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Wildfires, COVID The IoT & IAQ in a Changing World

This week we welcomed Dr. Jovan Pantelic, Ph.D. Well Living Lab for a show on COVID, IoT, Wildfires and IAQ. Jovan Pantelic, Ph.D., is a Research Scientist in the Well Living Lab. He earned his Bachelor of Mechanical Engineering and his M.S. from the Department of Thermal Engineering at the University of Belgrade (Serbia). He earned his Ph.D. from the National University of Singapore, where he studied in the School of Design and Environment, Department of Building.

Dr. Pantelic joined the Well Living Lab in September 2020 after transitioning from his positions as a Professional Researcher at the University of California Berkeley and Lawrence Berkeley National Laboratory, where he was completing COVID-19 related research. Over the past 17 years, Jovan has worked on various topics related to indoor air quality, spanning from the airborne spread of infectious diseases to the impact of large-scale episodic pollution events, such as wildfires, on indoor air quality. For the past seven years, Jovan has worked in the field on Internet of Things (IoT) sensing and is considered as one of the leading experts in the field.

<u>Nuggets mined from today's episode:</u>

Geographic differences in IAQ awareness and concerns (Europe, Asia, North America)? In Europe, heating and cooling systems are primarily water-based and ventilation is based on opening the windows and utilizing natural ventilation. North America adopted a different approach where heating and cooling are done with air and ventilation is mechanical supplied. Of course, in both places we have all sorts of systems. I believe that the expectations of IAQ in different parts of the world are also different.

The study of IAQ began in Nordic countries which have high energy costs. IAQ study combined energy efficiency measures with improving occupant comfort and IAQ.

In Serbia, where I was born, there is less IAQ awareness than in North America. Energy efficiency is a more significant concern than IAQ. Things in Serbia are changing and there are more smart and mechanically ventilated buildings.

Singapore is an island surrounded by a warm Pacific ocean that has a summer climate year-round. Singapore is humid (RH=75% at 30^{o}C/86^{o}F and 20 grams of moisture per kilogram of air). Singapore has many state-of-the-art mechanically air-conditioned and ventilated buildings, but mold is the biggest IAQ concern in Singapore, even in new state-of-the-art buildings. Mold grows at the interface between warm and cold air, and it is very challenging to prevent these interfaces, so we can see black ceiling tiles where mold grows. People in the tropical climate zone have different expectations and, in general, like to cool down quickly, so lower indoor air temperatures, for example, are very common.

What does the Well Living Lab research? The Well Living Lab conducts interdisciplinary research on the interrelationship between buildings, people and health. I am very proud to say that we did a lot of groundbreaking research on IoT (Internet of Things) applications in control of indoor air quality. It is also important to mention that in our studies we include physiology and psychology aspects. Energy efficiency was the primary driver of innovation for decades, which sometimes made us forget that the primary purpose of buildings is to house people. This trend is now shifting, and there is growing interest in making buildings healthy not just energy efficient. Because both aspects are essential to consider. Buildings that are marvels of architecture often don't prioritize indoor environmental quality enough. Instead, we should balance monetary savings from energy efficiency with money saved through improved occupant health.

Covid resurgence? Dr. Pantelic's PhD is in the study of airborne infection transmission. He became interested in airborne transmission during a SARS outbreak in Hong Kong in 2003. In his carrier Dr. Pantelic worked on several aspects of airborne transmission. Developing and characterization of specialized personalized ventilation device for mitigation of airborne transmission was part of Dr Pantelic's PhD work. Designing an exhaled breath aerosol sampler for collection of viruses while maintaining their viability was his later work with Professor Donald

