example, I think it's safe to say we will be seeing a whole new generation of 2-, 3- and 4-day wonders who will be able to point to their state issued licenses and proclaim that they are mold "experts". In New York, the new mold assessor designation is responsible for determining the clearance criteria of mold remediation projects. It is a certainty that, not knowing any better, many of these newly minted "experts" will choose to collect spore trap samples and assign some sort of arbitrary criteria without ever understanding the shortcomings and pitfalls of this methodology.

## Flow rates and inertial impaction

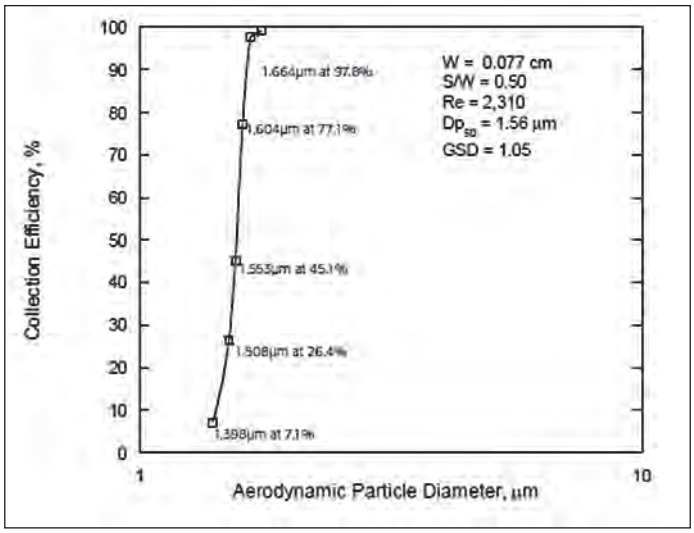
Standard spore trap sampling devices function by pulling air through a sample slit, which accelerates the particles in the air stream, and then ‡ing those particles at a small glass slide that is covered with a sticky sampling media (think ‡y-paper or a glue trap). The device works on the principal of inertial impaction, which I described in some detail in my June 2015 article for Healthy Indoors ('Ghosting and things that go Bump'). Short version – when air sharply turns and bends, particles in the air stream tend to keep moving in a straight line and bump into stuff. The bigger the particles, the more likely they will hit the surface and stick. The smaller the particles, the more likely they will bend with the air and pass right by. Each manufacturer has their own optimal ‡ow rate for their samplers and cassettes, which is designed to try to ensure that as many small particles as possible will be captured. If the ‡ow rate is too slow, then

the smaller particles, such as mold spores, will pass by and not get collected. Not really an ideal situation when you are trying to sample for mold spores. If the ‡ow rate is too fast, then larger particles will strike the surface of the collection media too hard and bounce off.




## Face velocity and outdoor sampling

The face velocity of a sampling cassette is essentially how fast the air is moving, at the face of the cassette, as it gets pulled in by the pump. In industrial hygiene, knowing the face velocity of the sampler is critical when doing isokinetic sampling in an airstream because of the inertial impaction thing. The face velocity of the standard Air-O-Cell spore trap cassette, when run at the recommended ‡ow rate of 15 liters per minute, is slightly less than three-and-a-half miles per hour. What this means is, right at the face of the cassette the air being pulled into the cassette is moving at three and a half miles per hour. As you move away from the face of the cassette, the air velocity drops off precipitously, so much so that the velocity a mere two inches away from the cassette face is virtually non-existent. So why does this matter? Well, if you are sampling in a nice quiet room where there are no real air ‡ows or currents, then we don't have any real issues. However, if you are collecting an outdoor air sample, and there is a wind blowing across the face of the cassette at a faster speed than a light breeze, then many of those small particles get blown right by and are never captured. The faster the wind speed, the more particles within that air stream that the device will fail to capture. So much for trying to compare the results from your outdoor samples to the indoor samples.




## Cut size and Aspergillus/Penicillum results

The 50% cut-size (D50) of a standard Air-O-Cell cassette, at room temperature and when run at the recommended ‡ow rate, is about 2.6 microns (um). What this means is that half of the particles with an aerodynamic diameter of 2.6um will impact the collection media in the sampler, and half of them will pass right by. Mind you, I said that half the particles will impact the collection media. This does not mean, however, that all of them will actually stick and stay there. The more particles that are already stuck on the media, the more likely that other particles will hit them and bounce off. In addition, the cut-size curve for spore trap samplers tends to be extremely steep. For instance, the D50 for the Via-Cell sampler is 1.56 um. However, when you get down to an aerodynamic diameter of about 1.51 um the collection effIciency drops down to about 26%, and at an aerodynamic diameter of 1.4 um it is only around 7%. So, you may ask, why is this important? Well the aerodynamic diameter for Penicillium and Aspergillus spores is generally in the 1 to 3 um range, so if you are sampling in an environment which has been contaminated by these types of mold then chances are you're likely missing more than half of the spores that are actually present when you collect your sample.

## The trouble with laboratory results

Another thing that many newly-minted mold assessors need to be aware of is just how inexact the laboratory analysis of spore trap samples really is. Back in 2011, Larry

Robertson and Bob Brandys published a paper looking at this particular issue. They submitted 16 pre-mounted spore trap samples to seven different American Industrial Hygiene Association (AIHA) environmental microbiology accredited laboratories for analysis. According to each of the labs, their most competent analyst in performing spore trap analyses analyzed the submitted samples and read 100% of the sample trace. The results were rather eye opening. Total spore counts from the laboratories were highly variable, with ranges varying by more than an order of magnitude. Results from the individual spore categories were also highly variable, with the standard deviation frequently exceeding the mean. Even more disturbing was the fact that only 75% of the laboratories consistently identifled Cladosporium, and only 50% of them were able to identify Aspergillus/Penicillium-like spores. Essentially, the take-home lesson is that if you don't like the results that you get from one laboratory, just send the same samples to another lab. Chances are, you will get completely different results.


*The "Subjective Science" of Mold Sampling with Bob Krell (2014)*
https://vimeo.com/157923743

Speaking of the Aspergillus/Penicillium-like group, many misinformed "experts" believe that the Asp/Pen spore counts that they receive from the laboratory mean that there actually is Aspergillus and/or Penicillium present in the sam-ple, and that these counts are representative of what was in the air at the time of sampling. What some people may not realize is that this group of spores is actually comprised of hundreds of different species of not only Aspergillus and Penicillium, but numerous other types of fungi, including Tricoderma, Cladosporium, Mucor, Beauveria, and Pae-cilomyces, as well. Indeed, this reported group of spores is nearly as meaningless as "amerospores", which many laboratories report in their sample results. Amerospores is actually a morphological category of spores, which con-sists of non-filamentous, single-cell spores with a length to width ratio of <15:1 and with no projections longer than ¼ of the body length of the spore. All sorts of unrelated fungal spores can fall under that category, including single spores of Aspergillus and Penicillium.

Which brings me to one of my greatest pet peeves – consultants who assign arbitrary criteria levels for spore trap samples and then tell a homeowner that the air in their apartment is unacceptable because the Aspergillus/Penicillium-like counts indoors are 500 spores per cubic meter higher than the outdoor levels. Seriously? What if your outdoor Asp/Pen counts were 10,000 spores per cubic meter - a number that you could reasonably expect to see outdoors in Florida or Louisiana during the summertime. Are you still going to stick with that absurd criteria? Or how about the consultants that say the air is unacceptable because the indoor spore levels are twice as high as those found outdoors? Are you really going to tell me that an indoor count of 200 spores per cubic meter is unacceptable because the outdoor sample that you took, when there was snow on the ground, only came back with 60 spores per cubic meter? Better hope that we don't end up on opposing sides in a courtroom.

Robertson LD and Brandys R. 2011. A multi-laboratory comparative study of spore trap analyses. Mycologia. 103(1):226-231.

***Jack Springston, CIH, CSP, FAIHA,*** *is the Industrial Hygiene Services Manager for ATC Group Services' metropolitan New York area operations. Jack is an industrial hygiene consulting professional with over 30 years of experience in recognizing, evaluating, measuring, and controlling employees' exposures to health hazards in their workplace. He has been a Certified Industrial Hygienist since 1993 and is one of less than 50 CIH's who also currently have a sub-specialty certificate in Indoor Environmental Quality. Jack has participated in and over-seen hundreds of indoor environmental quality studies. Contact him at: John.Springston@atcgs.com*

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# Air quality instrumentation Part III: Particle mass (PM) estimation

By David Pariseau

In the previous installments, I discussed ISO21501-4 (a standard used during particle counter calibration for the cleanroom industry) and how it served to bring a degree of rigor to air quality measurements in the cleanroom and manufacturing industry. In this installment, we'll discuss particle mass (PM) estimation in air quality instrumentation.

First of all, let's look inside some simplifled air quality sensors to see how they function. There are two main types of optical air quality sensors: optical particle counters and optical photometers. A general overview and discussion of the limitations and challenges for each type of sensor follow below.

