

Bulletin de veille Maladies aéroportées
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Objectif : *Air intérieur, ventilation, climatisation et propagation des maladies aéroportées*

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Google Scholar, Lens et WoS

Gao, M., Zhang, Z., Tao, Y., Chen, X., Wang, K., Niu, M.*, et al.*

AIPS: an automated interferential plasmonic system for on-site bioaerosol detection.

Sensors and Actuators Reports, Vol. **12**, (2026)

On-site quantification of airborne biological agents with low latency is critical for mitigating infection risks, informing ventilation strategies, and enabling rapid responses in high-risk environments. However, most existing aerosol detection approaches rely heavily on off-site laboratory analysis, which limits temporal resolution and hinders early intervention. Here, we report an automated interferential plasmonic system (AIPS) that integrates programmable aerosol collection, embedded microfluidic sample processing, sensitive and specific plasmonic sensing, and fully automated workflow control for in situ detection of bioaerosol. The AIPS combines a humidity-regulated condensation-growth module with an inertial liquid-impingement sampler to achieve high-efficiency capture of coarse and submicron biological particles, followed by an in situ lysis process to release intracellular nucleic acid components from microorganisms. An interferential nano plasmonic assay is subsequently employed to quantify the concentration of target biological agents with high specificity. The system achieves a practical detection limit in the collected liquid and completes the entire “air-sampling-to-result” label-free quantification process within 90 min (30 min sampling and 60 min processing and detection), along with a label-free alarm to target presence as fast as 1 min after completing the air sample. Integration of amplification methods can further enhance sensitivity and support more accurate detection across a wide range of scenarios. Real-world pilot measurements demonstrate that the AIPS enables high-spatiotemporal-resolution monitoring of indoor and outdoor bioaerosol dynamics and supports quantitative exposure assessment. This work establishes AIPS as a next-generation platform for continuous, autonomous surveillance of airborne biological threats and provides a promising solution for early warning of infection risks in healthcare, transportation, and other public environments.

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Suru, W. P., Odeyemi, F. G., Akande, A. A.

Assessment of indoor airborne microbial load and development of a biosafety risk prediction model for laboratories and lecture facilities in polytechnics in South-West Nigeria.

International Journal of Innovative Technology Integration in Education, Vol. **9** n°(2), (2026), 30–43 p.

Indoor air is a significant reservoir of microbial exposure, and in densely occupied laboratories and lecture facilities airborne bacteria and fungi can reach levels linked to ill-health. This study assessed indoor airborne microbial load and developed a biosafety risk prediction model for laboratories and lecture facilities in polytechnics in South-West Nigeria. A survey-and-modelling design combined microbiological measurement with predictive modelling. A total of 216 air samples were collected by settle-plate and active impaction across 18 facilities, with concurrent measurement of temperature, relative humidity, carbon dioxide, particulate matter, occupancy and ventilation. Mean bacterial and fungal loads were 1,842 and 1,264 CFU/m³, exceeding recommended limits in 62.4% and 48.6% of samples respectively. Predominant organisms were Staphylococcus aureus (28.4%), Bacillus spp.(22.6%), Micrococcus spp.(16.8%), Aspergillus spp.(18.2%), Penicillium spp.(14.6%) and Cladosporium spp.(10.8%). Microbial load was associated with occupancy density ($r= 0.62$, $p< 0.001$), carbon dioxide ($r= 0.58$, $p< 0.001$), relative humidity ($r= 0.46$, $p< 0.001$) and ventilation rate ($r=− 0.52$, $p< 0.001$). A regression model explained 68% of the variance in microbial load (adjusted $R^2= 0.64$), and a machine-learning risk model achieved 86.4% classification accuracy. The study provides an empirical baseline and a predictive tool for managing biosafety risk in Nigerian polytechnics.

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Gagnon, R.

Caractérisation des bioaérosols de deux zones urbaines au Canada avec des degrés d'urbanisation distincts.

Université du Québec à Chicoutimi. Thèse 2026

Les bioaérosols sont ubiquitaires dans l'environnement, autant à l'extérieur qu'à l'intérieur. L'assemblage des communautés microbiennes dans l'air est le résultat de processus complexes impliquant des facteurs environnementaux, le climat et les activités humaines. L'anthropisation du territoire est due à l'augmentation de l'urbanisation. Cette modification de l'utilisation du territoire entraîne des changements dans l'émission des bioaérosols, notamment dans la composition des communautés les constituant. Le système respiratoire humain est en constante exposition aux bioaérosols, qui, pour la grande majorité, n'ont pas d'effets significatifs sur la santé humaine. Cependant, certains peuvent exacerber l'inflammation des voies respiratoires, voire causer des infections, alors que d'autres peuvent avoir des propriétés anti-inflammatoires. Malgré l'intérêt en santé publique et les études portant sur leur présence dans le milieu de travail, peu se sont intéressées à l'impact du degré d'urbanisation sur le microbiome de l'air dans un contexte d'exposition quotidienne, et sur l'impact de ces communautés sur l'air à l'intérieur de bâtiments.

