



# WoS, Google Scholar et Lens

Samuel, C. S.

## [3 Goal of HVAC Systems.](#)

In: HVAC Fundamentals: System Design, Operation, Selection, and Optimization - 4th Edition. River Publishers; 2024. 33-44 p.

HVAC Fundamentals, System Design, Operation, Selection, and Optimization fully covers the full range of HVAC systems used in today's facilities and how they operate. HVAC systems are divided into components and controls for air, water, heating, ventilating and air conditioning to illustrate how each system, subsystem, control, or component contributes to providing the desired indoor environment. The reader will learn why one component or system may be chosen over another with respect to design, application, energy conservation, indoor air quality, and cost. This book also covers heat flow fundamentals and calculations used in selecting equipment and determining system operating performance and cost. Fluid flow fundamentals and equations and fundamentals of system testing, and verification of system performance are also covered in this book. This gives the reader a complete picture of systems from concept to operation. The chapters are organized in a way that one builds upon another, and systems, components, design, and application are revisited as the reader gains knowledge and insight about the workings of HVAC and heat pump systems. This new edition has been revised and expanded with new drawings to give the reader a complete picture of HVAC and heat pump systems. Along with the Tables chapter for reference the HVAC Math chapter has equations and example problems for many systems and components operation, energy, and cost calculations.

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Reddy, E. G., Damodhar, T. S. B., Y, S., Vathani, B. S., Sivakumar, S., Malathi, N.

## [Air Purification Robotics using Cloud and Deep Q Networks for Autonomous Systems.](#)

2024 1st International Conference on Innovative Sustainable Technologies for Energy, Mechatronics, and Smart Systems (ISTEMS). 25 June 2024. Dehradun, India

Rising urban air pollution poses serious health dangers. Through robots, cloud computing, and deep reinforcement learning, this research proposes a new air purification method. The suggested autonomous system analyzes real-time air quality parameters and optimizes air purification tactics using cloud-based data processing. Advanced sensors and purification processes allow robotic agents to intelligently adapt to shifting pollution patterns in dynamic settings. Robots use Deep Q Networks (DQN) to learn and change their purifying tactics based on past data and environmental input. Cloud computing and deep learning improve air purification efficiency and enable real-time pollution response decision-making. The autonomous system is scalable and adaptable to varied urban environments since it requires little human involvement. The cloud-based design lets autonomous agents communicate and coordinate to improve air quality. Experimental findings show that the suggested strategy improves air purification over previous approaches. This system advances environmental robotics and lays the groundwork for intelligent, autonomous systems that handle urban air quality and pollution issues.

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Li, G., Luo, B., Liu, M., Xue, H., Tian, Y., Meng, C., *et al.*

## [Air Quality in Fitness Centers: Status and Improvement Strategies.](#)

6th International Conference on Environmental Prevention and Pollution Control Technologies (EPPCT 2024).

As a place where people do physical activity for health, the indoor air quality of fitness center has a significant impact on human health. To systematically understand the current state of indoor air quality in fitness centers, this study reviews recent literature on the indoor environment of fitness centers, analyzes factors that affect air quality, and proposes a series of technical strategies to improve it. The analysis reveals: 1) Significant pollution issues with the indoor air quality in fitness centers; 2) Notable variations in air quality across different functional areas and time periods; 3) Air quality can be improved by adopting appropriate technical measures. This paper recommends that future air quality management strategies should consider factors such as the intensity of physical activity and crowd density to develop ventilation strategies, aiming for targeted air quality management that varies by area and time.

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López, A., Fuentes-Ferragud, E., Mora, M. J., Blasco-Ferre, J., Barber, G., Lopez-Labrador, F. X., *et al.*

[Air quality of health facilities in Spain.](#)

*Chemosphere*, Vol. **362**, (2024)

The present study examines indoor air pollution in health facilities, focusing on compounds from various sources, such as industrial products, healthcare activities and building materials. It assesses chemical and microbiological concentrations in two public hospitals, two public healthcare centres, and one public health laboratory in Spain. Measurements included indoor air quality, microbiological contaminants, ambient parameters and non-target analysis across ten different locations. Outdoor air quality was also assessed in the surroundings of the hospitals. The results showed that around 350 substances were tentatively identified at a high confidence level, with over 50 % of compounds classified as of high toxicological risk. Three indoor and 26 outdoor compounds were fully confirmed with standards. These confirmed substances were linked to medical, industrial and agricultural activities. Indoor Air Quality (IAQ) results revealed that CO, CO<sub>2</sub>, formaldehyde (HCHO), O<sub>3</sub> and total volatile organic compounds (TVOCs) showed average values above the recommended guideline levels in at least one of the evaluated locations. Moreover, maximum concentrations detected for CO, HCHO, O<sub>3</sub> and TVOCs in hospitals surpassed those previously reported in the literature. SARS-CoV-2 was detected in three air environments, corresponding to COVID-19 patient areas. Fungi and bacteria concentrations were acceptable in all assessed locations, identifying different fungi genera, such as *Penicillium*, *Cladosporium*, *Aspergillus*, *Alternaria* and *Botrytis*.

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Ding, Y., Jiang, X., Zhang, D., Yao, Y., Zhao, W., He, Y.

[Analytical model and comprehensive index construction of indoor air purification effect based on dynamic characteristics and energy efficiency.](#)

*Journal of Building Engineering*, Vol. **95**, (2024)

Meeting environmental regulation requirements while improving energy usage efficiency are crucial endeavors to achieve decarbonization and indoor environmental regulation. In this study, experimental testing, data analysis, and modeling are performed for the dynamic purification process of indoor PM<sub>2.5</sub> (fine particulate matter) in the context of regulating the indoor environment of buildings. The results show that indoor PM<sub>2.5</sub> levels are dynamically matched to the outdoor environment state and the requirements of environmental control. An analytical model of the effect of PM<sub>2.5</sub> purification is constructed, which can accurately reflect the dynamic changes in the PM<sub>2.5</sub> mass concentration during the indoor air purification process considering the outdoor PM<sub>2.5</sub> concentration and the purification efficiency of the purification filters and purification systems, thus supporting the prediction of purification outcomes and accurately constraining the actual indoor air quality purification process. Meanwhile, an indoor air quality control index (IAQCI) is established based on the purification effect and purification energy efficiency under various combinations of air filters and purification systems. This approach is used to quantitatively assess the dual control of energy efficiency and environmental regulation, as well as the purification effect and efficiency of indoor purification schemes based on outdoor dynamic PM<sub>2.5</sub> conditions. This study provides a set of innovative and feasible research methods for realizing comprehensive indoor environmental performance evaluations of buildings.

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Shen, J., Dols, W. S., Polidoro, B.

[ANT: A Multizone Indoor Air Quality \(IAQ\) and Ventilation Analysis Plug-in for Algorithm Aided Design.](#)

Eleventh National Conference of IBPSA-USA. Denver, Colorado. May 21 – 23, 2024

To facilitate the design and analysis related to indoor air quality (IAQ) and ventilation in buildings, a plug-in named ANT (contam-in-ANT) has been developed for Rhino/Grasshopper, an algorithm aided design platform. ANT is a whole-building IAQ and ventilation analysis tool based on CONTAM. ANT can be utilized to perform multizone simulations to assess airborne transmission risks, estimate health impacts due to inhalation exposure, perform parametric analyses, and optimize performance-driven building design and system settings. Cost-effective optimization of IAQ and ventilation for existing buildings is critical to the retrofitting required for these structures to achieve sustainability goals by 2050. A case study of a medium office building is used to demonstrate ANT and the post-processing of simulation results within Rhino/Grasshopper.

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Laicāns, I., Ķibilda, E., Žvagiņa, K., Martinsone, Ž., Pavlovska, I.

[Assessing Daily Intake of Indoor Air Pollutants from 3D Printing.](#)

Proceedings of the 15th International Scientific and Practical Conference. June 27-28, 2024, "Vasil Levski" National Military University, Veliko Tarnovo, Bulgaria

The scientific community is increasingly focusing on indoor air quality (IAQ) more than ever, driven by on-going research and fresh perspectives including development of 3D technologies. Exposure dose (EDa) resulting from inhalation of indoor air pollutants emitted by 3D printers were calculated in this study. The consideration of emissions from 3D printers is based on experimental data, primarily sourced from reviewed literature. However, this research also includes some experimental values, excluding the background levels of these pollutants. Experiments were conducted using several 3D printers available (Zortrax M300 Dual) to compare the indoor air pollutants generated and their concentrations with information gathered from earlier research. In the experiments, filaments containing ABS (acrylonitrile, butadiene, and styrene copolymer material, commonly used for 3D printing) were utilized. EDa values of styrene, toluene, formaldehyde, and acetaldehyde for 8-hour and 12-hour shifts for average and maximal (reported) concentrations were calculated based on the available experimental and literature data. The average concentrations of these pollutants were determined by calculating the arithmetic mean, which incorporated concentration values obtained from previous research and experimental data collected within this study. It was concluded that further investigation should focus on aerial concentrations of styrene generated during 3D printing. Calculated EDa for styrene from several studies exceeded the recommended guidelines for Tolerable Daily Intake (TDI) set by the World Health Organization (WHO) by at least 35%. Further exploration is imperative to incorporate additional pathways of indoor air pollutant exposure, such as skin contact and ingestion. This comprehensive approach will provide a more thorough understanding of the overall health risks associated with indoor air quality during 3D printing.

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Pham, A. D., Nguyen, T. T. H., Vu, T. M. H.

[Assessment of indoor air quality of the furniture manufacturers in Binh Duong industrial parks, Vietnam.](#)

IOP Conference Series: Earth and Environmental Science, Vol. **1368** n°(1), (2024)

Wood furniture and related products are created from raw wood and or wood products that require cutting, sanding, and other handling activities that generate wood dust. Exposure to indoor factory air pollutants can have significant health consequences for workers and nearby communities. Therefore, it was necessary to implement the assessment of indoor air quality in furniture manufacturers. This study mainly aimed to assess the indoor air quality status of physical and chemical aspects at 3 different furniture factories. Each sample was analysed for eight parameters including TSP, PM10, PM2.5, noise, temperature, humidity, wind, and light. Sampling and sample handling techniques were performed based on the usage test methods of Vietnam standards. The concentrations of TSP (194 – 493 µg/m<sup>3</sup>), PM10 (106.7 – 153.8 µg/m<sup>3</sup>), PM2.5 (72.8 – 95.6 µg/m<sup>3</sup>); and, the variables of noise (70.4 – 80.3 dBA), temperature (29.4 – 32.4 °C), humidity (58.0 – 69.4 %), wind (0.29 – 0.49) and light (327 – 573) these considered at 3 furniture manufacturers were within the allowable thresholds of QCVN 02:2019/BYT (Permissible exposure limit value of dust at the workplace), QCVN24:2016/BYT (Permissible exposure levels of noise in the workplace), QCVN26:2016/BYT (Permissible value of microclimate in the workplace); and, QCVN22:2016/BYT (Permissible levels of lighting in the workplace). However, long-term direct exposure of workers to these pollutants would also result in potential health risks. This study also suggested the management and technical control solutions to contribute to improving air quality for furniture manufacturers.