## Optical particle counter

In the case of an optical particle counter, the sensor estimates air quality as follows:

a) The air enters an inlet which reduces the ‡ow to a thin high-velocity stream of particles,

b) On exiting the nozzle these particles pass through a beam of focused light one at a time (ideally),

c) As each particle passes through the beam it scatters photons in all directions,

d) Some of these scattered photons will directly hit or be re‡ected onto the photo-detector,

e) The number of photons that reach the detector is closely correlated with the size of the particle, (assuming that they pass through a beam with reasonably uniform intensity at a reasonably uniform velocity),

f) A photo-amplifler amplifles and converts the signal from the photo-detector into a voltage pulse,

g) The amplitude (or height) of that voltage pulse is indicative of the particle size,

h) Sensor electronics bin these pulses by size into separate channels, and keep a count of pulses in each channel,

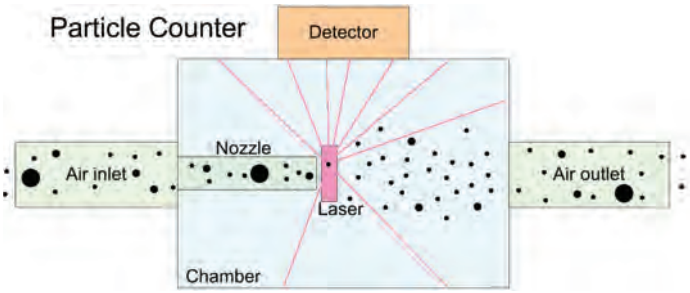
i) These channels are conflgured during a calibration process where particles of known sizes are used to establish the pulse height threshold for each channel,

j) Periodically these channels are read and reported, indicating particulate counts by size over a user-deflned sample period,

k) Using the elapsed sample period these counts can be easily converted into estimates of particle concentrations by size within a volume (e.g. cubic-foot, or cubic-meter),

l) To estimate particle mass, average size is attributed to each channel and then that size is used along with estimates for particle density and refractivity to determine an estimated mass for one particle within a channel,

m) The estimated mass for each channel coupled with the previously determined concentrations for each channel allows us to then estimate total mass by channel and then to group various channel masses to form more common mass measurements like PM2.5 etc.




Some of the challenges with estimating particle mass from such a sensor are:

**Manufacturing standard:** If a sensor pass passes ISO21501-4 it ensures a reasonable level of performance for this sensor. Sensors that are not ISO21501-4 compliant can have serious challenges in reporting accurate particle counts and hence providing any reasonable estimation of particle mass. Some 3rd party studies have shown very poor results for many of the low-cost "particle counter" type sensors being provided for the indoor air quality industry.

Coincident particulates: ISO21501-4 requires manufacturers to state the maximum concentration the sensor can operate in given minimal coincidence (i.e. more than one particle passing through the beam at a time). The user can then determine whether this meets the requirements of their expected environment and expect reduced accuracy when an environment that exceeds this stated threshold is encountered.

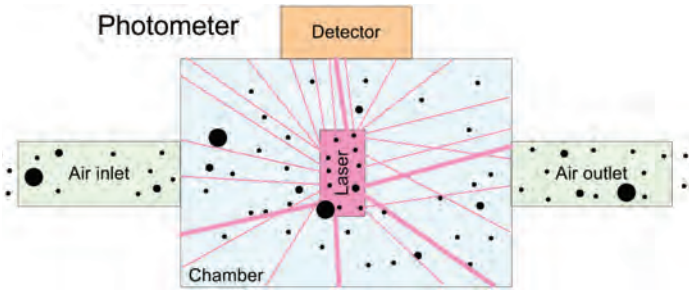
**Size estimation:** This is a critical factor in determining mass. Since the volume of a sphere is the cube of its diameter it's imperative that we arrive at a reasonably accurate estimation of the actual size of all of the particles we see. The table on the right shows an example of PM calculation by size for a 6 channel sensor. For the sample period this sensor saw nearly 13,000 particulates in the 0.3um channel and only 79 particulates in the 2.5um channel, yet, the estimated mass of the 2.5um particulates in the 2.5um channel is more than 5 times as large. It has a huge impact on the quality of this estimation and so the more accurately a sensor can estimate the size of particulates the more accurately that sensor can estimate particle mass for particulates in a channel (or multiple combined channels, as in PM2.5).

| Channel (um) | Channel (counts) | PM (ug/m3) |
|---|---|---|
| 0.3 | 12980 | 0.38 |
| 0.5 | 1413 | 0.28 |
| 1.0 | 181 | 0.45 |
| 2.5 | 79 | 1.93 |
| 5.0 | 12 | 2.34 |
| 10.0 | 9 | 14.04 |

**Other factors:** When estimating mass a number of factors impact this estimation. The density, refractivity, and even the geometry of particles passing through the sensor can impact the mass estimation. As you might imagine a dark, and very dense particulate will have a much lower mass estimation than a less dense and paler particulate even if they are of identical size. Typically the sensor allows the user to apply a correction factor to account for this, that way if the user knows something about their environment (e.g. gypsum production plant vs. a coal mine) they can take gravimetric samples and add the correction to the sensor to account for such a variation (if this is desired). High relative humidity can also have an effect on particulates. They can act like seeds and absorb moisture growing in apparent size within a sensor. This is more pronounced outdoors in high-humidity environments. In such environments, heaters can be installed on the inlet to attempt to remove the moisture from the incoming air stream in an attempt to improve sensor accuracy.

## Optical Photometer

In the case of an optical photometer, the sensor estimates air quality as follows:




a) A much larger inlet allows air into a chamber,

b) The air passes through the chamber, some of it passing through a beam of light within the chamber,

c) Particulates passing through the beam scatter photons, though in this sensor there are many particulates in the beam at the same time,

d) Some of these scattered and re‡ected photons will hit the photo-detector,

e) The detector collects an "aggregate" reading for ALL the particles it is currently "seeing" over some period,

f) The detector takes that reading and compares it to readings obtained during a much cruder calibration process and assigns that reading an estimated mass,

Some of the challenges with estimating particle mass from such a sensor are:

**Manufacturing standard:** As noted in previous installments, at present there is no manufacturing standard for such sensors, and most of the offerings targeted at the air quality space make use of a sensor that is only marginally better than a random number generator.

**Calibration:** Aside from inherent issues in the design of many of these sensors, the calibration process for these can also be an issue. The calibration typically relies on a reference instrument (with no requirement as to its traceability) providing a "measure" of air quality for the air in a large chamber. A poorly controlled amount of particulates are added and typically agitated within that chamber (i.e. some dust is added and blown around by fans) and a large number of sensors are connected to the chamber with the reference instrument. The value on the reference instrument is then used to "calibrate" all of the sensors, based on the value they are currently seeing. In such a system it's doubtful that repeating the process with a sensor would yield the same or similar calibration value.

**Size and count estimation:** At the root of the issue is the challenge of truly estimating the number of particles or estimating their size distribution.

- There are no size bins the reading is the aggregate of the total scattered light over some sample period. But, a handful of smaller particles in the beam can scatter a similar amount of light as one larger particle, but as we saw in the table above the mass estimation difference between smaller and larger particles (since mass is the cube of the size) is enormous, so it's impossible to get a good mass estimation without having some idea of the size distribution. The most expensive photometers have either manual or automated means of excluding larger particles from the air stream (e.g. impactors, cyclones, etc.) in an effort to better control the size distribution of particles they are measuring. But, it's a crude tool at best and doesn't provide any size distribution for the particles you are measuring, and none of the low-cost photometers have even this rudimentary ability.
- It's impossible to control the uniformity of a beam of light over a large area within a chamber (in a particle counter the alignment is critical to within a few microns!). So some particles will pass through a more intense area of the beam, while others will pass through the beam's fringes, while still others will miss the beam entirely. You can argue that this will average out, but since there is no uniformity to the particle sizes, and since there is such a huge impact from size on estimated mass, there would be a signiflcant variation in estimated mass if we passed the SAME air through such a sensor multiple times.
- Air‡ow velocity is important in particle counters since the amount of scattered light is directly related to the speed of the particle passing through the beam and the beam's intensity. In these sensors, because of the design of the chamber there is a large velocity gradient to the air moving through the chamber. Like a river where the water in the center of the stream is typically moving much faster than the water along the banks, the air in the center of the chamber is moving much faster than the air along the walls. So, slower particles passing through the beam will scatter more light than faster particles of the same size.
- Air‡ow laminarity (a measure of how linear the air‡ow is between the inlet and outlet) is important as well. The velocity gradient mentioned above and the geometry of the chamber creates eddies within the air ‡ow so that some of the particles will recirculate through the chamber and get counted multiple times. To make mat-

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ters worse, these eddies are much slower and so these particles will scatter much more light on subsequent passes than they do on their initial pass through the beam. Some particle counters we have the means to exclude these from being counted, but there is no such mechanism possible in a photometer.

**Other factors:** As with the particle counter the same external factors: particle density, refractivity, geometry affect the conversion of scattered light into an estimate of particle mass (i.e. if the sensor is measuring particles different than the ones it was calibrated with, we'll get different values for estimated mass). And, typically many of these sensors have no means for adding a correction factor. Also, the same issue applies for relative humidity and again there is seldom an option of adding a means of controlling humidity with these sensors.

