

Objectif : *Qualité de l'air intérieur*

Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

1

Google Scholar, Lens, WoS

Mir, N., Banu, A., Abdellatif, Y. M., Amhamed, A. I., Bicer, Y.

[Advanced direct air capture of CO₂ using air conditioning systems: a life cycle assessment.](#)

Thermal Science and Engineering Progress, Vol. **67**, (2025)

Rising global temperatures and deteriorating urban air quality underscore the urgent need for effective carbon removal technologies. Direct Air Capture (DAC) offers a promising solution, but its high energy demand raises concerns about overall sustainability. This study evaluates the environmental performance of a novel system that integrates DAC with Heating, Ventilation, and Air Conditioning (HVAC) infrastructure to improve energy efficiency and reduce environmental impact. A cradle-to-gate life cycle assessment (LCA) is conducted based on numerical modeling of the DAC-HVAC system. The integrated system exhibits significantly reduced environmental impacts compared to a standalone DAC unit. For the capture of 1 kg of CO₂, the DAC-HVAC system results in 0.206 kg CO₂ eq. (climate change), 7.521×10^{-7} kg P eq. (freshwater eutrophication), 7.282×10^{-8} kg CFC-11 eq. (ozone depletion), 8.889×10^{-5} kg PM_{2.5} eq. (particulate matter formation), and 2.051×10^{-3} m³ (freshwater consumption). Notably, the climate change impact is reduced by 15 %, and HVAC-related emissions are lowered by 42 % through integration. These reductions are attributed to decreased electricity requirements achieved via system synergies. Moreover, a sensitivity analysis on different adsorbents and electricity sources is performed. This research highlights the potential for reducing greenhouse gas emissions while addressing indoor air quality concerns. The findings also emphasize the importance of adsorbent selection in the overall environmental impact of the integrated DAC-HVAC system. Future research should explore comprehensive adsorbent assessments and consider end-of-life stages for a more comprehensive understanding of sustainability implications.

García, A. E., Lelis, J. M. R., Chávez, H. R.

[Análisis computacional de la eficiencia del efecto corona para el filtrado de aire: remoción de gotículas del orden de PM_{2.5}.](#)

CIENCIA ergo-sum, Vol. **32**, (2025)

Haciendo uso de la Dinámica de Fluidos Computacional se determinó la viabilidad que tiene el efecto corona para su aplicación en el filtrado de partículas PM_{2.5}. Tanto en el modelo teórico como la comprobación experimental se utilizó una configuración coaxial de 1.5 cm de diámetro, a través de esta se indujo un flujo de aire con velocidades de entre 0.5 y 1.5 m/s. En dicho flujo se liberaron gotículas con tamaños entre 0.3 y 2.5 μ m y sobre el electrodo central se aplicó un potencial de 10 kV. Los resultados muestran que entre menor sea el tamaño de las partículas, menor es la eficiencia del filtro para recolectarlas; sin embargo, se consiguió hasta un 98% de efectividad en su recolección.

Lo, C. K.

[The Application of Digital Twin for Indoor Air Quality Management: A Case Study in Hong Kong.](#)

Journal of Sustainable Built Environment, Vol. **2** n°(1), (2025), 11-22 p.

With the advocacy of the development of smart cities, buildings are also evolving to become smarter and more user-friendly. Employing cyber-physical technologies, such as the Internet of Things (IoT), Digital Twin (DT) and Building Information Modeling (BIM), can effectively monitor and control the built environment. DT is an emerging tool that connects the building to its digital replica so that the building's situation can be monitored and presented to users effectively. This paper proposes a DT framework for

building management to discover the applications of DT for indoor environment monitoring and control. A case study of a DT-driven indoor air quality (IAQ) system is completed to demonstrate the implementation of DT in the built environment. The system demonstrated the key features of DT, including monitoring, simulation, control and prediction, and showed their roles and functions in IAQ management. Finally, the difficulties and limitations, i.e. sensor selection and installation, of implementing the DT system in the built environment are presented after the case study.

Saputra, C., Munir, M. M.

[Applying unimodal models to high-performance bimodal air filtration membranes.](#)

Powder Technology, Vol. **469**, (2026)

Nanofiber-based air filters are promising for efficient particulate matter removal, yet the use of unimodal models in bimodal fiber systems remains limited. This study examines electrospun nanofiber filters produced from polyacrylonitrile (PAN) in N,N-dimethylformamide (DMF) at 12 % w/w (Solution A) and 7.5 % w/w (Solution B), yielding coarse and fine fibers, as well as their bimodal composites (AxB and BxA) reinforced with nylon mesh. Scanning electron microscopy confirms that Solution A generates thicker fibers, influencing filtration performance. Pressure drop and filtration efficiency were evaluated across face velocities (0–25 cm/s) and particle sizes (10–500 nm) using established models (Brown, Davies, Ogorodnikov, Lee, Bian, Lee & Liu, Liu & Rubow, and Payet). To extend unimodal models to bimodal systems, a new parameter—apparent packing density—was introduced. Results show that the Bian model accurately predicts pressure drop (errors within ± 5 %) by accounting for slip flow, while the Liu & Rubow model best fits filtration efficiency (errors within ± 5 %), especially near the most penetrating particle size (MPPS, 100–200 nm). Incorporating apparent packing density enables precise predictions for bimodal membranes. Furthermore, composite fiber fractions significantly affect quality factors and MPPS, revealing trade-offs between efficiency and resistance. Overall, bimodal composites demonstrate superior performance, combining lower pressure drop with high capture efficiency. This study identifies the Bian and Liu & Rubow models, when applied with apparent packing density, as the most suitable approaches for bimodal nanofiber membranes, providing guidance for the design of next-generation air filtration systems.

Garcia-Gonzalez, H., Lopez-Pola, M. T., Rodriguez, R., Fernandez-Rubio, P., Fernandez-Rodriguez, P.

[Assessing Volatile Organic Compounds \(VOCs\) in a laboratory and office building environment.](#)

Air Quality, Atmosphere & Health, (2025)

Indoor air quality (IAQ) is critical to human health, given the considerable amount of time spent indoors. Volatile Organic Compounds (VOCs) contribute substantially to IAQ degradation and potential health risks. VOCs significantly contribute to the degradation of IAQ and pose potential health risks. This study assessed VOC concentrations in the Instituto Nacional de Silicosis (INS) building, (which includes laboratories, offices, and common areas), according to ISO 16000-5 guidelines. Sampling was carried out using P-type pumps with Tenax® TA sorbent tubes and analysed via thermal desorption and Gas Chromatography–Mass Spectrometry (GC-MS), in compliance with UNE-EN 14,662 standards. Of the 49 targeted VOCs, 29 were detected across several chemical classes. Toluene was the most abundant compound, while benzene, a Group 1 human carcinogen, was found both indoors and outdoors, with concentrations reaching up to $0.89 \mu\text{g}/\text{m}^3$. All individual VOCs were below 1% of the Spanish Occupational Exposure Limit Values (OELVs), and total VOC (TVOC) levels remained consistently below the recommended threshold of $200 \mu\text{g}/\text{m}^3$. Certain areas, such as the cleaning room and the library, exhibited comparatively higher concentrations and a broader range of compounds. In the library, this was likely due to books containing thin slices of real lungs, preserved with varnish. Although the results indicate no immediate health risk, the detection of hazardous substances such as benzene, even at low concentrations, emphasises the importance of continuous monitoring. The study recommends potential mitigation strategies including improved ventilation and the use of indoor plants for biofiltration. These

findings support the need for proactive IAQ management and further research into the long-term health implications of occupational exposure.

Lopes, J. R.

[Avaliação de Desempenho de Soalhos Compósitos Industrializados: Estudo de Caso.](#)

Universidade do Porto (Portugal). Thèse 2025

The indoor air quality (IAQ) has been receiving increasing attention within the scientific community and the general public. The long exposure of most people to the indoor air is favourable to the appearing of an ensemble of health and comfort problems with negative repercussions on productivity and people's well-being. The hospital establishments lodge people that, due to their physical condition, are hypersensitive to the IAQ (besides all of the working teams that incorporate the administration and technical staff – physicians and nurses). In those cases, the IAQ can be responsible for the appearing of infections and the aggravation of health conditions. The exposure to microbiological contaminants, such as fungi, and its relation with environmental factors are two of the most important aspects on this matter.

Mccormick, E. L., Rider, T. R., Hu, J.

[Beyond the metrics: The discrepancy between indoor air quality benchmarks, outdoor access, and occupant satisfaction in U.S. office buildings.](#)

Indoor Environments, Vol. 2 n°(4), (2025)

Well-filtered air, biophilic design, and outdoor terraces are increasingly provided as workplace amenities intended to foster a connection to nature within the confines of urban infrastructure. Yet this mixed-methods study of four urban office spaces in the US Southeast and mid-Atlantic (Atlanta, Charlotte, Durham, and Washington, DC) reveals a persistent disconnect between design strategies and occupant experiences. Despite meeting or exceeding industry standards for ventilation, daylight, greenery, and access to outdoor space, study participants frequently expressed feeling “trapped,” “confined,” or “stuck in a cold box” during the workday, highlighting the gap between technical compliance and sensory satisfaction. Continuous air quality monitoring confirmed that average IAQ index values ranged from 34 to 50, CO₂ levels averaged 454–557 ppm, and PM_{2.5} concentrations rarely exceeded 15 µg/m³. Nevertheless, behavioral and perceptual data from surveys, interviews, and QR-based tracking revealed limited terrace use and a persistent desire for “fresh air,” environmental variability, and sensory richness. When terraces were used, they functioned primarily as recreational or social spaces rather than work environments, constrained by glare, noise, poor ergonomics, and a lack of supportive infrastructure. These findings demonstrate that technical benchmarks, while necessary, are insufficient to ensure well-being. Instead, more effective workplace strategies must therefore move beyond narrowly defined performance metrics to embrace environmental diversity, occupant perception, and cultivate more porous boundaries between the indoors and nature.

Renard-Julián, E. J., Olmos, J. M., García-Cascales, M. S.

[A BIM-Oriented Framework for Integrating IoT-Based Air Quality Monitoring Systems Using the AIBIMclass Classification.](#)

Applied Sciences, Vol. 15 n°(19), (2025)

This paper presents a BIM-oriented methodological framework for integrating air quality monitoring systems based on IoT sensors into building and infrastructure projects. A set of low-cost environmental sensors capable of measuring PM1, PM2.5, PM10, temperature, and humidity was deployed in a real residential setting to illustrate the proposed approach. To enable semantic integration within BIM workflows, a

structured classification system, AllBIMclass, was developed. It provides dedicated hierarchical codes for environmental sensors, defined by monitored parameters, installation location (indoor, outdoor, or mixed), power supply, and data handling mode. The pilot experience demonstrated how sensors can be registered, classified, and linked to BIM models, supporting data visualisation and basic management tasks. AllBIMclass is available in Revit 2026 (version 26.6.4.409, build 20250227_1515, 64-bit) (TXT) and Archicad 28 (version 28.0.0, build 3001, x86-64-bit) (XML) formats and is fully compatible with IFC schemas. Although the framework has not yet been applied to large-scale projects, its components are technically operational and ready for implementation. This research contributes to bridging the gap between environmental monitoring and digital construction workflows, paving the way for integration into digital twins, smart buildings, and sustainable infrastructure systems.

Akshaya Raman, M., Rajesh, C. M., Karthikeyan, K., Suguna Lakshmi, M.

