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Elliott Gall, PhD – Particle Mitigation Strategies; What Works?

This week we welcome Dr. Elliott Gall, Associate Professor at Portland State University to discuss some current research on particulate and gas phase pollutant mitigation. Particles are everywhere in indoor environments from skin cells to automobile exhaust to wildfires by-products. Particulate removal is also a big topic when it comes to the pandemic. What do we know about particle behavior and how well do various mitigation processes work? We talked to Dr. Gall about what his and other research shows about this important IEQ topic.

Nuggets mined from todays' episode:

After graduating from University of Texas/Austin, Elliott Gall did a postdoc on Indoor Environments in Tropical Climates in Singapore. He enjoyed learning and living abroad. While looking for a permanent academic position he was attracted to Portland State University because they sought an IAQ Scientist to join their faculty.

While frequent and extreme wildfires were common in Southeast Asia and part of the landscape due to burning on palm oil plantations; Elliott was surprised that wildfires were also a problem in the rainy Pacific Northwest.

Radio Joe's interest in Dr. Gall and his research was piqued by Dr. Rich Corsi's webinar where he summarized the presentations at a recent National Academy of Sciences Workshop. Key points from the presentations included:

- Mitigation of fine particulate matter exposures in schools
- Indoor Exposure to Fine Particulate Matter and Practical Mitigation Approaches
- Workshop on Mitigation of Indoor Exposure to Fine Particulate Matter National Academies of Science and Engineering (NAS)

Highlights from the NAS presentation:

15% of schools in the US are less than 250 meters from a high traffic roadway such as interstate highways with vehicle counts of 10.000s vehicles per day. Children in schools are among our most susceptible population. Schools near highways have higher levels of asthma incidence and greater numbers of cardiovascular events. Students learn better when the IEQ is better. IEQ is known to effect both thinking and health.

Obviously it's not just particulate that causes IEQ concerns you have also looked at how gas phase pollutants can be mitigated. Please tell our audience a little about sources and control of gas-phase pollutants and your groups recently published field study on the topic.

Dr. Gall discussed a positive example of what can be accomplished to reduce TRAP in a school located close to a highly trafficked highway when sufficient funding is combined with science, creative HVAC design and installation. The design incorporated MERV 8 pre filters + MERV 16 filters + CARBON and was shown to reduce black carbon by 85% and varied gases from 30%-40%. The carbon removed both airborne oxidants and fragrances and curtailed reactions between oxidants and cleaning/personal care products.

Much of the fine particulate matter in schools is attributable to Traffic Related Air Pollution (TRAP). This particulate is not a single substance and can be classified into 3 categories: Black Carbon, Ultrafine Particles and PM 2.5. The type of particles matters when classifying sources. The closer to the road the higher sources and particulate levels. Buildings should not have internal black carbon sources. Building occupants increase levels of PM 2.5.

Gases such as toluene and benzene are also related to vehicle emissions. The relocation of air intakes away from roadways can provide approximately the same benefit of a MERV 8 filter.

It's challenging to do indoor air monitoring in occupied buildings due to occupant concerns over the monitoring equipment.

Takeaways from the study: Opportunity to relocate the building air intakes away from the source, understand the pollutants, alter the timing of school activities, air

cleaning, address indoor sources, quench indoor chemistry via air cleaning or source reduction. Buildings can be used as a shelter during wildfires.

Per-Person and Whole-Building VOC Emission Factors in an Occupied School with Gas-Phase Air Cleaning

ABSTRACT: Using real-time measurements of CO2 and volatile organic compounds (VOCs) in the air handler of an occupied middle school, we quantified source strengths for 249 VOCs and apportioned the source to the building, occupants and their activities, outdoor air, or recirculation air. For VOCs quantified in this study, there is a source to the outdoors of 8.6 ± 1.8 g/h in building exhaust air, of which 5.9 ± 1.7 g/h can be attributed to indoor sources (the building and occupants and their activities). The corresponding whole-building area emission factor from indoor sources is 1020 ± 300 µg/(m2 h), including reactive VOCs like isoprene and monoterpenes (33 ± 5.1 and 29 ± 5.7 µg/(m2h), respectively). Per-person emission factors are calculated for compounds associated with occupants and their activities, e.g., monoterpenes are emitted at a rate of 280 ± 80 µg/(person h). The air handler included carbon scrubbing, reducing supply air concentrations of 125 compounds by 38 ± 19% (mean ± std. dev.) with a net removal of 2.4 ± 0.4 g/h of organic compounds from the building. This carbon scrubber reduces steady-state indoor concentrations of organics by 65 µg/m3 and the contribution of indoor sources of VOCs to the outdoor environment by ∼40%. These data inform the design and operation of buildings to reduce human exposure to VOCs inside buildings. These data indicate the potential for gas-phase air cleaning to improve both indoor air quality and reduce VOC emissions from buildings to the outdoor environment.

