Bulletin de veille AéroCovid
N°119 – 02/07/2025

Objectif : *Air intérieur, ventilation, climatisation et propagation du Covid-19*

> *La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS. Les éléments issus de cette veille sont founis sans garantie d'exhaustivité.*
>
> *Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.*

Les bulletins de veille sont disponibles sur le portail documentaire de l'INRS. L'abonnement permet de recevoir une alerte mail lors de la publication d'un nouveau bulletin (bouton « M'abonner » disponible après connection à son compte).

Google Scholar, Lens et WoS

Shao, X., Li, M., Wang, L., Han, H., Liu, Z., Huang, J.*, et al.*

An accurate reconstruction method for indoor bioaerosol concentration field from asynchronous and sparse LiDAR measurements based on latent diffusion models.

Building and Environment, Vol. **282**, (2025)

Bioaerosols are the primary route for pathogen transmission, and have a serious negative impact on human health. Accurately measuring the distribution of bioaerosol concentrations in the indoor environment holds significant importance. Current methodologies are constrained by limitations in measurement resolution and speed, and unable to obtain the global 3D concentration fields directly. We propose a Sparse Reconstruction Latent Diffusion Model (SR-LDM) that reconstructs the 3D global concentration field from the asynchronous sparse bioaerosol concentration data measured by LiDAR. The concentration field reconstruction is formulated as a conditional generation task, leveraging the powerful generative capabilities of the Latent Diffusion Models (LDM) to infer global distributions from sparse observational data. We employ a contrastive learning strategy to train a dedicated condition encoder, which extracts information from spatiotemporal sparse data measured at different locations and times to guide the generation of the global concentration field. We use a validated Computational Fluid Dynamics (CFD) solver to construct a dataset of aerosol concentration fields in an empty channel. The results indicate that our SR-LDM model effectively reconstructs the global concentration field formed by a single release source, using historical sparse measurement data that accounts for 1 %–3.2 % of the total number of units. In most cases, high-quality results are obtained after 6–16 iterations, and the similarity with CFD data reaches 80 %.

****
Djuraeva Robaxon, X.

Airborne droplet infections: transmission and current relevance.

International Multidisciplinary Journal for Research & Development, Vol. **12** n°(05), (2025)

Airborne infectious diseases, transmitted through aerosols and respiratory droplets, continue to pose significant global health challenges. Diseases such as measles, COVID-19, and influenza have demonstrated high transmissibility, leading to outbreaks even in regions with established vaccination programs. Recent data indicate a resurgence of measles cases in various parts of the world, attributed to declining vaccination rates and increased international travel. This article examines the current prevalence, transmission dynamics, and public health implications of airborne infectious diseases, emphasizing the need for sustained surveillance, vaccination efforts, and public health interventions.

****
Khankari, K.

Designing Building Ventilation to Exceed Codes and Standards.

ASHRAE Journal, Vol. **67** n°(6), (2025)

The standards for indoor air quality (IAQ) are essential for setting minimum ventilation rates for buildings to ensure a healthy environment for everyone. However, the prescriptive and mostly consensus-based recommendations in the codes and standards are not sufficient to address the details of ventilation design. In addition to the ventilation rates, the indoor airflow patterns and the resulting flow path of airborne contaminants can significantly affect the quality of air in the breathing zones of occupants. This article demonstrates how the science of computational fluid dynamics (CFD) can help analyze and optimize the ventilation designs. CFD analyses, along with the Spread Index—a ventilation effectiveness metric—can complement the codes and standards to create more comprehensive and human-centric ventilation designs.

****

Rivero-Cacho, A., Sánchez-Barroso, G., Pastor-Pérez, P., García-Sanz-Calcedo, J.

Forecasting indoor air quality in high-risk operating theatres in hospitals using Artificial Neural Networks.