[Bio-renewable, Nonvolatile, and Low Carbon: Leather Dust Composite Paves the Way for Eco-friendly Aircraft Interiors.](#)

Advances in Materials and Manufacturing Processes for Composite Applications (AMMPCOM)

Utilizing leather dust composite sheets presents a sustainable solution for aircraft interiors. These sheets comprise waste leather powder, polyurethane resin binder, and nanoclay reinforcing filler, yielding eco-friendly products. Mechanical testing revealed that the 80/20 PU/leather waste (LW) blend exhibited remarkable tensile strength, surpassing traditional materials. Additionally, the composite sheets resist water absorption and maintain stable electrical properties, vital for aircraft interiors. Fire resistance tests confirm the composites' ability to withstand flames, enhancing aviation safety. Embracing leather dust composites aligns the aviation industry with environmental goals, offering a unique, cost-effective material for sustainable aircraft interiors. This supports carbon reduction and circular economy practices, promoting environmental sustainability in aviation. The adoption of such materials not only mitigates environmental impact but also advances the industry toward more responsible practices. With the aviation sector facing increasing scrutiny over its environmental footprint, transitioning to eco-friendly materials like leather dust composites is imperative. This adoption supports initiatives aimed at carbon reduction and promotes practices in line with the principles of the circular economy.

Othman, H., Sieves, G., Guimarães, T., Azari, R.

[A calibration chamber framework for low-cost indoor air quality sensor validation.](#)

Building and Environment, Vol. **287**, (2026)

Advancements in micro-sensing technologies have revolutionized air quality monitoring, transitioning it from traditional networks to real-time systems capable of continuously detecting and measuring environmental parameters. These technological improvements have led to commercial availability and subsequent widespread application of compact low-cost sensors. These sensors are democratized due to their accessibility, ease of use, and minimal technical expertise needed for their maintenance and calibration. However, ensuring the accuracy, reliability, and performance of low-cost micro-sensors remains a challenge, particularly for indoor air quality (IAQ) monitoring. Low-cost sensors often provide inconsistent data and must be individually evaluated for the specific environmental conditions under which they will operate. This study presents a framework to evaluate and validate low-cost IAQ sensors using a double-skin calibration chamber to provide a stable, controlled environment for simulating real-world indoor environmental condition scenarios. We use this framework to assess and validate the performance of multiple low-cost sensors. In this work, we report on the design, construction, and validation processes of the calibration chamber using SolidWorks simulations and a rigorous experimental protocol. As well as evaluating the IAQ sensor performance under control conditions and developing a calibration code to enhance sensor reliability.

Kanaan, M., Gazo-Hanna, E., Amine, S.

CFD Assessment of the Inhaled Air Quality in a UFAD-Conditioned Office with Personalized Ventilation.

Engineering, Technology & Applied Science Research, Vol. **15** n°(5), (2025), 28128-28135 p.

The quality of the inhaled air in an Underfloor Air Distribution (UFAD) system assisted by Personalized Ventilation (PV) is evaluated based on the CO₂ concentration levels in the respiration zone. Also, whole-body thermal comfort is assessed using the Predicted Mean Vote (PMV) model. A comprehensive three-dimensional Computational Fluid Dynamics (CFD) model is developed to simulate the indoor airflow behavior, including the interactions between the PV jet, human exhaled flow, and thermal plume. A parametric study is carried out by varying the UFAD and PV flow rates to analyze their effects on the overall thermal comfort and inhaled air quality. The results indicate that, for the proposed configuration and terminal device, PV with a supply temperature of 24 °C and flow rates between 2.5 and 7.5 L/s may reduce the CO₂ concentrations in the respiration zone by up to 34%, while ensuring the occupant comfort. However, this finding cannot be generalized to all PV situations, as the present study accounts only for normal human breathing and a constant heat flux density. The variations in these parameters may alter the outcome due to the different interactions of the PV airflow in the occupant's microenvironment.

Ahmed, A.

Chapter 8. Heating, Ventilating, and Air-conditioning (HVAC) Systems.

In: Energy Management Handbook, 10th Edition. River Publishers; 2025. 227-266 p.

The Energy Management Handbook, 10th edition, delivers proven strategies to optimize energy use, reduce costs, and achieve sustainability in industrial and commercial settings. This comprehensive guide, the official reference book for the Certified Energy Management (CEM®) program by the Association of Energy Engineers (AEE®), spans 24 chapters, covering essential topics like HVAC, renewable energy, energy auditing, and building automation. It also delves into advanced techniques such as cogeneration, waste heat recovery, industrial refrigeration, and measurement and verification. Offering actionable insights, it helps improve energy efficiency across diverse systems—including pumps, fans, compressed air, steam, and more—while addressing decarbonization and economic analysis for long-term success. As global energy demands rise and climate challenges intensify, effective energy management has never been more critical.

Palejwala, Z.

Chapter 31 - Temperature in the working environment and effects on fatigue.

In: The Scientific Basis of Fatigue. Academic Press; 2026. 361-372 p.

Increasing global temperatures have resulted in a rise in environmentally focused research particularly on how environments that are thermally challenging can impact physical and mental fatigue levels in the working population. While cold working conditions are concerning for fishery and agricultural workers hot work environments are predominantly concerning for athletes, firefighters, medical staff, and mining workers. In general there is more research pertaining to the effects of heat stress on occupational health and safety, with a general understanding that hot work environments can impact physiological markers like heart rate, core temperature, and dehydration, as well as perceptual markers like thermal discomfort and perceived exertion, all of which are correlated with fatigue. While the temperature of the work environment and its relationship with fatigue has become a focus in occupational settings, additional factors like solar radiation, work intensity, and personal protective equipment can have a compounding effect on worker fatigue and should therefore be considered in conjunction with temperature to foster a healthy work environment.

Kennedy, A., Morawska, L., Adotey, V.

[Clearing the Air: Navigating Regulatory Frameworks for Indoor Air Quality Control.](#)

In: Air Pollution and the Brain. Springer Nature Switzerland; 2025. 185-203 p.

Indoor air quality (IAQ) is a pressing yet globally underregulated public health issue, with growing scientific evidence linking poor IAQ to a wide array of health problems, including respiratory illnesses, cardiovascular disease, cognitive impairments, and increased risk of infection. Given that people spend most of their time indoors, addressing IAQ has become a critical area for policy intervention. This chapter examines the regulatory landscape governing IAQ, distinguishing between voluntary standards, non-binding guidelines, and enforceable legislation. It analyses the strengths and limitations of each regulatory tool and argues for a strategic, integrated approach to IAQ governance. Drawing on comparative case studies from the United States, Belgium, the United Arab Emirates, South Korea, and Taiwan, the chapter identifies promising innovations, including real-time monitoring, public labelling schemes, and building certification systems, as well as highlighting gaps in enforcement, public awareness, and regulatory coverage. The chapter also explores how IAQ regulation can be strengthened by embedding standards within existing legal frameworks, such as work health and safety laws and building codes. Emphasising the need for cross-sectoral collaboration and adaptive regulatory design, the chapter concludes by advocating for resilient, inclusive, and evidence-informed approaches to IAQ regulation that prioritise public health, environmental justice, and long-term sustainability.

Li, Z., Song, G., Zhang, Q., Yu, J., Liu, Y.

[A Combined Weighting Method to Assess Indoor Environmental Sub-Factors for Human Comfort in Offices in China's Severe Cold Regions.](#)

Buildings, Vol. 15 n°(19), (2025)

Indoor environmental quality in offices, comprising thermal, acoustic, lighting, and air quality domains, is known to influence human comfort, yet the relative importance of their sub-factors—particularly in severe cold regions—remains unclear. This study addresses this gap by integrating objective (Criteria Importance Through Intercriteria Correlation, CRITIC) and subjective (Analytic Hierarchy Process, AHP) weighting methods, supported by field measurements and questionnaire surveys in open-plan offices in three provinces in northeastern China. Cluster analysis categorized acoustic sub-factors into outdoor traffic, outdoor entertainment, people conversation, burst sound, and people movement. Results show that temperature is the dominant thermal comfort driver (39.7% CRITIC; 45.5% AHP), exceeding air velocity and humidity, which had nearly equal influence. Indoor sound exerted greater impact than outdoor sound, with people conversation ranked highest among indoor noise sources, and burst sound and movement showing similar but slightly lower weights. Natural light outweighed artificial light in importance (54.2% CRITIC; 61.0% AHP), while air freshness and pollution were nearly equally influential. Compared to CRITIC, AHP produced more dispersed weights, reflecting subjective bias toward pronounced differences. These findings provide a quantitative basis for prioritizing environmental design interventions—such as controlling indoor conversational noise, optimizing natural lighting, and stabilizing temperature—to enhance comfort in offices in severe cold regions.

John, J.

[Comparative Study of the Gas-Sensing Mechanisms in Functionalized Graphene and MXene Nanocomposite Films for CO₂ Detection.](#)

ResearchGate, (2025)

The growing demand for efficient and selective carbon dioxide (CO₂) detection has driven extensive research into advanced nanomaterials with high surface reactivity and tunable electronic properties. This study presents a comparative investigation of the gas-sensing mechanisms in functionalized graphene and MXene (Ti₃C₂T_x)-based nanocomposite films for CO₂ detection. The materials were synthesized through controlled surface functionalization and composite formation with metal oxide nanoparticles to enhance adsorption sites and charge-transfer interactions. Structural, morphological, and electronic characterizations were conducted using XRD, Raman spectroscopy, SEM, and electrical measurements under varying CO₂ concentrations. The results reveal that functionalized graphene films exhibit physisorption-dominated sensing with moderate response and recovery times, whereas MXene-based composites demonstrate enhanced chemisorption behavior and higher sensitivity due to rich surface terminations and metallic conductivity. Comparative analysis of the band-structure modulation and gas-surface interactions suggests that the superior CO₂ detection performance of MXene nanocomposites arises from stronger charge-transfer efficiency and higher surface reactivity. These findings provide insight into tailoring 2D material-based sensors for selective CO₂ detection and contribute to the design of next-generation environmental monitoring systems.

Steve, M., Thapelo, M., Kobo, H.

[Design, Implementation, and Testing of an NB-IoT Smart Sensor's Signal Processor for Industrial Applications.](#)

Proceedings of the 2025 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems

This work presents the design, implementation, and testing of a signal processor for NB-IoT-enabled smart gas sensor systems for deployment in industrial facilities. The processor is designed with low-cost MOS gas sensors (MQ-6, MQ-7, and MQ-135) and an ATmega328P microcontroller for real-time detection of hazardous gases. Circuits for conditioning the sensor analogue outputs were designed for amplification and filtering, with the goal of accurate digitisation using the microcontroller's on-board analogue-to-digital converter (ADC). Simulations and experimental testing confirmed the processor's capability of delivering low-noise, stable, and responsive measurements for deployment in air quality monitoring. Initial attempts at interfacing the processor with the SIM7000E NB-IoT module revealed communication issues, but these are outside the processor and were documented for future correction. Overall, the proposed processor provides a low power, reliable platform for the integration of gas sensing into safety-critical industrial and environmental monitoring systems.

Horn, W., Klein, L., Bethke, R.

[Determination of uptake rates of VVOCs and carbonyls in indoor air on passive sampling system.](#)

AIRMON 2025 The 11th International Symposium on Modern Principles of Air Monitoring and Biomonitoring.

The identity and concentration of volatile contaminants are important factors in ensuring a healthy indoor environment. Volatile organic compounds (VOCs) in indoor air can be determined by using passive samplers that are exposed to the air for a well-defined period of time. This sampling method is often used in environmental surveys, e.g. the German Environmental Survey (GerES). Conclusions about indoor air concentrations can be drawn from substance and adsorption material specific uptake rates. For the assessment of indoor air quality, highly volatile organic compounds may also be substantial, but for many of these substances realistic uptake rates and suitable analytical methods are lacking. A small chamber is used to generate gas atmospheres with constant concentrations of the analytes at 23 °C and 50 % relative humidity. For a large number of compounds, a very small flow of pure liquid VVOCs is introduced into the chamber via a syringe pump and mixed with a constant flow of clean and humidified air. A gas mixture from cylinders is also used for this purpose. Carbograph 5TD has already been proven as a suitable sorption

material for active sampling for most of VVOCs. With this procedure up to 55 different VVOCs should be tested in this study. Stable concentrations of gas phase atmospheres of the first group of VVOCs (acetone, 2-butanone, methyl acrylate) were produced for exposure of passive samplers. Comparison of different adsorbent materials showed that Carbograph 5TD was the most suitable for passive sampling of these substances, with higher uptake than Carbopack X and Tenax® TA. Very strong adsorbents are not suitable for this experimental design as it adsorbs larger amounts of water. The effective uptake rates were calculated for the first three VVOCs on Carbograph 5TD tubes and an exposure time of 7 days. The same experiment will be performed for all VVOCs and ideally one material should be the best option for all of them.

