Bulletin de veille QAI
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Objectif : *Qualité de l'air intérieur*

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Google Scholar, Lens, WoS

Utama, D. A., Diandra, S. G., Abdullah, Y. A.

Evaluation of Indoor Air Quality: A Descriptive Study of PM2.5 Exposure at Building Material Store.

Buletin Keslingmas, Vol. **44** n°(4), (2025), 237 - 245 p.

Activities in building material stores potentially pollute indoor air through construction dust, particularly PM2.5, which poses significant health risks. This study aimed to evaluate indoor air quality regarding PM2.5 concentrations and identify respiratory complaints among workers at Building Material Store X, Gorontalo City. This descriptive observational study involved 15 active workers (total sampling) and measured PM2.5 concentrations at three strategic working points using a Portable Dust Monitor for one hour at five-minute intervals. The results indicated that all sampling points exceeded the threshold value of the Indonesian Ministry of Health Regulation Number 2 of 2023 (25 µg/m3), falling into the category of Not Meeting Requirements. The highest extreme concentration was found in the Cement Warehouse at 1,244.95 µg/m3 (nearly 50 times the threshold value), while the lowest concentration in the showcase area was recorded at 52.77 µg/m3. The health profile of workers revealed a dominance of upper respiratory tract irritation symptoms, with 60% of workers experiencing sneezing, 13.3% coughing, and 6.7% reporting chest tightness. The high particulate exposure, resulting from poor ventilation and lack of personal protective equipment compliance, classifies this work environment as hazardous, necessitating technical ventilation interventions and strict enforcement of occupational health and safety regulations.

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Khirwizam Md, H., Arif Akmal, S., Muhamad Haiqal Irfan Syaiful, A., Nur Dania Husna Mohamad, R., Muhammad Fathi Ajmal Muhd, F.

Improvement of indoor air quality in reducing the amount of co2 (carbon dioxide) using indoor floating garden.

Jurnal Kejuruteraan, Teknologi and Sains Sosial (JKTSS), Vol. **12** n°(1), (2026), 107 - 114 p.

This study aims to evaluate the effectiveness of an Indoor Floating Garden (IFG) system in improving indoor air quality by reducing carbon dioxide (CO_2) concentration, in alignment with the principles of green engineering in the field of Mechanical Engineering. The IFG system was designed as a modular, water-based floating plant installation with existing aquarium placed in a indoor space measuring 20 m². CO_2 concentrations were monitored over a 7-day period using anemometer, with measurements recorded every 3 hours within 8:00 am to 5:00pm respectively. A control room without the IFG system was used for comparative analysis. The results showed that the IFG system successfully reduced average CO_2 concentrations by 23.4 % compared to the control room, with a maximum daily reduction of up to 227 ppm. Plants such as Epipremnum aureum was identified as key contributors to CO_2 absorption through active photosynthesis on the water surface. Overall, the use of IFG as a passive approach to indoor CO_2 control presents significant potential in green engineering applications. This innovation not only contributes to the sustainable enhancement of indoor air quality but also offers integration possibilities in modern building designs to reduce reliance on energy intensive mechanical ventilation systems.

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Tari, S., Athalye, A.

Practical Challenges and Remedies in Sustainable Digital Textile Printing.

In: Digital Printing: Sustainable Solution to Fashion Industry. Springer Nature Singapore; 2025. 335-352 p.

Digital textile printing (DTP) has become a revolutionary technology in the textile industry providing benefits such as high-resolution design capabilities, reduced water usage, low-waste and on-demand production. The ability to quickly customize and minimize inventory waste makes it relevant to the current needs for sustainable textile processing. Achieving sustainability in DTP presents several challenges. Major issues include the reliance on synthetic inks, pigments and chemical additives, high energy demands, limited fabric compatibility and concerns related to effluent treatment. This chapter explores these practical obstacles and investigates the innovative strategies aimed at enhancing the sustainability of DTP. It discusses the advancements in eco-friendly ink systems, energy-efficient fixation techniques, sustainable pretreatment processes and closed-loop water management practices. Further sections of this chapter discuss the industrial practices that must be adopted and the future prospects for environmentally conscious digital printing. In a nutshell, this chapter discusses the practical challenges in the sustainability aspect of digital textile printing and the alternatives that can be employed to make digital textile printing greener and safer.

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Yeoh Poh, S., Nur Raihana, S., Mohd Redzuwan, D.

Occupational health risks from overspray in automotive workshops: a CFD-based analysis.

Jurnal Kejuruteraan, Teknologi and Sains Sosial (JKTSS), Vol. **12** n°(1), (2026), 212 - 222 p.

Overspray generated during automotive spray-painting processes poses significant occupational health risks, particularly in small to medium enterprises that often lack adequate ventilation and safety protocols. This study investigates the correlation between paint overspray dispersion and the development of health conditions such as Sick Building Syndrome (SBS) among workshop personnel. Utilizing Computational Fluid Dynamics (CFD) simulations, the research models the behaviour of airborne paint particles under varying spray angles and environmental conditions. The findings reveal that improper spraying techniques, especially at arced angles, result in a substantial increase in airborne particulates, with up to 70% of the paint material becoming airborne and failing to adhere to the target surface. Particle concentrations reached as high as 0.85 kg/m³ in simulated environments, with dispersion distances exceeding 1.5 meters from the spray origin. These conditions contribute directly to SBS symptoms such as respiratory irritation, headaches, and chronic fatigue. The study highlights the critical need for controlled spray environments, optimized spray techniques, and the implementation of effective extraction systems. It also provides evidence-based recommendations for mitigating health risks through informed workshop design and procedural interventions.

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Růžičková, J., Raclavská, H., Kucbel, M., Kantor, P., Švédová, B., Slamová, K.

Indoor Airborne VOCs from Water-Based Coatings: Transfer Dynamics and Health Implications.

In: Journal of Xenobiotics. 2025. pp. 197.

Volatile organic compounds (VOCs) emitted from indoor surface coatings can significantly impact indoor air quality and health. This study compared emissions from water-based polyurethane (PUR) and acrylate–polyurethane (ACR–PUR) coatings, identifying 94 VOCs across 16 chemical classes. Time-resolved concentrations were analysed via Principal Component Analysis (PCA), which revealed distinct temporal emission patterns and chemically coherent clusters. Aromatic hydrocarbons, alcohols, esters, and isocyanates dominated the emission profiles, with ACR–PUR releasing markedly higher concentrations of symptom-relevant compounds. Acute exposure was linked to toluene, styrene, phenol, and methyl butyl ketone (MBK), which decreased sharply within 60 days, while compounds such as 1,3-dioxolane, isopropylbenzene, and ethenyl acetate exhibited persistent emissions, suggesting increased chronic risk. Although total VOC levels remained below the German UBA “excellent” threshold (<200 µg/m3), neurotoxic and carcinogenic compounds remained detectable. The combination of PCA-based temporal insights with toxicological profiling and emission transfer dynamics offers a refined framework for indoor air risk assessment. These results underscore the need to complement total VOC indices with symptom-oriented,

time-resolved screening protocols to better evaluate SBS risk in indoor environments using water-based coatings.

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Zhang, H., Wang, T., Zhao, L., Jin, R., Sun, P., Lu, G.

Trace-level methanol detection at room temperature enabled by single-atom Pd stabilized on defective 2D WS2.

Journal of Alloys and Compounds, Vol. **1052**, (2026)

Conventional semiconducting gas sensors operating at high temperature (150–400 ℃) are unsuitable for detecting highly flammable methanol (CH3OH), thus necessitating room-temperature (RT) operation. However, most reported RT CH3OH sensors, hindered by low sensitivity, high detection limit, and poor stability, are impractical for precision gaseous analysis. This study presents a high-performance RT CH3OH sensor employing single-atom Pd stabilized onto defective WS2 nanosheets (Pd SA@WS2 NSs) as sensing material, overcoming the sensitivity, limit of detection, and stability limitations. Notably, 0.3 wt% Pd SA@WS2 NSs-based RT sensor exhibited high response (33.7% to 100 ppb CH3OH), stable repeatability and low detection limit at 23 ℃, surpassing the reported RT CH3OH sensors. The enhanced gas-sensing performance is attributed to the synergistic effect of the highly catalytic activity of atomically dispersed Pd, and the high methanol adsorption at sulfur defects on the WS2 surface. As a proof-of-concept, we constructed a portable real-time monitoring system using the as-prepared RT sensor, coupled with dynamic threshold alarm functionality that enables immediate indoor air quality assessment and early warning. This work establishes a new paradigm for CH3OH leakage monitoring.

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Klausmann, J., Holderied, P., Kastner, D., Küperkoch, M., Ratovo, K., Mutschler, T.*, et al.*

New innovative textile sealing systems for natural ventilation of buildings.

Communications in Development and Assembling of Textile Products, Vol. **6** n°(2), (2025), 160-169 p.

In the construction sector, elastic plastic seals are used for windows and doors. They seal against cold, draughts and moisture. The aim of this research is to develop innovative textile sealing concepts which guarantee conventional sealing properties as well as offering filtered gap ventilation. Knitted spacer fabrics offer air permeability due to their porous structure and have an adjustable structural elasticity. The innovation aims to offer another ventilation concept and reduce the needed artificial room ventilation, thereby reducing investment and operating costs. Their suitability for seals is evaluated in the research presented. Initially, a requirements profile for sealing systems is developed and appropriate testing methods are selected. To determine a suitable structure, a variety of different textiles are tested. Therefore, knitted spacer fabrics with different spacer yarns are developed. Two monofilaments with different diameters and a high-volume yarn are used as spacers. The fabrics are investigated based on the requirement profile for their grammage, thickness, compressibility, shape recovery, air permeability, thermal resistance, and thermal conductivity. The results show that the spacer fabric with the finer monofilament exhibits the greatest thickness, as well as the highest compressibility and air permeability. The fabric with the coarser monofilament achieves the highest values for thermal resistance, as well as the lowest thermal conductivity. The suitability of the developed seals and their influence on the indoor climate will furthermore be investigated using a self-developed test bench. The test bench determines the tightness of the sealing profiles with regard to moisture, air and particle (pollen) permeability.

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Hu, J., Sun, M., Ren, T., Lu, Y., Yu, J., Xie, J.

A comparative study of existing ventilation strategies in a high-occupancy conference hall: Advantages of impinging jet ventilation.