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Yang, Z. Y., Liu, Y. M., Chen, D., Miao, J. M., Chen, M. R., Liu, G., *et al.*

[A battery-free, wireless, flexible bandlike e-nose based on MEMS gas sensors for precisely volatile organic compounds detection.](#)

Nano Energy, Vol. **127**, (2024)

Real-time detection of VOCs in the car cabin is crucial for protecting driver 's health. MOS gas sensors, with the advantages of low cost, simplicity and fast response, are widely used for gas monitoring. However, they typically exhibit broad-spectrum responsiveness to multiple gases. Despite numerous improvement strategies proposed from the perspective of MOS material modification, achieving ideal gas selectivity remains challenging. An enose based on gas

sensor array is a promising approach for gas identification. However, the hardware circuit system and battery supply module in traditional e-nose result in large size, complex structure, and inconvenience in use. In this work, we synthesized MOS materials with different morphologies to form a microarray containing six MEMS gas sensors, and developed a novel belt-shaped wireless and battery-free flexible e-nose, where a mobile phone serves as its wireless power supply and data communication system. This design provides a flexible e-nose with excellent wearability and safety, allowing users to monitor surrounding gas conditions at any time conveniently. Subsequently, we design pattern recognition models using algorithms such as MLP, RF, XGBoost, and LGBM, in combination with ensemble learning strategies, achieving high accuracy in VOCs classification and low-error concentration prediction. This flexible e-nose holds significant application value for gas detection in car cabins and indoor environments.

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Molinier, B., Arata, C., Katz, E. F., Lunderberg, D. M., Ofodile, J., Singer, B. C., *et al.*

[Bedroom Concentrations and Emissions of Volatile Organic Compounds during Sleep.](#)

*Environmental Science & Technology*, Vol. **58** n°(18), (2024), 7958-7967 p.

Because humans spend about one-third of their time asleep in their bedrooms and are themselves emission sources of volatile organic compounds (VOCs), it is important to specifically characterize the composition of the bedroom air that they experience during sleep. This work uses real-time indoor and outdoor measurements of volatile organic compounds (VOCs) to examine concentration enhancements in bedroom air during sleep and to calculate VOC emission rates associated with sleeping occupants. Gaseous VOCs were measured with proton-transfer reaction time-of-flight mass spectrometry during a multiweek residential monitoring campaign under normal occupancy conditions. Results indicate high emissions of nearly 100 VOCs and other species in the bedroom during sleeping periods as compared to the levels in other rooms of the same residence. Air change rates for the bedroom and, correspondingly, emission rates of sleeping-associated VOCs were determined for two bounding conditions: (1) air exchange between the bedroom and outdoors only and (2) air exchange between the bedroom and other indoor spaces only (as represented by measurements in the kitchen). VOCs from skin oil oxidation and personal care products were present, revealing that many emission pathways can be important occupant-associated emission factors affecting bedroom air composition in addition to direct emissions from building materials and furnishings.

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Mane, M. K., Raffy, G., Glorennec, P., Bonvallot, N., Bonnet, P., Dumas, O., *et al.*

[Biocide and other semi-volatile organic compound concentrations in settled indoor dust of CRESPI daycare centers and implication for public health.](#)

*Journal of Hazardous Materials*, Vol. **471**, (2024)

This study investigates the presence of biocides and other semi-volatile organic compounds (SVOCs) in cleaning products used in daycare centers and health impact through ingestion of settled dust by young children. In Paris metropolitan area, 106 daycares area were investigated between 2019 - 2022. Fifteen substances were analyzed in settled indoor dust by gas chromatography-tandem mass spectrometry. Detection rates and concentrations ranged from 5 to 100%, and 14,267 ng/g, respectively. Galaxolide and benzophenone showed highest median concentration respectively 884 ng/g and 819 ng/g. The daily intakes (DI) of the substances through settled dust ingestion were evaluated and compared to those from food, inhalation, and dermal contact reported in the literature. Daily intakes from settled dust for musks, triclosan, geraniol, benzophenone, 2-phenylphenol, bifenthrin, and 4-n-nonylphenol were lower than those reported in the literature. The proportion of dust ingestion to total DI was negligible, except for benzophenone (DI=34%) for children aged 3 to 11 months. The DIs were well below the respective toxicological reference values for isothiazolinones, 4-tert-butylphenol, chlorocresol, and diclosan. Our results suggest that exposure to these biocides and the other SVOCs, taken individually, by dust ingestion in daycares, is not a major public health concern. Benzophenone, presumed carcinogen for humans, may require further investigation because of its presence in several daycares.

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Mendell, M. J., Chen, W., Ranasinghe, D. R., Castorina, R., Kumagai, K.

[Carbon dioxide guidelines for indoor air quality: a review.](#)

*Journal of Exposure Science & Environmental Epidemiology*, (2024)

The importance of building ventilation to protect health has been more widely recognized since the COVID-19 pandemic. Outdoor air ventilation in buildings dilutes indoor-generated air pollutants (including bioaerosols) and reduces resulting occupant exposures. Many countries and organizations have advisory guidelines or mandatory standards for minimum ventilation rates (VRs) to maintain indoor air quality (IAQ). Because directly measuring VRs is often difficult, many IAQ guidelines instead specify indoor concentration limits for carbon dioxide (CO<sub>2</sub>), using CO<sub>2</sub> exhaled by building occupants as an indicator of VR. Although indoor CO<sub>2</sub> guidelines are common, the evidence basis for the various CO<sub>2</sub> limits has not been clear.

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Salonen, H., Salthammer, T., Castagnoli, E., Täubel, M., Morawska, L.

[Cleaning products: Their chemistry, effects on indoor air quality, and implications for human health.](#)

Environment International, Vol. **190**, (2024)

The use of cleaning and disinfecting products both at work and at home increased during the COVID-19 pandemic. Those products often include surfactants, acids/bases, carcinogens such as chloroform, and endocrine-disrupting chemicals, such as cyclosiloxanes, phthalates, and synthetic fragrances, which may cause harmful health effects among professional cleaners as well as among people exposed at home or in their workplaces. The aim of this study was to synthesize the effects of the commonly used chemical, surface cleaning and disinfecting products on indoor air quality, focusing on chemical and particulate matter pollutants, exposure, and human health in residential and public buildings. We also provide a summary of recommendations to avoid harmful exposure and suggest future research directions. PubMed, Google Scholar, Scopus, and Web of Science (WoS) were used to search the literature. Analysis of the literature revealed that the use of cleaning products and disinfectants increase occupants' exposure to a variety of harmful chemical air contaminants and to particulate matter. Occupational exposure to cleaning and disinfectant products has been linked to an increased risk of asthma and rhinitis. Residential exposure to cleaning products has been shown to have an adverse effect on respiratory health, particularly on asthma onset, and on the occurrence of asthma(-like) symptoms among children and adults. Efforts to reduce occupants' exposure to cleaning chemicals will require lowering the content of hazardous substances in cleaning products and improving ventilation during and after cleaning. Experimentally examined, best cleaning practices as well as careful selection of cleaning products can minimize the burden of harmful air pollutant exposure indoors. In addition, indirect ways to reduce exposure include increasing people's awareness of the harmfulness of cleaning chemicals and of safe cleaning practices, as well as clear labelling of cleaning and disinfecting products.

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Hoyet, V., Robillart, M., Pannier, M.-L.

[Collecte de données multi-paramètres dans des logements: une base de données exhaustive pour l'évaluation du confort intérieur.](#)

Conférence IBPSA France-La Rochelle Oléron-2024

L'évaluation du confort intérieur dans les logements revêt une importance croissante pour garantir des environnements sains et agréables. Toutefois, ce type d'évaluation dépend de la disponibilité de données collectées en situation réelle. Cet article présente une base de données, recueillie depuis juin 2022, dans trois maisons et six appartements de participants volontaires, situés dans deux zones géographiques françaises. La base de données offre un aperçu détaillé des paramètres environnementaux (température, humidité, taux de CO<sub>2</sub>, niveau sonore) et du comportement des occupants (gestion des ouvertures de fenêtres) sur une période étendue. Le ressenti thermique a aussi été collecté pendant une courte période. Les possibilités offertes par cette base sont multiples et l'article expose son intérêt pour l'étude du confort au travers d'exemples. Les conclusions visent à identifier les usages actuels, éclairer sur les pratiques plus ou moins optimales et à formuler des recommandations pour un confort intérieur amélioré, tenant compte des préférences des occupants et de la qualité environnementale.

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Xin, X., Zhang, Z., Zhou, Y., Liu, Y., Wang, D., Nan, S.

[A comprehensive review of predictive control strategies in heating, ventilation, and air-conditioning \(HVAC\): Model-free VS model.](#)

Journal of Building Engineering, Vol. **94**, (2024)

Predictive control offers significant advantages in nonlinear control, high thermal inertia, and dynamic control. This article uses a Systematic Reviews and Meta-Analyses methodology to review 245 studies on predictive control in HVAC systems over the past 12 years, focusing on Model Predictive Control (MPC) and Model-Free Predictive Control (MFPC). In cooling systems, MPC is widely applied to energy efficiency management, continuous operation and maintenance, and overall system optimization in multi-zone residences. Its advantage is its ability to respond to system dynamics and precisely control key components such as cooling towers, condensers, evaporators, and pumps. Research focuses on simplifying models, reducing computational complexity, and enhancing real-time performance. In contrast, MFPC saves energy in equipment components and overall operation through intelligent valves, agent control programs, and other methods. Research focuses on developing new reinforcement learning algorithms to improve control efficiency and reliability. MPC research in heating systems focuses on hydraulic and thermal balance in central heating systems and expands to managing renewable energy hybrid systems. The research aims to dynamically adjust to meet user thermal comfort requirements while reducing energy consumption and improving efficiency. Key technologies include modeling techniques, distributed MPC, cross-regional integrated control, and efficient renewable energy integration strategies. MFPC precisely controls heating system water supply temperature, heat pump energy efficiency, and heating terminals through model-free algorithms like deep reinforcement learning and multivariable extremum seeking control. In integrated HVAC systems, MPC research focuses on managing multi-energy systems through hierarchical decomposition and multi-layer strategies, seamless renewable energy integration and optimization, and developing multi-objective optimization and decision support tools. MFPC research includes automatic grading strategies for integrated controllers, online optimization balancing methods, multi-agent methods, and developing intelligent model-free adaptive control strategies. However, MFPC integration in practical applications still needs strengthening. This review guides researchers in selecting the best predictive control mode for various HVAC system applications.