Warlina, L., Listyarini, S., Mohamed, M. A., Umar, R., Sambas, A.

[Development of a Real-Time IoT-Based Portable Particulate Matter Monitoring Device Using PMS5003 Sensor.](#)

Fusion: Practice & Applications, Vol. 21 n°(1), (2026)

Particulate Matter (PM) concentration significantly affects public health, exacerbating respiratory conditions and contributing to environmental challenges. This study presents a real-time Internet of Things (IoT)-based portable particulate matter monitoring device utilizing the PMS5003 sensor. The device measures PM1.0, PM2.5, and PM10 concentrations and uploads the data to the cloud at 15-second intervals for real-time visualization. A two-week observational study in South Tangerang, Indonesia, revealed peak PM2.5 and PM10 levels of 218 $\mu\text{g}/\text{m}^3$ and 232 $\mu\text{g}/\text{m}^3$, respectively, on weekdays, compared to a weekend low of 19.76 $\mu\text{g}/\text{m}^3$ for PM2.5. Variations were influenced by anthropogenic factors, including vehicular and industrial activity. Data analysis showed a 78% reduction in PM2.5 levels during weekends, highlighting the impact of human activity on air quality. These findings underscore the impact of anthropogenic activities on air quality and demonstrate the effectiveness of IoT-based systems in environmental monitoring. The study highlights the potential for such technology to support data-driven strategies for pollution management and public health improvement.

Gola, M., Laghezza, A., Yu, Y., Settimo, G., Capolongo, S.

[Digitalizzazione in Sanità e Indoor Air Quality degli ambienti confinati. Una metodologia per valutare l'IAQ negli spazi lavorativi attraverso sensori low-cost e la percezione del comfort degli utenti.](#)

58esimo Congresso Nazionale SItI. La Sanità Pubblica A Garanzia Dell'equità Sociale

Introduzione È risaputo che i rilevatori dell'Indoor Air Quality (IAQ), anche quelli considerati "low-cost", hanno un ruolo strategico nella promozione della salute; infatti, attraverso diverse modalità comunicano all'utente eventuali concentrazioni (su rilevamento reale o su base algoritmica) di inquinanti negli ambienti indoor. Nell'ambito della sanità pubblica ci si pone il quesito: sono veramente efficaci tali rilevatori e possono influire sul miglioramento degli stili di vita? Proprio per questo motivo il lavoro di ricerca si è basato su una metodologia di analisi qualitative dell'IAQ negli spazi di lavoro. In particolare, l'innovazione della ricerca consiste nello sviluppo di un questionario sulla percezione e il benessere degli utenti, basato sugli esiti di una scoping review, supportati da sensori low-cost per il monitoraggio dell'IAQ. Nello specifico l'analisi condotta è relativa all'applicazione su alcune aree dipartimentali di un'università. Materiali e Metodi Il processo di ricerca è stato così suddiviso: • in riferimento agli esiti della scoping review, è stato costruito un questionario da far compilare agli utenti e di supporto per il confronto con i dati quantitativi dei sensori; • applicazione della metodologia nelle aree di lavoro con il posizionamento dei rilevatori e somministrazione dei questionari, nelle diverse stagioni (2 giorni al mese); • analisi qualitative e correlazione dei dati; • definizione di strategie e buone pratiche da attuare. Risultati Il lavoro di ricerca ha permesso di validare la metodologia e di verificare l'efficacia dei dispositivi low-cost, come strumento di prevenzione. L'attività di monitoraggio è stata condotta per circa 9 mesi su 10 uffici dipartimentali e ha permesso di valutare sia la stagione invernale che quella estiva. Il data analysis ha

fatto emergere esiti di notevole rilievo in cui sono emerse differenze dettate dalle caratteristiche ambientali (dimensioni, esposizioni solari, sistemi di riscaldamento/ raffrescamento, ecc.) e dai diversi stili di vita dei partecipanti (circa 50), che hanno permesso la definizione di un decalogo di buone pratiche da attuare. Conclusioni Sebbene il data analysis non sia supportato da rilevatori ad alta performance, lo studio ha evidenziato diverse best practices per promuovere salute, e migliorare il comfort e il benessere degli occupanti in relazione all'aria che respirano. Tutto ciò ha permesso di sviluppare strategie anche di mappatura digitale e machine learning per una raccolta funzionale dei dati e il supporto dell'AI.

Luján Barba, P.

[Diseño de una instalación de climatización y ventilación de un edificio de usos múltiples.](#)

Universidad Politécnica de Cartagena. Thèse 2025

This project presents the comprehensive design of the HVAC and ventilation systems for the Espacio Fayrén de Cultura Urbana in Molina de Segura (Murcia, Spain). The objective is to ensure year-round thermal comfort and indoor air quality in compliance with RITE, CTE and UNE/ISO standards, using calculation methods tailored to the building's architectural, constructive and functional features. The facility comprises two above-grade floors and an inverted non-walkable roof used as a technical area for HVAC equipment, with maintenance-only access, hosting public spaces, auditorium, multipurpose rooms, a computer room, plus an office, a meeting room and common areas. Restrooms and technical rooms are treated as non-conditioned spaces, with hygienic ventilation only. Indoor design conditions follow RITE: 23–25 °C and 45–60 % RH in summer; 21–23 °C and 40–50 % RH in winter. Thermal load calculations consider worst-case scenarios in both seasons, including occupancy, internal gains from lighting and equipment, particularly in the computer room, and solar radiation on façades and roof. The selected scheme, in brief, uses a variable refrigerant flow (VRF) system for the largest, divisible area (Alternative Room + Auditorium) and room-by-room direct-expansion systems (ducted or wall) for the remaining spaces. Mechanical ventilation is provided by floor-level heat-recovery units and dedicated toilet exhaust, meeting HS3/RITE requirements while reducing ventilation-related loads. Ductwork and refrigerant piping have been sized per RITE and UNE recommendations, maintaining air velocities ≤ 10 m/s and typical ventilation pressure drops around 0.1 mm.w.g per metre. The project aligns with SDGs 3, 11 and 12, and includes load and airflow calculations, regulatory justification, technical description, drawings and a budget estimate, delivering a modern, efficient solution for a public cultural building.

Xu, K., Zhang, Z., Song, Y., Ke, Q., Liu, S., Huang, C.

[Eco-friendly, Dual-dimensional and Multi-functional Fibrous Filter Enables Efficient Indoor Air Purification.](#)

Journal of Materials Chemistry A, (2025)

Indoor air quality has garnered critical concern, driven by the pervasive presence of fine particulate matter (PM) and toxic gases such as formaldehyde. Despite the advancements in filtration technologies, developing sustainable filters that deliver efficient air purification without increasing pressure drop remains a formidable challenge. Here, we present a straightforward and scalable fibrillation strategy for fabricating sustainable and efficient air filters composed of micro/nanofibers. By sonicating Lyocell microfibre nonwovens in NaOH solution and then stirring in water, we integrated chemical hydrolysis, ultrasonic cavitation and vortex shearing to generate abundant nanofibrils on microfibre surface. The elongation and entanglement of these nanofibrils resulted in a stable nanofiber network with enlarged specific surface area (SSA) and reduced pore size, thereby enhancing the filtration efficiency (78.1%) while maintaining an ultralow pressure drop (7.4 Pa). Further synthesis and loading of hydroxyapatite (HAP) catalysts onto the nonwoven revealed a significant increase in catalyst loading capacity after fibrillation. The resultant filter exhibited high removal efficiency for both PMs (81.7%) and formaldehyde (99.1%) at room temperature.

We believe that the combination of biodegradable dual-dimensional fibrous network with eco-friendly catalysts, may provide important inspirations for developing next-generation indoor air filters.

James, A., Noel, D., Joshua, B.

[Energy Efficiency vs. Air Quality: Trade-Offs in E-Commerce Fulfillment Center Design.](#)

ResearchGate, (2025)

The rapid growth of e-commerce has accelerated the construction of large-scale fulfillment centers, where energy efficiency is increasingly prioritized to reduce operating costs and carbon footprints. Strategies such as advanced insulation, optimized HVAC systems, and sealed building envelopes have become common in the drive toward sustainable, low-emission logistics operations. However, these same design features may inadvertently compromise indoor air quality (IAQ), as reduced ventilation can lead to the accumulation of volatile organic compounds (VOCs), elevated carbon dioxide (CO₂) levels, and particulate matter. Workers in these facilities are thus exposed to a dual challenge: the benefits of energy-efficient environments on one hand and the potential health risks from poor IAQ on the other. This study employs a comparative assessment framework using energy simulation models and IAQ pollutant modeling to evaluate trade-offs in e-commerce fulfillment center design. Findings highlight that while energy efficiency yields measurable environmental and financial benefits, insufficient attention to IAQ can undermine worker well-being and productivity. The paper proposes integrated design solutions—such as smart ventilation, IoT-enabled monitoring, and adaptive HVAC systems—to achieve a balance between efficiency and health in future logistics infrastructure.

Mabizela, L. P., Makole, R., Morulane, K. L., Swart, H. C., Motaung, D. E.

[Engineering of metal-organic framework-derived semiconductor metal oxides based on Co₃O₄: In₂O₃ nanostructures for m-xylene detection.](#)

Microchemical Journal, Vol. **219**, (2025)

Accurate real-time detection of xylene isomers is a critical platform for advancing occupational safety and public health monitoring systems. This study focuses on a morphology-driven strategy for engineering metal–organic framework-derived Co₃O₄/In₂O₃ (Co: In) heterostructures with tunable Co ratios for the detection of o-, m-, and p-xylenes, as well as other interfering gases. The results showed that the selectivity of the sensors can be realized by tuning the operational temperature. At 75 °C, both CoIn and 2CoIn showed better p-xylene selectivity. At 100 and 125 °C, 3Co: In was highly selective towards m-xylene. The increased sensing performance originated from the facile engineered heterostructure, allowing improved interfacial synergy between Co₃O₄ and In₂O₃ for improved gas adsorption. A higher Co³⁺/Co²⁺ ratio, as evidenced by XPS, also promoted stronger adsorption and activation of oxygen molecules (O₂) on the sensor surface. The increased Co content on the 3Co: In surface, which led to more porous plate-like morphology, also contributed to the sensing performance due to increased catalytic activity, and tuneable properties of 3Co: In. The findings offer a promising route for developing next-generation chemiresistive sensors for real-time air-quality monitoring.

Bukke, S. N., Sa, D., Naik, B. K.

[Enhancement of Indoor Air Quality Using Portable Air Purifiers with UV-C Sterilization.](#)

1st International conference on Thermofluids Engineering (INCOTHERM), IIT (ISM), Dhanbad, 10–11 October 2025

Air pollution caused by airborne microorganisms—including viruses, bacteria, and fungi—poses significant risks to human health, extending beyond the well-known effects of particulate matter (PM_{2.5}). Conventional

air purifiers are mainly designed to capture fine particles, but recent global health challenges such as the COVID-19 pandemic have emphasized the importance of technologies that also deactivate harmful pathogens. This study reviews common indoor pollutants, their associated health impacts, and current purification strategies, while presenting a newly developed portable air purification unit that integrates mechanical filtration with UV-C sterilization. Comparative tests using HEPA filters and standard filters combined with UV-C light showed a marked improvement in eliminating and neutralizing airborne pathogens. To enhance environmental tracking, the system employs an Arduino ESP32 Nano paired with a DHT22 sensor for temperature and humidity monitoring, with data displayed on an I2C LCD module. The design incorporates simple jumper wiring for secure connections and easy assembly. A supporting literature review on portable air purifiers (PAPs) revealed substantial PM_{2.5} reductions (22.6%–92.0%) across diverse indoor settings such as homes, schools, and workplaces, with reported benefits including better respiratory health and reduced blood pressure, though outcomes varied. Collectively, the findings highlight the potential of combining HEPA filtration, UV-C sterilization, and real-time monitoring to improve indoor air quality and safeguard public health.