Journal of Building Engineering, Vol. **119**, (2026)

Centralized air conditioning systems, required to operate in both cooling and heating modes, compel high-occupancy spaces to rely on inefficient, energy-intensive mixing ventilation systems. The ventilation challenges in such spaces remain inadequately addressed. An appropriate ventilation strategy for high-occupancy spaces is crucial for improving thermal comfort as well as indoor air quality. This study uses numerical simulations, validated by experiments, to investigate the ventilation performance of impinging jet ventilation (IJV), mixing ventilation (MV), and side-air ventilation (SAV) in high-occupancy spaces. The average temperature, vertical temperature difference, energy utilization coefficient, ventilation efficiency, and energy-saving efficiency of the occupied zone are applied as evaluation indices. The results show that the impinging jet ventilation system consistently meets the 26 °C design temperature under all supply air conditions. The maximum temperatures in the occupied zone for the mixing and side-air ventilation systems under different supply air conditions are 27 °C and 28 °C, respectively. With the same thermal comfort in the occupied zone, the energy utilization coefficient of the IJV exceeds 1.25, larger than that of the MV (1.17) and SAV (1.1). The ventilation efficiency of the IJV exceeds 1.1, whereas the maximum values for the MV and SAV are recorded as 0.97 and 0.99, respectively. In design conditions, MV uses about 85 % more energy than IJV, SAV 60 %. This indicates that IJV achieves energy-saving efficiency improvements. Of the three systems studied, the obtained conclusions provide theoretical ventilation advantages of IJV in high-occupancy spaces and offer system design guidance in its practical application.

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Tiouti, Y., Berrabah, S., Bouhssine, Z., Oufaska, K., Ouladsine, R., Bakhouya, M.

Experimental and numerical assessment of a hybrid EAHE–HVAC system under sliding mode control for indoor temperature and CO2 regulation.

Case Studies in Thermal Engineering, Vol. **78**, (2026)

This study investigates the performance of an Earth-to-Air Heat Exchanger (EAHE) coupled with an Heating-Ventilation-Air-Conditioning (HVAC) unit in a small experimental building. A thermal and CO2 model was developed and validated with three days of winter measurements from Sal'e, Morocco. A Sliding Mode Control (SMC) strategy was implemented to regulate indoor temperature and CO2 simultaneously. The model reproduces the measured temperature within about ±0.9 °C and the CO2 levels within roughly 10 ppm, which is inside the sensor accuracy. Three operating modes were analysed: EAHE alone, HVAC alone under SMC, and a hybrid EAHE + HVAC configuration. Compared to the HVAC-only baseline, the hybrid mode reduces heating demand by about 17 % and peak power by around 22 %, while maintaining temperature and CO2 within comfort limits. These results show that combining a passive EAHE with a robust nonlinear controller can improve indoor comfort and reduce heating energy use in small laboratory buildings.

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Debnath, S., Yang, A., Alvarez, M., Swarts, M., Gomez, P.

Airflow-Pathogen Spread Dynamics: A CFD-ABS Approach to Optimizing Ventilation and Filtration Strategies to Reduce Risk.

SiGraDi 2025. 19-21 november 2025, Cordoba, Argentina.

Building ventilation systems are crucial in airborne transmission, yet current standards (ASHRAE) while meeting indoor air quality (IAQ) requirements, fall short in high-intensity environments like gyms due to high occupancy, prolonged interactions, and elevated respiratory rates. This study examines airborne pathogen risks using a Cardiopulmonary Rehabilitation Gym, addressing the aerosol dispersion from equipment induced forced convection and occupant thermal plumes as well as the effectiveness of transitioning from MERV-13 filtration system. An integrated framework synthesizes computational fluid dynamics (CFD) and agent-based simulation (ABS) to examine ventilation strategies (mixing vs. displacement) and MERV-13 filtration efficiency for reducing pathogen exposure. The CFD model simulates equipment and thermal induced airflow, incorporating HVAC boundary conditions including air change rates, stratification and filtration. Simulations, validated using Wells-Riley model and contaminant removal effectiveness (CRE), will

indicate induced convection increases horizontal pathogen dissemination by 50%. While MERV-13 filtration significantly reduces concentration despite superspreader impact.

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Hinojosa, J. F., Navarro, J. M. A., Vázquez-Ruiz, A.

Thermal analysis of an office with a double duct solar roof chimney on the roof and seated persons producing CO2.

Energy and Buildings, Vol. **354**, (2026)

The present investigation reports a detailed computational study of the effect of the vertical roof solar chimney (SC) position on heat transfer and airflow in an office with seated occupants. The office has a vertical wall receiving a constant heat flux due to the combined effect of absorbed solar radiation and temperature gradient with the ambient air. The computational model was validated with experimental temperature profiles reported in the literature. The temperature fields, flow patterns, and carbon dioxide distributions are analyzed. It was found that for offices with a heated wall, positioning the SC at the maximum distance from the wall and the minimum distance from the air intake optimizes the airflow path length. Moreover, all configurations had CO2 levels below the 8-hour TWA (Time-Weighted Average) PEL (Permissible Exposure Limit) of 5000 ppm, demonstrating compliance with key indoor air quality standards.

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Vakiloroaya, V.

HVAC System Selection Criteria.

In: HVAC and Building Services Rules of Thumb: A Quick Reference Guide. Springer Nature Switzerland; 2026. 73-137 p.

An HVAC system is a combination of components that work together to achieve heating, cooling, ventilation, and air quality objectives. Understanding these components and their configurations is crucial for designing, operating, and maintaining effective systems. In this chapter, we will explore the core elements of HVAC systems and the different ways they are configured to meet diverse building requirements.

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Vakiloroaya, V.

HVAC Standards.

In: HVAC and Building Services Rules of Thumb: A Quick Reference Guide. Springer Nature Switzerland; 2026. 389-408 p.

This collection of standards demonstrates the global diversity in HVAC practices, tailored to regional needs and climate conditions. For international projects, understanding and complying with local standards is critical for successful system design and implementation. These standards are essential for verifying the performance, efficiency, and reliability of HVAC equipment. They provide a consistent basis for product evaluation, ensuring that equipment performs as expected under real-world conditions. These standards are also particularly valuable for equipment selection, energy efficiency compliance, and ensuring occupant comfort. Always consult the latest standards and coordinate with other guidelines for a comprehensive approach to HVAC design and system integration. This chapter lists the standards and codes used globally in HVAC design and building services, categorized by regions and countries. These standards cover various aspects of HVAC systems, energy efficiency, indoor air quality (IAQ), fire safety, and building performance.

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Rizo-Maestre, C., Flores-Moreno, J. M., Nebot Sanz, A., Echarri-Iribarren, V.

Intelligent Ventilation and Indoor Air Quality: State of the Art Review (2017–2025).

Buildings, Vol. **16** n°(1), (2026)

Intelligent ventilation is positioned as a key axis for reconciling energy efficiency and indoor air quality (IAQ) in residential and non-residential buildings. This review synthesizes 51 recent publications covering control strategies (DCV, MPC, reinforcement learning), IoT architectures and sensor validation, energy recovery (HRV/ERV, anti-frost strategies, low-loss exchangers, PCM-air), active envelope solutions (thermochromic windows) and passive solutions (EAHE), as well as evaluation methodologies (uncertainty, LCA, LCC, digital twin) and smart readiness indicator (SRI) frameworks. Evidence shows ventilation energy savings of up to 60% without degrading IAQ when control is well-designed, but also possible overconsumption when poorly parameterized or contextualized. Performance uncertainty is strongly influenced by occupant emissions and pollutant sources (bioeffluents, formaldehyde, PM2.5). The integration of predictive control, scalable IoT networks, and robust energy recovery, together with life-cycle evaluation and uncertainty analysis, enables more reliable IAQ-energy balances. Gaps are identified in VOC exposure under DCV, robustness to sensor failures, generalization of ML/RL models, and standardization of ventilation effectiveness metrics in natural/mixed modes.

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Pahlavikhah Varnosfaderani, M., Heydarian, A.

Enhancing building ventilation through demand-driven strategies: Balancing indoor air quality and ventilation rate.

Building and Environment, Vol. **290**, (2026)

Traditional ventilation systems in buildings often consume high levels of energy and can underperform in maintaining optimal indoor air quality (IAQ), sometimes failing to adequately keep pollutants like volatile organic compounds (VOC) and carbon dioxide (CO2) within the recommended levels. This study introduces a novel approach to the operation of building ventilation systems, transitioning from traditional, schedule-based strategies to dynamic, demand-driven management to enhance energy efficiency and occupant well-being. By leveraging real-time data on IAQ, specifically concentrations of VOC and CO2, alongside occupancy patterns, our proposed method employs a linear ventilation scoring model that integrates these parameters to dynamically adjust ventilation rates and maintain air quality within recommended thresholds while optimizing energy usage. Through a four-month study of a real-life building (two months of dynamic and two months of scheduled operation), we compared the performance of dynamic and scheduled ventilation operations in terms of pollutant levels and ventilation rates. Our findings reveal that dynamic operation reduces the average concentrations of VOC and CO2, with mean values of 128 ppb and 497 ppm under dynamic conditions, respectively, compared to 206 ppb and 544 ppm under scheduled operation. Furthermore, the dynamic approach achieved a notable decrease in ventilation rates during unoccupied periods, leading to overall energy savings without compromising IAQ during occupied times. Specifically, the study observed a reduction in total ventilation rates from 154 CFM under scheduled operation to 125 CFM under dynamic operation, underscoring the efficacy of the proposed method in enhancing both energy efficiency and IAQ.

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Zhang, Y., Liu, J., Miao, G., Wang, Y., Chen, L., Guo, Z.

Au nanocluster-loaded porous SnO2 nanofibers for selective sensing enhancement of BTX gases.

Chinese Chemical Letters, (2026)

Detecting benzene, toluene, and m-xylene (BTX) is challenging for metal oxide gas sensors due to their chemical inertness, while conventional noble-metal modification of SnO2 often yields nonuniform particles with limited catalytic activity. Here, glutathione-protected Au nanoclusters (NCs) (~2 nm) were incorporated into electrospun precursor fibers and calcined to remove ligands, yielding porous SnO2 nanofibers uniformly decorated with ultrasmall Au NCs. The sensors deliver strong responses to 25 ppm BTX (34.81

for benzene, 46.09 for toluene, and 57.03 for m-xylene), while maintaining excellent stability, repeatability, and selectivity, and achieve trace-level detection (e.g., ∼1.80 at 10 ppb benzene), well below human exposure limits. Mechanistic studies reveal that Au clusters enhance sensing via Schottky barrier–mediated electronic sensitization and catalytic activation of surface oxygen. This strategy provides a generalizable platform for coupling ultrasmall noble clusters with nanostructured oxides, offering a blueprint for next-generation BTX detection.

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Bushan, S. V. V., Rithvik, S., Arjun, A. P., Harish, R.