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Veríssimo, M. I. S.

[A critical review of the analytical performance of the most recent MOS-based gas sensors for indoor air quality monitoring of WHO priority pollutants.](#)

*TrAC Trends in Analytical Chemistry*, Vol. **178**, (2024)

In the past few years, there has been significant progress in developing sensors for indoor air quality (IAQ) monitoring. Thanks to their miniaturization, low cost, and growing concerns for people's well-being, these sensors have become increasingly important. This paper reviews the latest metal oxide semiconductor (MOS)-based gas sensors published since 2019 for the WHO-priority gas pollutants. While MOS-based gas sensors initially had limitations, including low selectivity, high operating temperatures leading to high power consumption, and interference from humidity, these challenges have been overcome. Currently, MOS-based sensors can detect some of the WHO-priority target gases at room temperature, achieving guideline values established for human safety. This progress in MOS-based gas sensors instills optimism for their future role in IAQ monitoring despite the challenges that still need to be addressed.

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Agarwal, A. K., Tomar, A. S., Rajput, J. S., Trivedi, M. K.

[Data analysis of indoor air pollutants in the laboratories of an Indian engineering institute.](#)

*Journal of Air Pollution and Health*, Vol. **9** n°(2), (2024), 141-156 p.

Introduction: Indoor Air Pollution (IAP) is a serious problem, especially in enclosed environments where humans are present for a long period. Similar enclosed environments can be seen in educational Institutions, where employees and students spend much of their time. The objective of this research is to assess the Indoor Air Quality (IAQ) of engineering Institute's laboratories.

Materials and methods: The sample of Indoor Air Pollutants (IAPs) such as Particulate Matters (PM1.0, PM2.5, PM10), Total Volatile Organic Compounds (TVOC), Formaldehyde (HCHO), and Carbon dioxide (CO<sub>2</sub>) were obtained by using a portable air quality meter from 12 different laboratories during July 2021 to September 2021 from 10:00 to 17:00. The statistical analysis was performed to interpret the outcomes.

Results: As a result, the higher concentration of PM1.0, PM2.5, PM10, TVOC, HCHO, and CO<sub>2</sub> was observed in ML11, ML2, ML12, ML5 and ML4. The correlation analysis shows that all laboratories, with the exception of ML4, ML5, ML9, and ML11, show good positive correlation for Particulate Matter (PM) of all sizes ( $R^2 > 0.90$ ). Additionally, ML6 and ML9 exhibited a strong positive association ( $R^2 > 0.78$ ) for TVOC, ML4 and ML8 for HCHO ( $R^2 > 0.68$ ), and ML3 and ML10 for

CO2(R2>0.66). In addition, cluster analysis was performed on the datasets to group them into similar source categories. As a result, 3, 2, 2, 4, 3, and 3 clusters for PM1.0, PM2.5, PM10, TVOC, HCHO, and CO2 are extracted. Conclusion: Overall, it appears that the presence of IAPs is caused by nearby outdoor activities, sweeping and dusting, wood furniture, paints, and poor ventilation in laboratories.

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Xuexiao, C.

[Design of indoor formaldehyde multipoint real-time monitoring and alarm system.](#)

In: Proc.SPIE. 2024.

Aiming at the problems that the convenient household formaldehyde gas detector could not realize simultaneous multipoint detection, excessive warning and the remote monitoring, a kind of indoor formaldehyde gas detection system with wireless AD hoc networking capability was designed. With the Zigbee module CC2530 of TI Company as the core, it adopted the Zigbee network ad-supported capability to realize real-time collection of air quality in multiple rooms at the same time, and uploaded the detected data to Aliyun Internet of Things platform to realize the remote monitoring function. The experimental results show that the system can simultaneously detect the formaldehyde concentration in multiple test points. When the formaldehyde concentration exceeds the preset concentration threshold, the system can make sound and light alarm and release the data to the Internet of Things platform. The remote Internet of Things platform stores the formaldehyde data for PC and mobile terminal to access and check. The system can meet the requirements of indoor formaldehyde concentration detection.

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Hannad, A., Godon, A., Mercier, F., Dematteo, C., Chehouani, H., Pannier, M.-L.

[Detecting CO2 anomalies using machine learning: case study of a library.](#)

Conférence IBPSA France-La Rochelle Oléron-2024

Indoor air quality is a very important element of a healthy and comfortable environment. The use of low-cost sensors recording CO2 or other substances has become popular in recent years. However, the quantity and complexity of the data measured by these sensors present challenges for identifying anomalies and extracting meaningful information. This is where machine-learning techniques excel. As part of the ACQA project, a micro sensor composed of various air quality sensors was developed and deployed in a university library. This study examines the detection of anomalies in CO2 levels recorded, using various machine-learning models: K-Nearest Neighbors, Random Forest (RF), Gradient Boosting Regressor and Decision Tree Regressor. The models are evaluated based on their accuracy and efficiency in detecting anomalies. The results, quantified using R<sup>2</sup>, RMSE and MAE indicators, and show that the RF model is the most accurate.

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Uşma, G., Ölçer, D. E.

[Development and Assessment of a Post-Occupancy Evaluation Scale for Sustainable Office Environments: Insights from the FNN Sustainability Center.](#)

Prostor, Vol. 32 n°(1 (67)), (2024), 26-37 p.

This study explores the relationship between users and the built environment through a post-occupancy evaluation (POE) conducted at the FNN Sustainability Centre, a noteworthy sustainable building in the region. The study involved a comprehensive approach, encompassing site visits, managerial interviews, and staff surveys. To establish a robust evaluation framework, a scale was developed by analyzing pertinent literature, and indicators were identified to gauge various aspects of the building's performance. Throughout the scale development process, the SPSS data analysis program was used, and expert opinions were solicited to ensure a rigorous and comprehensive methodology. Evaluation categories included lighting, acoustics, climatic comfort and indoor air quality, use and comfort of systems, quality of space and perception, awareness of sustainability and productivity. The building emerged as a physically and psychologically conducive workplace that heightened employee awareness of sustainability. The study identified specific concerns, such as noise disturbance for open-office workers and glare-related issues, which serve as valuable feedback for potential adjustments.

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Suvarna, T., Ganga Reddy, K., Madhu Mohan, V., Lavanya, G., Ramana Reddy, M. V., Vardhani, C. P.  
[Development of an efficient ammonia gas sensor based on Al doped tin oxide at room temperature.](#)  
*Inorganic Chemistry Communications*, (2024)

This study aims to synthesize Al-doped SnO<sub>2</sub> nanostructures using a sol-gel process and investigate their gas-sensing properties, notably ammonia (NH<sub>3</sub>) detection at ambient temperature. X-ray diffraction (XRD) examination validated the tetragonal crystal structure of the produced Al: SnO<sub>2</sub> materials. Field emission scanning electron microscopy (FE-SEM) images showed aggregation of the prepared samples. Transmission electron microscopy (TEM) was used to evaluate the structural and morphological properties of AIS-2 and AIS-8, and selected area electron diffraction (SAED) confirms the crystal structure. As the concentration of Al doping in SnO<sub>2</sub> nanostructures increased, the optical band gap (E<sub>g</sub>) values decreased. The chemical composition was analyzed using X-ray photoelectron spectroscopy (XPS). Gas sensing studies were conducted on NH<sub>3</sub> gas concentrations ranging from 5 to 300 ppm, and AIS-8 emerged as the most promising sensor, with substantial responsiveness, rapid response, recovery durations (21 s/18 s), and linear behavior at ambient temperature. This improved performance shows that AIS-8 has the potential to be an excellent NH<sub>3</sub> detector, due to the higher adsorption of oxygen species made possible by Al doping. Surprisingly, continuous measurements over 30 days at five-day intervals revealed significant reactivity of the AIS-8 sensor even at concentrations as low as 100 ppm of NH<sub>3</sub> gas.

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Zhang, H., Srinivasan, R., Yang, X., Ganesan, V., Zhang, H.  
[Diurnal variation of indoor air pollutants and their influencing factors in educational buildings: A case study using LASSO-based ANNs.](#)  
*Atmospheric Environment*, Vol. **333**, (2024)

This study explores the diurnal variations and influencing factors of PM<sub>2.5</sub>, NO<sub>2</sub>, and ozone concentrations in educational buildings. Utilizing an integrated system of indoor and outdoor sensors, building automation control networks, and walk-through inspections, air quality data along with relevant characteristics were collected from ten educational buildings in Central Florida. Advanced Neural Network models (RNNs and CNNs), including the Long Short-Term Memory (LSTM) and the Attention Temporal Convolutional Network (ATCN) algorithms based on the Least Absolute Shrinkage and Selection Operator (LASSO), were developed to accurately identify diurnal patterns in indoor air quality (IAQ) and the differences in influencing factors. The findings indicate greater variability in diurnal differences and factors influencing indoor NO<sub>2</sub> and ozone concentrations compared to PM<sub>2.5</sub>. Although the factors influencing day and night PM<sub>2.5</sub> levels were similar, there were significant differences in the contribution weights of these factors. Optimized RNNs and CNNs significantly outperformed standard Artificial Neural Network (ANN) models in dynamically simulating and predicting target pollutants. Comparative analysis of the root-mean-square error (RMSE) demonstrated that LASSO-LSTM models comprehensively outperformed LASSO-ATCN models by averaging 13.4% ( $p < 0.05$ ). These results can be referenced in studies concerning Indoor Air Quality (IAQ) control conducted in similar environmental settings.

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Dună, A.  
[Dynamic Simulation Modeling.\(DSM\) for Building Energy Performance and HVAC Equipment Selection. A Case Study.](#)  
*Romanian Journal of Civil Engineering*, Vol. **115** n°(3), (2024)

The paper presents a case study in which a dynamic simulation modeling (DSM) calculation was carried out to assess the energy performance of a building in Giroc, a locality adjacent to the city of Timișoara, using the VABI Elements software. The characteristics were determined based on which the HVAC equipment was selected.

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Al Mindeel, T., Spentzou, E., Eftekhari, M.  
[Energy, thermal comfort, and indoor air quality: Multi-objective optimization review.](#)  
*Renewable and Sustainable Energy Reviews*, Vol. **202**, (2024)

The reliance on optimization techniques for robust assessments of environmental and energy-saving solutions has been largely driven by the increasing need to comply with international energy policies. However, numerous challenges arise

from inherently conflicting objectives for a sustainable built environment, that is, maximizing thermal comfort, and indoor air quality, while minimizing energy consumption, forming a multi-objective optimization problem. Consequently, studies seeking multi-faceted optimality in the design and/or operation of low-energy buildings have exponentially increased over the past few years. This research critically reviews the latest multi-objective optimization studies that present energy consumption, thermal comfort, and indoor air quality as competing targets. By examining 82 records between 2013 and 2022, key discussions focused on commonly investigated objective functions, design variables, and performance metrics. The review also investigates the latest research trends, optimization techniques, algorithms, and tools, and identifies gaps in knowledge and potential future research directions. The review results showed that most studies used a holistic approach that targeted all three objective functions, with the largest portion performed on office and residential buildings. The most commonly investigated design variables are system-related variables, whereas building-related and occupant-related variables are often overlooked. Coupling simulation tools and optimization algorithms is the most widely utilized optimization approach, with genetic algorithms being the most employed. These findings suggest a promising area for future research on methodological optimization approaches, which are expected to be significantly transformed with the rapid development of artificial intelligence technologies.