Nirmala Devi, N., Vigneswari, R., Swathi, M., Amala, V., Cherisha, V. S.

[Enhancing Air Quality Prediction Using Machine Learning Algorithms.](#)

Proceedings of the International Conference on AI and Robotics

Air quality prediction is critical for public health and environmental management. The study employs machine learning techniques to forecast air quality indices based on historical data and environmental variables. The dataset comprising meteorological conditions, pollutant levels, and temporal features to train various models, including linear regression, decision trees. This paper presents a hybrid classification model combining Random Forest and Naive Bayesian is proposed for air quality classification. Mutual Information-based feature selection is used to select informative features. The model achieves improved accuracy and robustness. The hybrid approach leverages strengths of both classifiers. Effective air quality classification is achieved. The experimental results conducted on Air quality India dataset with performance metrics such as Root Mean Square Error and R² were evaluated to assess model accuracy.

Islam, M. S., Mahmud, M., Fares, A., Rahman, A.

[Evaluating the Performance and Prospects of Green Buildings in Bangladesh: A Case Study Approach.](#)

Preprints, (2025)

Green building encompasses sustainable construction methods that reduce waste and energy consumption while integrating environmentally friendly practices, considering their impact on nature and human health. These buildings are designed and constructed to offer safe, healthy, and sustainable living spaces. They improve indoor air quality, conserve energy and water, preserve their value over time, and prioritize materials that promote health and resilience. In today's world, the demand for sustainable building practices has surged significantly. Developed countries aim to become leaders in green building, while in developing nations like Bangladesh, although adoption remains low, interest is steadily rising. Few studies have yet been conducted on green building practices in Bangladesh. This paper offers a critical review of existing research on green buildings in Bangladesh, identifying common themes and methodologies. Major topics include defining green buildings, comparing their benefits with conventional buildings, and exploring ways to achieve them. Using available data, this study also presents a case study of Karupannya Rangpur Ltd., regarded as one of Bangladesh's top green factories. Its LEED (Leadership in Energy and Environmental Design) rating is in the platinum category with a score of 71. The average internal and external temperature difference at this site was 4.33°C, compared to 1.67°C for a conventional building under similar conditions. Opinions from representatives about the prospects and overview of green buildings in Bangladesh were collected, along with data on temperature control and energy use. The findings of this research will be

valuable for people interested in green building practices and may guide future researchers, builders, and environmental specialists working in similar geographic areas.

Zhu, Y., Hu, D., Feng, X., Zhang, T., Zhang, X., Han, D., *et al.*

[Frosting characteristics and performance enhancement of membrane-based air enthalpy recovery device in severe cold regions of China.](#)

Energy and Buildings, Vol. **349**, (2025)

Due to the high airtightness and low air infiltration rates of ultra-low energy buildings, the implementation of mechanical ventilation system and the employment of total heat recovery device have become essential for improving indoor air quality and reducing fresh air load. To investigate the frosting characteristics and heat recovery efficiency of these devices during winter in severe cold regions, this study established an experimental system for the membrane-based air enthalpy recovery device (AERD) in an enthalpy difference chamber, and sequentially tests the effects of airflow rate, outdoor temperature, and indoor relative humidity on critical frosting conditions and heat recovery efficiency. The experimental results demonstrate that increasing the airflow rate elevates the outdoor critical frosting temperature, thereby heightening frost formation risks. Reductions in outdoor temperature or increases in indoor relative humidity lead to varying degrees of decline in the system's heat recovery efficiency. Furthermore, numerical simulations are systematically conducted in this research to investigate how the geometric parameters and material properties of the total heat exchange core (THEC) impact the heat recovery efficiency. The simulation results reveal that the height of airflow channel exerts the most significant influence on heat exchange efficiency. When the channel height increases from 1.5 mm to 6.5 mm, the latent heat exchange efficiency (LHEE), sensible heat exchange efficiency (SHEE), and total heat exchange efficiency (THEE) decrease by 13.4 %, 10.4 %, and 11.9 %, respectively. The research outcomes of this paper are anticipated to provide theoretical insights and technical support for the application and optimization of membrane-based AERDs in severe cold regions.

Ashwini, S., Dhwarithaa, R., Paranthaman, R. N., Preethiya, T., Ramya, G., Abinaya, G.

[Fuzzy System for Environmental Monitoring.](#)

In: Blockchain and the Water Supply Chain. 2025. 271-298 p.

Summary This chapter discusses environmental monitoring using a fuzzy system, with its signature ability to model even fuzzy relationships among environmental variables. It details fuzzy inference system's architecture, including fuzzification, rule-based reasoning and defuzzification. The chapter presents case studies including various fuzzy logic applications in air quality monitoring, water pollution assessment and climate change analysis, demonstrating its effectiveness in synthesizing multisource data to yield actionable insights. It analyzes merging fuzzy systems with artificial intelligence (AI) techniques such as machine learning (ML) and neural networks to enhance prediction accuracy and real-time environmental decision-making. ML techniques such as random forest and support vector machines have been widely used to improve fuzzy rule optimization. Techniques of optimized fuzzy rule reduction help to minimize computing complexity. By integrating IoT, edge computing and explainable AI techniques, the next generation of fuzzy systems will drive smarter, more sustainable decision-making in environmental science.

Chen, Z., Tang, L., Zhou, J., Wen, R., Ma, J., Zhang, C., *et al.*

[A high-performance fluorescence BTEX sensor: Film device optimization and optical unit design.](#)

Sensors and Actuators B: Chemical, Vol. **448**, (2026)

BTEX (benzene, toluene, ethylbenzene, and xylenes) are highly volatile and carcinogenic, making their on-site and real-time monitoring critical. Existing techniques, however, are hard to simultaneously achieve ppb-level sensitivity, rapid response, and long-term stability. To address this challenge, we developed a high-performance film-based fluorescence sensor using a highly fluorescent perylene bisimide derivative (P-PBI) as the sensing material. Through P-PBI-based film device optimization and improved optical unit design, our sensor achieves a significantly enhanced signal-to-noise ratio (SNR), enabling ultrahigh sensitivity (benzene: 8.6 ppb; toluene: 2.3 ppb; ethylbenzene: 1.9 ppb; o-xylene: 1.2 ppb; m-xylene: 2.0 ppb; p-xylene: 1.3 ppb), fast response (<4 s), and rapid recovery (<10 s). In addition, our sensor also demonstrates exceptional robustness, maintaining stability over eight months and enduring 1000 fatigue cycles tests—outperforming flame ionization detectors (FID) generally coupled with gas chromatography (GC) and portable photoionization detectors (PID). Field tests in gas stations, adhesive workshops, and public smoking areas further validated the sensor's reliability in real-world scenarios. This work provides a convenient solution for on-site and real-time BTEX monitoring, with significant implications for improving occupational and environmental safety.

Wiediartini, Kharisma Innayatul, Z., Am Maisarah, D.

[Identifying Significant Predictors of Sick Building Syndrome in the Office Area of a Fabrication Company.](#)

MEIN : Journal of Mechanical, Electrical & Industrial Technology, Vol. 2 n°(2), (2025), 25-30 p.

Introduction: Sick Building Syndrome (SBS) is a collection of symptoms or complaints experienced by occupants of modern buildings that are felt by a person when working or doing activities inside the building and disappear when leaving the building. This study was conducted on employees in the office area of a fabrication company. This study aims to determine what factors can influence the emergence of sick building syndrome complaints.</p><p>Methods: This study used a quantitative approach by collecting data from SBS questionnaires, PSS-10 questionnaires for work stress, lighting measurements, and secondary data from companies from 70 employees. The effect was tested using binary logistic regression. The variables studied included work mass, smoking habits, lighting, and work stress.</p><p>Results: The results of the SBS questionnaire showed that 70% of workers (49 people) experienced SBS symptoms, such as fatigue, drowsiness, and nasal congestion. The factors that influenced this study were smoking habits (p-value = 0.004), lighting (p-value = 0.026), and work stress (p-value = 0.003). Recommendations that can be implemented include adjusting the type of lighting, implementing standard operating procedures regarding smoking bans, implementing a peer support group smoking cessation program, and providing employee suggestion boxes.</p><p>Conclusion: This study concludes that smoking habits, substandard lighting, and work stress significantly affect Sick Building Syndrome (SBS) symptoms among office workers at fabrication companies. Its implications point to the need for improvements in the work environment to create a healthy and productive workplace.

Fonseca, A. S., Liisberg, J. B., Nøjgaard, J. K., Pleva, F., Jensen, S. B., Agathokleous, S., *et al.*

[Impact of air purifiers on occupational particle exposure in an enclosed bus workshop.](#)

Building and Environment, Vol. **287**, (2026)

Workers in bus workshops are exposed to elevated concentrations of fine (PM_{2.5}, <2.5 µm) and ultrafine particles (UFP, <0.1 µm) from diesel exhaust, brake and tire wear, and mechanical operations, which are associated with adverse respiratory and cardiovascular outcomes. To characterize exposures and evaluate mitigation strategies, two measurement campaigns were conducted in a bus workshop. Particle number concentrations (PNC), size distributions, black carbon (BC), elemental and organic carbon (EC/OC), and particulate mass (PM_{2.5}, PM₄, PM₁₀) were monitored at near field, breathing zones, and far field locations during maintenance tasks. The first campaign established baseline conditions, while the second assessed the impact of four air purifiers (APs). Baseline monitoring showed exposure peaks during high-emission

activities such as brake servicing, and cold engine starts, with PNCs reaching $4.5 \times 10^5 \text{ cm}^{-3}$ and PM₄ up to $549 \mu\text{g m}^{-3}$. While gravimetric concentrations remained below mass-based occupational exposure limits, UFPs and EC exceeded precautionary health benchmarks. The use of APs increased the effective air exchange rate and reduced PNCs ($<700 \text{ nm}$) by 38%, and PM_{2.5}, PM₄, and PM₁₀ by 45%, 49%, and 53%, respectively. EC decreased by 46%, whereas BC and OC showed negligible changes. Size-resolved analysis confirmed highest removal efficiency for coarse particles (60% at $10 \mu\text{m}$) and lowest (33%) within 300-700 nm range, the most penetrating particle size. This study demonstrates that bus workshops present clear risks of occupational particle exposure, and that APs can significantly reduce concentrations, though limitations remain for UFPs and semi-volatile organics.

Chamseddine, A., Elzein, I. M., Hassan, N.

[Indoor Air Quality in Critical Indoor Environments: A Review Paper.](#)

Water, Air, & Soil Pollution, Vol. **236** n°(13), (2025)

Indoor air quality (IAQ) plays a critical role in public health, particularly in environments where individuals spend prolonged periods of time indoors, and this become a key consideration to researchers and health practitioners. This comprehensive review investigates and highlights recent studies, conducted in diverse geographic regions, and published between 2019 and 2024 in peer-reviewed journals on indoor air quality (IAQ) in critical indoor environments such as healthcare facilities, schools, and residential buildings. The purpose of this review is to draw out recent key findings and highlights the gaps associated in air quality studies through a methodological analysis of a series of research articles. Major pollutants identified in such review study include particulate matter, carbon dioxide, carbon monoxide, volatile organic compounds, formaldehyde, and biological contaminants. This study highlights how poor ventilation, seasonal variations, building design, and daily indoor activities contribute to elevated pollutant levels. Evidence shows that these exposures are linked to a range of health outcomes, including respiratory illnesses, cognitive decline, and increased risks for vulnerable populations such as children and patients. The review highlights factors affecting IAQ resulting in exacerbated health risks, in addition to different air quality management strategies providing control programs and special requirements especially for critical indoor settings, where maintaining specific environmental conditions is essential to ensure safety, health, comfort, or proper functioning of sensitive processes or equipment. Considering future developments in IAQ, this review paper provides a forward-looking perspective and a comprehensive air quality management framework to serves as a valuable resource for researchers, engineers, practitioners, and policymakers.

Saxena, G., Singhal, P., Kumar, S.