**Coincident particulates:** One of the cited strengths of this architecture is that such a sensor is able, in theory, to operate in environments with higher particle densities. Since only an aggregate count is seen (i.e. we're not measuring every particle) the electronics are much simpler and there is very little processing required to yield a result (e.g. periodically just read the value on the detector and convert that to a PM value using a "calibration" factor). However, the reality is that in order to measure both a very clean environment AND a very dirty environment with the same sensor the actual dynamic range (the difference in the amount of light seen at the detector) is enormous. A very clean environment will have very few particles transiting the sensor and scattering precious few photons while a very dirty environment in such a sensor will create a standing cloud of particles in the beam which typically saturate the sensor. And, since there is no manufacturing standard or credible test for performance of these, even if these sensors were accurate there'd be no way to specify the accurate working range for one of these sensors. And, though some of these sensors claim to be able to detect ultra-flne particulates 0.2um and smaller, they only do so in aggregate (they look at the sum of the photons scattered), so they only start seeing the faintest of readings if MANY such particles are present and in such a case the flgure they gather is hardly representative of the population that may actually be present.

## The sad truth of optical photometry in air quality products

If the above is the case, then how do these sensors perform so well in the fleld? It doesn't seem like it would be possible for so many of the sensors scattered across a geographical area to agree on air quality if the above were the case. The above perplexed me some as well, and the reality of what has become common-place for "low-cost" sensors in this industry is quite shocking. Below are some of the methods these sensors use to attempt to improve their measurement accuracy.

a) As noted the best of these sensors use a system of size selection schemes (automated or manual) to attempt to create a size distribution with which to inform their mass estimation. At the upper end of the price scale, this improves the accuracy signiflcantly but they still have all the other challenges associated with this architecture but it is a reasonable attempt at improving measurement accuracy.

b) Reference instruments are often qualifled away from pollution sources (outside a city for example) in order to use the expected background levels as a means of achieving the desired accuracy. That's great if all your measuring is reasonably clean air away from the area you truly care about. But, it doesn't re‡ect the reality of the environment and conditions you want to ultimately monitor and function within.

c) Normalization and post-processing in the cloud. This is truly egregious. Some sensor networks push up all their raw data and perform some normalization algorithm in the cloud and then push a processed value back to the sensor for local display or display that processed value on the cloud. So, when all the sensors in a geographical area largely agree on the air quality, it's not a ‡uke that this is the case or a measure of how good these sensors are, it's a function of the smoothing algorithm that's used to turn bad data into apparently good results.

In some of these cases, these algorithms rely on a reference instrument located in that geographical area to provide the bulk of the reading and then slightly altering that reading based on the local sensor reading. The words sound good in a sales talk perhaps, with words like normalization and post-processing in the cloud lending an air of sophistication and technology to the offering. But, if we look at what's actually being done it becomes less much less appealing. Who would stand for the temperature sensor in their home going out to the cloud to ask what temperature other sensors in the neighborhood thought it was and then adding or subtracting a bit from that value based on the local sensor to arrive at an estimate for the local temperature?

You can argue that outdoor air quality is really homogenous, so doing "normalization" in that case improves performance. If that's the argument then why not simply download

a smartphone app to get the value directly from a reference instrument located nearby and ignore the local sensor entirely? This would be a much more transparent, and likely a more accurate, implementation. And, it's not even worth discussing how poorly such a system works for indoor air quality measurement.

## How did we get here and where do we go from here

So, how did we get here? Well, as we saw in previous installments, air quality measurement arose out of a need to control manufacturing environments in the cleanroom space. The companies that served this market created sophisticated instruments to measure in many cases handfuls of tiny particulates. Over time these grew to be rather complex and expensive instruments.

The commercial and residential air quality space by contrast needed products that were much lower in cost and much simpler for the average user (not an air quality expert) to use. So, sensors were cobbled together that gave some measure of air quality, however crude, since something was better than nothing. I've heard that phrase repeated many times to explain the current state of sensors in this space. And, the reality it's true in cases where you understand the accuracy of the data you're getting and make allowances for the uncertainties when you make decisions based on that data. However, when your sensors are ‡at out lying to you and guessing at what the air quality might be based on data from external sources at best very poorly related to your sensor then inferring anything from that data puts you at great risk of making the wrong decision.

The purpose of this article isn't to run down particular companies or products, as you've likely noted I haven't mentioned any company by name. To date we've had in-depth discussions with most of the companies offering products in this space globally. Nearly all of them are well-intentioned and trying to do the best they can for their clients with what they have. Most are eager to hear about and evaluate new technology with an eye to improving their products for their clients.

We're at an exciting time in this industry. We're seeing huge growth as an industry and air quality is increasingly on everyone's mind and being considered. The readers of this publication are largely the stewards and experts in this space and as such it's our responsibility to help shape and guide progress in measurement so that we improve the quality of our measurements and make them as accurate and reliable as we can. In doing so we can safeguard the health and well-being of those who rely on us and the technology we use and provide.

Finally, it's clear from multiple papers that PM measurements only tell a small part of the story and that size distribution, particularly vis-à-vis ultra-flne particles, is increasingly critical in safe-guarding health and well-being. If we're to address to provide a means of characterizing air quality to re‡ect this reality it's clear we'll have to modify or extend what we're currently doing to encapsulate this information. In the next installment, I'll discuss how the cleanroom industry specifles the cleanliness of a room, with the intention of proposing we how we might measure and report indoor/outdoor air quality to provide more information than a simple mass flgure.


## About the Author

***David Pariseau*** *is an embedded systems design engineer with 36 years of development experience in consumer electronics, financial payment, medical devices, lab instrumentation, industrial controls, and machine design. David was the original founder of Lighthouse Associates (now known as Lighthouse Worldwide Solutions) in 1985, Technology Plus in 1995 and SinoEV Technologies in 2009. He co-founded Particles Plus in 2010 which is focused on bringing quality products into the mainstream commercial air quality monitoring space. He can be reached at* dpariseau@particlesplus.com

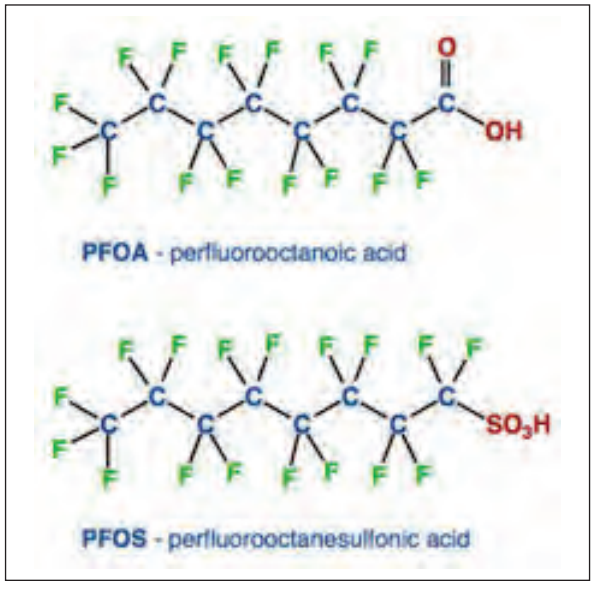
# Toxic Water – The PFAS Dilemma

*By Dr. Alice Delia*

There's a new bad guy in the environmental world. A group of about 3,000 man-made chemical compounds known collectively as PFAS (per and poly-fluoroalkyl substances) is being hailed as a contaminant of emerging concern.

Starting in the 1940s, PFAS have been used in non-stick cookware, water and/or stain resistant fabrics and carpets, some food packaging, fire-fighting foams, and pretty much anything that resists heat, water, oil, or grease.

Because of the wide range of uses, PFAS contamination has spread far from the original sources and can now be found at low levels in many areas and in blood samples of the general population. The two most extensive members of this group are PFOA (perfluorooctanoic acid) and PFOS (perfluorooctanesulfonic acid).



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# ASK DR. ALICE

## So, what makes these substances so dangerous?

They are persistent in the environment, meaning they do not break down quickly. Many of the larger PFAS can remain in the environment for years and spread through water (including drinking water), sediment, and soil.

Most PFAS are also highly toxic. Due to their persistence, PFAS bioaccumulate in the human body, i.e., they don't break down. Studies show a large range of possible effects from exposure, including liver and kidney damage, thyroid conditions, low infant birth rate, and possibly cancer for some members of the group.

The health effects of exposure to PFAS are still being studied, but enough information has been gathered to provide estimates of daily human exposure that does not represent appreciable risk of adverse health effects.

## How do PFAS compare with other contaminants in terms of toxicity?

| | | |
|---|---|---|
| Formaldehyde | 300 | Primarily found in wood products |
| PFBS | 10 * | Per‡uorobutane sulfonic acid; replacement for PFOS |
| PCE | 8 | Perchloroethylene; dry cleaning |
| Chlordane | 0.6 | Pesticide |
| DDT | 0.5 | Dichlorodiphenyltrichloroethane; Insecticide |
| PCBs | 0.03 | Polychlorinated biphenyls; lubricant and heat-resistant ‡uids |
| GENX | 0.08 * | Trade technology that does not use PFOA (replacement) |
| PFOA | 0.003 | Per‡uorooctanoic acid |
| PFOS | 0.002 | Per‡uorooctanesulfonic acid |
| TCDD | 0.00002 | 2,3,7,8-Tetrachlorodibenzodioxin (dioxin) |

* Draft chronic toxicity value (US EPA).