CFD approach to hybrid ventilation for mitigating hydrogen leak dispersion in double-decker fuel cell bus cabins.

Building and Environment, Vol. **291**, (2026)

As hydrogen emerges as a clean and efficient fuel for public transportation, ensuring onboard safety in hydrogen-powered vehicles becomes critical, especially during leaks in enclosed compartments. This study presents a computational fluid dynamics analysis of hydrogen dispersion dynamics in a double-decker hydrogen-powered bus following a leakage event. The primary motivation is to address safety concerns caused by the rapid dispersion of hydrogen, particularly in enclosed passenger areas where gas buildup near ignition sources may create significant hazards. The novelty of this work lies in systematically evaluating passive and active mitigation strategies, including strategically placed air curtains and emergency vents, to suppress cross-deck hydrogen transport and enhance rapid dilution. A detailed parametric study assessed the effects of air curtain placement, vent positioning and their combined interaction on hydrogen concentration distribution, leakage containment and venting efficiency. Simulation results demonstrate that a symmetrically installed dual air curtain system around the leak source achieved optimal safety performance, reducing the hydrogen mass fraction in the lower deck by up to 85.7% while preventing vertical migration to the upper deck. Alternative configurations such as rear-mounted ventilation systems and strategically positioned air curtains at the front and rear, also significantly reduced the hydrogen accumulation by up to 63.11%, highlighting the role of combined buoyancy and momentum-driven mitigation mechanisms. The findings provide critical design insights for developing hydrogen-powered transportation systems with enhanced leak resilience and occupant protection, offering valuable guidelines for future regulatory and safety frameworks in the hydrogen mobility sector.

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Mitova, M. I., Lueso, M. G., Kleinhans, S., Goujon-Ginglinger, C., Yamaji, S., Khoo, Y. S. K.

Occupational Exposure to Environmental Aerosols from Heated Tobacco Products in Japanese Catering Venues: a Pilot Study.

ACS Chemical Health & Safety, (2026)

A study was conducted in six Tokyo venues, each with separate nonsmoking and heated tobacco product (HTP)-use areas. Additionally, three of the venues had a smoking booth within the HTP-use area. Airborne nicotine was used as a specific marker to assess the occupational exposure of waitstaff in these venues. In nonsmoking areas, area monitoring generally demonstrated airborne nicotine levels below the detection limit or marginally exceeded it, except for one venue (maximum 0.278 μg/m3). In HTP-use areas, nicotine levels ranged from 0.237 to 2.16 μg/m3 (minimum–maximum range, median 0.681 μg/m3). For personal exposure in nonsmoking areas, 15 out of 19 8 h time-weighted averages were below the limit of quantification (LOQ). In cigarette smoking booth-equipped venues, most personal exposure measurements of the waitstaff entering HTP-use areas were quantifiable at low levels. Whereas the venues without cigarette smoking booths showed lower exposure levels, with 58% of samples below LOQ. All parameters for working environment control class assessment defined by the Japan Society of Occupational Health were below 1% of the threshold limit value for nicotine (TLV, 500 μg/m3). Area monitoring data were used to statistically model the predictive nicotine distribution, indicating a 0.7% probability of exceeding 5 μg/m3. The findings of this study support that separated nonsmoking and HTP-use areas, active mechanical

ventilation, and negative pressure in HTP-use areas to direct airflow help to reduce waitstaff's occupational exposure to nicotine (used as proxy for HTP environmental emissions) below 1% TLV as well as help prevent HTP aerosols from entering nonsmoking areas.

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An, Y., Lei, Y., Du, B., Song, C., Pan, W.

Mitigating near-wall contaminant exposure in industrial plants via local swirling-flow ventilation system.

Building and Environment, Vol. **291**, (2026)

Vortex-flow ventilation systems have demonstrated substantial potential for contaminant control and energy efficiency in industrial environments. However, their performance deteriorates when addressing near-wall contaminant sources, which restricts wider applications. To overcome this limitation, a novel local swirling-flow (LSF) ventilation system was developed and evaluated. The system was evaluated through a 1:50 scale model experiment and three-dimensional numerical simulations. Key geometric and operational parameters—including the rectangular cylinder (bluff body) width and offset, exhaust outlet position, and airflow rate—were systematically investigated using dimensionless analysis and orthogonal testing. The swirl strength criterion was employed to accurately identify vortex regions, ensuring reliable assessment of vortex stability and contaminant capture. Results indicate that the rectangular cylinder width, lateral offset, and exhaust outlet location are the dominant factors controlling the effective contaminant capture area (Aeff). Optimal performance is achieved with a non-dimensional cylinder offset of 0.5 and the exhaust outlet adjacent to the narrow-side supply jet. Reduced cylinder thickness enhances vortex formation and stability, while airflow rate exhibits a non-monotonic effect: moderate increases improve Aeff, whereas excessive airflow rate can destabilize the columnar swirling-flow and facilitate contminant escape. These findings not only provide practical design guidelines for near-wall contaminant control but also demonstrate the methodological and application novelty of the LSF ventilation system, extending the applicability of vortex-based ventilation in industrial workshops.

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Ye, T., Han, M.

Data optimization methods and training strategies for small-sample convolutional neural networks in indoor pollution source localization.

Journal of Building Engineering, Vol. **119**, (2026)

Indoor pollution source localization is critical for public health. With the increasing application of neural networks in pollution source localization, traditional neural networks still face challenges including insufficient data volume, empirically driven optimization methods, and inadequate cross-scenario adaptability. This study analyzes various data processing methods and model training parameters to improve prediction accuracy under data-scarce conditions, aiming to establish a data processing and model training pipeline suitable for small-sample scenarios to achieve rapid and high-precision source localization. We explore small-sample data augmentation strategies, including image rotation and cropping, alongside network architecture adjustments, particularly the use of residual layers. A comprehensive training strategy is introduced, combining multi-scenario data into a lightweight ResNet model to achieve cross-scenario generalization through feature decoupling and commonality learning. Using Shapley value analysis, we quantitatively evaluate the contributions of each strategy, revealing that the synergistic effect between image cropping and ResNet depth is the most influential factor, while convolutional kernel optimization contributes 32.5 %. In contrast, general image augmentation contributes only 5.9 %, confirming its limited utility. Based on this analysis, redundant operations were eliminated to streamline the model. Experimental results show that the optimized model achieves an R2 value of 0.998 for single-point prediction and an average localization error of 0.23 m across both furnished and unfurnished scenarios—a 55.98 % improvement over the baseline. For pollution sources outside the validation set, the average error is 0.12 m, outperforming conventional models by 76.64–83.24 %. Despite reliance on simulation data, this

study presents a unified, efficient framework that reduces dependency on large datasets and enables rapid, high-precision localization in complex indoor environments.

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Chen, M., Jiang, L., Mi, S., Shen, X.

Study on the difference of air flow organization in exhibition halls of archives in Beijing.

7th International Symposium on Architecture Research Frontiers and Ecological Environment (ARFEE 2025)

This paper compares and analyzes the actual measurement data of airflow organization in the exhibition hall of an archive in Beijing during winter, revealing that the overall visitor route and design of the exhibition hall are relatively complex. The internal structure and space design struggle to achieve uniform symmetry, and asymmetrical structures lead to deviations in internal temperature uniformity. Moreover, when the secondary detailed design of the exhibition hall is carried out, there is no corresponding adjustment in equipment configuration for airflow organization and humidity control, resulting in uneven distribution of temperature and relative humidity. To address these issues, it is proposed to strengthen the setting of temperature and humidity control values for different control systems, adopt dual-system control with separate regulation to maintain consistent greenhouse and humidity ranges across different systems, better meet the needs of different spaces, improve the uniformity of temperature and humidity, and reduce the differences in airflow organization among various areas within the exhibition hall.

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Li, H., Xu, W., Gao, R., Zhang, X., Zhang, C., Tian, Y.*, et al.*

Analysis of the resistance and flow characteristics of a square diffuser under adjacent influence conditions based on design of experiments.

Building and Environment, Vol. **292**, (2026)

Air terminals are crucial components of ventilation and air conditioning (VAC) systems, ensuring efficient airflow that maintains the indoor air quality and a favorable noise environment. Uneven outflows at the supply air endpoint disrupt the indoor air distribution under adjacent influence conditions (AICs) and affect the hydraulic balance of transmission systems, leading to resistance deviations. This study combines design of experiments (DoE) and numerical simulations to examine the changes exhibited by the outflow and resistance characteristics at the air supply end under AICs using a central composite design (CCD). An interaction analysis of the factors that influenced the outflow of a square diffuser was conducted using the response surface methodology (RSM). The full-scale experimental data provided the envelope surface distribution, throw distance, and axial velocity attenuation of the flow pattern of the square diffuser, confirming the accuracy of the numerical simulation. Under AICs, the coupling pressure loss coefficient of the square diffuser was reduced by 22.4% compared with that of the traditional methods. This research introduces a more accurate approach for predicting resistance in duct distribution systems, optimizing airflows, minimizing noise, and achieving energy savings. These findings have significant implications for improving HVAC system designs, reducing energy consumption levels, and enhancing the comfort of occupants in real-world applications.

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Candra, J., Hazimah.

IoT-Based Smart Air Quality System: A Real-Time Monitoring Solution for Indoor Air Quality.

Journal of Computer Networks, Architecture and High Performance Computing, Vol. **8** n°(1), (2026), 54-65 p.

Indoor Air Quality (IAQ) plays a crucial role in maintaining human health and comfort. This study aims to design and implement an Internet of Things (IoT)-based indoor air quality monitoring system integrated with

a mobile application for real-time observation. The system employs sensors to measure environmental parameters such as temperature, humidity, and carbon dioxide (CO?) levels, with data transmitted wirelessly and visualized through the mobile app. The applied method includes hardware design, IoT-based software development, and system testing in several rooms with different activity conditions. The implementation results show that the system can accurately display air quality data and provide automatic notifications when pollutant levels increase. Based on seven days of measurement, the kitchen area indicated a “Poor Air” category, while the living room and bedroom were classified as “Fresh Air.” This system effectively delivers fast and accurate air quality information, enabling users to take preventive actions to maintain healthy indoor air conditions.

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Nilabhra, M., Prashant, A.

A novel occupant-centric control framework for building to urban scale hybrid-energy simulation.