[Indoor Air Quality: Impact on Workers' Health and Role of IoT Monitoring System.](#)

In: *The Role of Smart Technology and Industry 4.0 in Shaping Smart Cities*. CRC Press; 2025. 167 p.

Humans require oxygen for survival and can only endure its absence for a short time. The respiratory system draws oxygen from the air. Everyone deserves clean air. Good indoor air quality (IAQ) is essential for those who spend most of their time at work. Poor IAQ poses considerable dangers, particularly for vulnerable groups including children, elderly persons, and those with chronic conditions. Maintaining high-quality indoor air is crucial for persons who spend at least one-third of their day working. Workplace indoor air quality significantly impacts worker health across all industries. The relationship between indoor air quality and human well-being in the workplace is a long-standing topic. Proper IAQ in the workplace is crucial for employee health, comfort, and well-being. Air quality (IAQ) fluctuates due to factors including temperature, humidity, velocity, and chemicals from workplace processes and human activities. Workplace IAQ is affected by several factors such as materials, equipment, cleaning agents, chemicals, and particle emissions. Maintaining indoor air 168quality (IAQ) in the workplace is critical for worker health, efficiency, accident rates, absenteeism, and productivity. The Internet of Things (IoT) has significantly impacted several sectors, including interior environment monitoring. Indoor air pollution is nothing new.

Lovrić, M., Petrić, V., Strbad, D., Terzić, T., Frka, S., Kušan, A. C., *et al.*

[Indoor and ambient air pollution dataset using a multi-instrument approach and total event monitoring.](#)

Scientific Data, Vol. **12** n°(1), (2025)

Indoor air quality (IAQ) significantly influences human health, as individuals spend up to 90% of their time indoors, where air pollutants can accumulate and interact dynamically. Despite advancements in monitoring technology, challenges remain in capturing the temporal and spatial variability of pollutants and understanding the interaction between indoor and outdoor environments. This study addresses these gaps by introducing a comprehensive dataset from a controlled experimental room in Croatia, leveraging a multi-instrumental approach to monitor IAQ across various real-life scenarios. The dataset integrates measurements from low-cost sensors, reference-grade devices, and auxiliary systems to track pollutants such as particulate matter (PM), black carbon (BC), volatile organic compounds (VOC), and indoor events deemed relevant for the assessment of pollutant levels. Key experiments simulated household activities, including cooking, cleaning, human presence, and ventilation, capturing their impacts on IAQ with high temporal resolution. The resulting dataset comprises over 19 subsets. This work contributes to the Horizon EDIAQI project, supporting the development of evidence-driven strategies to improve IAQ.

John, J.

[Influence of Surface Functionalization on the Electronic and Structural Properties of Graphene and MXene-Based Thin Films for Enhanced CO₂ Sensing Performance.](#)

Research Gate, (2025)

This study investigates the influence of surface functionalization on the electronic and structural properties of graphene and MXene-based thin films, aiming to enhance their CO₂ sensing performance. Pristine and chemically modified thin films were systematically analyzed using spectroscopic and microscopic techniques to elucidate changes in surface chemistry, morphology, and charge transport behavior. Density functional theory (DFT) calculations were employed to correlate experimental findings with adsorption energetics and electronic band modifications induced by functional groups such as -OH, -F, -O, and -NH₂. Results reveal that appropriate surface terminations significantly improve gas adsorption affinity, carrier mobility, and sensor response time by optimizing the interaction between CO₂ molecules and the film surface. The synergistic effect of heterostructure engineering between graphene and MXene layers further enhances sensitivity and selectivity. These findings provide critical insights into designing next-generation, high-performance CO₂ sensors based on functionalized two-dimensional materials.

Liu, J., Xie, H., Lu, J., Xie, Q., Chen, J.

[Integrated Approach for Comprehensive Screening of Indoor Semi-Volatile Organic Compounds via Passive Air Sampling Coupled with Non-targeted Analysis.](#)

Environmental Science & Technology, Vol. **59** n°(42), (2025), 22701-22712 p.

Indoor semi-volatile organic compounds (SVOCs) pose significant health risks due to their widespread presence. However, their comprehensive profiling remains difficult due to the inherent limitations of conventional active sampling techniques and targeted analytical approaches. Here, we present an integrated approach that combines polydimethylsiloxane (PDMS) foam-based passive air sampling with non-targeted analysis for high-throughput screening and semi-quantitative evaluation of indoor SVOCs. Two passive samplers, specifically optimized for capturing gas-phase and particle-bound SVOCs, were calibrated under real-world indoor conditions. The experimentally derived sampling rates were then used to construct predictive models aimed at extending quantitative applicability across diverse compounds. In

addition, a reference-compound-based semi-quantitative strategy was established to support the non-targeted analysis. Field application in a building material market showed strong agreement between passive and active sampling results for both gas-phase and particle-associated SVOCs. Overall, this integrated approach enhances conventional indoor air monitoring by enabling broader chemical coverage and semi-quantitative analysis, offering a practical tool for exposure assessment and risk-informed chemical management.

Bamidele, A. A., Justin, N., Adanne, S.

[Integrating machine learning with environmental chemistry to forecast pollutant releases in coatings production.](#)

World Journal of Advanced Research and Reviews, Vol. **27** n°(3), (2025), 1061-1072 p.

Coating and paint manufacturing is a large generator of toxic emissions and intricate waste streams, which consists of volatile organic compounds (VOCs), hazardous air pollutants (HAPs), heavy metals and strong wastes. These contaminants are highly dangerous to the health of the environment and human health and also cause issues with regulation under the regime of the Clean Air Act and the National Emission Standards for Hazardous Air Pollutants (NESHAP). The review studies models that can be used in predicting emissions, composition of waste streams, and process improvement by combining environmental chemistry with artificial intelligence (AI) and machine learning (ML) methods. Environmental chemistry has insight into the mechanistic understanding of the pollutant sources, transformation pathways and its analytical detection whereas AI can be used to enhance the predictive ability through multi-output modeling, deep learning architecture, and physics-informed frameworks. Examples of applications are VOC and particle emission modelling, heavy metals indoor wastewater residue forecasting, on-line estimation of process parameters to optimise the process to control emissions. This combination of AI and environmental chemistry has high promise in terms of proactive regulatory compliance, enhanced occupational health and sustainable manufacturing. Nevertheless, there are still issues of data quality, poor interpretability, scalability, and regulatory acceptability. The results highlight the change-making nature of AI-augmented environmental surveillance as a means of reducing the environmental impact of the coating and paint manufacturing industry.

Wang, M., Moshayedi, A. J., Lu, H., Guo, B., Bassir, D.

[Integration of Electronic Noses and UAVs for Intelligent Gas Detection: A Review of Methods and Challenges.](#)

Smart Manufacturing, Structural Health Monitoring and Digital Twins, Vol. **80**, (2025), 82-89 p.

Unmanned aerial vehicles (UAVs) equipped with gas sensors have emerged as powerful tools for real-time environmental monitoring and emission detection. This review highlights recent developments in UAV-based gas sensing systems, covering sensor types such as metal-oxide, electrochemical, and NDIR sensors. Applications span diverse domains, including ship emission tracking, wastewater treatment monitoring, volcanic gas detection, and indoor air quality assessment. Advanced algorithms, including machine learning and multivariate analysis, have enhanced gas identification and source localization capabilities. Key challenges remain, such as sensor calibration during flight, environmental variability, and limited energy capacity. The review compares UAV systems based on flight duration, detection accuracy, spatial coverage, and response time. It also outlines potential improvements through miniaturization, IoT integration, and intelligent data processing. Overall, UAV-based gas detection technologies offer significant advantages over traditional methods, enabling more flexible, accurate, and timely assessments in complex or hard-to-reach environments.

Sutikno, T., Dahlan, U. A., Arsadiando, W., Purnama, H. S.

Internet of Things-based Air Quality Monitoring system using Carbon Monoxide and Particulate Matter Parameters.

ResearchGate, (2025)

Air pollution, especially from fine particulate matter (PM_{2.5}) and carbon monoxide (CO), is a type of pollutant that is harmful to human health. This paper presents the development of an IoT-based air quality monitoring system. To measure pollutants, we use a GP2Y1010AU0F sensor to detect PM_{2.5} concentrations, an MQ-7 sensor to measure carbon monoxide levels, and a DHT22 sensor to measure ambient temperature and humidity. In this paper, to ensure accurate sensor output, we calibrate the sensors using a polynomial regression method for PM_{2.5} and a linear regression method for CO values. Furthermore, when measuring the Air Quality Index (AQI) value, we use manual linear interpolation based on concentration breakpoints established by international standards, including those of the United States Environmental Protection Agency (US EPA) and the World Health Organization (WHO). Furthermore, the processed data is displayed on a device with an OLED LCD screen and sent to the cloud on the Ubidots IoT platform. This allows for real-time remote monitoring and visualization. Finally, the developed system is very suitable for implementation in the community and can help increase public awareness.

Nisse, P.

Le syndrome des bâtiments malsains, une entité à ne pas méconnaître.

Toxicologie Analytique et Clinique, Vol. **37** n°(3, Supplement), (2025), S97 p.

Avant les années 70, ce concept ne semble pas exister. La modernisation des milieux de travail observée à partir des années 70 est possiblement à l'origine de l'émergence de ces épidémies de symptômes inexplicables qui ont pour effet de plonger dans le désarroi les médecins et les autorités sanitaires. C'est en 1983 qu'un groupe d'experts de l'OMS va définir le Syndrome des bâtiments malsains ou « sick building syndrome ». Il est décrit comme une association de symptômes atypiques, bénins et variés qui ne sont pas spécifiques à un agent pathogène identifié mais qui sont étroitement reliés à un lieu, un bâtiment, touchant une partie de la collectivité y séjournant et dont l'étiologie reste souvent mystérieuse, aucune cause spécifique ou organique n'étant retrouvée. Il est ainsi différent du concept des maladies liées à la construction (building-related illnesses) où les symptômes sont imputables à une cause identifiée et spécifique (par exemple, infection à *Legionella*). À la notion de pollution de l'air intérieur généralement retenue, se sont rajoutées plus récemment des variables psychologiques individuelles (anxiété, dépression, hypochondrie), ainsi que le stress professionnel fréquemment associés aux symptômes rapportés dans ces bâtiments. Ainsi, un syndrome psychogène va se propager par mimétisme et s'amplifier en prenant un profil épidémiologique épidémique. L'intervention des services d'urgence et des médias concoure à amplifier le phénomène en « validant » l'existence d'une situation à risque pour leur santé. De fait, seules les explications environnementales paraîtront acceptables aux personnes symptomatiques. L'examen médical du patient reste primordial. Il peut permettre d'identifier une étiologie, telle une allergie, ou de découvrir l'existence d'une maladie méconnue du patient. Les facteurs psychosociologiques et organisationnels devront être recherchés (isolement, stress psychique, faible reconnaissance professionnelle). Quand on a écarté la présence d'une pathologie organique chez le patient, il est temps de procéder à une évaluation méthodique du bâtiment à la recherche d'une étiologie corrigeable et à s'intéresser à la qualité de l'air intérieur. Différents paramètres physiques (température, humidité, renouvellement d'air) et chimiques (COV, biocides, parfum, revêtements des sols) devront être étudiés. Ces investigations peuvent avoir un coût important (mais l'absentéisme aussi). Au final, si le diagnostic de syndrome des bâtiments malsains était retenu, le plus difficile pour le praticien sera de rendre les résultats au collectif, notamment quand il ne peut pas y apporter une solution et en particulier quand le syndrome des bâtiments malsains apparaît dans des locaux conformes aux normes et aux réglementations en vigueur.

Riani, U., Melkounian, N., Harvey, D., Akmeliawati, R.