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Abalaka, O. O., Essien, J., Chimezie, C., Ogharandukun, M.

[Enhancing Patients Outcomes and Infection Control through Smart Indoor Air Quality Monitoring Systems.](#)

Journal of Computer and Communications, Vol. **12** n°(6), (2024), 25-37 p.

Air pollution poses a critical threat to public health and environmental sustainability globally, and Nigeria is no exception. Despite significant economic growth and urban development, Nigeria faces substantial air quality challenges, particularly in urban centers. While outdoor air pollution has received considerable attention, the issue of indoor air quality remains underexplored yet equally critical. This study aims to develop a reliable, cost-effective, and user-friendly solution for continuous monitoring and reporting of indoor air quality, accessible from anywhere via a web interface. Addressing the urgent need for effective indoor air quality monitoring in urban hospitals, the research focuses on designing and implementing a smart indoor air quality monitoring system using Arduino technology. Employing an Arduino Uno, ESP8266 Wi-Fi module, and MQ135 gas sensor, the system collects real-time air quality data, transmits it to the ThingSpeak cloud platform, and visualizes it through a user-friendly web interface. This project offers a cost-effective, portable, and reliable solution for monitoring indoor air quality, aiming to mitigate health risks and promote a healthier living environment.

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Mazurkiewicz, W., Sak, J., Nowiński, M., Fus-Mazurkiewicz, L. A.

[Environmental exposure to formaldehyde and effects on human health.](#)

Environmental Medicine, (2024)

Introduction and objective Formaldehyde is a common toxic substance in the environment, formed both naturally and as a result of human activity. Due to its widespread use, it can pose a threat to a significant portion of the population. The aim of this study was to analyze scientific research on environmental exposure to formaldehyde and its effects on human health. Abbreviated description of the state of knowledge The concentration of formaldehyde in indoor air of buildings reaches much higher values than in the open air. It most often enters the human body through the respiratory tract, less often through the skin. Formaldehyde can be one of the causes of sick building syndrome or non-specific building-related health symptoms. Occupational exposure to formaldehyde most often affects workers in the health care, factory, construction and garment industries. The results of the study analysis suggest that formaldehyde exposure may be associated with a higher risk of cancer, especially nasopharyngeal cavity cancer and leukemia. Formaldehyde exposure can also cause the development of asthma in both children and adults, as well as some brain diseases. Summary Many workers, by virtue of their occupation, are exposed to concentrations of formaldehyde that exceed permissible levels. This can become the cause of the development of many diseases. Adequate education of workers, provision of protective measures, and exposure prevention systems can reduce the risk of adverse health effects.

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Raheem, M. A., Hadi, F. M., Abdulla, J. a. K., Hamzah, H. K., Jum, M. S., Hani, J. S., *et al.*

[An Evaluation of the Air Quality Index in Najaf Governorate \(Al-Sadr Teaching Hospital for the Case Study.](#)

Journal of Current Medical Research and Opinion, Vol. **7** n°(06), (2024), 2843-2857 p.

Monitoring indoor air pollution in health institutions is important for building occupants. In this study, an environmental assessment of the indoor air quality index (AQI) was conducted at Al-Sadr Teaching Hospital, where volatile organic compounds (TVOC), carbon monoxide (CO) concentration, and carbon monoxide (CO) concentration were measured. Carbon dioxide (CO<sub>2</sub>) and formaldehyde gas concentration (HCHO), using an Air Quality Detector.

In this study, 59 sites were measured within Al-Sadr Teaching Hospital, and the results showed that 25 sites out of 59 were the most polluted sites, which had an air quality index category ranging from (6-5), that is, within the range of severe to dangerous pollution, as these places are closed and do not contain a ventilation system. It is suitable and contains electronic devices inside it, some of which deal with microorganisms, in addition to the use of sterilizers and scented detergents, which expose patients and even medical staff to severe and toxic health effects the longer they stay and are exposed to these gases, as the gases exceed safety limits. The results also showed the places which recorded moderate pollution values, which were 5 sites out of 59, and the air quality index value was (4). While the least polluted places, which numbered 21 sites out of 59, were recorded as the air quality index value ranged from (2-1), so the air quality index category was excellent to good because the places had appropriate ventilation systems and were not crowded with people at that time.

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Karaiskos, P., Martinez-Molina, A., Alamaniotis, M.

[Examining the Impact of Natural Ventilation versus Heat Recovery Ventilation Systems on Indoor Air Quality: A Tiny House Case Study.](#)

[Buildings](#), Vol. 14 n°(6), (2024)

Adverse health effects can arise from indoor air pollutants, resulting in allergies, asthma, and other respiratory problems among occupants. Concurrently, the energy consumption of residential buildings, particularly concerning heating, ventilation, and air conditioning (HVAC) systems, significantly contributes to global energy usage. To address these intertwined challenges, heat recovery ventilation (HRV) has emerged as a viable solution to reduce heating and cooling demands while providing fresh ventilation rates. This study aims to investigate the indoor air quality (IAQ) of an experimental tiny house building equipped with an HRV unit by simulating real-life scenarios contributing to IAQ. The research evaluates the effectiveness of HRV compared to natural ventilation in managing particle matter (PM), total volatile organic compounds (TVOC), formaldehyde (CH<sub>2</sub>O), carbon monoxide (CO), and carbon dioxide (CO<sub>2</sub>) levels. This research significantly contributes to the understanding of the different ventilation strategies' impact on IAQ in tiny houses and offers valuable insights for improving living conditions in a unique building typology that is underrepresented in the research literature.

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Pál, L., Lovas, S., Mckee, M., Diószegi, J., Kovács, N., Szűcs, S.

[Exposure to volatile organic compounds in offices and in residential and educational buildings in the European Union between 2010 and 2023: A systematic review and health risk assessment.](#)

[Science of The Total Environment](#), Vol. 945, (2024)

Chronic exposure to indoor volatile organic compounds (VOCs) can result in several adverse effects including cancers. We review reports of levels of VOCs in offices and in residential and educational buildings in the member states of the European Union (EU) published between 2010 and 2023. We use these data to assess the risk to population health by estimating lifetime exposure to indoor VOCs and resulting non-cancer and cancer risks and, from that, the burden of cancer attributable to VOC exposure and associated economic losses. Our systematic review identified 1783 articles, of which 184 were examined in detail, with 58 yielding relevant data. After combining data on VOC concentrations separately for EU countries and building types, non-cancer and cancer risks were assessed in terms of hazard quotient and lifetime excess cancer risk (LECR) using probabilistic Monte Carlo Simulations. The LECR was used to estimate disability adjusted life years (DALYs) from VOC-related cancers and associated costs. We find that the LECR associated with formaldehyde exposure was above the acceptable risk level (ARL) in France and Germany and that of from exposure to benzene was also above the ARL in Spanish females. The sum of DALYs and related costs/1,000,000 population/year from exposure to acetaldehyde, benzene, formaldehyde, tetrachloroethylene, and trichloroethylene were 4.02 and €41,010, respectively, in France, those from exposure to acetaldehyde, benzene, carbon tetrachloride, formaldehyde, and trichloroethylene were 3.91 and €39,590 in Germany, and those from exposure to benzene were 0.1 and €1030 in Spain. Taken as a whole, these findings show that indoor exposure to VOCs remains a public health

concern in the EU. Although the EU has set limits for certain VOCs, further measures are needed to restrict the use of these chemicals in consumer products.

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Lyu, Y.

[Field and intervention study on indoor environment in professional classrooms.](#)

Building Engineering, Vol. 2 n°(1), (2024)

To study the variation of environment in the professional classroom during lecture hours, multiple field experiments and intervention experiments on indoor and outdoor temperatures were conducted in a university professional classroom in Shaoxing during the spring. Environmental data, including indoor and outdoor temperatures, relative, and CO<sub>2</sub> concentrations, were recorded every 5 min. Volatile organic compounds (VOC) were sampled, and indoor air quality was evaluated repeatedly. Results showed that the classroom's average indoor air temperature ranged from 17.8–29.2 °C, the average indoor relative humidity from 34.5%–91.0%, the average CO<sub>2</sub> concentrations from 921.6–1805.2 ppmv, and total VOC concentrations from 330–682 ppbm. The subjective evaluation conducted during the intervention experiments indicated a significant increase in perceived odor intensity upon entering the classroom. When the CO<sub>2</sub> concentration reached 2000 ppmv, the satisfaction and acceptability of the air quality for the subjects and invitees decreased significantly. In the temperature range of 17–31 °C, the CO<sub>2</sub> emission rate of human body was estimated to increase by 0.78 L/h for every 1 °C increase in temperature. To maintain the indoor CO<sub>2</sub> concentration at 1000 ppmv, the required ventilation rate for each person must be increased by 0.25 ± 0.3 L/s.

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Gyurova, L.

[The fluid flow simulation of the thermal comfort in theatre.](#)

Environment. Technologies. Resources. Proceedings of the International Scientific and Practical Conference, Vol. 3, (2024), 75-78 p.

This paper examines the use of Computational Fluid Dynamics (CFD) simulations to improve thermal comfort in enclosed spaces, such as theatres, halls, and offices. Thermal comfort is crucial for occupant well-being and productivity, and is influenced by various factors, including air temperature, humidity, and airflow. To create tailored models for specific spaces, we suggest using CFD simulations to predict airflow patterns and temperature distribution, thereby identifying discomfort zones. This research aims to optimize thermal comfort and improve building design and energy efficiency by iteratively adjusting ventilation strategies. The practical applications of this approach include improved design and construction, as well as retrofitting existing buildings. To achieve this, CFD simulations should be integrated into the design phase to proactively address thermal comfort issues and achieve energy-efficient layouts. Customising CFD models for existing buildings allows for the analysis of airflow patterns and optimisation of ventilation strategies to enhance thermal comfort. HVAC systems can be evaluated using CFD to identify areas for improvement and select energy-efficient solutions, leading to enhanced energy efficiency. The benefits of these improvements include enhanced well-being and productivity, as improved thermal comfort can lead to better occupant health and focus, ultimately boosting productivity. Additionally, the risks of Sick Building Syndrome (SBS) can be reduced. CFD analysis can help reduce the risks of Sick Building Syndrome by optimizing ventilation and improving indoor air quality. In the future, it is recommended to integrate CFD simulations with Building Information Modelling for comprehensive thermal comfort analysis. This study highlights the potential of CFD to optimize thermal comfort in enclosed spaces by promoting occupant well-being and energy efficiency through iterative ventilation adjustments. It is important to adhere to established standards when integrating CFD.