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Husainy, A. S. N., Vishwakarma, A., Jagtap, S., Gharage, S.

Design and Development of a Smart HVAC Duct Cleaning Robot Incorporating Real-Time Vision Monitoring and UVGI-Based Microbial Control.

Asian Review of Mechanical Engineering, Vol. **15** n°(2), (2026), 57–65 p.

Indoor air quality within HVAC systems significantly influences occupant health, thermal comfort, and energy efficiency. Over time, air ducts accumulate dust, debris, allergens, and microbial contaminants, leading to reduced airflow performance and increased health risks. This paper presents the design and development of an Autonomous Air Duct Cleaning Robot integrated with high-pressure water jet cleaning and Ultraviolet Germicidal Irradiation (UVGI) technology. The robotic system is equipped with a compact locomotion mechanism, ESP32-CAM for real-time monitoring, and a controlled rotary nozzle operating at high velocity for effective contaminant removal. Fluid dynamic principles validate the cleaning mechanism, achieving dust removal efficiencies exceeding 90% for fine particles. In addition to mechanical cleaning, the UVGI module operating at approximately 254 nm enables microbial inactivation within enclosed duct environments, enhancing biological safety. Experimental evaluation confirms stable navigation, reliable wireless communication, and sufficient battery endurance for sectional duct cleaning tasks. The integrated approach reduces human exposure to hazardous environments while improving HVAC efficiency and indoor air quality. The proposed system offers a cost-effective and scalable solution for modern duct maintenance applications.

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Moran Treviño, K. J.

Diseño de aire acondicionado de una sala de operaciones multifuncional para un hospital de Essalud tipo 3 en la región de Arequipa aplicando la metodología BIM.

Universidad Católica de Santa María. Thèse 2026

This study was developed within the context of designing HVAC systems for an operating room at an EsSalud Type III Hospital in Arequipa, aiming to guarantee thermal comfort, indoor air quality, and infection control.

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Zacarías, S. M., Martin, D., Petersen, V. W., Kočí, K., Alfano, O. M., De Los Milagros Ballari, M.

Distinguishing photochemical and photocatalytic contributions through kinetic modelling of Aspergillus niger conidia inactivation on TiO2-based paints.

Results in Engineering, (2026)

Airborne fungal contamination in indoor environments requires effective microbial control strategies. TiO2-based photocatalytic building materials offer a promising approach for in situ inactivation of fungal conidia, but quantitative kinetic descriptions under relevant environmental conditions remain limited. This study investigated Aspergillus niger conidia inactivation on paints containing rutile TiO2, used as a non-photocatalytic reference, and anatase TiO2, photocatalytically active under UV-A irradiation. Experiments were conducted in a batch reactor under controlled relative humidity (RH) and incident radiation flux. An empirical kinetic model was developed to distinguish the direct photochemical contribution from the additional photocatalytic contribution. The model describes the dependence of apparent inactivation constants on radiation flux using a power-law function, while the two experimentally investigated RH regions were incorporated through a single multiplicative humidity factor. The direct photochemical contribution showed a sublinear dependence on incident radiation flux, whereas the photocatalytic contribution exhibited a superlinear dependence. The model showed satisfactory agreement with the experimental data, with an overall relative RMSE of 22.23%. Increasing RH from the 50% region to the 70–80% region produced no detectable change in the direct photochemical contribution but markedly enhanced the photocatalytic contribution, corresponding to an approximately 33-fold increase in its apparent inactivation constant. Regrowth tests showed that UV-A treatment impaired fungal reproductive development, with slower development on anatase TiO2 paint during subsequent dark incubation, indicating a more persistent effect associated with the photocatalytic coating. This study provides a quantitative framework for evaluating and optimizing photocatalytic coatings for fungal control within the investigated environmental domain.

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Navarro, P., Tejero-González, A., Varela, F., Ruiz, J.

Experimental determination of water carryover in the airstream from PVC evaporative cooling pads.