[Learning from Nature: Bio-Inspired Designs and Strategies for Efficient on-Earth and off-Earth Ventilation Systems.](#)

Preprints, (2025)

Efficient ventilation systems are crucial for maintaining optimal air quality in indoor and enclosed environments, both on and off Earth, such as buildings, space habitats, international space station crew quarters, tunnels, underground mines, and other structures. However, traditional ventilation systems face challenges, such as uneven air distribution, energy inefficiency, noise, and limited adaptability to dynamic environmental conditions. Meanwhile, many organisms in nature are capable of constructing structures that can facilitate efficient air exchange and heat regulation, such as ant nests, termite mounds and prairie dog burrows. This study explores, analyzes, and summarizes the mechanisms, structures, and strategies found in nature that can inspire the design of efficient and effective ventilation systems. To highlight the practical implications of such designs, this paper reviews the progress of bio-inspired ventilation research, with a focus on air regulation, component optimization, and environmentally adaptive strategies. A bibliometric analysis and research trend are presented to illustrate the key developments in this field for over the past 25 years. The potential of integrating the bio-inspired strategies into ventilation systems, particularly with the focus on the applications to the off-Earth habitats and underground mines, is discussed. This study presents comprehensive insight into developing bio-inspired ventilation systems, thus paving the way for achieving innovative and more efficient design solutions.

Muhammad Afiq, A., Huda, A. M.

[Lora Enable Air Quality Monitoring Network for Smart City.](#)

Progress in Engineering Application and Technology, Vol. 6 n°(2), (2025), 235-241 p.

This project introduces the LoRa Enable Air Quality Monitoring Network for Smart City, an innovative Internet of Things (IoT) solution that utilizes Long Range (LoRa) communication technology for real-time urban air quality monitoring. The system measures environmental parameters including particulate matter (PM1.0, PM2.5, PM10), volatile organic compounds (VOCs), temperature, and humidity. It integrates low-power sensors and a centralized platform for cost-effective, scalable, and energy-efficient monitoring. The project aims to deploy and validate the system in urban locations, ensuring accurate data collection and long-range communication. Leveraging cloud technology, the collected data will be visualized through dashboards and reports to provide actionable insights. The ultimate goal is to identify pollution hotspots, aid policymakers in urban planning, and enhance public awareness of air quality, demonstrating a sustainable and scalable solution for smart city objectives and a healthier urban environment. The project successfully deployed and validated the system in real-world conditions, demonstrating accurate real-time data acquisition and long-range transmission of environmental parameters, as evidenced by successful data reception on The Things Network (TTN) console and efficient processing via Node-RED. Data visualization through Grafana dashboards confirmed the system's capability to provide actionable insights. The results highlight the system's efficiency, reliability, and scalability, emphasizing its potential to identify pollution hotspots, assist policymakers in urban planning, and improve public awareness of air quality issues, ultimately contributing to a healthier urban environment.

Gupta, M.

[The Magic of Flat Materials: How Graphene and MXene Can" Sniff" Out CO2 Gas.](#)

ResearchGate, (2025)

Carbon dioxide (CO₂) is an invisible but crucial gas to monitor. Keeping track of its concentration is vital for everything from ensuring the air quality in our homes and offices to monitoring human health. For years, scientists have built CO₂ sensors, but many of them require high temperatures to work, making them complex and energy-hungry [1]. But what if we could build a sensor that was not only highly sensitive but also worked efficiently at room temperature? The answer lies in a revolutionary class of materials so thin they are ...

Luijten, C., De Jong, J. D.

[Moisture-Buffering Properties of Biobased Building Assemblies.](#)

International Conference on Moisture in Buildings (ICMB25), UM Guimarães 23-24 Oct 2025

As the demand for sustainable, vapour-open dwellings rises in the Netherlands, there is growing interest in biobased insulation materials for their potential to improve indoor relative humidity (RH) stability through moisture buffering. These materials, coupled with low embodied emissions, align with both environmental and indoor air quality goals. This study examines light timber frame walls with and without vapour barriers, assessing their impact on structural integrity (keeping the construction dry) and indoor air quality (maintaining RH within 30–70%). Findings are validated by comparing monitored data from two residential demo buildings—one with a vapour barrier and one without—to digital simulations. Additional component testing evaluates real-world feasibility and performance.

Hernik, A., Sugihara, M., Padunnappattu, A., Stock, N., Ameloot, R., Naydenova, I.

[Nanoimprinted Holographic MOF Diffraction Gratings—Advancing Selective Volatile Organic Compound Detection at Low Concentrations.](#)

ACS Applied Materials & Interfaces, Vol. **17** n°(42), (2025), 58512-58519 p.

Metal–organic frameworks (MOFs) hold remarkable potential for detecting volatile organic compounds (VOCs) in applications ranging from indoor air quality monitoring to breath-based diagnostics. However, the integration of MOFs into optical sensors remains a significant challenge. In this study, we present an optimized soft lithographic approach for fabricating high-quality surface relief diffraction gratings composed entirely of MOF nanoparticles, as replicas of holographic structures. By increasing the height amplitude of the gratings, we significantly enhanced the sensitivity, as predicted by the Raman–Nath theory. For instance, a ZIF-71 grating with a depth of 530 nm demonstrated exceptional sensitivity to six VOCs, achieving a detection limit of 60 ppb for toluene. The general applicability of the approach was demonstrated by integrating other porous materials, resulting in an improved sensitivity to acetone. This work represents a step toward developing an optical VOC sensor array.

Di Renzo, T., Marro, M., Ridolfi, L., Salizzoni, P., Vesipa, R.

[Natural Ventilation of a Room-Atrium Building with Opposing Wind: A Deterministic and Stochastic Analysis.](#)

ResearchSquare, (2025)

Natural ventilation is key for reducing energy demand and ensuring indoor air quality. We study the deterministic and stochastic dynamics of a naturally ventilated system where a room with a steady buoyancy source connects to an unforced atrium (an arrangement representative of many real buildings). The buoyant fluid accumulates at the ceiling of both spaces. A stratification arises, inducing the stack effect which drives the ventilation of the system. We consider the occurrence of an opposing wind. Firstly, a constant wind is imposed, and the steady states are analysed for different atrium geometries. It is known that when no external wind occurs the atrium may either enhance or worsen the ventilation of the room

depending on its geometry. We find that for any geometry the atrium enhances the ventilation for a wind velocity large enough. Secondly, stochastic fluctuations are introduced in the wind velocity. These induce a 'noise-induced transition': the mean position of the interface between warm and cold layers lies below that observed under constant wind. This phenomenon was already known for single-room systems; however, we find that the room-atrium system is less sensitive to this effect and to variations in the coefficient of variation of wind velocity.

Genovés, V., Xu, T., Tumolin, R., Gómez, T.

[Non-Contact Ultrasonic Inspection of Filtration Membranes Using Air-Coupled PMUT.](#)

2025 IEEE International Ultrasonics Symposium (IUS), 15-18 Sept. 2025, Utrecht, Netherlands

Industry 5.0 emphasizes smart, connected systems, integrating MEMS-based sensors, IoT, and AI to enable advanced, real-time monitoring solutions. In this study, we present a non-contact, non-destructive ultrasonic inspection method for filtration membranes using air-coupled piezoelectric micromachined ultrasonic transducers (PMUTs) suitable to be deployed in the fabrication line for in-line and real time testing of the production. Filtration membranes play a critical role in respiratory protection and ventilation systems, where ensuring consistent performance—measured via particle filtration efficiency (PFE) and pressure resistance—is essential. We designed and fabricated a novel 200 kHz PMUT array optimized for air-coupled through-transmission measurements of porous materials. Experimental validation was performed on different meltblown polypropylene membranes.. The PMUT results were benchmarked against a broadband air-coupled ultrasonic transducer. The transmission coefficient measured by the PMUT array demonstrated sensitivity sufficient to distinguish between membranes with different filtration properties. These findings suggest the feasibility of using PMUTs for rapid, high-precision quality assessment of filtration materials.

Zheng, Y.

[Numerical Simulation of Different Ventilation Methods in Small Meeting Rooms.](#)

Frontiers in Science and Engineering, Vol. 5 n°(9), (2025), 1-7 p.

For a long time, conference rooms have served as vital workplaces where indoor air quality directly impacts the physical and mental well-being as well as work efficiency of occupants. Therefore, selecting a ventilation method that simultaneously meets human comfort and indoor air quality requirements while achieving energy-saving objectives is particularly crucial. This paper employs Fluent software and computational fluid dynamics (CFD) analysis to simulate and analyze the velocity field distribution within different ventilation configurations for conference rooms, providing a theoretical basis for creating optimal indoor environments.

Wagh, A. S., Nazimuddin, S. O., Hassan, S. S., Joshi, R. S., Raysaheb, M. A.

[Optimized Design and Economic Analysis of an Energy-Efficient HVAC System for a Multi-Story Commercial Building.](#)

International Journal of Scientific Research in Engineering & Technology Vol. 5 n°(4), (2025), 1-10 p.

This research focuses on the design and cost analysis of an energy-efficient Heating, Ventilation, and Air Conditioning (HVAC) system tailored for a six-story commercial building located in Aurangabad, Maharashtra. A detailed heat load analysis was conducted considering solar radiation, occupancy, lighting, equipment, and outdoor conditions. The resulting total cooling load was 114 TR (1,359,937 BTU/hr). To optimize system performance and minimize lifecycle costs, a Variable Refrigerant Flow (VRF) system was selected. Cost analysis shows that installation expenses range between ₹5.7 to ₹6.9 million, depending on

the design parameters. The integration of climate-specific adaptations ensures year-round operational efficiency. This research provides a structured framework for developing sustainable HVAC solutions in commercial buildings in similar climatic zones. A key aspect of this design is its site-specific adaptation, considering the climate and environmental conditions unique to Location. This localized approach ensures that the HVAC system operates efficiently throughout the year, maximizing energy savings. The analysis also underscores the importance of conducting a detailed economic evaluation to ensure the system's long-term economic viability. This study adds to sustainable building practices by integrating energy optimization and economic analysis into HVAC system design, promoting greater efficiency and reduced environmental impact.

Frigo, S.

[Optimized design process of a full air system in a specific industrial building and comparison with the current HVAC system installed.](#)

Universita di Padova. Dipartimento di Ingegneria Industriale. Thèse 2025

Try to optimize as much as possible the design process of a full air system in a specific industrial building. Starting from the development of a 3D model of the case study, to define then the heating and cooling load, considering also indoor air quality needing. Design of the full-air system with its air handling unit to purchase the required loads through a whole year of operation. Comparison with the current HVAC system installed.

Abadie, M., Geffre, E., Picard, C.-F., Loomans, M., Babich, F., Monge-Barrio, A., *et al.*

[PANDORA: An open-access database of indoor pollutant emission rates for IAQ modeling.](#)

Journal of Building Engineering, Vol. **114**, (2025)

Modeling indoor air quality requires reliable data on pollutant emission rates (ERs) from indoor sources. While many studies focus on measuring indoor pollutant concentrations, far fewer provide the source-specific ERs needed for predictive modeling, and those that do often report fragmented and non-standardized formats that limit their use. This paper addresses this gap by introducing PANDORA (a comPiAtion of inDOor aiR pollutAnt emissions), an internet-based open-access database designed to improve consistency and transparency in indoor air quality assessments. PANDORA systematically compiles ERs data for gaseous and particulate pollutants from a wide range of indoor sources. It classifies 747 sources into comprehensive categories such as construction and decoration materials (354), furniture (38), cleaning products and air fresheners (123), occupants and occupant activities (134), heating and cooking appliances (48), electrical equipment (40), whole room or building (6) and others (4). In this paper, we summarize key experimental methods used to assess the pollutants. To aid in informed decision-making, statistical analyses are provided for selected indoor pollutants of interest, including PM_{2.5}, formaldehyde, benzene, and TVOC. Additionally, we compare the impact of using three different modeling approaches and assumptions through a case study that uses the PANDORA data to evaluate indoor pollutant ERs in a room. This application shows how PANDORA supports more transparent and consistent use of emission rate data. Our findings highlight that, despite compiling 9968 emission rate entries, expanding PANDORA with new measurements will further strengthen the accuracy and reliability of indoor air quality modeling and exposure assessments.

Ujimoto, K., Tan, K., Miki, Y., Sugawa, A., Hashimoto, A., Nakayama, T.