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Liang, Z. C., Zhou, L. Y., Chen, K. P., Lin, Y. H., Lai, A. C. K., Lee, P. K. H., *et al.*

[Formation of secondary aerosol by 222 nm Far-UVC irradiation on SO<sub>2</sub>.](#)

Atmospheric Environment, Vol. 330, (2024)

222 nm UV indoor disinfection using KrCl\* excimer lamps has been gaining popularity due to claims of minimal ocular and skin damage from direct irradiation. However, the secondary aerosol formation under irradiation of KrCl\* excimer lamps, which could be an inhalation hazard, is less explored. SO<sub>2</sub>, a well-known precursor of outdoor sulfate aerosol, is also ubiquitous in indoor environments in urban cities in northern China where coal is used for domestic heating and

cooking. In this work, we studied secondary aerosol formation by 222 nm irradiation on SO<sub>2</sub>, using a Go: PAM flow reactor, a scanning mobility particle sizer (SMPS), and a time-of-flight aerosol chemical composition monitor (ToF-ACSM). The formation of sulfate nanoparticles was found much more effective at 222 nm than at 254 nm and under fluorescent lamp (FL) irradiation at the same UV doses and RH, likely due to different SO<sub>2</sub> oxidation mechanisms. We have also found that NH<sub>3</sub> and cooking volatile organic compounds (CVOC), as other indoor-relevant gases, promoted the formation of secondary aerosols by 222 nm radiation on SO<sub>2</sub>. Overall, 222 nm disinfection can generate secondary pollutants in indoor environments. Caution should be taken during its indoor applications, especially in areas with high SO<sub>2</sub> concentrations such as coal-fueled households.

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Jia, C., Fu, X., Webster, T. F., Ceballos, D. M.

[Fragrance chemicals in nail salons: Personal inhalation exposures and potential sources.](#)

[Atmospheric Pollution Research](#), Vol. 15 n°(9), (2024)

The indoor air of nail salons is full of volatile organic compounds (VOCs), many of which have fragrances. Little is known about the fragrance chemicals in nail salons, as fragrance ingredients are not required on nail product labels and are considered trade secrets. This study aimed to identify fragrance chemicals and their potential sources and exposures in nail salons. Indoor air samples were collected in seven nail salons in the Greater Boston Area between November 2016 and June 2017. Personal samples were also collected from ten nail salon workers during their work shifts. Follow-up area sampling was performed in two salons one year after the initial visits. All air samples were collected using thermal desorption (TD) tubes and analyzed on a TD-gas chromatography/mass spectrometry (GC/MS) system targeting 55 fragrance chemicals. Eighteen compounds were detected in air samples, including terpenes, alcohols, carbonyls, ethers, and esters. The concentrations displayed limited spatial variation within a salon but moderate variation over time. The highest median personal inhalation concentrations were benzaldehyde (36.4 µg/m<sup>3</sup>), 2-ethylhexanol (30.0 µg/m<sup>3</sup>), d-limonene (16.6 µg/m<sup>3</sup>), and 2-butoxyethanol (12.6 µg/m<sup>3</sup>). Highest personal levels were reached by maximum concentrations of 2-butoxyethanol (<1611 µg/m<sup>3</sup>), d-limonene (<413 µg/m<sup>3</sup>), and methyl salicylate (<113.5 µg/m<sup>3</sup>). Personal concentrations of most compounds were highly correlated with area concentrations (Spearman correlations = 0.69–0.92). Fragrance concentrations from area and personal air samples did not correlate significantly with the ventilation rate. Cleaning agents, personal care products, and nail products were identified as important possible emission sources. This study reveals a subset of fragrance chemicals in nail salons' indoor air and calls for future research on a full spectrum of these chemicals, their health effects among nail salon workers, and ways to reduce these exposures.

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Zouari, M., Marrot, L., Devallance, D. B.

[Functional biocarbon-based coatings for wood protection and indoor air depollution.](#)

[Building and Environment](#), Vol. 261, (2024)

Growing concerns about indoor air pollution heighten the need to develop depolluting materials to achieve a healthy built environment. This study developed functional coatings for wooden surfaces using 20 wt% photocatalytic biocarbon particles doped with manganese oxide (BC-MnO<sub>2</sub>) and two different coating materials (linseed oil and waterborne acrylic). The samples' surface hydrophobicity and color properties were tested before and after accelerated aging. The depolluting potential of the samples was evaluated by formaldehyde removal efficiency test in indoor conditions. Results showed that adding BC-MnO<sub>2</sub> particles increased the hydrophobicity regardless of the coating material's type. After accelerated aging, the hydrophobicity of all samples increased, which was attributed to the curing of the oil and acrylic polymers and the increase in surface roughness eventually caused by surface damage. The color change (ΔE) was more intense in the case of uncoated wood and samples without BC-MnO<sub>2</sub>. However, the BC-MnO<sub>2</sub>-containing coatings were effective in color preservation (ΔE < 2), which was attributed to the anti-UV property of biocarbon. The BC-MnO<sub>2</sub>-containing coatings exhibited a promising formaldehyde removal efficiency of up to 24 % and 46 % for oil and acrylic samples, respectively. The combination of BC-MnO<sub>2</sub> and acrylic material was more favourable to attracting the formaldehyde molecules, likely due to the similar polarity. The developed functional coatings exhibited an acceptable ability for wood protection and formaldehyde remediation and can be potentially used to enhance indoor air quality.

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Mathews, A. J., Krishnan, E. N., Joseph, A., Annadurai, G., Fauchoux, M. T., Simonson, C. J.

[Gaseous contaminant transfer in membrane-based air-to-air energy exchangers.](#)

Energy and Buildings, Vol. **318**, (2024)

Membrane-based air-to-air energy exchangers (M-AAEEs) transfer heat and moisture between building exhaust air and fresh ventilation air streams through a membrane, thereby reducing the energy required for conditioning the fresh ventilation air. Energy exchangers are typically used in buildings with relatively clean building exhaust air, such as office buildings and schools. Recently interest in using energy exchangers in a wider range of buildings has grown, to reduce the energy consumption associated with the heating, ventilating, and air-conditioning (HVAC) systems in these buildings. However, if the building exhaust air is not clean, as would be the case for laboratories or factories, new risks are encountered when using energy exchangers. It is possible that gaseous contaminants in the exhaust air may also transfer along with the moisture through the membranes, contaminating the incoming fresh ventilation air. Current test standards provide a test procedure to determine the contamination of the fresh ventilation air by measuring the transfer of an inert tracer gas in an energy exchanger. However, the tracer gas test may not represent the transfer of common indoor air contaminants due to differences in their transport properties. Therefore, in this study, an experimental facility is developed to determine the transfer of seven different contaminants through two membranes (porous and dense) at different flow rates. Contaminant transfer is quantified using a parameter called the exhaust contaminant transfer ratio (ECTR), which gives the fraction of the contaminants transferred from the exhaust air to the fresh ventilation air. A theoretical model based on the effectiveness-number of transfer units ( $\epsilon$ -NTU) correlation and moisture transfer resistance of the membrane is presented to determine transfer through porous membranes and validated with experimental results. The major contribution of this paper is that it presents a simple method to predict the transfer of different contaminants through a porous membrane based on the moisture transfer resistance of the membrane at different operating conditions. It is found that as contaminant diffusivity decreases, ECTR generally also decreases, and as the flow rate increases, ECTR decreases, which is consistent with the predictions from the correlation.

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David, M., Sucker, K., Hameister, J., Gerull, F., Grams, H., Röhl, C., *et al.*

[The German approach to evaluate complaints about odour annoyance in indoor environments.](#)

Indoor Environments, Vol. **1** n°(3), (2024)

The perception of unusual or unexpected odours in indoor air can give rise to complaints about odour annoyance. These complaints are frequently accompanied by concerns for adverse health effects as a consequence of exposure to indoor air substances. The German Committee on Indoor Air Guide Values (AIR) developed a practical guidance on how to evaluate if the complaints about odour annoyance in indoor environments are reasonable and how to reduce odour exposure when a so-called odour guide value (OGV) is reached or exceeded. The AIR describes the procedure to derive odour guide values for relevant odorous substances in indoor air and recommends a graded approach of odour reduction measures.

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Osman, E., Banerjee, C., Poonia, A. S.

[HDLP: air quality modeling with hybrid deep learning approaches and particle swarm optimization.](#)

Innovations in Systems and Software Engineering, (2024)

Predicting air pollution in cities has become an important tool for preventing its negative impacts. Therefore, citizens should be aware of air quality level, especially for individuals suffering from diseases caused by air pollutants. Collective efforts from researchers, environmental institutions, governments, industrial companies, and policy makers are shaping the future of the Air Quality Index (AQI) to effectively address severe air pollution in urban areas. Many air quality prediction models have been introduced in the literature; modern advances in deep learning techniques are promising more precise prediction results and data integration. The aim of this paper is to review methods, contributions, findings, limitations, and gaps in predicting air quality index and PM2.5 concentrations using a hybrid deep learning approach. A literature review led researchers to propose a Hybrid Deep Learning model with Particle Swarm Optimization (HDLP) which combines CNN, LSTM, and PSO. Algorithm, first Discrete Wavelet Transform (DWT) is used to solve the air pollution signal, then it is fed to CNN-LSTM neural network for PSO optimization to get the final prediction result. Optimized parameters input models are trained on the original data. In addition to the beneficial assessment cycle, to outperform current models.

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Fan, G., Guan, J., Yu, H., Zhu, Q., Han, N., Mo, J., *et al.*

[Highly sensitive formaldehyde gas sensor based on SnO<sub>2</sub>/Zn<sub>2</sub>SnO<sub>4</sub> hybrid structures.](#)

*Building and Environment*, Vol. **262**, (2024)

Formaldehyde, a common indoor air pollutant emitted from building decoration materials, poses a significant health hazard, potentially leading to cancer. Therefore, developing a gas sensor capable of real-time monitoring of indoor formaldehyde concentration is essential. Herein, a metal oxide semiconductor gas sensor with SnO<sub>2</sub>/Zn<sub>2</sub>SnO<sub>4</sub> hybrid structure as the sensitive material has been successfully fabricated. The sensor exhibits the ability to detect formaldehyde down to 50 ppb, meeting the safety concentration limit proposed by the World Health Organization (WHO). Additionally, it displays rapid response characteristics, with a response time of 84 s and a recovery time of 46 s for 50 ppb of formaldehyde at 200 °C, respectively. Moreover, the sensor demonstrates good selectivity and long-term stability, making it promising for real-time monitoring of indoor air pollutants. Furthermore, the evolution process of intermediates in the sensing reaction was investigated by in-situ diffuse reflectance infrared fourier transformations spectroscopy, providing a comprehensive understanding of the surface chemistry. This in-depth comprehension offers valuable insights into the mechanisms underlying formaldehyde sensing.