Proceedings of Building Simulation 2025: 19th Conference of IBPSA

Decarbonizing urban energy systems requires effective reduction strategies. While AI/ML models provide insights, simulation-based frameworks offer reliable long-term assessments. A key challenge is capturing interactions between indoor environments, occupants, and HVAC usage. This study introduces aPKf, a hybrid occupancy model integrating prior space usage knowledge with real-time probabilistic transitions. Unlike traditional models, aPKf adapts based on past occupancy states, improving accuracy using real-time energy and air quality data. Simulations of 51 office buildings show aPKf predicts a 23.3–24.4% rise in total energy demand and 37.6–39.6% in cooling demand, underscoring the importance of behavior-driven modeling in post-COVID cities.

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Ming, L., Dong, L., Kun, W., Di, G., Zhong, X.

Research on optimisation of real-time monitoring system for factory area carbon emissions based on electricity-carbon collaborative computing.

Australian Journal of Electrical and Electronics Engineering, (2026), 1-18 p.

Real-time carbon emission monitoring and optimization systems are increasingly critical as industries address climate change and sustainability requirements. Industrial facilities consume large amounts of energy beyond production activities and generate significant carbon dioxide emissions. This study presents a hybrid deep learning framework for real-time prediction and optimization of CO2 emissions in industrial environments using Long Short-Term Memory networks, Convolutional Neural Networks, and Multi-Layer Perceptrons. The proposed system integrates electricity consumption data and carbon information collected from factory sensors and pollution monitoring tools to deliver accurate and timely emission forecasts. These forecasts are then utilized to design real-time optimization strategies that reduce emissions while preserving operational efficiency. To achieve this, the Hunger Games Search algorithm is employed to dynamically adapt operational parameters according to predicted emission levels, thereby lowering energy consumption and associated costs. Experimental results validate the effectiveness of the proposed approach, achieving an R^2 score of 0.99625, an RMSE of 0.0177 kg CO2, and an MAE of 0.0061 kg CO2, outperforming traditional models. Additionally, the system incorporates a real-time feedback and alert mechanism that supports compliance with environmental regulations. The framework promotes sustainable industrial management and contributes toward carbon-neutral manufacturing practices, using high resolution hourly data.

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Figiel, E., Leciej-Pirczewska, D., Słowak, K.

Indoor air quality monitoring in the office building.

Instal, Vol. n°(12), (2025), 38-43 p.

The aspect of indoor air quality has found special recognition in the current EU Directive on the energy performance of buildings (EPBD (2024/1275/EU), Article 13). It identifies a system for monitoring and regulating the parameters that contribute to indoor air quality as a key technical solution necessary to achieve and maintain adequate indoor air quality. It specifies that building automation and control systems must enable the monitoring of indoor environmental quality by 29 May 2026 at the latest. Air quality analysers based on radio technology enabling Internet connectivity (IoT) are a minimally invasive alternative to classic cable systems in this respect. Thanks to this functionality, they enable a significant reduction in the costs associated with equipping buildings with air quality monitoring and control systems. For this reason, meters with smart sensors based on IoT technology were deliberately used to measure air quality in a sample non-residential office and service building. The devices were selected based on an analysis of technical data provided by the manufacturer. The aim of this article is to further the particularly topical discussion on the role of indoor air quality monitoring in promoting a healthy, energy-efficient and productive indoor environment by presenting an example of good practice in this area. It reviews scientific literature on the relationship between indoor air quality and ventilation, with an emphasis on the negative effects of poor air quality. The article presents sample results of indoor air quality measurements carried out in an office room, which are only a small part of the air quality analysis presented.

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Guo, X., Shen, J., Liu, Z., Guo, B. B., Love, D., Mckinney, P. J.*, et al.*

Experimental evaluation of low-cost metal oxide volatile organic compounds sensors for indoor air quality monitoring.

Building and Environment, Vol. **291**, (2026)

Low-cost and portable volatile organic compound (VOC) sensors, such as metal oxide (MOx) sensors have been developed and implemented in many indoor environments. But there is a lack of comprehensive studies on how accurate and reliable these sensors are and how to interpret the data from such sensors. This study aims to address these gaps in knowledge and data by conducting a comprehensive evaluation of current low-cost VOC sensors. The performance and limitations of the sensors were assessed in terms of stability, sensitivity, accuracy, detection limits, and recovery time for 11 individual VOCs of indoor air quality (IAQ) concern including toluene, formaldehyde, acetone, dichloromethane, tetrachloroethylene, 1,1,1-trichloroethane, m-xylene, naphthalene, acetaldehyde, phenol, and benzene. A standard procedure was developed for investigating the sensors in a 50 L stainless steel chamber with various VOC concentration levels that are relevant to realistic indoor environmental conditions. A total of seven types of commercially available off-the-shelf sensors with different configurations of various operating temperatures and sleep cycles, were tested. Sensor's performances were quantified and evaluated based on their sensitivity, accuracy and stability and were classified into three levels: high, medium and low performances. Results show that six sensors exhibited reliable detection capabilities for at least one of the following compounds: acetaldehyde, acetone, benzene, phenol, tetrachloroethylene, and toluene while the sensor's performance level varied among the compounds and sensor configurations. Among 40 tested sensor-configuration pairs, 11 showed high performance for acetaldehyde detection, 10 for acetone, 5 for tetrachloroethylene, 1 each for benzene, phenol, and toluene, while others showed medium to low performance. The test results revealed the limitations of most existing low-cost sensors including poor compound specificity, low sensitivity, low stability and poor accuracy. Future improvements are needed on sensing materials, on-chip signal processing, and interpretation of sensor data for IAQ assessment. These findings will help develop guidance for selecting and using low-cost VOC sensors for IAQ monitoring and control as well as for new sensor development and evaluation.

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Mäkinen, A., Perämaa, O., Juvela, J.-P., Rosti, B., Fečer, T., Alam, A. G.*, et al.*

Analysis of Ventilation Performance and Indoor Air Quality Through Correlations with Indoor and Outdoor Air Conditions.

Proceedings of the 15th REHVA HVAC World Congress - CLIMA 2025

Understanding the behavior of indoor air quality (IAQ) parameters under different operating conditions is essential for effective control of ventilation systems to maintain a healthy and comfortable indoor environment, especially in sensitive spaces such as hospitals and schools. This study investigates the operating conditions of ventilation and indoor air quality by analysing the correlations of indoor and outdoor air quality parameters.

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Kamar, A. a. M., Mavroudis, I., Petridis, F., Kazis, D., Ciobîcă, A., Gheban, D., *et al.*

The Occupational Indoor Pyrethroid Exposome: Mechanistic Insights into Chronic Multisystem Toxicity and Regulatory Gaps.

Preprints, (2026)

This review intro-duces the concept of the occupational indoor pyrethroid exposome—the cumulative exposure environment created by recurrent spraying, residue persistence, and resuspension—and identifies mechanistic links to thyroid, neurological, cardiovascular, hepatic, and immune toxicity; Methods: A structured literature review was conducted across biomedical and environmental databases. Included studies addressed (i) indoor pyrethroid use and resi-due persistence in dust or surfaces; (ii) resuspension and HVAC-mediated redistribution; (iii) human biomonitoring and health outcomes; and (iv) mechanistic data related to en-docrine, hepatic, neurological, cardiovascular, and immune effects. Only peer-reviewed studies were analyzed; Results: Evidence shows that pyrethroid residues persist in indoor dust and textile reservoirs, leading to chronic, low-dose exposure through resuspension and contact transfer. Mechanistic findings indicate that voltage-gated sodium channel modulation, mitochondrial dysfunction, oxidative stress, and inflammatory signaling act as convergent pathways linking chronic exposure to neuroexcitation, endocrine disrup-tion, hepatic enzyme induction, vascular dysfunction, and immune dysregulation. Limited occupational data highlight a consistent association between long-term indoor spraying and elevated biomarkers of hepatic and thyroid stress; Conclusions: The absence of clear occupational safety standards for indoor pyrethroid use constitutes a major gap in pesti-cide regulation and workplace health protection. Integrating residue monitoring, ventila-tion assessment, and mechanistic biomarkers into occupational risk frameworks is essen-tial to guide safe spraying intervals, improve exposure surveillance, and prevent chronic multisystem toxicity among workers in enclosed environments. This framework not only supports the development of evidence-based occupational pesticide safety standards and improved ventilation policies in enclosed workplaces, but also highlights a critical regu-latory gap — the current absence of any evidence-based guidelines defining safe frequen-cy or interval for indoor pyrethroid spraying.

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Wang, J., Wang, Q., Wang, T.

Review on the generation, characteristics and control methods of indoor ozone pollution.

Frontiers in Built Environment, Vol. **11**, (2025)

Under the dual effects of outdoor ozone (O3) pollution intrusion and indoor pollution source generation, the formation mechanism, characterization, prevention and control methods of indoor O3 pollution have been one important scientific issue in the field of indoor air quality (IAQ) research. To have a systematic understanding of this issue, this study summarizes the trends and hotspots of indoor ozone pollution research, systematically reviews the sources, hazards, and characteristics of indoor ozone pollution and analyzes the different prevention and control methods of indoor ozone pollution, including active and passive ozone removal technologies. On this basis, the engineering applications of indoor ozone pollution prevention and control methods in residential, educational, and commercial scenarios are further discussed. Furthermore, the development trends and technical challenges of indoor ozone pollution prevention and control are pointed out. The development of efficient and low-cost ozone removal materials, the optimization of intelligent monitoring systems, and integrated pollution control strategies adapted to climate change should be focused on in the future, in order to provide healthier and safer indoor air environment. The insights could inform designers, engineers, and policymakers seeking to integrate ozone-

responsive strategies into building ventilation, material selection, IAQ management, and air-cleaning systems.

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Bousiotis, D., Sanghera, D. S., Carrington, J., Hodgkiss, G., Jajarmi, F., Rajab, K. Z., *et al.*

Parameterising the effect of human occupancy and kinetic energy on indoor air pollution.

npj Climate and Atmospheric Science, Vol. **9** n°(1), (2026), 4 p.

Indoor air quality (IAQ) is increasingly recognised as one of the most important aspects for public health, workplace safety and productivity. While indoor and outdoor factors both influence indoor pollutant levels, human presence and activity are key drivers of the emission of specific pollutants, including particulate matter (PM), total volatile organic compounds (TVOCs) and carbon dioxide (CO2). This study investigates the relationship between occupancy, physical activity measured by kinetic energy (KE), and air pollution concentrations in a real-world office setting, by combining data from air quality and radar motion sensors. Two exemplar office spaces were investigated, comprising an open-office area and a meeting room. PM, in the PM1 and PM2.5 size fractions, were found to be highly correlated with the outdoor conditions, whereas PM10 correlates more closely with indoor occupancy (up to r = 0.65). Even higher correlations, up to r = 0.74, were found between human activity, quantified as KE, and the PM10 concentrations. The TVOCs and CO2 showed even stronger correlations with KE (up to r = 0.83), suggesting that these metrics can be used as excellent proxies for estimating certain types of indoor air pollution. Notably, the impact of additional occupants varies depending on room characteristics and usage, underscoring the need for contextualised models of IAQ. By quantifying both outdoor infiltration and indoor emissions, this study offers a framework for disentangling pollutant sources and guiding interventions to optimise IAQ. These insights support evidence-based strategies to create healthier and more productive office environments.