Journal of Building Engineering, (2025)

Airborne particulate matter is a vehicle for transmitting infectious diseases. Therefore, operating theatres must undergo periodic audits to verify that their indoor air quality remains within acceptable ranges. However, the months that may pass between on-site data collections mean that the temporal discretisation of the audit sample is not representative of the room's indoor air quality. This research aimed to forecast the particulate matter in high-risk operating theatres as a novel approach to continuously monitor indoor air quality in hospitals employing artificial neural networks. For that purpose, three types of artificial neural network architectures were analysed: Multilayer Perceptron, Long Short-Term Memory, and Nonlinear Autoregressive Exogenous. Temperature, relative humidity, airflow supply and extraction, and the renewal rate in high-risk operating theatres were used as input variables for each model. Airborne particulate matter data were used as the predicted parameter. The networks were trained and validated using a curated dataset obtained from 20 hospitals in Spain over five years. The Nonlinear Autoregressive Exogenous model exhibited better performance metrics in forecasting both 0.5 and 5 μm particles. This research demonstrates that real-time HVAC variables can accurately forecast the presence of airborne particles in operating theatres, thereby reducing the risk of nosocomial infection. Findings are extremely useful for hospital managers, easily applicable in the operation and maintenance of critical facilities.

****

Oh, J., Ko, H. S., Yoo, I., Kwon, D.-S., Hwang, J.

Heat-induced fragmentation of airborne bacteria enables real-time concentration sensing.

Chemical Engineering Journal, (2025)

Rapid measurement of airborne bacterial concentration is crucial in various fields, including bioaerosol research, indoor air quality management, and biosafety. Airborne bacteria contribute to indoor air quality deterioration, as certain bacterial species can cause health challenges such as respiratory infections and allergic reactions. We measured the concentration of airborne bacterial particles and electrical currents carried by the bacterial particles at room and high temperatures. Some S. aureus were fragmented into nano-sized (5–100 nm) particles at temperatures exceeding 300 °C for 3.7 s. At 400 °C, extensive bacterial fragmentation resulted in a substantial increase in electrical current compared to that at 20 °C. Moreover, number concentration and electrical current measurements were performed at room and high temperatures for Polystyrene Latex (PSL) particles, representing airborne particulate matter (dust). PSL particles did not undergo fragmentation at high temperatures, resulting in no difference in the electrical currents they carried at 20 °C and 400 °C. After observing the differences both in bacterial number concentration and electrical current between 20 °C and 400 °C, we introduced a methodology to predict the number concentration of airborne bacteria particles at 20 °C in real-time. For particle mixture (PSL:bacteria = 2.2) suspended at 20 °C, the airborne bacterial concentration was calculated by measuring the electrical current carried by the bacterial particles and comparing it to the current measured after exposure to 400 °C. The calculated bacterial concentration was 98.7 particles per 1 cm3 air, closely aligning with the measured bacterial concentration, 100.5 particles/cm3 (1.7% difference).

****

Brusaferro, S., Brunelli, L., Arnoldo, L., Arzilli, G., Sangiovanni-Vincentelli, A., Privitera, G. P.

[Microwave irradiation for airborne virus inactivation: evidence and future perspectives.]()

Journal of Infection, (2025)

Non-thermal microwave (MW) irradiation has emerged as a promising approach for inactivating airborne viruses by exploiting their vibrational properties through selective resonant energy transfer (SRET). In this narrative review, we synthesize current evidence on the antiviral efficacy of non-thermal microwave (MW) technologies, evaluate their feasibility for indoor infection control, and highlight existing limitations as well as future research directions. A literature search was conducted across PubMed, Scopus, Google Scholar, and ScienceDirect for studies published between January 1, 2015 and March 7, 2025 using keywords related to MW irradiation, SRET, and airborne viruses. The evidence was organized into three key themes: mechanistic foundations of the technology, effectiveness against airborne viruses, and regulatory and safety considerations. The available data indicate that MW irradiation disrupts viral structures through vibrational resonance mechanisms, with effectiveness varying by viral type and depending on optimized frequency and exposure duration. Regulatory authorities recently acknowledged its potential to reduce airborne transmission, contingent on meeting stringent safety standards for electromagnetic compatibility, specific absorption rates, and power density. In summary, non-thermal MW irradiation offers a scalable solution for reducing airborne respiratory virus transmission. Pending further real-world validation, integrating this technology into public health strategies offers a promising approach to strengthen infection prevention and control in both healthcare settings and indoor environments, effectively targeting both human and zoonotic infections.