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Wang, N. J., Müller, T., Ernle, L., Bekö, G., Wargocki, P., Williams, J.

[How Does Personal Hygiene Influence Indoor Air Quality?](#)

*Environmental Science & Technology*, Vol. **58** n°(22), (2024), 9750-9759 p.

Humans are known to be a continuous and potent indoor source of volatile organic compounds (VOCs). However, little is known about how personal hygiene, in terms of showering frequency, can influence these emissions and their impact on indoor air chemistry involving ozone. In this study, we characterized the VOC composition of the air in a controlled climate chamber (22.5 m<sup>3</sup>) with an air change rate at 3.2 h<sup>-1</sup>) occupied by four male volunteers on successive days under ozone-free (similar to 0 ppb) and ozone-present (37-40 ppb) conditions. The volunteers either showered the evening prior to the experiments or skipped showering for 24 and 48 h. Reduced shower frequency increased human emissions of gas-phase carboxylic acids, possibly originating from skin bacteria. With ozone present, increasing the number of no-shower days enhanced ozone-skin surface reactions, yielding higher levels of oxidation products. Wearing the same clothing over several days reduced the level of compounds generated from clothing-ozone reactions. When skin lotion was applied, the yield of the skin ozonolysis products decreased, while other compounds increased due to ozone reactions with lotion ingredients. These findings help determine the degree to which personal hygiene choices affect the indoor air composition and indoor air exposures.

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Samuel, C. S.

[HVAC Fundamentals: System Design, Operation, Selection, and Optimization](#)

In: HVAC Fundamentals: System Design, Operation, Selection, and Optimization - 4th Edition. River Publishers; 2024.

HVAC Fundamentals, System Design, Operation, Selection, and Optimization fully covers the full range of HVAC systems used in today's facilities and how they operate. HVAC systems are divided into components and controls for air, water, heating, ventilating and air conditioning to illustrate how each system, subsystem, control, or component contributes to providing the desired indoor environment. The reader will learn why one component or system may be chosen over another with respect to design, application, energy conservation, indoor air quality, and cost. This book also covers heat flow fundamentals and calculations used in selecting equipment and determining system operating performance and cost. Fluid flow fundamentals and equations and fundamentals of system testing, and verification of system performance are also covered in this book. This gives the reader a complete picture of systems from concept to operation. The chapters are organized in a way that one builds upon another, and systems, components, design, and application are revisited as the reader gains knowledge and insight about the workings of HVAC and heat pump systems. This new edition has been revised and expanded with new drawings to give the reader a complete picture of HVAC and heat pump systems. Along with the Tables chapter for reference the HVAC Math chapter has equations and example problems for many systems and components operation, energy, and cost calculations.

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Ayeni, O., Agada, V. O., Mahamat, A. A., Ibrahim, E. C., Stanley, A. M., Abdulsalam, D.

[Impact of indoor air pollutant concentration levels on the health of press operators of printing facilities in Zaria Metropolis, Nigeria.](#)

*Environmental Technology and Science Journal*, Vol. **15** n°(1), (2024)

Long-term exposure to air pollutants in printing facilities is detrimental to the health, well-being, and productivity of press users. This study investigated the concentrations of indoor air pollutants in 22 printing facilities in Zaria, Nigeria, as well as their interactions with press operators' perceptions of feeling Sick Building Syndrome (SBS) symptoms. The study employed quantitative methods. The concentrations of indoor air pollutants (CO<sub>2</sub>, CO, TVOC, HCHO, PM<sub>2.5</sub>, and PM<sub>10</sub>) were monitored with air quality multifunction devices in the different printing facilities. Questionnaires were also administered to assess press operators' health and perceptions of feeling SBS symptoms in the printing facility. The results showed that indoor air pollutant concentrations vary in the different printing facilities, with pollutant concentration values in the range of 0.323–9.999 mg/m<sup>3</sup>, 0.030–0.078 mg/m<sup>3</sup>, 21.33–426.67 µg/m<sup>3</sup>, and 28.0–568 µg/m<sup>3</sup> for TVOCs, HCHO, PM<sub>2.5</sub> and PM<sub>10</sub>, respectively and some exceeding the NESREA standard values. Findings also show that press operators rarely felt 14 SBS symptoms in the printing facility. The questionnaire results suggest that health-related problems experienced by press operators may worsen if operators continue to have long-term exposure to these pollutants. From this study, press operators need to be cautious of the adverse health impacts associated with long-term exposure to indoor air pollutants. Indoor air quality (IAQ) monitoring equipment and indoor air pollutant capture systems should be installed in all printing environments to minimize the adverse impacts of indoor air pollutant concentrations. The findings of this study advance the knowledge of the health impacts of prolonged indoor air pollutant exposure in printing facilities and the connections between elevated concentrations and adverse effects on press operators. Implications include the need for enhanced occupational health practices, regulatory compliance, awareness training, and infrastructure investment to safeguard press workers' well-being and productivity in printing facilities.

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Li, Y., Zhang, S., Guo, Z., Wang, L., Qiao, L., Chen, Y., *et al.*

[An in-situ versatile screening method for identifying SVOC sources in indoor environments.](#)

*Environment International*, Vol. **189**, (2024)

Indoor semivolatile organic compounds (SVOCs) pose a substantial threat to human health. However, identifying the sources of these emissions has been challenging owing to the scarcity of convenient and practical on-site methodologies. Herein, a novel method for source screening was proposed using aluminum silicate sampling strips to adsorb SVOCs from the surface air of indoor materials. The adsorbed SVOC levels indicate the emission intensity of these materials into indoor environments. Additionally, compact sampling strips can be readily fixed to any vertical surface using a static sticker, facilitating the characterization of various materials in practical settings. Laboratory-simulated experiments demonstrated the capability of the proposed method to differentiate between source and non-source materials within a 10-cm distance in the same space. In practical scenarios, the primary emission sources identified via this method exhibited a consistent correlation with the contents of the corresponding materials obtained from the traditional solvent-extraction method. As the adsorbed SVOCs were directly transferred to a GC–MS through thermal desorption instead of the solvent-extraction procedure, the proposed method demonstrated several-fold improvements in analytical sensitivity and efficiency. Using this versatile screening technique, some emerging and important SVOC species were identified within specific indoor materials. Eliminating these sources has been demonstrated as an effective approach to mitigate SVOC pollution. Overall, the proposed method offers a powerful tool for managing indoor pollutants and safeguarding human health.

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Pereira, S., Santiago, A., Reis, C., Pinto, J., Bentes, I.

[Indoor Air Quality in a Residential Building – A Health Issue.](#)

International Conference on Wireless Mobile Communication and Healthcare. 29-30 November 2023. Vila Real, Portugal.

This study addresses the often-overlooked issue of indoor air quality, emphasizing its significance for the health and well-being of individuals spending a majority of their time indoors. Factors such as building occupancy, construction materials, and ventilation systems contribute to indoor air quality. Recognizing it as a critical environmental risk factor,



this research focuses on assessing air quality in The Castle House, Lamego, through the measurement of PM10 and PM2.5 particles, temperature, barometric pressure, relative humidity, and carbon dioxide. The paper provides context, presents the study case, analyzes results, and concludes with implications for future research.

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Bahrami, A., Haghghat, F., Zhu, J.

[Indoor Environment Gas-Particle Partitioning Models of SVOCs and Impact of Particle Properties on the Partitioning: A Review.](#)

[Building and Environment](#), (2024)

Spending most of our time in a closed environment such as homes, schools and offices makes indoor air quality a cornerstone aspect of our daily life. Semi-volatile organic compounds (SVOCs) are widespread chemicals in the environment and have boiling points ranging from 240°C to 400°C. The existence of particle matters in indoor environment amplifies the volatilization of SVOCs and leads to an increase in the overall concentration of SVOCs in the air. This enhancement occurs by facilitating the exchange of SVOCs between their gaseous and particulate phases; a gas-particle partitioning process. Particle properties, including composition, morphology, and size, play a crucial role in regulating the partitioning behavior of SVOCs between gas and particles. For instance, particles with a higher organic content are more readily to absorbing SVOCs compared to inorganic-rich particles. Certain SVOCs are co-emitted with primary fine particles, particularly the particles stemming from combustion-related pollutants. More volatile compounds tend to partition into coarse particles, formed by the growth of primary particles, making them more prevalent in extremely fine particles and coarse particles. On the other hand, less volatile compounds are less likely to volatilize from fine particles, making them dominant in this size fraction.

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Wang, X., Dong, B.

[Long-term experimental evaluation and comparison of advanced controls for HVAC systems.](#)

[Applied Energy](#), Vol. **371**, (2024)

The tremendous energy usage from buildings leads to research studies on their improvement, among which advanced building control plays an important role. In advanced building controls, data-driven predictive control (DDPC), differentiable predictive control (DPC), and reinforcement learning (RL) have shown advantages, but their comparison often lacks in existing studies. The simulation-based prior comparison studies have inconsistent results due to different assumptions and simplifications. Therefore, to comprehensively compare the three advanced strategies for real-time building HVAC controls, we implemented DDPC, specifically, hierarchical DDPC (HDDPC), DPC, and RL in a real building testbed for more than 5 months. The results show that all three advanced controls maintained the indoor environmental quality (IEQ) cost-effectively. Overall, HDDPC outperformed the baseline control with more than 50% energy savings, followed by RL with 48%, and DPC with 30.6%. Most control failures were related to API communication issues. Besides, the information gaps between room and system level controllers and non-optimal control decisions will degrade HDDPC's performance. Such degradation did not happen in DPC and RL, which led to better performance of agent-based control over HDDPC. Moreover, HDDPC needs minutes to make control decisions whereas DPC and RL need milliseconds, indicating higher online computing resources required by HDDPC. For agent training, DPC is faster than RL, as DPC training needs minutes and RL needs hours, but its performance is not as good as RL. This study provides a comprehensive understanding and assessment of the pros and cons of advanced building controls and sheds light on future research on building controls.

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Pattis, A.-L.

[Market analysis bio-based binder particleboards.](#)

Thèse 2024

The adhesion of wood-based composites, such as particleboard used in furniture and flooring, is typically facilitated by the use of certain resins. These resins, which are derived from fossil-based organic materials, are inexpensive and effective, but they raise certain environmental and health concerns.

To address these issues, companies such as Koskisen Oyj are pioneering the use of bio-based binders instead. Their ZERO furniture board uses a bio-based binder, lignin. Lignin is a by-product of the paper manufacturing process and represents a more environmentally sustainable option.