*Values are oral intermediate (2 weeks to 1 year) ATSDR Minimal Risk Levels except as indicated, expressed as ug/kg/day.*

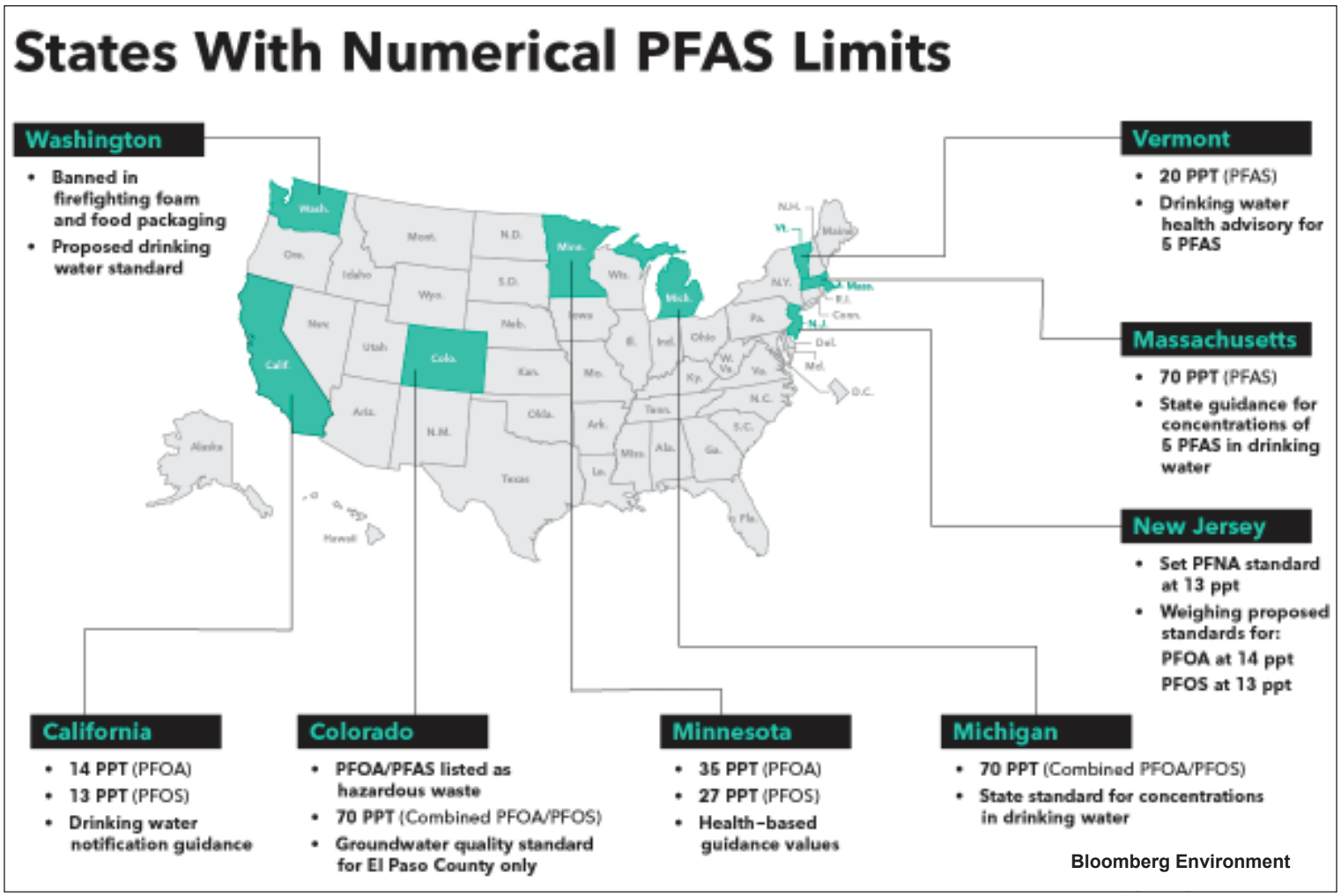
It wasn't until the year 2000 that industry began taking steps to replace PFAS with alternatives. Since then, the production of PFAS has been declining and ceased in the US in 2015. However, PFAS are still being manufactured in other countries. In addition, signiflcant stored PFAS-containing materials exist that have the potential to extend contamination events for many years.

As production and availability of commonly used PFAS such as PFOA and PFOS has declined, replacements were necessary to maintain the features that made these compounds so desirable. However, the replacements are similar to PFOA and PFOS with the main difference being the size. Molecules having fewer than 6 carbons (PFOA and PFOS have 8 carbons) are less persistent in the environment and are thought to be less toxic, although toxicity studies are still ongoing. Two of the most common replacements so far are PFBS (per‡uorobutane sulfonic acid) and GenX (brand name for a process that does not use PFOA).


## Where do PFAS come from?

Since PFAS are so effective at repelling almost anything, they can be found in many consumer products. Fortunately, the potential for individuals to absorb PFAS from most of these products is extremely small. That leaves only a few large possible sources to be concerned about.

- **Fire training or response sites**
  Aqueous flm-forming foams (AFFF) have been used for decades to extinguish flres. It works by coating the fuel source, thereby preventing the interaction with oxygen that sustains a flre. It is especially useful for flres where the fuel is a liquid; in addition to sealing off oxygen, it cools the liquid and suppresses vapors as well as maintaining the coating on the surface which minimizes reignition. In addition to training and response sites, AFFFs have been widely used at airports and military facilities.
- **Industrial sites where PFAS are produced**
  These are facilities where PFAS-containing products are made or PFAS is used in the process of making something else.




**• Landfills**
Everything ends up in a landfill sooner or later, including consumer products containing PFAS and industrial waste and sewage sludge contaminated by PFAS.

**• Wastewater treatment plants or biosolids**
Point sources, unintended releases, and disposal can all contribute to PFAS at wastewater treatment plants and the water treatment process itself can generate PFAS as a byproduct.

In addition to these sources, most municipal incineration systems do not reach a high enough temperature to affect PFAS so discharge from these facilities may contribute to PFAS contamination as well.

Another possible hazard aside from the water itself is fish or other animals that may have been exposed to elevated levels of PFAS. Some areas have "do not eat" advisories posted for fish following testing that revealed high levels of PFAS. Other animals are not typically tested but may be affected in a known high PFAS area; this can include wild animals such as deer as well as pets and livestock. There is also concern about the effect of PFAS on crops and local gardens, but studies so far are inconclusive.

## What's being done?

Several states have initiated water testing programs to locate areas with high PFAS concentrations. However, most of the locations tested are municipal water supplies and schools, those with separate water supplies such as well water are not typically being tested.

There are a number of technologies that are effective at removing PFAS but most are larger systems that would be employed in a water treatment system or for treatment of soil or other solid materials. In terms of technologies that can be used in homes and businesses, granulated activated carbon (GAC) filters are one of the most common options.

# ASK DR. ALICE

## Timeline

1947 3M starts manufacturing PFOA.

1951 DuPont starts using PFOA to make Te‡on.

1953 PFOS found to repel oil and water, e.g., for products like Scotchgard.

1960s 3M and US Navy develop flre-flghting foam.

1970s Military, civilian airports, flreflghting training centers use flre-flghting foam worldwide.

1980s Findings of PFAS toxicity and widespread presence in human blood.

2000 3M announces voluntary PFOS and PFOA production halt.

2006 Major manufacturers encouraged to stop making PFAS by EPA (PFOA Stewardship Program).

2009 EPA issues drinking water health advisory of 200 ppt and 400 ppt for PFOS and PFOA respectively.

Annex B of the Stockholm Convention on persistent Organic Pollutants (POPs) was amended to include PFOS.

2010 US FDA bans use of 8 carbon or larger PFAS, which includes PFOA and PFOS, in paper or paperboard food contact materials, e.g., wrappers, microwave popcorn bags, pizza boxes, etc.

2012 EPA directs large public water systems for PFAS.

2016 EPA issues non-enforceable lifetime health advisory for PFOA and PFOS, individually or combined, at 70 parts per trillion (equivalent to 70 nanograms per liter).

2018 PFAS contamination detected at 121 military sites and at least 564 nearby drinking water supplies. Military informs dairy farmer that PFAS from nearby military facility contaminated his wells, land, cows and their milk; increased public awareness and concern.

## Useful Resources

US EPA PFAS: www.epa.gov/pfas

Interstate Technology & Regulatory Council PFAS: pfas-1.itrcweb.org

Michigan PFAS Response: www.michigan.gov/pfasresponse/

***Dr. Alice Delia*** *is the Laboratory Director at Prism Analytical Technologies. In addition to her responsibilities for maintaining and expanding Prism's high-quality services, Dr. Delia is leading the development of several initiatives to expand overall understanding of various aspects of indoor air quality from consumer to air quality professionals. She spearheaded the development of a test for VOC indicators in tobacco smoke in 2012 and the first commercial test for chemical fire and smoke indicators in 2014.*

*She has also attended many conferences and has delivered over 20 presentations in the last 7 years, including several webinars. In addition, Dr. Delia has produced articles for various trade publications as well as white papers, application notes, and other industry-relevant works.*

*In 2017, Dr. Delia became a member of the IAQA Board of Directors and she chairs the IAQA annual meeting convention committee.*

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***IAQ Radio's*** *co-hosts Cliff Zlotnik (left) and Joe Hughes (right) during one of their weekly online broadcasts*

For over ten years (and 500 episodes), **IAQradio** is the place where the world discusses indoor air quality, the built environment and disaster restoration issues. It's a live-streamed, online broadcast, and now a video show in ***Healthy Indoors***!
The show hosts are **Joe Hughes**, President of IAQ Training Institute and **Cliff Zlotnik**, President Emeritus of Microban Systems.