Thermal Science and Engineering Progress, Vol. **80**, (2026)

The increasing need for energy-efficient cooling strategies in buildings has renewed interest in Direct Evaporative Cooling (DEC) as an alternative to compression-based systems. However, it introduces engineering challenges such as the risk of microbial growth and its subsequent dissemination into the supply air as aerosols. Compared to DEC misting, wetted media pads do not inherently generate aerosols, although water entrainment may occur if operating at high air velocities. This phenomenon of water carryover, defined as the unintended entrainment of liquid droplets into the outlet airflow, remains insufficiently documented, particularly in synthetic media such as corrugated PVC. This gap is not merely academic: uncontrolled entrainment may have significant operational and hygienic implications in relation to aerosolized water and pathogen dispersion. This study offers a detailed experimental characterization of water carryover in a commercial PVC evaporative pad. The sensitive paper method was used to assess droplet deposition patterns and quantify entrainment under a range of operating conditions. Air flow rates varied between 500 and 1500 ls−1, with water loading set between 40 and 80 lmin−1m−2. The results indicate that the entrainment remains negligible, on the order of 10−6 kgs−1, at air flow rates below 1000 ls−1, but increases significantly beyond that threshold, reaching values as high as 10−4 kgs−1 under more demanding conditions. Most droplet diameters were within 20–30μm, except in specific cases, 1250 and 1500 ls−1, where significantly larger droplets were observed.

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Wang, Z., Lausch, K. H., Lichtner, E., Ramasetti, E. K., Kriegel, M.

A Fourier neural operator framework for indoor contaminant transport prediction, source localization, and release strength estimation.

Building and Environment, Vol. **307**, (2027)

Indoor air quality is a key concern in building design, as occupant exposure is strongly governed by pollutant transport and removal through ventilation flows. Computational fluid dynamics (CFD) provides detailed indoor contaminant concentration fields, but its computational cost limits repeated evaluations over many pollutant source locations. In this work, we develop a Fourier neural operator (FNO) framework for rapid prediction and inverse localization of indoor contaminant transport, in which a soft rectangular source mask provides geometric fidelity and differentiability. It is evaluated in the two-dimensional IEA Annex 20 room with fixed geometry and prescribed ventilation. The FNO achieves a mean relative L2 error of 0.0326±0.0022 over three training seeds, predicts a full field in approximately 0.64 ms, about 1.3×105 times faster than the CFD workflow, and yields lower errors than a fully convolutional network (FCN), U-Net, DeepONet, and inverse-distance weighting (IDW), with accuracy comparable to the geometry-informed neural operator (GINO). A model trained at 192×64 transfers directly to the 384×128 grid with an error of 0.0360±0.0021. For inverse localization, the surrogate is combined with coarse global screening and gradient-based refinement, achieving mean localization errors of 0.103, 0.165, and 0.372 m with eight sensors at relative noise levels of 0, 0.02, and 0.05. For 15 off-grid sources with unknown release strengths, locations and strength are estimated jointly with noise-free mean errors of 0.126±0.007 m and 0.106±0.009. These results demonstrate that neural-operator surrogates can support field prediction and inverse source localization within the evaluated setting.

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Tavakkalovich, I. D.

Hygienic assessment of indoor air ventilation and ventilation systems.

BG pulse journal, Vol. **2** n°(10), (2026), 1174–1176 p.

Indoor air quality is a major determinant of human health because modern populations spend most of their daily lives in enclosed spaces. Ventilation systems play an essential role in maintaining acceptable microclimatic conditions by regulating temperature, humidity, air velocity, and contaminant concentrations. This article evaluates the hygienic significance of ventilation systems and analyzes criteria used to assess their effectiveness. A narrative review and hygienic analysis were conducted using public health principles and environmental hygiene standards. The results indicate that adequate air exchange significantly reduces carbon dioxide accumulation, excessive humidity, dust, microorganisms, and unpleasant odors. Effective ventilation improves comfort, cognitive performance, occupational productivity, and disease prevention. The study highlights the importance of monitoring air exchange rates, carbon dioxide concentrations, thermal conditions, and ventilation-system performance as core indicators of hygienic safety.

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Fouad, M. A., Rizk, M. A., Alhajry, A., Abdelmoez, M. S.

Multi-Scale Computational Fluid Dynamics Investigation of Ventilation-Controlled and Gravity-Controlled Respiratory Aerosol Transport in an Office Environment: Implications for Heating, Ventilation, and Air Conditioning Design and Airborne Infection Mitigation.

In: Buildings. 2026. pp. 4297.

