# Emerging Trends and Research Gaps in Environmental Health

2025

## An Environmental Health Committee Report to ASHRAE Technology Council

This report is prepared as a part of the MBO's assigned to Environmental Health Committee. Based on the feedback from the members of the EHC a list of recent trends and research gaps in the environmental health field and their impact on HVAC&R industry was prepared.

## Microplastics as a source of particulate matter

Microplastics are an emerging environmental contaminant found in air, water, soil, and biota. Despite rising concern over their potential health and ecological impacts, the absence of standardised methods for sampling and analysis remains a major barrier to understanding their distribution, abundance, and effects. Current techniques vary widely depending on the sample matrix, particle size, and study objectives, with methods including enzymatic digestion, spectroscopic analysis, forensic fiber techniques, and thermal decomposition.

No single analytical approach is suitable for all environmental conditions, and even similar sample types may require different processing depending on characteristics such as particle density or organic content. Given this complexity, harmonization—rather than full standardization emerges as a more achievable short-term objective. Harmonization focuses on using consistent reporting units, quality control protocols, and transparent documentation of analytical procedures.

This allows data comparability across studies and supports monitoring of spatial and temporal trends in microplastic pollution. It supports future regulatory standards, particularly in sectors such as water treatment and public health. Collaborative method development and shared best practices will be essential to advance the field.

## Chlorine flushing as a source of chloroform

Chloroform, a volatile disinfection byproduct formed during the chlorination of water, is now recognised as an indoor air pollutant of concern. Recent studies have shown that routine use of chlorinated water in homes—particularly during activities like showering, washing, or cooking—can release chloroform into the indoor environment through volatilisation. This process can be intensified during chlorine flushing of water distribution systems, a standard maintenance practice aimed at ensuring water safety. Studies show indoor chloroform concentrations may exceed outdoor levels by up to tenfold, posing potential inhalation risks.

Evidence suggests that chloroform emissions during residential water use are not only common but also underreported. In some cases, indoor exposure may surpass that from drinking water ingestion. Elevated concentrations have also been documented in facilities using chlorinated water, such as swimming pools and laundries. As concern grows over indoor air quality, chloroform emissions from municipal water treatments and household activities represent an emerging trend in environmental health research, highlighting the need for better ventilation strategies and exposure risk assessments.

## Wildfires

Recent research highlights the varying health impacts of particulate matter (PM) produced by wildfires, depending on the materials burned. While vegetation fires generate organic carbon particles, wildfires that consume buildings, vehicles, and other urban infrastructure release more complex and potentially more hazardous pollutants. These may include heavy metals, volatile organic compounds, and synthetic chemicals not typically present in natural biomass.

This variability in composition suggests that not all wildfire smoke poses equal health risks. In urban-interface fires, the inhalation of toxic combustion products may have more severe respiratory and systemic health effects compared to exposure to smoke from forested areas. As climate change increases both the frequency and scale of wildfires, understanding the source-specific toxicity of emitted particulate matter is becoming a critical area of public health research and regulatory concern.

## Using Disability Adjusted Life Years for justifying and setting standards

Over the past few decades, the field of public health has developed a unified metric of harm called the Disability Adjusted Life Year, or DALY, that includes both quality of life lost to illness or disease and life lost to premature death. DALYs are now the standard metric for evaluating public health programs, international aid, and government regulations. IEQ researchers and ASHRAE standards committees are now starting to use DALYs in their work. DALYs solve two problems for us:

First, DALYs can help justify IEQ standards. We can show that improving IAQ prevents harm, i.e. 'purchases' life and health, for a good price compared to other health regulations. This is true even in situations where improved standards are not profitable for business owners.

Second, DALYs can be used to make better standards. At minimum, we can use them to set thresholds based on the harm that a contaminant would cause. The cutting edge of standards, as demonstrated in the revised 62.2 Standard, is to define good IEQ as minimizing the total harm caused, and create a 'harm budget' that the environment cannot exceed.

## Sensors

In 2025, the deployment of real-time air quality monitoring devices within buildings is becoming standard practice for new, and existing, buildings (during renovations). The combination of real-time monitoring, smart ventilation, and predictive modeling is a game-changer for indoor and outdoor air quality management. With open data platforms aggregating sensor data, it also enhances transparency and public awareness. These devices, when integrated with smart ventilation systems, can provide tenants with assurance of a healthy indoor environment. These advancements will directly impact building regulations, sustainability initiatives, or tenant well-being.

The integration of real-time data collection and advanced modelling techniques is revolutionizing the scope of air quality monitoring.  With the proliferation of open data platforms and networks of sensors deployed across urban and rural areas, it is now possible to compile live measurements from numerous devices. These datasets feed into sophisticated models that provide a comprehensive understanding of air quality over a large area. Such developments empower governments, researchers, and the public with the ability to track pollution levels dynamically, to predict air quality trends, and to develop effective mitigation strategies. New research using the data obtained from sensors will enhance understanding and use of controls, and will enable building owners to control the indoor environmental quality in their buildings.  Sensor accreditation, currently underway at the American Industrial Hygiene Association Laboratory Accreditation Program (AIHA LAP), will become important since there is currently no formal, recognized process to validate the performance of direct-reading sensor devices. This validation will potentially undermine the health and safety of the individuals they intend to protect.

Sensor networks are increasingly being integrated with artificial intelligence (AI) platforms. These systems combine real-time data with predictive modelling, occupancy patterns, and weather forecasts to optimize building operations. However, concerns remain over algorithm transparency, data privacy, and the real-world validation of AI tools. Formal testing protocols and performance standards are needed to ensure health and safety are not compromised.

As these technologies develop, collaboration between environmental health researchers, building engineers, and AI specialists will be essential to ensure that both sensor data and AI systems support healthier indoor environments.