Every week, **IAQradio** interviews industry experts, on a variety of topics. The show is designed to help promote education and communication for industry professionals and consumers in need of assistance with IAQ, built environments, and disaster restoration issues.

## LISTEN/WATCH LIVE SHOWS

**IAQradio** streams a live show every Friday at 12pm EST, via Zoom Meeting, which enables up to 100 live audience participants.
You can join the live broadcast each Friday from your computer or mobile device at:
**https://zoom.us/j/711720275**

The weekly meeting ID is: **711 720 275**


iaqradio
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# Healthy indoors

Improving Your Indoor World

# Consumer Section

# Home Performance Channel: Healthy Indoors Minute *March 2019*

Corbett and Grace Lunsford, of the ***Building Performance Workshop***, and hosts of the new weekly PBS TV series, ***Home Diagnosis***, bring you the next installment of the **"Home Performance Channel - Healthy Indoors Minute."**


**https://www.youtube.com/watch?v=6fCxBvy7Q_U**

Grace and Corbett discuss the simple approach to controlling indoor chemistry, and how exactly they plan to do that in their own family home. The three most basic rules to follow:

1. Don't bring bad stuff inside
2. Ventilate
3. Keep it dry

More on this house at:
http://HomeDiagnosis.tv/atlanta-homestead

Their goal is to package building performance, so it can easily be understood and used by professionals and consumers alike, for better buildings worldwide. In 2009, Corbett started teaching pros through his Building Performance Workshop (where each student happily admits to being an idiot at the beginning of every class), and he's hosted over 300 YouTube videos and 80 interviews for the Building Performance Podcast. Without anybody to tell him he couldn't, Corbett wrote the book Home Performance Diagnostics: the Guide to Advanced Testing, and developed the APT Reports software tool. In 2016 they built the world's highest performance tiny house on wheels, the #TinyLab, and toured the US before settling down in Atlanta, Georgia.

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# Tips for Bathroom and Kitchen Renovations



It's exciting to have a bathroom renovated or a kitchen updated in a home you've been living in for a while. If you're buying a new home, you may want to have those pink bathroom tiles replaced or get rid of those Formica countertops in the kitchen.

There are some steps that should be taken during the renovation that can prevent indoor-air-quality problems.

First, construction dust and paint fumes can spread into other rooms. Whether or not you are living in the house during the renovation, the work space should be isolated from adjacent rooms. Plastic "walls" can be hung up to prevent the spread of dust. You can even ask that workers come and go through a hallway similarly isolated. Lay down "tacky mats" (www.pro-tect.com) where workers enter and exit, to prevent dust on their shoes from entering your home. Insist that workers use new drop cloths, because old ones may contain lead paint dust as well as allergens from other jobs.

The mechanical system should not be operated in the spaces undergoing renovation, because biodegradable or allergenic dust can collect on radiators and baseboard heating convectors, as well as in ducts. Supplies and returns of ducted systems should be covered with impervious material, and radiators and baseboard heating convectors with sheet plastic. If necessary, the work space can be heated or cooled with portable units.

When the work is done, the surfaces in the area that has been renovated as well as spaces directly adjacent should be thoroughly cleaned, including use of a HEPA vacuum (one with HEPA flltration) with a bag.

While you are making choices about how you'd like a space renovated, I'd like to recommend the following improvements to the kitchen and bathroom, if such conditions are not already in place.

## The Kitchen

**Appliances:** Install an exhaust fan over the stove that vents to the exterior.

Appliances like refrigerators that create air‡ow can spread contaminants. If you are keeping your old refrigerator, clean moldy gaskets with a dilute solution of bleach and water (one part bleach to ten parts water) or use any suitable cleaning product.

Take this opportunity to roll the refrigerator out so you can clean the top, bottom and sides, as well as the alcove in which the appliance sits. HEPA vacuum the coils. Clean the drip tray. If the tray is at the bottom, you can probably remove it. If the tray is at the back behind a panel, remove the panel and clean the tray as best you can. You should clean a refrigerator like this annually. If the refrigerator has an ice maker, be careful not to damage the water line when you are moving the appliance. And now is a good time to place a ‡oor-water alarm next to a refrigerator that has a water line.

**Kitchen cabinets:** If you are replacing your kitchen cabinets, choose solid wood or plywood cabinets rather than cabinets made of particle board, which can off-gas formaldehyde. If you are keeping your old cabinets, take this opportunity to clean the cabinet kick-spaces, which can accumulate dust that becomes moldy when these surfaces are dampened by ‡oor mopping or spilled foods. Check out the cabinet under the sink for any mold growth. If the cabinet is not too decayed due to leaks and spills, you can clean and then paint-seal the cabinet's inner surfaces.

*Visible Aspergillus mold growth in kitchen-sink cabinet*
*May Indoor Air Investigations LLC*

**The sink:** If you are keeping your old sink and sink cabinet, be sure there are no leaks under the sink. If you are keeping your countertop, there should be no cracks between the sink and countertop or the countertop and backsplash —cracks that could allow water to leak down into the cabinet below.

**Flooring:** I never recommend carpeting in a kitchen, be-

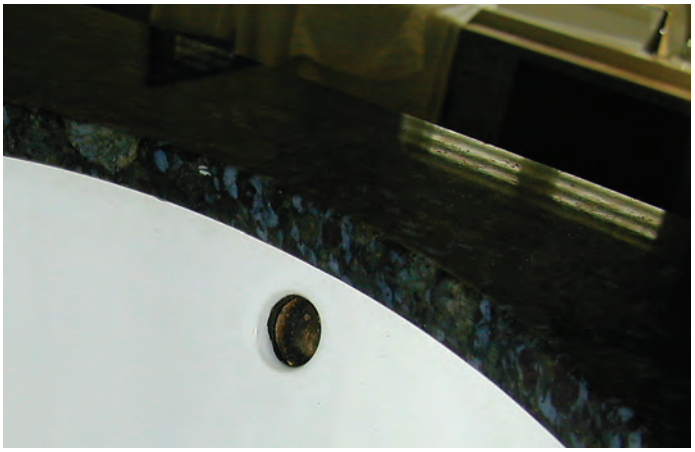
cause the fiber captures biodegradable dust which can never be removed, even with the most thorough vacuuming. It's inevitable that kitchen ‡ooring will become damp; then the dust in the carpet fibers will become fodder for mold growth.

## The Bathroom

**Tiles:** Have loose wall or ‡oor tiles repaired and loose or missing grout replaced; otherwise, water can leak behind/into cracks and loose tiles, causing damage and mold growth in the wall or ‡oor. If the water is leaking into a wall, mold growth can occur in the wall cavity. If the water is leaking into a crack in the ‡oor, damage and mold growth may occur in the cavity between that ‡oor and the room below. You may even see leak stains on the ceiling below the bathroom.

**The Shower:** If you have a shower curtain, install splash guards at each end of the tub to prevent leakage. If you are having a shower door installed, make sure that the bottom corners of the frame are embedded in caulk in order to prevent leaks.

**The sink:** If you are keeping your old sink and tub, you can clean out the over‡ow with a dilute bleach solution and an old toothbrush. This may seem trivial, but I have worked with at least two clients who stopped using a bathroom because of an unpleasant odor emanating from the sink. It ended up that in each case, microbial growth (mold, bacteria, yeast) had occurred in the sink over‡ow and was causing the stink. In the future, such over‡ows should be cleaned on a regular basis.



*Odiferous sink overflow  May Indoor Air Investigations LLC*

**The ceiling:** If mold repeatedly appears in one area of the ceiling, despite your best efforts to dry out a bathroom after someone showers, have the contractor check the ceiling insulation. There may be a spot where the insulation is inadequate. This results in more condensation and then mold growth on that cooler area of the ceiling. For a bathroom that's under the attic, just placing some sheet foam insulation on the ceiling can solve the problem.

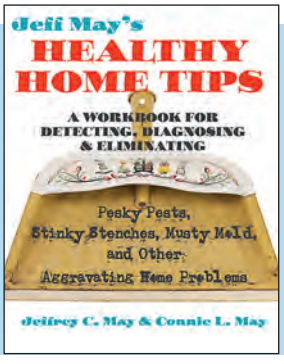
## Paints and Varnishes

If you find odors from paints and varnishes irritating, insist that your contractor uses low VOC (volatile organic compounds) products. Some of the product should first be applied to a scrap piece of wood, however. Once the surface has dried, you can sniff the wood to see if the product's odor is still present and is bothering you.

Odors such as these are caused by off-gassing of the product applied. It can take some time for paints and varnishes to finish off-gassing, because a thin boundary layer of motionless air on surfaces slows down evaporation of the solvents. You can speed off-gassing by creating more air‡ow in the space.

Put one fan on supply in one window and another fan on exhaust in another window. Then put one or two oscillating fans in the room. These steps will create air‡ow that will reduce the thickness boundary layer of air, and the air in the room will be exhausted quickly, carrying the odors with it to the exterior.