Before we go into some more practical wildfire tips let's discuss the article you did with BRENT STEPHENS, MOHAMMAD HEIDARINEJAD and DELPHINE K. FARMER. It's titled: Interpreting Air Cleaner Data Performance.
https://www.nxtbook.com/nxtbooks/ashrae/ashraejournal_PICVBT/index.php?startid=20#/p/20

What led to writing this article? Covid created a surge in the marketing and sales of air cleaning devices resulting in exaggerated claims resulting in confusion in the marketplace due to lack of uniform testing.

What are the key takeaways? These devices fall into 2 categories those that are "subtractive" and those that are "additive".

A subtractive device is an air cleaner based solely upon mechanical filtration (HEPA filter), adsorption (bulk Activated Carbon) or a combination of both. These devices add nothing to the environment and remove substances from it.
An additive device injects something into the air with the goal that the substance injected will remove something from the environment without leaving anything behind.

This distinction between additive and subtractive technologies is not always a rigid, clear line.

There is a lack of standardized performance metrics which limits the ability to compare devices and translate performance to operation in real occupied spaces:

- Testing in small sealed chambers that can overestimate performance in actual buildings;
- Testing that does not account for control conditions (such as natural decay rates);
- Testing conducted at elevated (or sometimes unreported) concentrations of additive/reactive constituents that might not reflect real-world use;
- Lack of chemical by-product testing or demonstration of complete oxidation;
- Omission of test parameters, such as chamber volume or mixing conditions;
- Variation in parameters between control and test conditions.

Now let's go into a more practically oriented guide to reducing exposures during a wildfire published on medium: https://elliott-gall.medium.com/wildfires-and-the-air-quality-inside-your-home-54961e374238

You break it down into some simple steps let's review them:

1. Create a clean room within your home. (A small area, often a bedroom preferably with a window.)
2. Either purchase or make a suitably sized air cleaning device. *An example:* The floor area of your bedroom is 150 ft². To meet the ANSI/AHAM 2/3rd rule, the smoke CADR should be at least 100 cfm (100/150 = 2/3). Upsizing is better as a larger air-cleaning device may have speed settings and be quieter. Note- Wildfire events can last for weeks.
3. Air sealing windows reduces air infiltration. Seal windows with 3M window insulator kits (or equivalent).

Your group is also currently studying wildfires and IAQ through an EPA grant. Can you tell us a little about this work and any preliminary results?

Household Atmospheric Dynamics under Elevated Smoke (HADES): Holistic Evaluation of Interventions for Reducing Indoor Levels of Wildland Fire Emissions
And was recently awarded an EPA grant to study this: https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract_id/11203/report/0

Your group also did some work developing a low-cost, DIY, rapidly deployable air cleaners for use during emergency situations, This was an EPA design contest on the topic and your design was one of 5 winners. Let's take a look at the system you came up with.

https://www.epa.gov/air-research/winners-cleaner-indoor-air-during-wildfires-challenge

https://www.pdx.edu/news/portland-state-team-wins-epas-cleaner-indoor-air-during-wildfires-challengel
https://content.library.pdx.edu/files/PDXScholar/Portland-State-Magazine-Spring-2022/14/

Any recommendations for what homeowners can do after the wildfire to cleanup?
As for post fire, I think there's lots we need to learn, and a lot of folks are working on this. Clean up after the fire recommendations are evolving. A not comprehensive list for homes near fires would include: continued ventilation and air-cleaner operation (high MERV/HEPA and activated carbon) post fire, wearing PPE while cleaning surfaces (or avoid this if susceptible/at-risk), surface cleaning that includes vacuuming with a HEPA vacuum, and, for the moment, I'd say cleaning of floors with standard commercial floor cleaners. And replacement of furnace filters. We're investigating retention of organics and different solvents for organic compound removal from other surfaces as part of our EPA project.

Do you have any recommendations for indoor post wildfire surface sampling methods?
For post fire surface wipe sampling, we're focusing on PAHs as part of our EPA project. We've developed a method (which certainly is based on existing, similar studies in the literature) to wipe interior surfaces with an isopropyl alcohol cloth that is then extracted in another solvent that can be injected into a mass spec. We've also tested this method on drywall surfaces. We're also taking samples of HVAC filters and directly extracting the PAHs that are present post smoke exposure. We're aiming to understand if PAHs, as semi-volatile species, might slowly emit from filters post-fire and how this might impact exposure and filter changeout recommendations post fire.

Z-Man signing off

Trivia:

Name the protective covering of silk or other fibrous substance spun by the larvae of moths and certain other insects as a cover for the pupa?

Answer: Cocoon
Answered By: Don Fugler