This study presents a comprehensive transient Computational Fluid Dynamics–Discrete Phase Model (CFD-DPM) investigation of aerosol and droplet transport in an air-conditioned office containing one infected occupant and three susceptible occupants. The transition from ventilation-controlled to gravity-dominated transport of respiratory aerosols in office settings remains poorly characterized. Continuous emission over 300 s was simulated for particle diameters of 1, 5, 10, and 50 µm. The continuous airflow field was resolved using the pressure-based solver, energy equation, and Shear Stress Transport k-ω turbulence model, validated against experimental temperature and relative humidity data with mean absolute errors of 0.59 °C and 1.26% relative humidity, respectively. The airflow model was validated against temperature and relative humidity data only; the discrete-phase predictions were not validated directly against experimental aerosol data. A critical finding is the identification of three distinct transport

regimes: Regime I (1–5 µm), characterized by ventilation-dominated behavior with strong airflow coupling, approximately 50% outlet removal, and 38–39% airborne fraction at 300 s; Regime II (10 µm), representing a mixed-transition zone where gravitational effects begin to compete with aerodynamic forces; and Regime III (50 µm), dominated by gravitational settling with 93% deposition and only 1.6% outlet removal at 300 s. The critical transition diameter between ventilation-controlled and gravity-dominated transport was estimated to be approximately 20–30 µm based on interpolation between the 10 µm and 50 µm cases and dimensionless analysis; this estimate requires further validation with intermediate particle sizes. Dimensionless analysis revealed that particles with Stokes numbers below 0.1 remain strongly coupled to the airflow, while those exceeding 1.0 exhibit ballistic trajectories dominated by inertia and gravity. Outlet-2 consistently served as the dominant removal path for all particle sizes, confirming an asymmetric ventilation transport route attributable to the supply jet trajectory and recirculation patterns. Human 2 received the highest body-deposition fraction for aerosol-sized particles (0.287% for 1 µm, 0.123% for 5 and 10 µm at 300 s), identifying this location as a critical exposure zone. For 50 µm droplets, susceptible occupant deposition was negligible (<0.0005%) because gravitational settling deposited most mass on the floor (64.1%) and the infected occupant (25.5%) before far-field transport occurred. These findings establish a quantitative framework for designing ventilation systems that optimize removal of aerosol-sized particles while recognizing the inherent limitations of air extraction for droplet control. The proposed transport-regime classification provides a framework for HVAC engineers, with recommendations for return grille placement, air change rates, and supplementary source-zone controls for large droplets. These recommendations are derived from a single office geometry and ventilation configuration and should be validated across different room layouts, ventilation strategies, and operating conditions before being generalized. The methodology and findings contribute to the growing body of knowledge on airborne infection risk mitigation in occupied spaces, with direct applicability to post-pandemic building design and operation.

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Norvihoho, L. K., Xu, Z., Mubashir, M., Zhou, Z., Guo, H.

Numerical investigation of evaporation and hygroscopic equilibrium in multicomponent respiratory droplet surrogates under winter indoor conditions.

International Communications in Heat and Mass Transfer, Vol. **180**, (2026)

Accurate characterization of respiratory droplet evaporation microphysics is critical for assessing indoor airborne transmission risk of seasonal respiratory pathogens, especially in dry heated winter environments. This study numerically investigates evaporation dynamics of four compositionally distinct respiratory fluid surrogates under controlled winter indoor conditions, using large eddy simulation coupled with a multicomponent discrete phase model (DPM). A single 100 µm droplet is held in stationary levitation to isolate mass-transfer effects from transport and sedimentation. Simulations vary ambient relative humidity (20–60%), temperature (293–303 K), and background airflow (0–0.2 m/s) across pure water, 0.9% isotonic saline, saliva-like, and glycerol-enhanced lower-respiratory-tract surrogates. Analysis of variance confirms relative humidity dominates drying kinetics, accounting for 73.3% of total variance in t95 (time to 95% diameter reduction), followed by ambient temperature at 18.5%. Surrogate composition and weak airflow contribute only 2.2% and 3.2% of variance, respectively; airflow is not statistically significant at the 95% confidence level. Final residual nucleus diameter is determined solely by initial non-volatile solute content and is invariant across all tested conditions, with ratios ranging from 0.196 for saline to 0.363 for glycerol-enhanced mucus. Evaporative cooling reduces surface temperature by 21–25 K at 293 K for all surrogates; solute-laden droplets rewarm to ambient after drying, while pure water droplets remain at wet-bulb temperature. These findings provide a systematic microphysical basis for improving indoor respiratory aerosol transmission models.

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