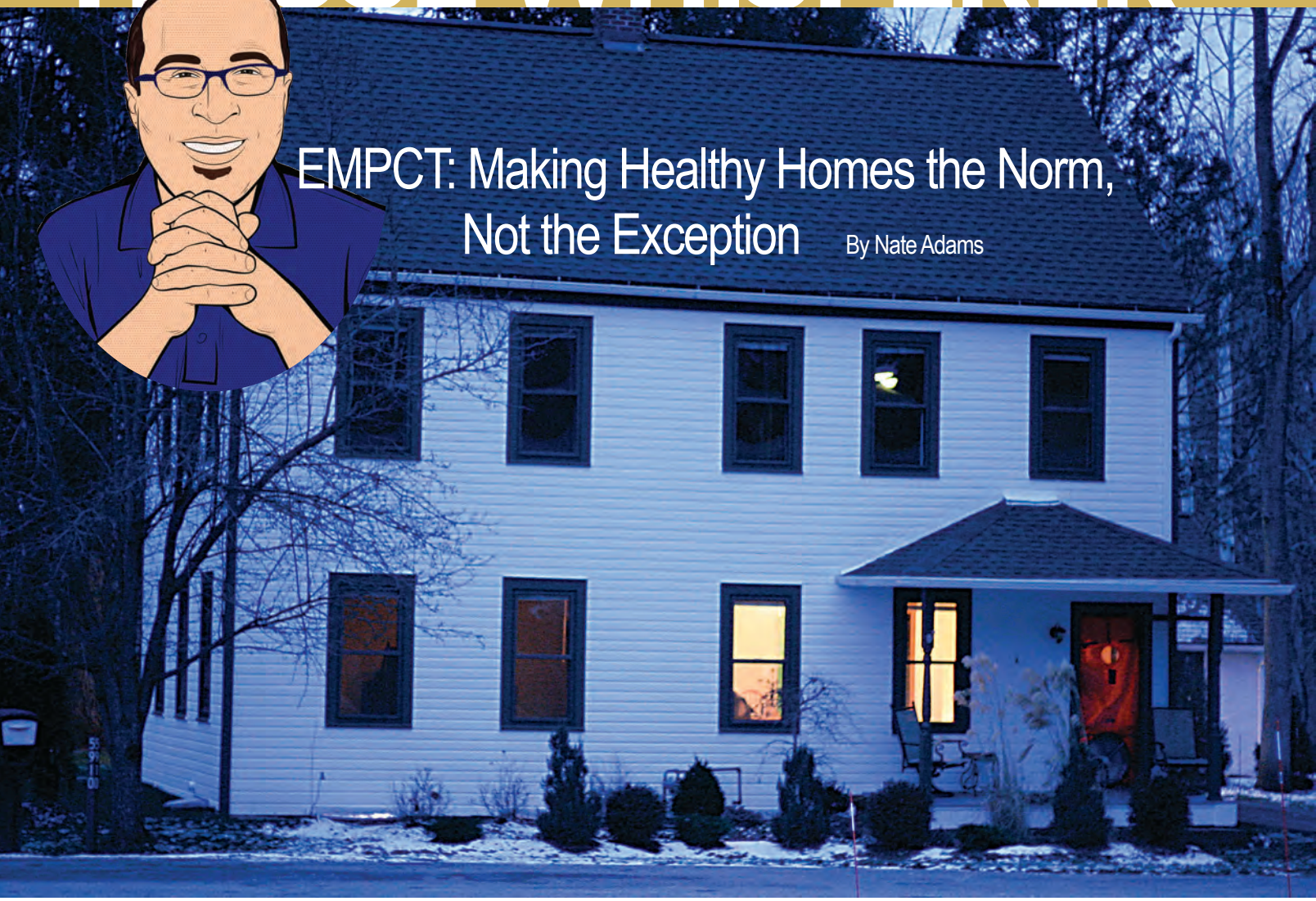
*Founder and Principal Scientist of May Indoor Air Investigations LLC in Tyngsborough, MA (www.mayindoorair.com), Jeffrey C. May combines his education as an organic chemist and his over twenty-five years of experience investigating building problems to specialize in indoor air quality (IAQ). He is a former Adjunct Faculty Member in the Department of Work Environment at University of Massachusetts Lowell, and is author or co-author of four books on indoor air quality (published by The Johns Hopkins University Press), including My House is Killing Me: The Home Guide for Families with Allergies and Asthma. Jeff is a nationally recognized speaker at annual conferences for the IAQ Association and the Maine IAQ Council, among others. He is a Council-Certified Microbial Consultant (ACAC) and a Certified IAQ Professional (AEE), and is licensed in the NH and FL as a mold inspector/assessor. Jeff holds a B.A. from Columbia College (chemistry) and an M.A. from Harvard University (organic chemistry). See http://www.mayindoorair.com for details about Jeff's company's services, and www.myhouseiskillingme.com for more information about Jeff's publications and work. You can contact Jeff at jeff@mayindoorair.com or call 978-649-1055.*




Refer to our book *Jeff May's Healthy Home Tips* for for more guidance on creating a healthy home enenvironment.

**Available on amazon.com**

# HOUSE WHISPERER



## EMPCT: Making Healthy Homes the Norm, Not the Exception

By Nate Adams

If you're reading this, you'd probably like to see healthy homes be the norm, not the exception. We and our clients breathe about 3000 gallons of air a day. More than 90%+ of these are indoors. Shouldn't we care about this at least as much as the cleanliness of the ½ gallon of water we drink per day?

This column is about the severity of the current health problem in American homes, and what a process to solve this at scale might look like.

Bill Hayward of Hayward Healthy Homes (PSA: their survey is thoughtful and helpful) has been Tweeting a lot recently about the poor conditions in military housing. At Tinker Air Force Base, half of the homes were reported to have mold or water damage. Many of these homes are newer, built in the last decade. He's feeling very frustrated about these challenges, as am I.

I agree this is a problem in new homes, and we've been following the story a Gulf War veteran: Hilary Gronas and her husband Terje. Hilary has battled with symptoms of Gulf War Syndrome since her service in 1991 as a Navy Hospital Corpsman. Hilary was diagnosed with Chronic Fatigue Syndrome in 2008 of which she still receives treatment for to this day.

The Gronas Family built an Energy Star Home in Georgia because they thought it would be the best choice for Hilary's health especially. They were alarmed when they noted substantial condensation on the windows that winter, indicating poor moisture control and exacerbating Hilary's symptoms. Dr. Richard Corsi has found that high relative humidity and VOC release are directly related, so high humidity levels can exacerbate chemical sensitivities.

The Gronas family asked for help from the builder, energy rater, RESNET, and Energy Star, to no avail. They opted to completely replace the HVAC system with one that could control indoor air quality, 18 months after building their home.

They changed cities after that experience to Raleigh NC to get a fresh start. Also, they picked a place where as a family they might enjoy better health and where Hilary would have easier access to better health care and the VA Hospital. Shortly after moving to NC they decided to build a Townhouse. The only choices close to Terje's work in their price range were Energy Star homes. Reluctantly, Terje chose the least bad option which had the least complicated HVAC system and planned to add supplemental dehumidifIcation.

They recently had to break the contract because Danny Gough, who specializes in building performance inspections and HVAC design, found so many out of compliance deflciencies there were high odds of a repeat of their last experience. He told them to "run away, not walk away" from this home. I did a FaceTime call with Terje and felt the same way, as did Stephen Rardon, one of the best HVAC techs I know.

The fact that this happened twice in different markets with different builders suggests a systemic problem. If you want to dig deeper into the Gronas stories, join the "Energy Star Homes, The Horrors" group on Facebook and subscribe to their YouTube channel.

Then there are the problems of existing homes. Jack Storey of Saving Cities, who has been in the low-income housing world in both Cleveland and Columbus, has told me about inner city kids having very high incidence of asthma and allergies. Kevin Kennedy of Children's Mercy Hospital in Kansas City could tell you stories for weeks about these kids. It's sad that these kids that already have a tough start in life have even more factors working against them.

But don't think this is just a military or low-income problem. The largest moisture study of existing homes by Spengler et al in 1994 found that 50% of homes had dampness or mold issues.

The problem appears to be worsening. Many of my east coast Home Performance colleagues reported drastic increases in moisture related problems this year, which matched our own experience., This led me to present on "The Coming Mold Explosion" at IAQ Radio's Healthy Building Summit last October. A YouTube presentation with the same name is aimed at homeowners explaining how we can expect this increase to continue based several issues like higher dew points, more severe rain events, poor dehumidifIcation from newer single stage air conditioners, and moisture sensitive engineered building materials.

If you're like me, this worries you. We have the basic knowledge and the tools to solve this problem, but we need an army with a good business model to go out there and do the work of making American homes healthy.

## A Potential Solution

We believe healthy American homes become the norm with a mixture of empathy and impact, or as the acronym gods would have it, EMPCT:

E — Education
M — Measurement
P — Process
C — Contractor Network
T — Transparency of results

Doing this requires a mix of tools we already have today, and a few new ones that need to be developed. Let's look at what's involved in EMPCT, then in my next column I'll outline a potential solution we're developing in more detail.