Milton. As a part of Professor Milton's team, Dr Pantelic showed viable virus in exhaled breath of people providing evidence for consideration of airborne mode of Influenza transmission. This was also the first study that quantified number of viruses in exhaled breath. Dr Pantelic's lates work on airborne transmission took place in Lawrence Berkeley National Laboratory. Findings from this study show that if the same amount of air is supplied in heating and cooling mode from the overhead mixing supply, dilution in heating mode is significantly lower. This is important because it points out that during the heating season it would be important to increase air supply in spaces with overhead mixing ventilation. Dr Pantelic's prior work support this finding because flow rates and airflow patterns are the most important contributing factor in dispersion of aerosolized viruses. In some cases when displacement ventilation is used, air patterns can create an air cushion and trap aerosolized virus in the breathing zone. To analyze potential effects of airflow patterns, require use of sophisticated tools like computational fluid dynamics. One of Dr Pantelic's interesting observation when they quantified number of viruses in exhaled air, was that among 200 study participats there were some people with one to two orders of magnitude large numbers of viruses in exhaled breath. This observation to some extent supports the idea of existence of super spreaders, although we can't conclude that. More research is needed to better understand airborne viral transmission. To conclude, Dr Pantelic suggested that when we have overhead mixing air supply supplying more air dilutes airborne viruses better, but with any other systems of air supply we need to be more careful and potentially do more analysis. In general, fresh air is preferred over recirculated. Naturally ventilated buildings can have both high and low air exchange rates and therefore periods very favourable for airborne transmission, so we need to understand how much natural ventilation is available and how much is utilized because on average only 20-30% of time we keep windows open. When we are sick we tend to close windows even when air outside has air temperature that would allow natural ventilation utilization.

How to use environmental IoT ***Sensors to prevent transmission of infectious disease?*** IoT environmental sensing assumes measurements of environment with high granularity. They can help in detecting zones that are not well ventilated through the use of CO_2 as a proxy for ventilation and exhaled air.

UVGI? UVGI is proven technology. There are some challenges in the design. Because the exposure time between the UV light and the virus is short, it takes a high intensity of UV light to expose virus to the necessary does to inactive it. When deciding to use UVGI we need to consider financial investment in UVCI lighting, related energy consumption and maintenance cost.

Ionization systems are potentially very good for infection transmission control. They can be installed directly in the space where viruses might be released, but unfortunately research is missing to provide evidence how to use this technology effectively. It's very unfortunate that this technology didn't receive more research attention. I was very interested in it especially during my time in UC Berkeley, but simply there were no grants offered that would support research.

Portable air cleaners placed close to the people you want to protect from airborn transmission is a good option for many commercial spaces, especially with the limited occupancy.

Improvements in low-cost sensors? Dr Pantelic suggested that IoT environmental sensors has been substantially improved over the last 7 to 8 years since he started working with them. Particle counters are much improved. VOC sensors still face some challenges mostly due to challenging definition of VOC that comprises of the list of over 300 chemical compounds. CO_2 sensors are improved in the terms of lifespan and stability of readings. Temperature and RH sensing were and continue to be good. We still need to agree on standards and data quality. Some standards are in place

Wildfires? Buildings are not designed to have resilience to episodic high intensity air pollution events like wildfire. One of ASHRAE committees is working on guidelines for designing resilient buildings. Research that I previously did showed that IoT sensors can provide valuable information about building operation and during the wildfire events can show indoor and outdoor levels of $PM_{2.5}$. This provides some insights about if buildings have sufficient filtration or they have to improve filtration capabilities.

ROUNDUP-

Dr. Pantelic is passionate about improving communication of IAQ data to non-professionals.

IoT sensors places throught the building can provides more information to building occupants, but there are still some question if that is a good thing or not. Does the data confuse people if presented as numbers? How do we present this information in a useful form so that building occupants can benefit from it. Dr. Pantelic is supportive of intuitive methods for providing info to non-techies (e.g. traffic light pattern, Red, Yellow, Green), and he would like to improve them by offering actionable recommendations (e.g. open windows when cooking).

Airborne infection transmission and mitigation is complicated. When we have mixing system more air is better, more fresh air is always better. During the heating season increase air supply if overhead mixing is used. For other air supply system would be good to understand airflow patterns before just increasing the air supply. Natural ventilation is good and can serve very well, but make sure you understand how much of it is available considering air temperature and air pollution limitation and how much of that available potential your building uses.

The Last Word- More funding is needed to do more research to better understand complex issues and implement tools to find answers.

Z-man signing off

Trivia:

Name the type of glazing that assists in temperature control by using electricity to change tint preventing unwanted het loss or gain?

Electrochromic Smart Glass

Answered by: Bruce White