## Heat Stress

Rising global temperatures are increasing the frequency and severity of heatwaves, with significant implications for vulnerable populations indoors. While thermal comfort and temperature thresholds are well established in building design, there is growing interest in early biomarkers of physiological heat stress, particularly in settings such as schools, care homes, and hospitals.

Heat shock proteins (HSP70, HSP90) are consistently upregulated in response to elevated core body temperature and cellular stress. They are detectable in blood, saliva, and potentially urine, and rise before clinical symptoms appear. Their use as early warning indicators is well supported by studies in occupational and athletic settings. Other markers—such as cortisol, inflammatory cytokines (IL-6, TNF-α), and oxidative stress indicators—may complement this molecular profile, offering a fuller picture of subclinical stress during heat events.

There is an opportunity to integrate physiological screening with environmental monitoring. A pilot study could track HSP70 levels in children or elderly individuals during a heatwave, alongside hydration, symptoms, and indoor environmental data. This could support the development of heat stress risk tools for caregivers, enabling targeted interventions before occupants become clinically unwell.

These developments underline the need for better integration between building performance metrics and occupant health monitoring, especially as climate change intensifies thermal exposure risks indoors.

## Novel Airborne Diseases

Health agencies are increasingly focused on several emerging airborne disease threats. A key concern is the recent mutation of avian influenza A (H5N1), with cases in North America showing changes that could increase transmissibility to humans. Risk remains low, but pandemic potential requires ongoing monitoring.

Human metapneumovirus (HMPV), a respiratory virus similar to RSV, is also drawing attention due to rising cases in China and the U.S. Although seasonal, spikes in infections and severity—particularly among children and older adults—suggest the need for enhanced surveillance.

In Central Africa, an unidentified illness dubbed ‘Disease X’ has raised alarm. This illness affects primarily young children, and the symptoms include fever, cough, and severe anemia. Its cause and transmission route remain unknown, but potential airborne spread is under investigation.

Finally, the World Health Organization has revised its definitions of airborne transmission to better guide responses to both familiar and novel pathogens. Together, these developments reflect growing concern about the adaptability of respiratory viruses, underscoring the importance of early detection, global coordination, and preparedness for future outbreaks.

## Fungal Pathogens and Indoor Risk

*Candida auris* is an emerging fungal pathogen of global concern. Since its first identification in 2009, *C. auris* has caused difficult-to-control outbreaks in hospitals across five continents, including in several EU countries. Spain and the UK have reported hundreds of cases, many linked to nosocomial transmission in intensive care settings. *C. auris* is often resistant to multiple antifungal drug classes and can persist on surfaces and equipment, making it highly suited to healthcare environments.

Recent research supports the hypothesis that *C. auris* emerged from environmental origins, potentially accelerated by global warming. Wild-type isolates from the Andaman Islands differ genetically and phenotypically from clinical strains—showing slower growth at mammalian temperatures and lower antifungal resistance. This supports the idea that thermal adaptation, in response to rising global temperatures, allowed *C. auris* to cross the endothermy barrier (the high body temperature of mammals and birds restricts many fungal species, making them less likely to cause infections) and become pathogenic to humans.

In the EU, outbreaks have demonstrated the organism's potential for rapid intra- and inter-facility spread. Laboratory misidentification, limited decolonization strategies, and persistent environmental contamination all contribute to outbreak difficulty. The ECDC recommends targeted infection control measures, including screening, isolation, and rigorous disinfection with fungicidal agents. Many member states have yet to fully implement surveillance systems or reference laboratory capacity.

The emergence of *C. auris* highlights a broader concern: fungal pathogens with environmental reservoirs and high thermal tolerance may become increasingly common in buildings. Indoor environments that serve vulnerable populations—especially hospitals and care homes—should monitor emerging fungal risks as climate trends, antifungal use, and healthcare practices continue to evolve.

## Second Hand Emissions from Non-Tobacco Sources

Second-hand exposure to smoke from non-tobacco sources, such as marijuana and hookah, is now an emerging health concern. While tobacco smoke is known for indoor air pollution and health risks, recent studies show that marijuana smoke may produce even higher levels of fine particulate matter ($PM_{2.5}$). Some studies indicates that second-hand marijuana smoke can emit over three times more $PM_{2.5}$ than tobacco cigarettes, raising concerns about respiratory and cardiovascular risks for bystanders, particularly in poorly ventilated spaces.

Similarly, hookah use generates substantial second-hand smoke exposure. A single smoking session can emit significant quantities of pollutants including carbon monoxide, volatile organic compounds, and particulates. Despite the water filtration process, emissions from hookah smoke still contain harmful substances that can linger in indoor environments, affecting non-users nearby.

These findings challenge the perception that non-tobacco smoking is less harmful and point to a need for updated health policies. As social and legal norms around marijuana and hookah evolve, understanding and addressing second-hand exposure risks is becoming more important for indoor air quality management and health protection.

## Tradeoffs between De-carbonization, Energy Efficiency, and Indoor Environmental Quality

Balancing sustainability goals with indoor environmental quality (IEQ) is an emerging challenge in building design and environmental health. De-carbonization and energy efficiency measures are accelerating, but they do not always align with efforts to protect occupant health. This tension is increasingly recognized and reflected in phrases such as '*Sustainability Without Compromise*', '*Healthy Energy Efficiency*', and '*Energy-Efficient IAQ*'.

Despite this attention, frameworks to evaluate and manage trade-offs between energy use, carbon reduction, and indoor environment quality remain limited. Progress will be difficult without clear principles that prioritize human health within sustainability targets. Collaboration between environmental health researchers, building scientists, and policymakers is needed to develop standards that safeguard both planetary and human health.