## Education

My good friend Joe Hughes, co-host of IAQ Radio, once told me that he prefers UN-educated clients to educated ones in his work, because so much of the information they have heard or read is wrong. As such, it's very difflcult to get the "educated" clients on the right track.

This highlights an important need: education that is helpful to caring practitioners who are trying to solve client problems.

In my experience there are two different paths for education: preventative and treatment.

The typical "preventative" measures, like good flltration, fresh air, and dehumidifIcation that should be included in a new HVAC system, can be handled by simpler educational pieces and by HVAC and Home Performance Specialists. My book, *The Home Comfort Book*, can help with this, we've made the flrst two chapters free to use with no strings attached to be used for educational purposes.

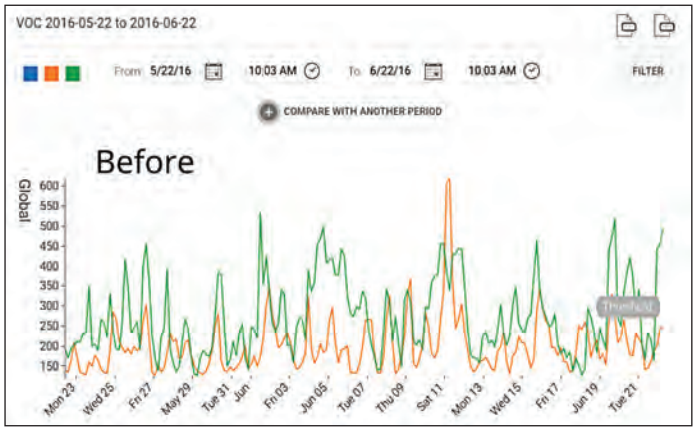
The more difflcult "treatment" path is for health compromised individuals who need help flrst from medical professionals to diagnose their health issues, and then from a Home Performance Specialist to help solve the root causes in their homes. Health compromised clients will need different educational materials such as the ones organizations like ISEAI and Hayward Score are working on. These two professionals will need to work together in education, diagnosis, and treatment. Our job as Home Performance Specialists is complicated enough dealing with the home. We've really struggled trying to keep up with the medical issues of health compromised clients. That has made this second path obvious to us.

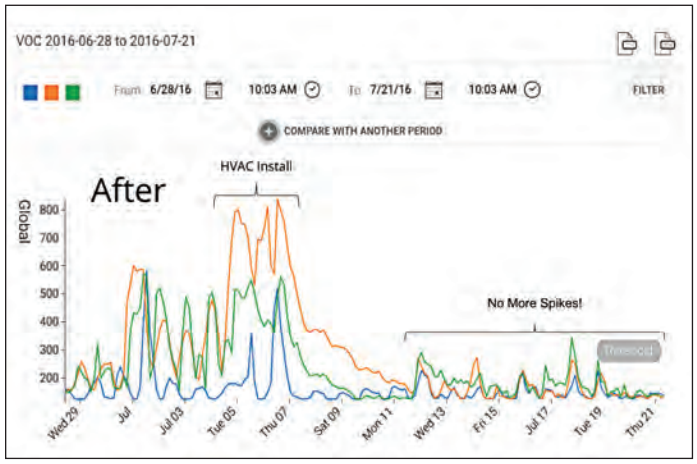
## Measurement

If you've been reading this column for a while, you'll know that I'm a huge fan of consumer grade Indoor Air Quality monitors. They automatically track things like temperature,

humidity, dust (PM2.5), chemicals (tVOC), carbon dioxide, carbon monoxide, and more. See my December 2017 column for a review of 7 air quality monitors or the April 2018 Health Thief column.

These devices have given us tremendous insight into what's going on in client homes so we can learn and adjust with the feedback loop they provide. For example, we knew that we had changed this one client's home positively when we saw the following charted results from 3 Foobot air quality monitors, each measuring the leading IAQ monitoring points of temperature, humidity, and tVOC in the home of a health compromised client.




We also believe measured parameters like these to be a crucial beginning for consumers looking to create healthy homes.

You can't manage what you don't measure. Once a problem is found (like indoor air consistently above 60% relative humidity), consumers care far more about finding a solution. Until they are made aware of how these parameters can directly affect their personal health, it's an ethereal, almost imaginary, problem.

Measurement paired with education is likely to lead to action if a problem is discovered. This now leads us to the next step: Process.

## Process—The 4 Levels

Our clients have found this four-level process to be helpful. The goal is to try things that are not a waste of time and money but can be built upon if further steps are needed.

- **Level 1: Under $100.** Simple solutions like using bath fans or buying a filter fan (taping a 4" MERV 11 or higher furnace filter to a box fan).
- **Level 2: Under $1000.** Reaching out to a medical professional, buying air quality monitor(s), buying a dehumidifier, or air purifier, DIY replacement of a bath fan, etc.
- **Level 3: Contractor installed "best guess" measures.** This is the most dangerous level because the measures often turn out to be ineffective. Level 3 may include important items like new bath fans, a range hood, media filter on the furnace/AC/heat pump, whole home dehumidifier, etc. Too often a contractor-installed measure does not include a root cause analysis for why the home is negatively affecting the health of its occupants
- **Level 4: Comprehensive Home Performance.** This consists of diagnosing and treating a home to make it healthy, with a high probability of results, based upon careful analysis of the root causes of the home being unhealthy, with targeted solutions being properly implemented.

Ideally, the first two levels will return positive results, where consumers can largely guide themselves while consuming good educational materials, but if these attempts don't return positive results it's time to level up.

In our experience, we recommend skipping Level 3 because of the high risk of failure it entails - making upgrades that are either ineffective or, worse, need to be redone at substantial additional cost. Instead spend money on diagnostics and design.

The trouble is, someone needs to do the Level 4 work. And Level 4 work requires its own level of contractor education and careful process, with or without a medical professional.

## Contractor Network

If you thought good education, measurement, and Levels 1 & 2 were challenging, you were wrong. Building a contractor network is probably the most difficult step here. As Peter Troast of Energy Circle has argued, there is no business model for Healthy Homes, as of yet. While the Building Performance Institute has a Healthy Home Evaluator program, I haven't heard of a company making a business model out of it yet.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### RICK FEDRIZZI

***Rick Fedrizzi***, chairman and CEO at the International WELL Building Institute (IWBI), will deliver a keynote on **The Second Wave: Welcome to the WELL Movement**. He will also unpack the "why" behind wellness: why the health narrative has taken off, as well as how everyone from product manufacturers to architects can tell their wellness story responsibly, accurately, and in a way that speaks to and inspires their target audience. Prior to his work at IWBI, Rick co-founded the U.S. Green Building Council and is a native of Syracuse, N.Y., with an MBA from Syracuse University.

### JASPER VAN DEN MUNCKHOF

***Jasper van den Munckhof***, founder and director at Energiesprong, will discuss Energiesprong's work **creating a mass market for net zero energy homes**. He will discuss his progress on Retrofit-NY, a NYSERDA initiative to bring a large number of affordable housing units to or near net-zero energy use by 2025 using the Energiesprong approach. Energiesprong has brought 4,500 units of affordable housing to net-zero energy with 18,000 more in the pipeline.

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We'd argue that's because in most cases home health issues are not a major pain point for homeowners. Even if it is, it's often not enough on its own to drive an effective project, so there need to be more goals besides health.

Using empathetic questions, it's not hard to find these objectives. It's one of the key secrets to the large jobs that Energy Smart Home Performance executes.

If an effective Healthy Home contractor network existed, members within it could ask what those goals are and see if there might be a viable project that matches those goals, the needs of their home, and their budget.