This thesis examines the impact of these changes on the particleboard industry, from its historical development to its future prospects. It also analyses the market in Austria, Germany, Switzerland and Poland.

To achieve this, the thesis combines in-depth research, online data analysis and expert interviews. The aim is to gain a comprehensive understanding of the current state of the particleboard industry, identify future trends and provide a broad overview of the current and future impact of natural binders on the particleboard market.

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Vitaliano, S., Cascone, S., D'urso, P. R.

[Mitigating Built Environment Air Pollution by Green Systems: An In-Depth Review.](#)

[Preprints](#), (2024)

Air pollution is a critical issue impacting urban environments, leading to severe health problems and environmental degradation. This comprehensive review examines the potential of green systems—specifically green walls, active green walls, and urban greenery systems—to mitigate atmospheric pollutants such as particulate matter (PM), volatile organic compounds (VOCs), and carbon dioxide (CO<sub>2</sub>). By systematically analyzing 44 recent studies, the review highlights the pollutant capture efficiency of various green technologies and plant species in both indoor and outdoor settings. Active green walls, particularly those utilizing plant species such as *Chlorophytum comosum* and *Sansevieria trifasciata*, were found to be highly effective, with VOC reduction efficiencies up to 96.34%, PM reductions by 65.42%, and CO<sub>2</sub> reduction rates reaching 4.8% under optimal conditions. The review identifies key strengths in current research, including diverse experimental setups and the use of sophisticated measurement techniques, but also notes significant limitations such as variability in experimental conditions and a lack of long-term performance data. The study underscores the importance of proper maintenance to sustain green systems' efficacy and highlights the potential issue of pollutant resuspension, which remains under-researched. Practical implications for urban planning are discussed, advocating for the integration of effective green systems into urban infrastructure to enhance air quality and public health. Recommendations for future research include the need for standardized metrics, long-term studies, economic feasibility analyses, and real-world validation of simulation models to better understand and optimize green systems for urban air pollution mitigation.

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Wu, T., Tasoglou, A., Wagner, D. N., Jiang, J., Huber, H. J., Stevens, P. S., *et al.*

[Modern buildings act as a dynamic source and sink for urban air pollutants.](#)

[Cell Reports Sustainability](#), Vol. 1 n°(5), (2024)

Summary Urban air undergoes transformations as it is actively circulated throughout buildings via ventilation systems. However, the influence of air exchange between outdoor and indoor atmospheres on urban air pollution is not well understood. Here, we quantify how buildings behave as a dynamic source and sink for urban air pollutants via high-resolution online mass spectrometry measurements. During our field campaign in a high-performance office building, we observed that the building continually released volatile organic compounds (VOCs) into the urban air and removed outdoor ozone and fine particulate matter. VOC emissions from people, their activities, and surface reservoirs result in significant VOC discharge from the building to the outdoors. Per unit area, building emissions of VOCs are comparable to traffic, industrial, and biogenic emissions. The building source-sink behavior changed dynamically with occupancy and ventilation conditions. Our results demonstrate that buildings can directly influence urban air quality due to substantial outdoor-indoor air exchange.

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Wang, X., Wang, Q., Yoo, S.-J., Gomyo, T., Sotokawa, H., Chung, J., *et al.*

[Multi-layered ventilation duct system for heat exchange with air purification.](#)

[Building and Environment](#), Vol. 262, (2024)

In a typical house with a mechanical ventilation system, a ventilation duct with a certain installation length is placed along the exterior walls or in the ceiling shed space. To effectively use this ventilation duct, we aimed to develop a novel ventilation duct system with sensible heat exchange and passive air purification mechanisms. The proposed ventilation

duct comprises multiple layers of a counterflow heat recovery ventilator (HRV). Baffles were installed in the middle of the flow channel to collect particles in the outdoor air by forming a circulating flow associated with the separation flow and gravitational settling in a local domain in the flow channel. To optimize the design of this new ventilation duct concept in terms of particle removal and heat exchange efficiencies, we conducted a computational fluid and particle dynamics analysis as a function of design parameters such as airflow rate, particle size, and air temperature. Through a series of numerical analyses, differences in the heat exchange efficiency and effectiveness of particle removal corresponding to different baffle designs were quantitatively evaluated, and finally, the optimal design for the air channel as an HRV was determined.

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Jeong, S.-G., Kim, S., Hong, S., Lee, J.

[Multi-sensor monitoring and analysis of indoor pollutant emissions in response to laser cutter operating conditions.](#) *Environmental Pollution*, Vol. **357**, (2024)

This study analyzed pollutant emissions from laser cutters used in modeling in a laboratory, which can have harmful effects on indoor air quality and health. Four conditions were tested: material thickness, laser cutter strength, minimum strength per thickness, and air purifier level. Four pollutants were analyzed: PM<sub>2.5</sub>, HCHO, VOCs, and CO<sub>2</sub>. The study found that the emissions of PM<sub>2.5</sub>, HCHO, and VOCs increased with paperboard thickness, while CO<sub>2</sub> emissions were not significant. PM<sub>2.5</sub> was more affected by laser cutting strength, while HCHO and VOCs were more affected by paperboard thickness. Additionally, we analyzed the PM<sub>2.5</sub> emission rates based on the thickness of the paperboard and the laser cutting strength. Therefore, emission rates based on thickness and laser cutting strength ranged from 7275 to 18,783 µg/min. The air purifier significantly reduced PM<sub>2.5</sub> but not HCHO and VOCs. To reduce these gaseous pollutants, combining mechanical ventilation or using an air purifier with a filter that adsorbs HCHO and VOCs is effective. This study highlights the importance of considering laser cutters as a potential source of indoor air pollutants and implementing measures to mitigate their harmful effects.

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Latifah, A., Supangkat, S. H., Leksono, E., Indraprastha, A.

[Navigating the Future of Building Management: A Deep Dive into Prescriptive Digital Twins.](#) *Preprints*, (2024)

This paper presents the development of a prescriptive digital twin model designed to optimize building environments by leveraging advanced smart technologies such as machine learning, artificial intelligence, cloud computing, and the Internet of Things. The study identifies critical factors affecting user activities, including lighting, HVAC, indoor air quality, and acoustics, and incorporates these into the model to enhance user productivity and comfort in workspaces. Our findings demonstrate that the integration of smart technologies can significantly improve workspace efficiency and user satisfaction, providing actionable insights for future implementations. This study not only highlights the potential benefits of prescriptive digital twins in smart buildings but also emphasizes the importance of comprehensive data gathering and analysis from various sources to support further research. Ultimately, our work offers valuable contributions to the field of building management and underscores the need for continued exploration of digital twin technologies.

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Qin, M., Rasmussen, O. S., Chen, J., Wadsö, L.

[Novel MOF-based autonomous humidity control materials for energy-efficient indoor moisture regulation.](#) *Building and Environment*, Vol. **261**, (2024)

The concept of autonomous humidity control material (AHCM) is inspired by phase change material. AHCM is a new type of functional sorbent material. It can adsorb/release sufficient water vapor at the target relative humidity level and autonomously maintain the indoor relative humidity at a set value/range without external intervention, which cannot be achieved by conventional sorbents (e.g., zeolite, silica gel, etc.). In this study, a novel metal-organic framework (MOF) based AHCM is prepared, and its application for energy-efficient indoor moisture control has been investigated. The new MOF-AHCM has an S-shaped water vapor isotherm, large porosity, and high moisture adsorption capacity. The trigger points for adsorption and desorption occur at 60 % and 40 % RH, respectively. It means MOF-AHCM can autonomously regulate the indoor relative humidity to fall within 40%–60 % RH, which fits the thermal comfort range

recommended by ASHRAE well. The physicochemical and hygrothermal characteristics of the synthesized MOF-AHCM have been assessed. Full-scale chamber tests were carried out to verify the humidity control ability of the new material. The experimental results show that MOF-AHCM can significantly mitigate indoor humidity fluctuation and regulate the humidity level within the target range autonomously. Furthermore, numerical simulation has been performed to investigate the impact of MOF-AHCM on building energy consumption in different moisture regions globally, namely, arid, semiarid, dry, moist, and wet areas. The results reveal that MOF-AHCM has an excellent humidity control capacity and can reduce the latent cooling demand of HVAC systems in most climates, especially in arid, semiarid, dry, and moist areas.

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Wang, L., Yu, W., Zhou, H., Zhang, Y., Guo, M., Li, B., *et al.*

[Numerical prediction model for long- and short-term concentration of indoor volatile organic compounds from building materials.](#)

*Environmental Technology*, (2024), 1-12 p.

Emission models of volatile organic compounds (VOCs) from individual indoor building materials have been developed and validated. However, multiple indoor building materials release VOCs simultaneously, and neither single building material nor multiple building material emission models can predict the entire release cycle of VOCs accurately. This study established a long- and short-term numerical prediction model for indoor VOC concentration. The model includes an attenuation coefficient  $\theta$ . To describe the decay rate of the total VOC content, which is mainly influenced by time, and by designing experiments and testing in environmental warehouses under different seasonal conditions, the value of  $\theta$  was first obtained. Then, after successfully plotting the emission curve of indoor pollutant concentration over time through numerical solution and using  $\theta$ , the VOC content was corrected for various seasonal conditions. On the basis of this model, an exposure dose integration algorithm was proposed to evaluate the environmental health risks, as an application of this model. In comparison with previous research results and experimental data, this model has better predictive performance.

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Wang, L. X., Yu, W., Zhou, H. X., Zhang, Y., Guo, M., Li, B. Z., *et al.*

[Numerical prediction model for long- and short-term concentration of indoor volatile organic compounds from building materials.](#)

*Environmental Technology*, (2024)

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Chandra, S., Bricknell, L., Makiela, S., Bruce, S., Naweed, A.

[Odour and indoor air quality hazards in railway cars: an Australian mixed methods case study.](#)

*Journal of Environmental Health Science and Engineering*, (2024)

This case study aimed to diagnose the cause(s) of a seasonal, and objectionable odour reported by travellers and drivers in the railway cars of Australian passenger trains. The research questions were to: (1) identify whether significant microbial colonisation was present within the air handling system of trains and causing the odours; to (2) identify other potential sources and; (3) remedial options for addressing the issue.

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Deng, H. F., Qiu, J., Zhang, R. Q., Xu, J. L., Qu, Y. K., Wang, J. X., *et al.*

[Ozone Chemistry on Greasy Glass Surfaces Affects the Levels of Volatile Organic Compounds in Indoor Environments.](#)  
*Environmental Science & Technology*, Vol. **58** n°(19), (2024), 8393-8403 p.