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Martínez De Dios, J. A., Carrera Velueta, J. M., Magaña Villegas, E.

Simulation of PM2.5 behavior due to non-essential activities in poorly ventilated spaces.

Revista AIDIS de ingeniería y ciencias ambientales: Investigación, desarrollo y práctica, Vol. **18** n°(1), (2025), 78-93 p.

Indoor air quality has gained importance due to significant time people spend in these spaces unaware of the air they're exposed to. PM2.5 is a major indoor pollutant. Thus, this study aimed to analyze PM2.5 scenarios during activities like burning candles, incense, and mosquito coils, using mass balance models. Sparkler candles and spiral mosquito coils were the highest emission sources, with PM2.5 levels up to 12,124 µg/candle and 775 µg/min. Notably, a 30 m³ room burning a mosquito coil for 53 minutes led to poor air quality for 116 minutes. Similarly, a 60 m³ room with a sparkler candle generated poor air quality for 65 minutes. These findings reveal short-term emission sources can still compromise health due to high PM2.5 concentrations. Wind speed and room dimensions also mattered. This research informs individuals to engage in these activities more health-consciously.,

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Rinza, B. E. S., Rosas, G. M., Ramírez, M. a. M.

Sensor de Evaluación de Calidad del Aire en Ambientes Interiores por medio de IoT IoT-Based Sensor for Indoor Air Quality Assessment.

In: Dimensiones De La Computación, Una Exploración En Inteligencia Artificial, Datos Masivos Y Protección Digital. 2025. 7-19 p.

This work proposes the development of a distributed system to evaluate indoor air quality, using a BME680 environmental sensor and an ESP32 microcontroller with Wi-Fi connectivity. The device will enable real-time measurement of parameters such as temperature, humidity, atmospheric pressure, and volatile

organic compounds (VOC) index, providing useful information about the state of the indoor environment. The system will be oriented toward remote data visualization through a simple mobile application, facilitating its application in homes, classrooms, offices, among others, and promoting the integration of IoT technologies in environmental monitoring.

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Swati, P.

Biocompatible and biodegradable materials based nanogenerators for self-powered healthcare sensors.

DGIST. Department of Robotics and Mechatronics Engineering. Thèse 2026

This collection of chapters presents a comprehensive overview of the potential and applications of PENGs and TENGs in self-powered sensor technologies. From exercise monitoring, oral health assessments, environmental sensing, pathogen detection, to accelerated wound healing, the diverse applications of these energy-harvesting devices highlight their versatility and importance in a wide range of industries, including healthcare, environmental monitoring, and smart systems. These chapters emphasize the growing need for biocompatible and sustainable materials in energy harvesting technologies, as well as the importance of fabricating devices that are self-powered and do not require external power sources or batteries. The advancements made in this thesis showcase the transformative potential of self-powered sensor systems, paving the way for more sustainable, efficient, and eco-friendly solutions in various applications. As research continues to progress, it is expected that the integration of energy harvesting devices with sensors will play a critical role in the development of next-generation healthcare devices.

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Pellegrino, J., Aziza, H., Guerin, M., Taranto, P.

Negative Group Delay Predictor Application for CO2 Gas Concentration in Real Environment Condition.

37th International Conference on Microelectronics (ICM). 14-17 Dec. 2025, Cairo, Egypt.

This paper presents the design and real-world deployment of a portable, low-power multi-sensor device for air quality monitoring, focused on the prediction of CO2 concentration using the Negative Group Delay (NGD) algorithm. Unlike prior studies conducted under controlled laboratory conditions, we validate the NGD-based prediction method in real-life urban environments through three different experimental scenarios carried out in Marseille, France: (1) periodic indoor-outdoor transitions, (2) mobile outdoor urban trajectory, and (3) public transportation monitoring. The air quality monitoring device integrates a high-efficiency CO2 sensor (SCD41) and is based on an ARM Cortex M4 microcontroller platform with Bluetooth Low Energy (BLE) connectivity. The NGD predictor has been theoretically formulated and tested offline with recorded CO2 sensor concentrations. Experimental results confirm the feasibility of CO2 concentration prediction several seconds in advance, even in dynamically changing urban conditions. The findings highlight the robustness of the NGD approach and the potential of such solutions for smart city air quality forecasting.

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Qian, J., Wynn, T., Liu, B., Shan, Y., Bartington, S. E., Pope, F. D.*, et al.*

Enhancing Accuracy of Indoor Air Quality Sensors via Automated Machine Learning Calibration.

Atmos. Meas. Tech., Vol. **19** n°(2), (2026), 603-615 p.

Indoor fine particles (PM2.5) exposure poses significant public health risks, prompting growing use of low-cost sensors for indoor air quality monitoring. However, maintaining data accuracy from these sensors is challenging, due to interference of environmental conditions, such as humidity, and instrument drift. Calibration is essential to ensure the accuracy of these sensors. This study introduces a novel automated

machine learning (AutoML)-based calibration framework to enhance the reliability of low-cost indoor PM2.5 measurements. The multi-stage calibration framework connects low-cost field sensors to be deployed with intermediate drift-correction reference sensors and a reference-grade instrument, applying separate calibration models for low (clean air environment) and high (pollution events) concentration ranges. We evaluated the framework in a controlled indoor chamber using two different sensor models exposed to diverse indoor pollution sources under uncontrolled natural ambient conditions. The AutoML-driven calibration significantly improved sensor performance, achieving a strong correlation with reference measurements ($R2 > 0.90$) and substantially reducing error metrics (with normalized root-mean-square error (NRMSE) and symmetric mean absolute percentage error (sMAPE) roughly halved relative to uncalibrated data). Bias was effectively minimised, yielding calibrated readings closely aligned with the reference instrument. These findings demonstrate that our calibration strategy can convert low-cost sensors into a more reliable tool for indoor air pollution monitoring. The improved data quality supports atmospheric science research by enabling more accurate indoor PM2.5 monitoring, and informs public health interventions and evaluation by facilitating better indoor exposure assessment.

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Moosa, M. Y., Sathyakam, P. U.

From structure to sensing: Metal Organic Framework for ammonia gas detection.

Materials Today Physics, Vol. **61**, (2026)

Ammonia (NH3) serves as a significant environmental pollutant, a clinically important biomarker, and a critical target in industrial process monitoring. These varied roles drive the need for high-performance gas sensors that can operate effectively at room temperature. Metal–Organic Frameworks (MOFs) have emerged as promising materials for gas sensing due to their high surface area, tunable pore architecture, and tailorable chemical properties. This review critically analyses recent advances in MOF-based ammonia sensors from a structure-to-sensing performance perspective, highlighting how rational structural design directly governs sensing behavior. Key strategies—including pore size optimization, the incorporation of open metal sites, linker functionalization with acidic or polar groups, defect engineering, and metal encapsulation are evaluated for their ability to enhance NH3 adsorption through Lewis acid–base interactions and hydrogen bonding. These structural features directly contribute to the exceptional sensing characterized by sub-ppm to ppb-level detection limits, large response amplitudes, rapid response/recovery times at room temperature, and improved selectivity. Post-synthetic modifications that improve stability and sensing reliability under high humidity conditions are also examined. By correlating MOF structural characteristics with experimentally demonstrated sensing benchmarks, this review provides a clear framework for the rational design and scalable integration of MOF-based ammonia sensors, supporting their transition from laboratory studies to practical sensing devices.

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Hellman, N.

Toimitilojen ominaisuudet, joita yritykset arvostavat: tutkimus kiinteistökehittämisen tueksi (Caractéristiques des locaux commerciaux appréciées par les entreprises : étude pour soutenir le développement immobilier).

Lapland University of Applied Sciences. Thèse 2026

The purpose of this thesis was to examine which features companies value in industrial, warehouse and hall-type premises, and how well their current facilities meet operational needs. The aim was to produce practical information to support the development of business premises and to answer research questions concerning the most important facility, maintenance and location factors, as well as the requirements set for future premises. The knowledge base consisted of articles related to the functionality of business premises, the quality of the work environment and companies' spatial needs, as well as previous studies on the topic. The research was conducted as a quantitative survey using an electronic questionnaire, and the collected data were analysed using quantitative methods focusing on averages and the distribution of responses.

According to the results, the respondents were generally satisfied with their current facilities. Technical core features such as heating, water and sewage, ventilation, fire safety, indoor air quality and internet connectivity emerged as the most important facility attributes. Among maintenance and service factors, winter maintenance of outdoor areas, yard cleanliness and the responsiveness of the landlord were considered the most significant. Based on the findings, companies value premises that offer functionality, safety and flexibility, and they are willing to pay for facilities that provide a balanced price-quality ratio. The results can be utilised in property renovations, the planning of new developments and the improvement of leasing operations, and they also support companies in making facility-related decisions and planning future space solutions.

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Atalie, D., Fikre, Y.

Smart textiles for pollutant gas sensor and capture: Advancement and future perspective.

Journal of Hazardous Materials Advances, Vol. **21**, (2026)

The burgeoning field of smart textiles for pollutant gas sensing and capture is poised to revolutionize personal safety and environmental monitoring, offering a crucial alternative to bulky, stationary systems by providing personalized, real-time data. This comprehensive review synthesizes the latest advancements across the entire technology spectrum, starting with fundamental sensing principles. We analyze the mechanisms, materials, and recent breakthroughs in chemiresistive sensing (leveraging materials like graphene and carbon nanotubes for high-sensitivity electronic response) and optical/colorimetric sensing (providing visible, quantifiable feedback). Furthermore, we detail the active pollutant removal capabilities, encompassing adsorption such as Metal-Organic Frameworks (MOFs) for high-capacity capture), absorption, and catalytic conversion (for proactive pollutant neutralization). The review highlights the role of innovative nanomaterials and the scalability of key fabrication methods, including inkjet, screen printing, electrospinning, and In-situ growth. These technologies underpin promising applications in personal protective equipment, indoor air quality monitoring, environmental protection, and medical diagnostics. Ultimately, while smart textiles hold immense potential, their widespread integration hinges on overcoming critical challenges in ensuring long-term durability, developing flexible and efficient power solutions, and prioritizing sustainable, eco-friendly design.