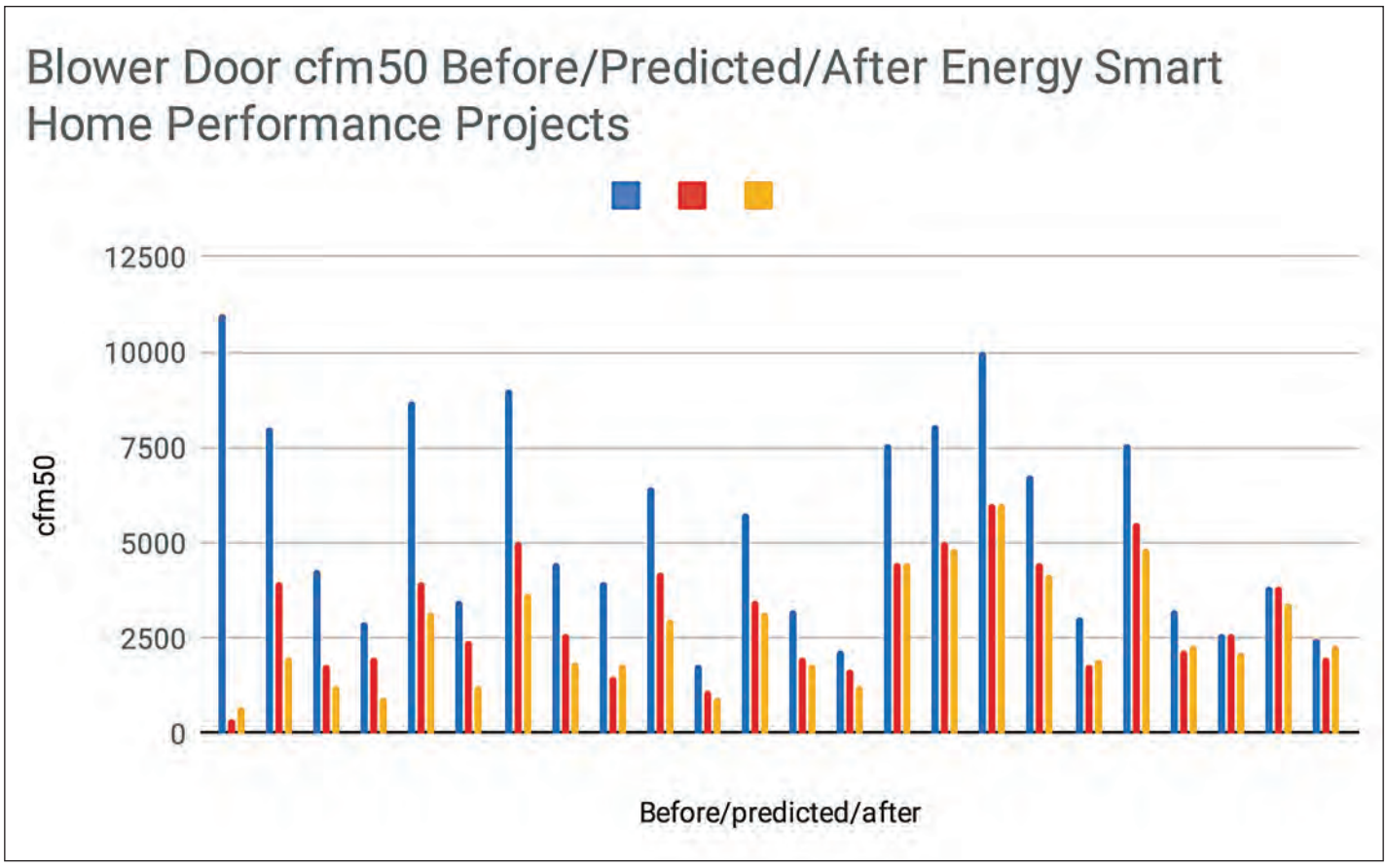
I'll speak to this directly in my next column about how to create an army of *House Whisperers*.

## Transparency

Here's where I need to climb on a soapbox for a moment: in Indoor Air Quality and Home Performance work we measure a ton of stuff, but no one else gets to see the measurements. This is a travesty because a) it's how we can learn as an industry and b) it's how consumers can find the best practitioners to work with.

Hilary and Terje Gronas' experiences relate directly to this lack of transparency and accountability, in my opinion. If they were able to compare builders on blower door leakage and energy usage, they would have good proxies for the quality of the home they could expect.

For Home Performance/Healthy Home work we propose tracking before, predicted, and after metrics for both blower door (in cfm50 leakage) and energy use. These are concrete metrics and are relatively easy to predict in our experience. For new homes obviously only predicted and actual metrics can be tracked.



We already walk the walk in this regard with our case studies at energysmartohio.com. Here's a chart of before/predicted/after blower door leakage of a number of our projects.

For home health, a more nascent area of home performance, I'm open to suggestions. Our experience with deploying consumer grade indoor air quality monitors, available at reasonable cost, has already netted positive results in not only assistance with diagnosing problems within a client's home, but also effectively monitoring how effective the solutions are post project.

## Conclusion

Using the EMPCT method, we can make healthy homes the norm and not the exception by providing a viable path to measurably healthier homes through a repeatable empathetic and impactful process.

The challenge before us is that many things need to be built to make this a reality. I've written The Home Comfort Book to serve as an educational onramp for both consumers and contractors for creating healthy, high performance homes - please use the flrst two chapters and let us know how they are helpful. Hayward Score is also working on the education side.

But that still leaves us with unaware consumers, and the lack of a contractor and medical professional network to serve consumers.

In my next article, we'll talk about a plan already underway to flx the shortcomings within Home Performance, and within unhealthy homes, and how to make EMPCT an accepted norm within the industry vs. an exception. Stay tuned!

***Nate Adams*** *is the founder of Energy Smart Home Performance in Cleveland Ohio and of NateTheHouseWhisperer.com. Rather than focus on energy efficiency, Nate focuses on solving the root causes of client problems like uncomfortable rooms, mold, wet basements, and icicles. As a fan of radical transparency, he has published the most detailed case studies in the industry on these projects.*

*Nate is currently writing The Home Comfort Book, a guide showing people how their homes really work and how to truly solve problems, instead of putting band-aids on bullet wounds. It is meant to create consumer demand for this work rather than the traditional supply focus that has been taken for forty years.*

*His writing has been published in numerous outlets including GreenTech Media, CleanTechnica, the Journal of Light Construction, Green Building Advisor, and more.*

*Learn more at: http://energysmartohio.com/*

# MOMS Clean Air Force

# Montana's Wildfire Smoke Affects Climate and Health

By Jackie Semmens

MOMS clean air FORCE

FIGHTING FOR OUR KIDS' HEALTH

When the smoke from the Rice Ridge Fire cleared two years ago, a team of researchers from University of Montana began tracking the lung health of local residents. Until recently, there had been no research on the effects of wildfire smoke on the general population. The results of the study are eye-opening for any parent who struggles to keep their child safe from wildfire smoke.

The Rice Ridge Fire burned through the Seeley Lake region of Montana, pushing air quality to never seen before lows, as it burned over 160,000 acres and lasted for nearly two months before rain fell.

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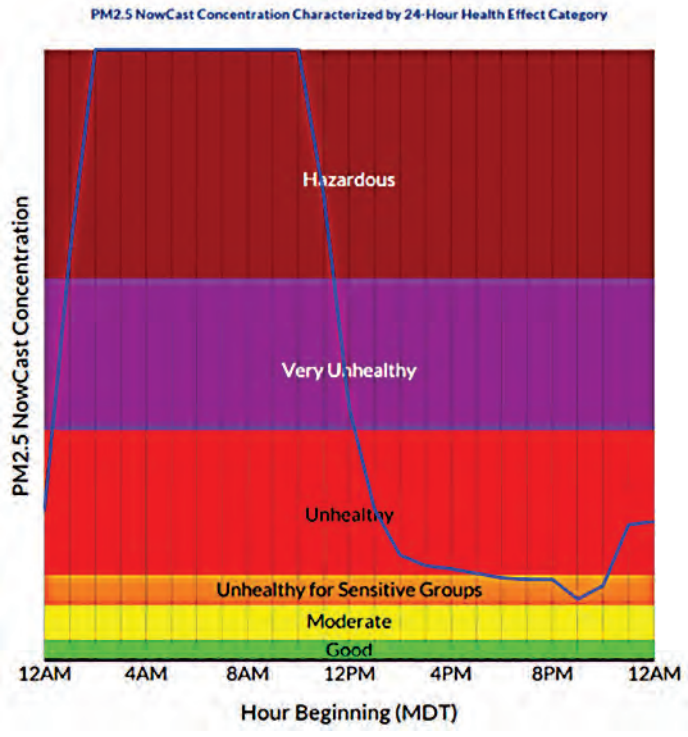
Montana tracks the amount of small particulate matter from ash in the air (called PM2.5) and considers air quality "good" with a concentration of 0 – 12 micrograms per cubic meter, unhealthy at 55.5 – 150.4, and hazardous above 250.4. For several days in August 2017, the Rice Ridge Fire caused PM2.5 concentrations that were literally off the charts – with peaks near 1,000 micrograms per cubic meter, four times what is considered hazardous.

I spoke to Christopher Migliaccio, a researcher at University of Montana's School of Pharmacy. Prior to this study, most research into the effects of wildfire smoke on the general population had been retrospective, focusing on hospital admissions and emergency room visits. "This is the first time somebody has been able to follow people right after a smoke event," says Migliaccio.

The dangers of inhaling particulate matter are well-documented, and can lead to coughing, difficulty breathing, irregular heartbeat, aggravated asthma, and even heart attacks or premature death. Children, along with people who have heart or lung disease and older adults, are most likely to be affected by particle matter exposure.




The Rice Ridge Fire study found lung function decreased significantly for residents of Seeley Lake over the course of the following year. Of the people who came back to be retested a year later, 90 percent saw a decrease in lung functioning. Nearly a third of these people now had abnormal lung functioning, compared to 17 percent a year earlier.

The researchers were not able to include children in their Rice Ridge Fire study, but they hope to look at the effects of wildfire smoke exposure on children in the future. While its currently recommended that sensitive individuals —including children — decrease their outdoor activity when air quality is poor, researchers are still determining how activity levels affect health.

For now, Migliaccio recommends that people at risk create safe air spaces indoors by using HEPA filters in order to decrease exposure to smoke.

The Rice Ridge Fire study is a concerning first peek into the effects wildfire smoke has on people in affected areas. But as climate change increases the risk of wildfires through warmer temperatures and drier conditions, the issue of smoke inhalation on developing lungs will become even more pressing.

For families like mine across Montana when wildfires rage on and on, climate change isn't a down-the-road problem. It's already impacting the health and safety of our friends, neighbors, and children. We don't have any time to lose. Now is the time we must speak up, and tell our elected officials they must protect our families and act on climate change.

# Healthy indoors magazine

## Marketplace