[Performance valuation of a newly developed portable FAIMS instrument for atmospheric trace gas detection.](#)

Journal of Environmental Management, Vol. **395**, (2025)

This study aims to evaluate a newly developed portable field asymmetric ion mobility spectrometry (FAIMS) instrument for the detection of atmospheric trace gases. This instrument has a custom atmospheric pressure chemical ionization source and an interdigitated comb structure using a silicon-on-insulator micro-electro-mechanical system for miniaturization. The performance of the FAIMS instrument has been tested with several key atmospheric trace gases, including ammonia (NH₃), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), hydrogen sulfide (H₂S), α -pinene, carbon monoxide (CO), and carbon dioxide (CO₂). The changes in the FAIMS spectra in a positive corona discharge were successfully observed for different concentrations of NH₃ and α -pinene, whereas those in a negative corona discharge were observed for different concentrations of NO₂, SO₂, α -pinene, CO, and CO₂. The detection limits for NH₃, NO₂, SO₂, H₂S, and α -pinene were estimated to be 0.1, 0.2, 0.2, 200, and 4 ppb, respectively. Although humidity was found to influence the signal intensities for the detections of NH₃ and SO₂, these influences can be removed by normalizing these signals with the reactant ion signals under moderate and high humidity conditions above 8.5 g/m³, which corresponds to a relative humidity of 41.5 % at 25°C. Reasonable temporal variations in ambient NH₃ concentrations, ranging from sub-ppb to a few ppb, were successfully obtained during a 17-day preliminary field test at an industrial site in Japan. This research demonstrates that the FAIMS instrument is applicable for the real-time and mobile measurements of multiple gases, particularly NH₃, NO₂, and SO₂, under typical ambient concentrations and is promising for a variety of air quality monitoring applications.

Kurtulmuş, G., Bilge, K., Menciloğlu, Y. Z.

[Reduction of Volatile Organic Compounds With Hydrazine-, Carboxybetaine- and Aminosilane-Functionalized Halloysite Nanotube in Recycled Polyolefin Blends.](#)

Journal of Applied Polymer Science, Vol. **n/a** n°(n/a), (2025), e58053 p.

ABSTRACT Recycled polyolefin (rPO) is a promising material for sustainable applications, but its use is limited by the release of volatile organic compounds (VOCs), which cause odor and reduce indoor air quality. This study introduces a strategy to address this issue by chemically modifying halloysite nanotubes (HNTs) to improve their VOC adsorption efficiency and multifunctional performance in rPO. HNTs were functionalized through a three-step process involving N-[3-(trimethoxysilyl)propyl]ethylenediamine (TMPED), monochloroacetic acid (MCA), and hydrazine hydrate (HH), producing amine-rich surfaces. Modified HNTs were incorporated into rPO at 2 and 5 wt% and compared with unmodified HNTs. VOC reduction was assessed using headspace gas chromatography-mass spectrometry (HS GC-MS) and jar testing, while structure and properties were analyzed by FTIR, NMR, TGA, DSC, SEM, BET, and tensile tests. The 5 wt% TMPED-MCA-HH-HNT composite reduced total VOC intensity by 91%, particularly, key odorants such as acetaldehyde and cyclotrisiloxane. This effect is attributed to dual action: physical adsorption in the HNT lumen/mesopores and selective chemisorption via hydrogen bonding and Schiff base formation between amine/hydrazide groups and polar VOCs. Thermal stability, tensile modulus (+25.3%), and crystallinity (73.4%) were also improved. These findings highlight functionalized HNTs as efficient additives for enhancing both the mechanical and odor performance of rPO.

Lu, X., Huang, B., Chen, Y.

[A reference large office building emulator within the BOPTEST framework for evaluating complex HVAC control systems.](#)

Science and Technology for the Built Environment, Vol. **31** n°(9), (2025), 1110-1126 p.

The demand for energy-efficient and adaptive HVAC control has led to advanced algorithm development, but evaluations are often case-specific, limiting general comparisons. Real-world tests face high costs and logistical challenges. Frameworks like BOPTEST address this by enabling standardized benchmarking but lack a test case for large office buildings, which constitute more than 50% of the total commercial building floor area in the U.S. and involve complex automation systems. To fill this gap, we developed a high-fidelity

large office emulator within the BOPTEST framework, based on a Spawn-of-EnergyPlus model. This model retains DOE prototype geometry and load schedules while incorporating Modelica-based HVAC systems for accurate thermal load and control sequence representation. The emulator models supervisory and local-loop control logic at small timescales, overcoming EnergyPlus-only model limitations. It features a central plant with chillers, boilers, and VAV systems with terminal reheat. As a demonstration, the emulator evaluated two controllers: a rule-based controller implementing selected measures from ASHRAE Guideline 36 and a model predictive controller (MPC). Results emphasized the need for parameter tuning in rule-based controls and proper MPC formulation to optimize energy efficiency and thermal comfort. This standardized emulator serves as a vital tool for benchmarking and informed decision-making in building energy management.

Humaidan, O., Almazam, K., Agboola, O., Oladokun, O., Dodo, Y. A.

[A review on the strategies for green building construction: The role of nanomaterials in green buildings for a sustainable future.](#)

Journal of Building Engineering, Vol. **114**, (2025)

The construction industry is currently going through a radical change in the direction of sustainability, stimulated by the crucial need to reduce environmental impact and enhance energy efficiency. Green building construction is a forward-thinking approach rooted in sustainable practices aimed at reducing a structure's environmental impact. It offers an opportunity to mitigate the negative effects of buildings on both the environment and occupant health. This study utilized a systematic review to give an overview of sustainable construction strategies focusing on energy efficiency, resource conservation, waste minimization, and indoor environmental quality. 231 documents were reviewed, this includes Elsevier, Springer, MDPI, Taylor and Francis, and Wiley and other Government documents from World Green Building Council and UN. The review focused on nanomaterials as emerging solutions for enhancing green building performance, improving thermal insulation, structural reinforcement, air purification, self-cleaning capabilities, and corrosion resistance while also addressing the associated challenges. Hence, the study discussed green building as an environmentally-friendly structures that employ fewer resources, reduce waste and improve indoor air quality. Furthermore, the research limitations and geographical impacts of sustainable buildings were discussed and some recommendations were outlined. The study contribution depicted how nanomaterials can be intentionally integrated in every stage of a building's life, from the choice of design that is aim at lowering operational energy, systematic utilization of water and other resources to construction techniques that consider waste reduction, reassembly strategies that extend life, and deconstruction plans that recover value, making them an integrating tool for green building adoption.

Mula, V., Bogdanov, J., Petreska Stanoeva, J., Zeneli, L., Mehmeti, V., Gelmini, F., *et al.*

[Semi-Quantitative Characterization of Volatile Organic Compounds in Indoor and Outdoor Air Using Passive Samplers: A Case Study of Milan, Italy.](#)

Atmosphere, Vol. **16** n°(9), (2025)

This study presents a semi-quantitative characterization of volatile organic compound (VOC) concentrations and their emission sources in indoor and outdoor environments across four residential and laboratory sites in Milan, Italy, during the summer of 2024. Radiello® passive samplers (Fondazione Salvatore Maugeri in Padova, Italy) were employed for VOC collection, followed by gas chromatography–mass spectrometry analysis. The semi-quantitative mean total VOC (TVOC) concentration was $220.8 \pm 195.4 \mu\text{g}/\text{m}^3$ for the outdoor air and slightly higher at $243.6 \pm 134.3 \mu\text{g}/\text{m}^3$ for the indoor air, resulting in an indoor-to-outdoor relative ratio of 1.10. The outdoor VOC profile was dominated by hydrocarbons, accounting for $80.3\% \pm 4.6\%$ ($173.2 \pm 143.8 \mu\text{g}/\text{m}^3$) of TVOCs, followed by aromatic hydrocarbons at $13.3\% \pm 5.5\%$ ($37.2 \pm 49.7 \mu\text{g}/\text{m}^3$). Indoors, hydrocarbons also predominated, representing $34.1\% \pm 15.2\%$ ($95.2 \pm 80.1 \mu\text{g}/\text{m}^3$) of the TVOCs, followed by terpenes at $20.7\% \pm 15.5\%$ ($49.0 \pm 46.4 \mu\text{g}/\text{m}^3$). Other VOC

groups contributed smaller fractions in both environments. The emission profiles from cleaning and personal care products were assessed semi-quantitatively to determine their relative percentage contributions to the indoor VOCs. Source attribution was further supported by diagnostic relative ratios—benzene/toluene, toluene/benzene, and (m + p)-xylene/ethylbenzene—which provided insight into dominant emission sources and photochemical aging.

Linares Alzamora, R. G., Maia Sampaio, P. N., Rodríguez Peralta, L. M., Posada Barrera, A. I., De Oliveira Nunes, É.

[Sick Building Syndrome and Indoor Air Quality: Leveraging Kolmogorov-Arnold Networks for Predictive Pollutant Control.](#)

ICITS 2025, 22-25 January, Mexico City, Mexico

Air pollution, especially in enclosed spaces, poses serious health risks due to everyday activities like cooking and cleaning. Poor indoor air quality can lead to conditions such as Sick Building Syndrome (SBS), highlighting the need for advanced predictive models. Kolmogorov-Arnold Networks (KAN) provide an innovative solution for predicting pollutants such as CO₂, TVOC, PM_{2.5}, and PM₁₀ using historical and real-time data. This study applies KANs to forecast pollution risk levels and demonstrates their potential for integration with IoT technologies to enable continuous, precise monitoring for safer indoor environments.

Vijayachitra, S., Prabhu, K., Sreesh, T. N., Vishalini, A. N., Sulaiman, A.

[Smart Dust Collection System for Textile Industries.](#)

2025 9th International Conference on Inventive Systems and Control (ICISC)

The accumulation of dust and lint in textile manufacturing environments presents a dual threat: deteriorating worker health and reduced machinery efficiency. This paper presents the design and evaluation of a Smart Dust Collector Bot tailored for textile industries. Built using an ESP8266 Node MCU microcontroller, this mobile robot integrates a high-speed suction fan, IR proximity sensors for obstacle avoidance, and IoT-based remote control using the Blynk platform. Unlike static dust extraction systems, this bot autonomously navigates textile floors, collects airborne lint and fiber, and stores them in a waterfilled chamber. The system eliminates manual intervention, reduces operational costs, and enhances air quality. Testing in simulated factory conditions confirmed its efficacy in collecting dust and avoiding obstacles in real time. Future enhancements include integration with dust level sensors, automated path planning, and selfcharging mechanisms.

James, A., Noel, D., Joshua, B.

[Smart Technologies for Dual Risk Management: IoT Monitoring of Structural Safety and Indoor Air in Industrial Facilities.](#)

Research Gate, (2025)

Industrial facilities face a dual challenge of safeguarding structural integrity against extreme weather while maintaining healthy indoor environments for workers. Severe storms, tornadoes, and seismic activity pose acute risks to warehouse and logistics infrastructure (FEMA, 2023; NOAA, 2022), while poor indoor air quality (IAQ) from volatile organic compounds (VOCs), carbon dioxide, and particulates creates chronic occupational health concerns (OSHA, 2021; EPA, 2022). Traditionally, these risks have been managed separately, limiting opportunities for comprehensive resilience. This study explores the potential of Internet of Things (IoT) technologies as a convergent framework for monitoring and managing both structural safety and IAQ in industrial facilities. Drawing on FEMA hazard maps, OSHA and EPA standards, and recent IoT applications (Hossain, 2024; Zhou et al., 2022; Zhang & Kumar, 2021), we outline a comparative

assessment integrating GIS hazard mapping, IAQ sensor simulations, and real-time data analytics. Results highlight the value of IoT-enabled platforms in providing early warnings, predictive insights, and adaptive management strategies. The findings suggest IoT monitoring can bridge structural resilience and occupational health, offering a dual-risk management model for future-ready industrial systems.

Bartolomeus, L. M., Lim, S. I., Lestari, T. E., Alfakihuddin, M. L. B., Desmiwati, D.