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Mesenhöller, E., Jacobs, S., Vennemann, P.

The potential of unsteady versus steady room ventilation methods – A comparative study.

Building and Environment, Vol. **292**, (2026)

Efficient ventilation is a critical aspect of modern building design, balancing the need for good indoor air quality and increasing energy efficiency demands. For this reason, the approach of unsteady ventilation techniques was investigated in this study, in which the supply air volume flow is varied on short timescales. This study explores the comparative performance of steady and unsteady operational modes in mechanical ventilation systems under isothermal conditions, utilising 2D Particle Image Velocimetry (PIV) and a statistical design of experiments. Time-averaged and instantaneous velocity fields in the longitudinal axis of a Reynolds-scaled model room were analysed to evaluate the influence of dynamic supply flow rates on velocities in the occupied zone, and mixing by looking at spatio-temporal dominant structures and vortices. The results of the unsteady scenarios were compared with steady ventilation scenarios and existing literature in this field, but also in the field of pulsating jets. Some considerable differences in velocities, large and small-scale flow structures were found for selected operating modes, enhancing mixing and a more homogeneous velocity distribution. But effects of the flow rate variations on the investigated area were observed in all unsteady cases, e.g., the varying number of vortices or velocity fluctuations in the occupied zone.

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Brockmann, G.

Exhaust positioning and stagnation risk in mixing ventilation.

Université technique de Berlin. Institut de technologie énergétique. Thèse 2026

Cette thèse introduit une nouvelle métrique d'évaluation de l'efficacité de la ventilation, le risque de stagnation, qui quantifie la probabilité d'accumulation de contaminants dans les zones mal ventilées. Ces zones de stagnation entraînent des concentrations localement élevées de polluants insuffisamment dilués ou éliminés, ce qui représente un risque potentiel pour la santé et le confort. L'objectif principal est d'évaluer systématiquement l'influence du positionnement de l'air extrait sur la formation et l'étendue des zones de stagnation. À cette fin, une étude paramétrique numérique a été menée, en faisant varier les stratégies d'insufflation et le conditionnement du flux. Les résultats de la simulation ont été validés par des mesures expérimentales et des données bibliographiques afin d'en garantir la robustesse. À partir des données de simulation, des analyses de corrélation et de sensibilité ont été réalisées pour identifier les principaux paramètres influents. Ces investigations ont conduit à la formulation de recommandations générales pour l'optimisation de la conception de la ventilation. En complément de l'approche numérique, un modèle analytique a été développé, permettant de prédire le risque de stagnation en se basant principalement sur l'efficacité du renouvellement d'air. Celle-ci dépend elle-même principalement de la configuration des ouvertures d'insufflation et d'extraction pour un flux d'air enveloppant la pièce. Les résultats démontrent que la position de l'extraction affecte significativement les performances de la ventilation. L'indicateur de risque de stagnation proposé permet une évaluation concise et informative de l'efficacité du système et facilite la conception de systèmes de ventilation minimisant la formation de zones de stagnation. Cette approche constitue un outil pratique pour les ingénieurs et les chercheurs souhaitant améliorer la qualité de l'air intérieur grâce à des stratégies de ventilation plus efficaces et économes en énergie.

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Sakina, N., H, R., Bagali, K. G., A. K, K. L., M, M. N., Murthy, C.

Cloud-Integrated, Low-Cost Air Quality Monitoring Using AI-Powered Sensor Calibration and Forecasting.

2025 9th International Conference on Computational System and Information Technology for Sustainable Solutions (CSITSS). 20-22 November 2025 ,Bangalore, India

Real-time air quality measurement is vital for tracking pollution levels which are continuously increasing in urban areas. This work presents a smart IoT-based system for monitoring harmful gases and dust, using inexpensive, valid sensors. The sensor readings are sent continuously to the ThingSpeak cloud where they are stored, visualized, and accessed with a backend in Python. The time-series data collected is preprocessed to train a Long Short-Term Memory (LSTM) neural network to predict pollution levels for the next 48-hour period. The smart application not only allows visualization of real-time readings from the sensors but also short-range predictions so the end-user can make potential reactive or proactive decisions about the air quality. Given its accuracy and low hardware cost, this technical framework has capacity for scalability into smart cities. This project addresses a larger set of smart solutions that integrate IoT, cloud-based solutions, and deep learning. The framework also provides a practical and efficient means to facilitate proactive air quality management and advance environmental decision processes. This combination of hardware, cloud infrastructure, and AI-driven analytics provides a powerful and scalable solution that can be applied within a smart city framework. The system serves to empower individuals with air quality insights, and enable data-driven environmental governance. The low cost, scalability and forecasting capabilities of the system makes it a large stride toward democratized anticipatory air quality management, for urban and semi-urban contexts.

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柯霽恩, 陳睿麒, 許根誠, 許若茵, 曾堯宣.

Recherche sur la prévention des moisissures intérieures dans les systèmes de climatisation.

Réfrigération et climatisation & Science et technologie de l'énergie, Vol. n°(154), (2025), 82-87 p.

Taiwan, located in a subtropical climate zone, experiences high humidity during the summer and plum rain seasons, causing residents to suffer from frequent indoor mold problems. With the ongoing global energy crisis, traditional dehumidifiers are no longer the optimal solution, making the development of alternative approaches that achieve lower energy consumption and long-term indoor dryness an important issue. In this study, an environmental purifier system based on photocatalytic oxidation was developed to generate reactive species capable of degrading airborne organic compounds and inhibiting microbial growth. Both laboratory and field tests demonstrated its effectiveness in reducing surface contaminants. Antifungal performance was further evaluated through mold culture experiments, and the results indicated that the gases released from the purifier not only degraded pollutants but also achieved dehydration-based mold prevention, highlighting its promising practical applicability.

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Wang, M., Chen, X., Cao, S.

Asphalt fume concentration distribution and health risk in tunnel paving area.

Alexandria Engineering Journal, Vol. **137**, (2026), 89-100 p.

During tunnel paving, it is difficult to dissipate the asphalt fumes released by the hot asphalt mixture, and the accumulating fumes is a threat to the health of on-site workers. This study used a portable VOC detector to monitor the distribution of asphalt fume concentration during paving of the Wushaoling No. 4 highway tunnel. Based on the theory of equivalent toxicity of benzopyrene, it evaluated the health risk to workers using the Monte Carlo method. The results show that the concentration of asphalt fumes was influenced by the wind direction and the relative position of the fumes' source. Moreover, asphalt fumes intake was closely related to the worker's labor intensity. For paving upwind, asphalt fumes presented a greater health risk to more people, compared to paving downwind, but most of workers were at high health risk regardless of wind direction. Although it is difficult to eliminate every risk in tunnel paving, wearing gloves and masks can significantly reduce the health risk of asphalt fumes. Controlling the concentration of asphalt fumes below 0.4 mg/m³ can keep the carcinogenic risk faced by workers at an acceptable level.

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Lu, K. H.

Using AI to Improve Sensor Data Analysis for Environmental Monitoring.

2nd International Conference on Engineering Management, Information Technology and Intelligence

Environmental monitoring plays a crucial role in detecting and resolving issues such as air and water pollution, and climate change. However, the sheer amount of data from environmental sensors produces problems concerning noise, precision, and real-time processing. The conventional methodologies are not capable of processing such information efficiently and meaningfully. The work explores integrating AI paradigms with environmental sensor networks to enhance the value and quality of data processing. The study details various types of environmental sensors, e.g., air quality, water quality, and multi-parameter sensing modules. It deliberates on how AI methodologies—such as machine learning, deep learning, and AIoT—may be employed to filter, decode, and predict sensor information results. The work provides several real-world use cases to demonstrate how AI enhances environmental monitoring networks concerning accuracy, scalability, and advance knowledge deliverability. The work sets forth the hope of AI-based answers to transform environmental sensing to render it more intelligent, agile, and adaptive. The work attempts to offer actionable knowledge to researchers, developers, and policy-planners designing the monitoring infrastructure of the decade ahead.

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Duffy, B., Scarlett, M.

Assessing Indoor Air Quality in a Comparative Study Among ASHRAE Ventilation Standards Compared to a Control with a Continuous Active In-Room Air Cleaning Device.

2025 Winter Conference, Orlando, FL

The objective of this analysis is comparisons between various ventilation methods specified in ASHRAE Standards 62.1, 241, and 170 for indoor air contamination of standard ASHRAE air contaminant, with those values obtained with a control, using a continuous active in-room air cleaning device (CA-IRAC). For consistency of data, the study used the laboratory air chamber testing methods, specified in 241 for each outside air exchange rate (ACH), repeated utilizing the CA-IRAC. Testing trials were conducted in the same 30 m3 (1060 ft3) chamber, with trials repeated in triplicate at 4, 8, 12, 16, 20, 30, 45 and 60 minutes, after appropriate flushing and decontamination of the chamber, to assess consistency of test results. These were evaluated statistically, by ANOVA, t tests and Standard Deviations, reported as log reductions. The bacteriophage MS2 is specified in Standard 241 as a testing surrogate for indoor aerosolized pathogens because it is safer to conduct air testing with a more resistant microbe than with other common respiratory pathogens, such as SARS-CoV-2, and influenza virus, H1N1. Additionally, baseline natural decay tests of MS2 were measured over the same time periods, ensuring computed results for net log reductions. While the total volume of air within a testing chamber would not be expected to replace all air with only four (4) air exchanges, the resulting reduction of the pathogen in a 5 ACH system would not be expected to obtain results greater than 99.9% in a one-hour time period. The CA-IRAC (at 5 ACH) not only reached 99.5% in one-hour testing, the CA-IRAC showed a 70.26% reduction of pathogen, at the 4-minute test of continuous operation. In the same 4-minute time period, 1.52% reduction was obtained using 62.1 Standard ventilation rates, a 49.50% reduction for 170, and 32.39% reduction for 241, respectively. By comparing the results from these three repeated trials and CA-IRAC control conducted in the same way, relative effectiveness of each ventilation rate from each of the three standards was measured, compared to the CA-IRAC. Thus, this study demonstrates the effectiveness of the CA-IRAC, compared to various ventilation rates, specified within the three ASHRAE standards in a time period that may exceed delivery of infectious doses of pathogens indoors. These data can be used in re-evaluating current ventilation methods across ASHRAE standards, consistent with the 241-testing Standard for reduction of indoor airborne pathogens, including any future Pathogen X, to reduce potential exposure to occupants within building settings.

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Olsson, D., Maripuu, M.-L., Alasmi, R., Ekberg, L.