****

Huang, Z., Zhong, K., Kang, Y., Jia, H.

Numerical investigation of interpersonal respiratory aerosol transmission risks and mitigation strategies in an impinging jet ventilation room.

Indoor and Built Environment, (2025)

Impinging jet ventilation (IJV) systems offer significant advantages in maintaining indoor air quality. However, the influence of thermal stratification on the spread of the respiratory aerosol in IJV rooms has not yet been fully studied. The present study used validated numerical simulation methods to investigate the transport of respiratory aerosols and their impact on occupant exposure under typical thermal stratification conditions. Furthermore, the efficacy of various return vent layout strategies in controlling aerosol exposure was systematically evaluated. The results showed that the respiratory aerosol is 'lock-up' under thermal stratification scenarios at the height near the thermal stratification interface or infected person. This locking behaviour is contingent upon the relative positioning of the infected person in relation to the thermally stratified interface. The aerosol exposure in IJV rooms can be effectively reduced by reasonably adjusting the thermal length scale (Lm) to generate suitable thermal stratification. When Lm is kept between 1.15 and 1.27, exposed individuals' intake fraction (iF) is the lowest overall. Moreover, in IJV systems employing the exhaust/return-split configuration, it is recommended to situate the return vent near the thermal stratification height. In this case, the iF can be reduced by approximately 25–60%..

****

Wang, C., Xu, J., Huo, Y., Guo, H.

Numerical study of the exposure to volatile organic compounds released from liquid crystal displays in an office.

Indoor and Built Environment, (2025)

People spend about 90% of their time indoors and indoor volatile organic compounds (VOCs) are critical to human health. Liquid crystal displays (LCDs) widely used in offices are a new source of indoor VOCs, with an emission rate of 8.25×10^{9} molecules s^{-1} cm^{-2} reported by Liu and Abbatt (2021). Therefore, this work studied the exposure to LCD VOCs in a four-person office environment through numerical simulation. Air change rate per hour (ACH), geometric setting and partition were also investigated. The results revealed that at an ACH of 4, human users inhaled 0.07%–0.25% of the released VOCs. The deviations for different users were 4–9 times due to various locations. Different geometric settings resulted in 2–3 times exposure deviations. Increasing the ACH to 20 led to an 88% reduction. The estimated lifetime exposure via inhalation was 8.2×10^{18} VOC molecules or 1 mg per LCD. This study contributed to the understanding of exposure to VOCs from LCDs.

****

Zhang, Q., Essien, D., Zhang, K. Y.

A Review of Air Ionization with Negative Ions for Aerosol Removal and Inactivation of Airborne Microorganisms in Confined Spaces.

KONA Powder and Particle Journal, (2025)

A comprehensive literature review was conducted to summarize and analyze the mechanisms and applications of air ionization for aerosol removal and inactivation of airborne microorganisms in confined spaces. This review focuses on engineered ionization systems (ionizers) that generate negative ions through corona discharge. Numerous studies have proven that air ionization is effective in removing aerosols and inactivating airborne microorganisms in confined spaces. Multiple physical, chemical, and biological processes may be involved in air ionization, including corona discharge and ion generation, attachment of ions to aerosol particles, transport of ions and aerosols in the air, electrostatic drift, deposition of aerosol particles on surfaces, and inactivation of biological agents if air ionization is used to prevent the spread of airborne pathogens. Each of these processes, as well as their interactions, is extremely complex, and only a limited number of studies have explored the interplays of these processes or attempted to integrate them into models that quantify the fundamental behavior of air ionization.

****