Statistical quality control analysis in monitoring air pollution: Indoor particulate matters, temperature, and humidity (case study: South Jakarta, Indonesia).

The 10th International Conference on Energy, Environment, and Information Systems (ICENIS 2025)

Assessing air quality is essential for minimizing exposure to harmful pollutants and creating strategies for cleaner air. Detailed air quality monitoring offers valuable insights into pollution sources, trends, and potential health risks. Quality Control (QC) is a fundamental component of process monitoring and improvement across various industries. Traditionally applied in manufacturing and industrial settings, QC principles have increasingly been adapted for use in environmental and public health monitoring due to their reliability in ensuring data accuracy and identifying abnormal patterns. Analysis in monitoring air pollution using statistical quality control has an objective to detect patterns and trends in particulate matter levels over time, track variations in air quality to ensure it remains within acceptable limit to identify potential sources of indoor air pollution. Based on the result of quality control analysis it shows that the implementation of Hotelling's T2 control chart effectively demonstrated all variables indicating that the indoor air quality process is currently stable and under statistical control.

Ma, Y., Tao, Y., Chen, S., Wang, Y., Cheng, Y., Tu, J.

Thermodynamic performance modeling and decarbonization impact assessment of latent heat storage-integrated ventilation systems for solar-assisted air preheating.

Energy, Vol. **339**, (2025)

To enhance indoor air quality through fresh air ventilation while reducing energy consumption in air handling processes, this study proposes integrating a latent heat thermal energy storage system into fresh air systems for air preheating. Initially, numerical simulations were conducted to analyze the thermal charging-discharging performance of the storage system under low solar radiation and dynamic outdoor meteorological parameters. Results demonstrate that the thermal charging process can be completed despite limited solar irradiation duration and low radiation intensity, while achieving over 95 % heat release efficiency during nocturnal discharging process through heat transfer to outdoor air. Subsequently, the energy-saving performance of the novel fresh air system was systematically evaluated under varying meteorological conditions. Analysis reveals that daily energy-saving rates (0–22.4 %, averaging 13.7 %) correlate predominantly with daily solar irradiation over a week. A fitted empirical formula quantifying the relationship between energy-saving rates and meteorological parameters was developed. Extrapolating this model to winter-scale applications, the system demonstrates an average seasonal energy-saving rate of 13.2 %, corresponding to 79, 405 kWh electricity savings and 21.6 t carbon reductions. This research advances the utilization of low-grade renewable energy in built environments while providing feasible pathways for near-zero energy building development and dual carbon goal attainment.

Georges, M.

Toxiques inhalés : actualités en 2025.

Revue des Maladies Respiratoires Actualités, Vol. **17** n°(1, Supplement 1), (2025), 1S29-21S35 p.

En plus de la fumée de cigarette, des preuves épidémiologiques récentes ont reconnu l'importance de la pollution de l'air atmosphérique, notamment due au trafic automobile ou à la combustion domestique de biomasse dans les pays en développement. Mais les toxiques inhalés représentent un large spectre de particules qui peuvent pénétrer dans l'organisme via les voies respiratoires entraînant des lésions pulmonaires ou des atteintes systémiques. Cet article fera le point sur les données récentes en faveur d'une toxicité respiratoire chez l'homme de la silice cristalline libre issue du travail de la pierre artificielle, de la cigarette électronique et des microplastiques.

Massey, D. D., Taneja, A., Habil, M., Dubey, S.

[Transforming Indoor Air: Technologies and Interventions.](#)

In: Quality of Indoor Environment - New Trends, Performance and Applications. IntechOpen; 2025. p.

To examine the impact of air purification technologies, particularly high-efficiency particulate air (HEPA) filters, on indoor air quality and health outcomes, while also highlighting recent innovations in the field. The abstract reviews existing literature and market data on air purification technologies, focusing on the efficacy of HEPA filters in removing pollutants and their recognized status by leading health organizations. It also surveys emerging air purification methods and the integration of technology and advancements for enhanced performance and monitoring. The abstract highlights the increased adoption of air purifiers, especially during the pandemic, and the substantial market growth of air treatment systems. Studies demonstrate HEPA filters' effectiveness in removing SARS-CoV-2 and improving various health outcomes, including allergic symptoms, lung function, blood pressure, and inflammation. The abstract also showcases novel air purification methods using materials like transparent pan filters, soy proteins, silk nanofibers, and photochemical materials, along with advancements in wireless and water-based filtration. This work contributes to the existing body of knowledge by summarizing the effectiveness of established air purification technologies like HEPA filters while also showcasing cutting-edge innovations in materials and smart technologies. It emphasizes the importance of air purification in mitigating health risks associated with indoor air pollution and points toward future directions in the field. The integration of AI and IoT for optimized performance and real-time monitoring is highlighted as a key area of advancement.

Chevalier, D., Ferrari, L., Fouillet, B., Gaffet, É., Gaie-Levrel, F., Géhin, E., *et al.*

[Valeurs repères d'aide à la gestion de la qualité de l'air intérieur pour le tétrachloroéthylène - Rapport \(HCSP\)](#)

2025

Le HCSP recommande une Valeur Repère d'aide à la gestion de la qualité de l'Air Intérieur (VRAI) pour le tétrachloroéthylène de 40 µg/m³ pour des expositions chroniques (durée d'exposition supérieure à 1 an), qui pourra être ramenée à 4 µg/m³ lorsqu'une méthode de mesure sera accréditée et validée ; une Valeur d'Action Rapide (VAR) à 200 µg/m³, dont le dépassement doit conduire à identifier les sources en cause et mettre en œuvre les actions correctives pour atteindre une concentration inférieure à la VRAI. Dans l'attente des actions correctives, il faudra procéder à une fermeture de l'établissement recevant du public ou à la relocalisation des habitants exposés, jusqu'à un retour sous la VAR et avec un retour sous la VRAI dans un délai de 3 ans maximum. Le HCSP précise les délais de mise en œuvre de ces actions correctives et les méthodes de mesure recommandées. Le HCSP recommande également le maintien des contrôles de conformité dans les pressings contigus à des locaux occupés par des tiers jusqu'en 2035.

Zaky, N., Li, T., Stopps, H.

[Validating the performance of low-cost IAQ sensors through co-location.](#)

[Journal of Building Physics](#), (2025)

Low-cost indoor air quality (IAQ) sensors offer new opportunities for real-time monitoring in the built environment by occupants and researchers. However, their performance can vary substantially depending on the environmental conditions. This study presents a comprehensive evaluation of carbon dioxide (CO₂) and fine particulate matter (PM_{2.5}) measurements from two consumer-grade low-cost sensors (the Airthings View Plus for CO₂ only and Air Gradient Pro for CO₂ and PM_{2.5}) through co-location tests with two reference instruments, Graywolf DSII-8 for CO₂ and Lighthouse Handheld 3016 for PM_{2.5}. Using time-series analysis, linear regression, Pearson correlation, Root-Mean Squared Error (RMSE), Bland-Altman test, and paired t-tests, we assess the precision and accuracy of these sensors. At a 5-minute sampling interval, the Air Gradient sensor had a higher coefficient of determination (R²), stronger Pearson correlation, and narrower range of limits of agreement (LoAs), but higher bias (i.e. the mean difference) and RMSE, suggesting higher precision but lower accuracy when compared to Airthings. As a result, it can perform well for tracking the relative changes in CO₂, though less ideal for absolute concentrations without calibration. For PM_{2.5}, the Air Gradient also had relatively high R² (0.79), moderately strong Pearson correlation ($p = 0.69$, $p < 0.05$), and a narrow range of LOAs (30.1 µg/m³) and low RMSE (5.8 µg/m³). Averaging the 5-minute measurements over 30-minute intervals generally improved the accuracy and precision of both sensors. However, statistically significant differences from the reference instruments remained for both sensors. Overall, this study offers a multi-metric assessment of consumer-grade sensors and highlights the need for in-situ calibration prior to long-term deployment.

Mai, J.-L., Yang, Y., Zeng, Y., Liu, S., Huang, Z.-S., Wu, J.-H., *et al.*

[Volatile organic compounds in various workplaces and during commutes in a Chinese city: occurrence and health risks for different occupations.](#)

Environmental Research, Vol. **285**, (2025)

The workplace, residence, and commute constitute the vast majority of people's exposure to air pollutants, whereas their apportionment is poorly understood. This study measured volatile organic compounds (VOCs) in various workplaces, residences, and commuting vehicles in a Chinese megacity. The total concentrations of target VOCs (Σ VOC₂₀) in workplaces (2.56 – 671.69 µg/m³, geometric mean = 57.32 µg/m³), with the highest concentrations in shopping malls and furniture malls and the lowest in libraries and museums, were significantly higher than those in residences (18.66 µg/m³). However, both workplace and residential concentrations were significantly lower than those inside vehicle cabins (buses, subways, and cars) (107.62 µg/m³). Principal component analysis identified four main sources of VOCs in the workplaces: use of cleaning and disinfectant agents indoors (26 %), various indoor product surfaces (23 %), the interior of furnishings and construction materials (20 %), and outdoor/vehicle emissions (31 %). On-road vehicle emissions were the major source of in-vehicle VOCs. Aromatics and alkanes were the major species in all the microenvironments, in contrast to esters and halocarbons. Similar composition profiles of VOCs in the workplaces were found, which were significantly influenced by outdoor sources. Both the cancer and non-cancer risks for the driver occupation were substantially higher than those of other cohorts. Occupational exposure remains the largest contributor to the risks if drivers are excluded. This study provides a comprehensive assessment of VOC exposure in a megacity. It underscores significant health risks related to traffic-related VOCs, highlighting the need for strategies to mitigate vehicle emissions of VOCs in Chinese cities.

Sakellaris, I., Mandin, C., Da Silva, E. P., Orsi, L., Bonnet, P., Siroux, V., *et al.*

[Wednesday Posters : Occupational Exposure to VOCs/Aldehydes and associations with asthma symptoms in daycares workers: the French CRESPI cohort.](#)

Occupational & Environmental Medicine, Vol. **82** n°(Suppl. 2), (2025)

Objective Since the early 2000s, interest has grown in understanding the influence of poor Indoor Air Quality (IAQ) on respiratory disorders like asthma. Although exposure to inhaled pollutants including

disinfectant and cleaning products is common in many workplaces, it remains poorly investigated, especially in daycare settings. The aim of this work is to investigate associations between IAQ and the respiratory health of daycare workers.

Material and Methods In the French CRESPI cohort (2019-2022), concentrations of 67 volatile organic compounds (VOCs) and aldehydes were measured in 106 daycares during one day and concentrations were studied in 4 categories based on quartiles (Q1 to Q4). Using a self-administered standardized questionnaire, we evaluated asthma through the asthma symptom score, which consists of the sum of 5 asthma symptoms reported in the past 12 months: breathless while wheezing, woken up with chest tightness, attack of shortness of breath at rest, attack of shortness of breath after exercise and woken up by attack of shortness of breath. Cross-sectional associations between daycare VOC/aldehyde concentrations and the asthma symptom score (0 to 5) were estimated. Negative binomial models accounting for daycare effect, were adjusted for age, smoking status, body mass index and job type.

Results This study included 300 women (mean age: 44 years; current smokers: 11%; job type: child-care: 69%, cleaning/cooking/washing: 7%, administration: 24%). Higher concentrations of hexamethylcyclotrisiloxane (D3) (Mean-Score Ratio Q4 versus Q1, 95% CI:1.74, 1.06–2.87; p-trend<0.01), octamethylcyclotetrasiloxane (D4) (2.24, 1.35-3.71; p-trend<0.01), and tetrachloroethylene (1.67, 1.03-2.73; p-trend=0.04) in daycare settings were associated with increased asthma symptom score. No significance remained after correction for multiple testing.

Conclusion Workplace exposure to specific indoor air pollutants was associated with asthma symptoms in daycare workers. Further analysis is ongoing to investigate associations between multipollutant groups and asthma. These findings highlight the need to implement additional measures to reduce pollutant concentrations and control their sources in daycare environments.