Alternativ till ökade uteluftflöden i vårdlokaler (Alternatives à l'augmentation des apports d'air extérieur dans les établissements de santé : une perspective d'ingénierie immobilière).

Rapport 2025

Ce rapport, qui s'appuie sur un précédent rapport PTS de 2024, vise à étudier, du point de vue des technologies du bâtiment, des alternatives à l'augmentation des apports d'air extérieur dans les établissements de santé. L'étude porte également sur l'analyse des coûts énergétiques liés au chauffage urbain, au refroidissement urbain et à l'électricité, ces derniers représentant une part de plus en plus importante des coûts d'exploitation.

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Sakinah, H. L., Milanda, F., Pratiwi, R. A.

Pengembangan Bio-Hybrid HEPA Filter Berbasis Serat Alami dan Karbon Aktif untuk Pengendalian Polutan PM 0, 25 dan CO di Lingkungan Industri Farmasi (Développement d'un filtre HEPA bio-hybride à base de fibres naturelles et de charbon actif pour le contrôle des polluants PM 0,25 et CO dans les environnements de l'industrie pharmaceutique).

JURNAL REDOKS: JURNAL PENDIDIKAN KIMIA DAN ILMU KIMIA, Vol. **9** n°(1), (2026), 28-35 p.

Dans l'industrie pharmaceutique, la pollution de l'air est souvent dominée par les particules fines (PM) et les gaz dangereux tels que le monoxyde de carbone (CO), qui peuvent affecter la santé des travailleurs et la qualité des produits. Cette étude vise à développer un filtre HEPA bio-hybride à base de papier recyclé, de fibres de coco et de charbon actif, comme alternative écologique, économique et efficace pour le contrôle des PM jusqu'à 0,25 µm et du CO. Le prototype de filtre est composé de trois couches : un filtre

mécanique (papier recyclé), un filtre poreux naturel (fibres de coco) et une couche d'adsorption (charbon actif). Des tests de performance ont été réalisés à l'aide d'un compteur de particules et d'un test de gaz simple. Les résultats ont montré que la combinaison des trois matériaux permettait une efficacité de filtration des PM2,5 de 90,21 % et une réduction de la concentration de CO de 94,88 %, supérieures à celles des filtres composés d'un seul matériau. Cette amélioration est principalement due à la surface spécifique et au volume poreux du charbon actif, qui favorisent l'adsorption des gaz. Ces résultats indiquent que le filtre biohybride présente un potentiel en tant que milieu de filtration alternatif, efficace et durable, applicable aux installations de l'industrie pharmaceutique de petite et moyenne taille. Ce produit pourrait également être développé comme solution locale de filtration d'air à base de biomasse, facile à produire et respectueuse de l'environnement.

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Gentile, V., Perino, M.

Design, development and test of a low cost, fast-response, multi-gas tracer gas measurement apparatus.

14th International Symposium on Heating, Ventilation, and Air Conditioning (ISHVAC 2025). November 29-December 2, 2025, Tokyo, Japan

Tracer gas measurements are a family of well know and widely applied experimental techniques adopted to test and verify the performance of ventilation and air conditioning systems. They are aimed at measuring either the ventilation air flow rates and or the performance of the air distribution. They make use of nontoxic, non-flammable, odourless and easy to detect gasses that are injected in the air and whose concentration is then monitored over a period of time. For this sake quite sophisticated, costly and delicate measuring apparatuses are typically used. The main disadvantages of the existing apparatuses are represented by their cost, size and the impossibility of leaving the system in the field for medium/long term monitoring campaigns. Besides, the time response is usually rather long and this hinder their use in all those cases where the ventilation air flow rates are high or when many measuring points need to be monitored simultaneously. For these reasons a new measuring system (TEBE-SENSE) was designed and built. It adopts a number of small, wireless measuring devices that can communicate with a central unit and can measure, store and elaborate the time histories of the tracer gas. The measurement apparatus is developed, so far, to work with three different tracer gases simultaneously (e.g. CO2, SF6, Propane), allowing also the analysis of inter-zonal air exchanges. The response time is in the order of a fraction of a second, a feature that allows to properly follow fast transient ventilation phenomena and to analyse strongly ventilated environments. In this paper the main features of this new system will be presented. A validation was done by comparing the results obtained with the newly proposed system with those provided by a traditional photoacoustic measurement apparatus.

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Park, J., Oh, W.

Numerical Evaluation of an Air-curtain Table for Indoor Aerosol Control.

Journal of Korean Institute of Architectural Sustainable Environment and Building Systems, Vol. **19** n°(6), (2025), 394-406 p.

The objective of this study was to evaluate the effectiveness of an air-curtain table in reducing aerosol dispersion, a major transmission pathway of respiratory infections in indoor environments. Computational Fluid Dynamics (CFD) simulations were performed to assess and compare the aerosol reduction performance of air-curtain tables and partition walls under various table configurations and air-curtain supply flow rates. The results indicate that although partition walls altered the direct pathway of aerosol dispersion, they generated stagnant airflow zones within the breathing zone. In contrast, the air-curtain table effectively reduced aerosol dispersion by forming an upward airflow barrier that enhanced ventilation in the breathing zone and diluted contaminated air. Increasing the air-supply velocity further reduced the average indoor aerosol concentration by up to 92%, including approximately 34% reduction in the infected

person’s breathing zone and more than 90% reduction for susceptible people. These findings highlight the potential of air-curtain tables as an effective indoor airflow control strategy for mitigating aerosol accumulation and reducing infection risks in enclosed environments.

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Wu, X., Ren, Z., Wang, Y.

Design of a High-Uniformity Temperature and Humidity Air Handling System for Large-Scale Climatic Environment Laboratory.

2025 IEEE 7th Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC)

To meet the demands of large-scale climatic environmental laboratories for broad-range temperature and humidity control and highly uniform spatial distribution of thermal conditions, this study investigates an optimized air handling system scheme. Based on an analysis of the laboratory's environmental control requirements, the operational principles of the air cycling system, fresh air system, and slight positive pressure system are delineated. A distributed multi-stage heat exchange air handling system is proposed, and a control process is established for high-/low-temperature testing projects. Experimental results and engineering applications demonstrate that the system achieves temperature regulation within -55 °C to +70 $^{\circ}$C and relative humidity control within 10%RH to 95%RH, with temperature uniformity below 2 °C and humidity uniformity within 5%RH across the laboratory space. The system exhibits high redundancy and operational reliability, providing a reference for the design of analogous systems.

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Manikandan, R., Gobinath, G., Gokul, G., Boobalan, D.

AI-Driven IoT Framework for Real-Time Air Quality Monitoring and Stress Correlation Analysis.

1st International Conference on Research and Development in Information, Communication, and Computing Technologies - ICRDICCT`25. April 4th.-5th, 2025. Inde

Burden, air pollution, and stress in homes, offices, and urban settings. This project strikes at the nexus between environmental monitoring and mental health, given that air pollution is a significant global challenge, it has far-reaching implications on physical and mental health. The negative effects of poor air quality on the respiratory and cardiovascular systems are by now well established, but the same cannot be said for the impact of its phytotoxicity on the psyche, especially in real-time, localized contexts. Here, we put forward an AI-driven IoT framework for real-time air quality monitoring and stress prediction, which provides users with actionable intelligence without requiring any manual input. The system is a combination of low-cost IoT sensors (PM2. 5, CO2) using an ESP32 microcontroller to acquire data from the environment in real time and transmit it to a backend hosted in the cloud for analysis. It uses a machine learning model trained on a dataset with information linking air pollution and metrics of stress to predict stress, based on current pollution levels. The anticipated stress levels, along with air quality data, are shown on a mobile app, which also provides recommendations tailored to the user (for instance, “Open windows,” “Avoid outdoor activities”) and issues alerts when air quality worsens or stress levels are expected to increase. Utilizing the advances in artificial intelligence according to Internet of Things this system provides a scalable solution for monitoring the both contributing towards smart health technologies and promote living in sustainable way.

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Abdelraheem, W. H., Roberts, J. L., Kurtz, K. S., Streicher, R. P., Robbins, Z. G.

Development of an air sampling method for quantifying 12 legacy and emerging PFAS with the OSHA Versatile Sampler (OVS) tube and analysis by HPLC-MS/MS.

Talanta, Vol. **300**, (2026)

This study evaluates an air sampling method for quantifying twelve legacy and emerging per- and polyfluoroalkyl substances (PFAS) with the OSHA Versatile Sampler (OVS) tube. We expanded the application of the OVS tube beyond perfluorooctanoic acid (PFOA) by adding multiple acidic PFAS classes including perfluorocarboxylic acids (PFCAs), perfluorosulfonic acids (PFSAs), undecafluoro-2-methyl-3-oxahexanoic acid (HFPO-DA, commercially known as GenX), and the sodium salt of 4,8-dioxa-3H-perfluorononanoic acid (DONA-Na). A two-step spiking approach was employed to introduce PFAS to the OVS tube. Non-volatile PFSAs and DONA-Na were statically spiked onto glass fiber filters and XAD-2 media, and then semi-volatile PFCAs and HFPO-DA were introduced via vapor generation with active airflow from spikes applied to the polytetrafluoroethylene (PTFE) retaining ring within the OVS tube. PFAS were quantified by high-performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS) with calibration ranges of 0.5–200.0 ng/mL (1.0–200.0 ng/mL for HFPO-DA) and analytical limits of detection (LODs) of 0.1–1.5 ng/mL (equivalent to air sampling LODs of 0.4–6 ng/m3). Extraction of OVS media with methanol yielded mean recoveries of 97.1–100.1 %. Spiked PFAS compounds at air concentrations of 0.1–20 µg/m3 (0.1–5 µg/m3 for DONA-Na) were retained on the OVS tube over a 28-day storage period at 23 °C (mean recoveries: 91–103 %) with breakthrough <5 % for all analytes. These findings establish the OVS tube as a reliable sampling device for monitoring occupational air exposures to a broader range of PFAS compounds, providing critical support for health risk assessment and exposure mitigation in workplace environments.

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Raji, S., Saidi, M., Eslami, J.

Numerical study of hinged door rotation rate effect on aerosol permeation in a cleanroom.

Results in Engineering, (2025), 108922 p.

Maintaining optimal air quality in cleanrooms is critical for contamination control in sensitive industries, such as pharmaceuticals, electronics, and healthcare. Among the factors affecting cleanroom integrity, door movement plays a significant role in disturbing airflow and enabling contaminant intrusion. This study analyzed the hinged door motion effect on airflow dynamics and particle distribution employing computational fluid dynamics, discrete phase method and dynamic mesh approach. A novel index was proposed to quantitatively assess contamination transfer under varying operational scenarios. The simulation setup modeled a cleanroom connected to an airlock, with door opening and closing speeds ranging from π/8 to π/4 rad/s. Obtained numerical results were verified with literature experimental data to ensure the accuracy of the velocity field and particle concentration. The findings reveal that both the door speed and direction substantially influence contaminant transport. Based on these results, this study suggests optimal door operation strategies to minimize contamination risks, offering practical guidance for improved cleanroom design and protocols. A variable-speed door operation opening slowly and closing at twice the opening speed was shown to reduce the contaminant levels by 21%. Additionally, a new parameter, Normalized Particle Exposure Index (NPEI), was introduced to quantify contamination persistence, revealing that phased door movement improved performance by 17% compared to a 3-second opening and by 15% compared to a 2-second opening.

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Vachon, J.

Influence des modèles d’ apprentissage automatique sur la prédiction des particules ultrafines ambiantes et son association avec la mortalité.

Université de Montréal. Ecole de santé publique. Thèse 2025

Cette thèse visait à évaluer le potentiel des méthodes d’apprentissage automatique à améliorer l’estimation de l’exposition chronique aux concentrations ambiantes de PUF, et examiner leur association avec la mortalité. Le premier article présentait une revue systématique des études comparant les performances des méthodes statistiques et d’apprentissage automatique pour modéliser des polluants hétérogènes comme les PUF, le dioxyde d’azote (NO2) et le carbone noir (BC). Les différences de performance entre

types de méthodes ont été extraites, agrégées et comparées globalement et par regroupements de caractéristiques méthodologiques. Les résultats montrent un avantage net de l'apprentissage automatique pour le NO2 et le BC, mais aucune supériorité claire pour les PUF, notamment en raison du nombre limité d'études disponibles. La revue souligne également la sous-utilisation des méthodes statistiques non linéaires et le faible nombre d'approches comparées dans la plupart des études, d'où la nécessité d'évaluations plus approfondies et systématiques pour la modélisation des PUF. Le second article développe et compare, à partir de données d'une campagne d'échantillonnage mobile à Québec, plusieurs modèles statistiques et d'apprentissage automatique des concentrations quotidiennes et annuelles de PUF. Les modèles d'apprentissage automatique, notamment ceux à base d'arbres de régression, ont surpassé les approches statistiques. Le modèle Extreme Gradient Boosting (XGBoost) a obtenu la meilleure performance ($R^2 \approx 0,86$), supérieure à celles rapportées dans la littérature, tandis que les modèles statistiques non linéaires présentaient des résultats intermédiaires entre les approches linéaires et d'apprentissage automatique. Enfin, le troisième article évalue, au sein d'une cohorte rétrospective d'adultes de la ville de Québec (2000 à 2017), les associations entre l'exposition chronique aux PUF et la mortalité toutes causes et par cardiopathie ischémique. L'exposition a été estimée aux codes postaux à partir des surfaces des concentrations annuelles de PUF développées dans l'article précédent. Les analyses de Cox, ajustées pour divers facteurs sociodémographiques et pour la co-exposition au PM2,5 et au NO2, ont révélé des associations positives et non linéaires entre l'exposition aux PUF et la mortalité, dont les courbes de fonctions de réponse variaient selon le modèle d'exposition utilisé. En somme, cette thèse démontre que l'apprentissage automatique, et en particulier les algorithmes basés sur les arbres de régression, améliore significativement la modélisation de l'exposition aux PUF, renforçant la robustesse des analyses épidémiologiques. Elle met également en évidence l'importance de poursuivre les travaux pour mieux comprendre les effets de santé associés aux PUF, et renforce la pertinence d'intégrer les PUF dans les réseaux de surveillance de la qualité de l'air.

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Yaoxuan, K. J. E. C. R. X. G. X. R. Z.

Recherche sur l'application des purificateurs à photoionisation dans les systèmes de climatisation auxiliaires pour la prévention des moisissures intérieures.

Réfrigération, climatisation et technologies énergétiques, Vol. n°(154), (2025), 82-87 p.

Taiwan, located in a subtropical climate zone, experiences high humidity during the summer and plum rain seasons, causing residents to suffer from frequent indoor mold problems. With the ongoing global energy crisis, traditional dehumidifiers are no longer the optimal solution, making the development of alternative approaches that achieve lower energy consumption and long-term indoor dryness an important issue. In this study, an environmental purifier system based on photocatalytic oxidation was developed to generate reactive species capable of degrading airborne organic compounds and inhibiting microbial growth. Both laboratory and field tests demonstrated its effectiveness in reducing surface contaminants. Antifungal performance was further evaluated through mold culture experiments, and the results indicated that the gases released from the purifier not only degraded pollutants but also achieved dehydration-based mold prevention, highlighting its promising practical applicability.

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Kong, M., Byun, K., Pope, Z. C., Hogan, C. J., Knobloch, Y., Olson, B.

Effect of ventilation and filtration control on an office: Environmental and energy analysis.

Journal of Building Engineering, Vol. **119**, (2026)

Effective ventilation and filtration strategies are essential for maintaining healthy indoor air quality (IAQ) in office environments, yet their real-world performance and associated energy costs remain poorly quantified. The IAQ effects of ventilation and filtration strategies, including replacing minimum efficiency reporting value (MERV) 8 filters with MERV 13 and activated carbon filters, portable air purifiers, double ventilation rate, and pre-purge, on removing particulate matter (PM), carbon dioxide (CO2), and total volatile organic

compounds (TVOC) were examined in an open-floor-office living lab. Their energy cost under 16 different climate conditions in the U.S. was simulated to demonstrate their benefit/cost ratios. Double ventilation rate decreased average incremental CO2 levels by less than 50 %, likely due to infiltration and variation in occupancy, but reduced incremental TVOC levels by 76 % compared to Baseline. Alternatively, portable air purifiers with VOC adsorption filters could reduce incremental TVOC by 52 %, while activated carbon filters in the air handling unit and pre-purge could cause reductions by 18 % and 15 %, albeit insignificant due to the small sample size. Portable air purifiers were also effective in reducing indoor PM2.5 and PM10 concentrations by 70 % and 78 % while the MERV 13 filters could reduce the indoor PM2.5 and PM10 by 71 % and 56 %. Energy simulations indicated that 1) Pre-purge caused the most additional energy in 14 out of 16 climates; 2) MERV 13 filter was the most energy-efficient approach for removing indoor PM2.5 and PM10; 3) double ventilation was more efficient for removing CO2, PM10, and TVOC in mild climates. The findings could help researchers and engineers better understand the real-world performance and cost of ventilation and filtration strategies in various climates.

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Ribeiro, M. B. A., Tibiriçá, Á. M. B., Coelho, A. L. D. F., Campos, J. C. C., Rosa, H. M. P.

Application of Artificial Neural Networks (ANN) for modeling Personalized Ventilation Systems (PVS) using CFD data.

Acta Scientiarum. Technology, Vol. **48** n°(1), (2025)

This study investigates the application of Artificial Neural Networks (ANNs) for modeling Personalized Ventilation Systems (PVS) using data from Computational Fluid Dynamics (CFD) simulations. In recent years, machine-learning techniques like ANNs have been increasingly used to accelerate CFD analysis and improve the accuracy of temperature and airflow velocity predictions in indoor environments. The methodology involved conducting twelve CFD simulations in a three-dimensional space, followed by data filtering and normalization to train and test the neural network. The room was composed of two individuals, positioned side by side, both seated and receiving air from a ceiling supply system. Both individuals were modeled to maintain a constant surface temperature while also transferring heat to the environment. The quality of the results were analyzed by comparing the neural network outputs with data that had been omitted from the network. The results demonstrated the effectiveness of the model, with average errors ranging from 1% to 3% and maximum errors between 6% and 15%. This approach significantly reduces the computational time required for traditional CFD simulations while maintaining high accuracy, offering promising prospects for optimizing PVS performance in various indoor settings. The use of machine learning makes the analysis and design of personalized ventilation systems faster and more efficient, with practical applications in offices, classrooms, and residential spaces.

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M’hayham, M. D., Dougniaux, G., Sabot, B., Mougeot, X.

Modelling of Alpha Aerosols Spectra—Application to Continuous Air Monitors (CAMs).

32nd International Conference on Nuclear Engineerin ICONE 2025, 22–26 June, Weihai, China

In nuclear facilities, managing atmospheric contamination risks from the release of radioactive aerosols is critical for maintaining safety and radiation protection. Continuous Air Monitors (CAMs) assess such risks by continuously sampling ambient aerosol and measuring air activity concentrations. Despite their utility, CAMs face challenges in environments containing both radon progeny aerosols and larger non-radioactive particles, particularly in dismantling sites. These challenges lead to the degradation of alpha spectra and potential false alarms. This study introduces a simulation-based model to replicate and understand the behaviour of CAMs in such environments, aiming to refine their performance under atypical conditions. This simulation-based model combines a Diffusion-Limited Aggregation (DLA) algorithm to simulate aerosol deposition and a Monte Carlo (MC) algorithm to model alpha particles transport through these deposits, thereby replicating the detector response in such environments. Preliminary results demonstrate the model's promising capabilities, with the impact of individual aerosols accurately represented, validating the

performance of the MC approach. Ongoing efforts aim to deepen the representation of aerosol deposition processes, thereby leading to improve the model's results.

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Trul, A. A., Gaidarzhi, V. P., Abramov, A. A., Toirov, S. K., Borshchev, O. V., Dubinets, N. O.*, et al.*

Toward the OFET-Based Electronic Nose without Receptor Layers.

ACS Applied Electronic Materials, (2026)

The development of electronic nose systems is an important but rather challenging task nowadays. Organic field-effect transistors provide a powerful platform that is promising for electronic nose creation. In this work the sensory properties of a recently synthesized series of siloxane dimers of benzothieno[3,2-b][1]benzothiophene (BTBT) with different terminal alkyl groups (D2-Und-BTBT-Alkyl) as well as the possible mechanism of their sensitivity were investigated in detail. It was found that in spite of very similar chemical structure the dimers demonstrated dissimilar sensitivity and selectivity to various analytes─H2S, NH3, SO2, NO2, and several volatile organic compounds. The proposed mechanism of the patterns observed depends on both the correlations between the HOMO/LUMO energy levels of the dimer and the analyte and the dimer layer morphology/molecular packing. PCA analysis allowed us to choose the best four OFETs based on different siloxane dimers without any receptor layer for separation of the analytes and determining their concentrations on a 2D plot. These findings demonstrate that a rather small difference in the chemical structure of the organic semiconducting materials used for the OFET fabrication makes it possible to apply them as an array for the electronic nose creation.

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