The chemistry of ozone (O<sub>3</sub>) on indoor surfaces leads to secondary pollution, aggravating the air quality in indoor environments. Here, we assess the heterogeneous chemistry of gaseous O<sub>3</sub> with glass plates after being 1 month in two different kitchens where Chinese and Western styles of cooking were applied, respectively. The uptake coefficients of O<sub>3</sub> on the authentic glass plates were measured in the dark and under UV light irradiation typical for indoor environments (320 nm <  $\lambda$  < 400 nm) at different relative humidities. The gas-phase product compounds formed upon reactions of O<sub>3</sub> with the glass plates were evaluated in real time by a proton-transfer-reaction quadrupole-interface time-of-flight mass spectrometer. We observed typical aldehydes formed by the O<sub>3</sub> reactions with the unsaturated fatty acid constituents of cooking oils. The formation of decanal, 6-methyl-5-hepten-2-one (6-MHO), and 4-oxopentanal (4-OPA) was also observed. The employed dynamic mass balance model shows that the estimated mixing ratios of hexanal, octanal, nonanal, decanal, undecanal, 6-MHO, and 4-OPA due to O<sub>3</sub> chemistry with authentic grime-coated kitchen glass surfaces are higher in the kitchen where Chinese food was cooked compared to that where Western food was cooked. These results show that O<sub>3</sub> chemistry on greasy glass surfaces leads to enhanced VOC levels in indoor environments.

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Link, M. F., Robertson, R. L., Shore, A., Hamadani, B. H., Cecelski, C. E., Poppendieck, D. G.

[Ozone generation and chemistry from 222 nm germicidal ultraviolet light in a fragrant restroom.](#)  
*Environmental Science: Processes & Impacts*, Vol. **26** n°(6), (2024), 1090-1106 p.

Devices using 222 nm germicidal ultraviolet light (GUV222) have been marketed to reduce virus transmission indoors with low risk of occupant harm from direct UV exposure. GUV222 generates ozone, an indoor air pollutant and oxidant, under constrained laboratory conditions, but the chemistry byproducts of GUV222-generated ozone in real indoor spaces is uncharacterized. We deployed GUV222 in a public restroom, with an air change rate of 1 h<sup>-1</sup> one weekend and 2 h<sup>-1</sup> the next, to measure ozone formation and byproducts generated from ozone chemistry indoors. Ozone from GUV222 increased background concentrations by 5 ppb on average for both weekends and reacted rapidly (e.g., at rates of 3.7 h<sup>-1</sup> for the first weekend and 2.0 h<sup>-1</sup> for the second) with gas-phase precursors emitted by urinal screens and on surfaces. These ozone reactions generated volatile organic compound and aerosol byproducts (e.g., up to 2.6  $\mu\text{g m}^{-3}$  of aerosol mass). We find that GUV222 is enhancing indoor chemistry by at least a factor of two for this restroom. The extent of this enhanced chemistry will likely be different for different indoor spaces and is dependent upon ventilation rates, species and concentrations of precursor VOCs, and surface reactivity. Informed by our measurements of ozone reactivity and background aerosol concentrations, we present a framework for predicting aerosol byproduct formation from GUV222 that can be extended to other indoor spaces. Further research is needed to understand how typical uses of GUV222 could impact air quality in chemically diverse indoor spaces and generate indoor air chemistry byproducts that can affect human health.

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Subri, M. S. M., Arifin, K., Sohaimin, M. F. a. M., Abas, A.

[The Parameter of the Sick Building Syndrome: A Systematic Literature Review.](#)

[Heliyon](#), (2024)

Sick Building Syndrome (SBS) is a collection of symptoms assumed to be related to spending time in a certain building, most typically a workplace, but no specific cause has been identified. The need to measure and assess various types of parameters of SBS is crucial and it is important to explore what parameter has been used in the previous studies of SBS. Therefore, this study aims to systematically review the parameter that has been used to monitor the SBS. This study was conducted using the PRISMA Statement and the search was conducted using two scientific databases which were Scopus and Web of Science. After a thorough and tight process, a total of 55 articles have been finalized and selected for thematic analysis. Two themes have been identified which were a) Indoor Environmental Quality (IEQ) and b) Occupant. This study also found that the spatial distribution pattern revealed that the Sick Building Syndrome research was spread over 26 nations, with the majority of articles originating from the United States and China. In terms of context, the majority of the selected publications employed the survey approach to investigate SBS parameters. Aside from that, the most researched form of building is the business building. This study has found that it would be more impactful for the SBS study if researchers could incorporate both indoor environmental quality and occupant factors into a study, resulting in more holistic conclusions.

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Robin, Y.

[The potential of deep learning for gas sensor evaluation and calibration.](#)

Saarländische Universitäts-und Landesbibliothek. Thèse 2024

Metal oxide semiconductor gas sensors are promising candidates for selectively measuring harmful pollutants indoors. However, they suffer from their lack of selectivity, sensor-to-sensor variance, and drift over time. Advanced calibration and operation modes are required to overcome some of these sensor drawbacks. During calibration, the sensor is exposed to many gas mixtures to build robust, data-driven models. Based on the sensor response, these models deduce the target gas concentration present. Special operation modes like temperature-cycled operation are used to gain additional information from the transient behavior of the sensor. However, calibration can be costly, time-consuming, and complicated, even without complex operation modes. Within this thesis, a new data-driven model for the evaluation and calibration of metal oxide semiconductor gas sensors is introduced. The newly developed model, TCOCNN, is a multi-layer convolutional neural network. Together with methods from the field of deep learning, like transfer learning, it is possible to tackle long calibration times and sensor-to-sensor variation. It was shown that it is possible to reduce the calibration time by up to 99.3 % and significantly reduce the influence of sensor-to-sensor variance. In some aspects, the TCOCNN surpasses state-of-the-art methods and provides insights into the model's inner workings, the temperature cycle, and the sensor itself.

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Mishra, A., Mishra, S., Tripathi, S. K., Roy, B., Ghosh, R., Upadhyay, C., *et al.*

[Progress in Ventilated Walls and Double-Skin Facades for Sustainability.](#)

[Thermal Evaluation of Indoor Climate and Energy Storage in Buildings](#), (2025), 79-98 p.

A sustainable house, also known as a green house or an eco-friendly house, is a residential building that was designed to have a minimally negative impact on the surrounding environment and to encourage sustainable living. Ventilated double-skin facades, also known as VDFs, make use of the thermal interaction that occurs between the interior and exterior of a building in order to reduce the amount of energy used for heating and cooling as well as the emissions of

greenhouse gases. Building a sustainable house requires a holistic approach considering the house's design, materials, systems, and lifestyle choices. It's also important to note that local climate, regulations, and available resources may influence the specific strategies and technologies used in constructing a sustainable house. VDFs incorporate various strategies and technologies to reduce energy consumption, conserve natural resources, minimize waste generation, conserve water, understand biodiversity, and create a healthy and comfortable living environment. They also provide natural ventilation, daylight, and thermal and acoustic insulation, depending on parameters. The thermal behavior, influencing parameters, and classification criteria of VDFs are discussed. This chapter discusses several key features and considerations of a sustainable house through a circular economy.

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Link, M. F., Robertson, R., Claflin, M. S., Poppendieck, D.

[Quantification of Byproduct Formation from Portable Air Cleaners Using a Proposed Standard Test Method.](#)  
Environmental Science & Technology, Vol. 58 n°(18), (2024), 7916-7923 p.

In response to the COVID-19 pandemic, air cleaning technologies were promoted as useful tools for disinfecting public spaces and combating airborne pathogen transmission. However, no standard method exists to assess the potentially harmful byproduct formation from air cleaners. Through a consensus standard development process, a draft standard test method to assess portable air cleaner performance was developed, and a suite of air cleaners employing seven different technologies was tested. The test method quantifies not only the removal efficiency of a challenge chemical suite and ultrafine particulate matter but also byproduct formation. Clean air delivery rates (CADRs) are used to quantify the chemical and particle removal efficiencies, and an emission rate framework is used to quantify the formation of formaldehyde, ozone, and other volatile organic compounds. We find that the tested photocatalytic oxidation and germicidal ultraviolet light (GUV) technologies produced the highest levels of aldehyde byproducts having emission rates of 202 and 243  $\mu\text{g h}^{-1}$ , respectively. Additionally, GUV using two different wavelengths, 222 and 254 nm, both produced ultrafine particulate matter.

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Van Quang, T., Doan, D. T., Yun, G. Y.

[Recent advances and effectiveness of machine learning models for fluid dynamics in the built environment.](#)  
International Journal of Modelling and Simulation, (2024), 1-27 p.

Indoor environmental quality is crucial for human health and comfort, necessitating precise and efficient computational methods to optimise indoor climate parameters. Recent advancements in machine learning (ML) and computational fluid dynamics (CFD) are promising. However, applying ML to complex building airflow presents challenges. This research aims to investigate the integration of ML with CFD in the context of built environment applications using a systematic review approach. It highlights a critical knowledge gap: the need to synthesise innovative approaches that address the limitations of indoor modelling using data-driven ML methods. The review examines contemporary literature, identifying current developments and suggesting potential future directions. It delves into the innovations in combining ML with CFD to predict thermal comfort and indoor air quality, uncovering key limitations such as the lack of high-quality experimental data for training and validation, the computational complexity of detailed CFD simulations, and the interpretability issues of 'black-box' ML models. The emergence of data-driven techniques in fluid mechanics offers promising prospects for modelling in the built environment. Future research should focus on incorporating physics-based rules in ML models, adapting turbulence closure models for indoor flows, and enhancing model validation using real-world datasets. The research emphasises the synergistic relationship between ML and CFD; it proposes pathways to overcome current limitations, aiming to enhance the precision and efficiency of indoor environment modelling through their integration.

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Akhter, P., Arshad, A., Hussain, M.

[A review on environmental impacts of paints and strategies for producing eco-friendly-paints.](#)  
International Journal of Environmental Science and Technology, (2024)

Painting the variety of surfaces have been practices from ancient times in domestic and on industrial level. From a chemistry perspective, paints are widely used in homes, businesses, school buildings, industrial machinery, and automobiles. Smart manufacturing has a lot to offer in the paint and coatings sector which depends on the plasticizers,

pigment dispersions, organic and aqueous solvents, polymer resins, and other additives that make up a modern paint/coating product. Mixing, grinding, milling, filling, and storage performance should be the major elements of the paint producing method. During the manufacturing process, the quality products, the primary testing for density, viscosity, and concealment is forwarded to the laboratory for further inspection to obtain a desired product. There are also a variety of trials, as well as the possibility of washing and challenges occurred in quality control (QC) testing. Owing to vast applications of paint, serious negative effects have been observed on human health, including headaches, the induction of allergies, asthmatic reactions, irritation of the skin and eyes, and increased strain on the heart. In addition to that, paint and its byproducts may cause lethal effects to both human beings and the environment, which on the other hand create serious environmental pollution. Review emphasizes the formulation, manufacturing steps, causes of failure, environmental pollution, and negative human health issues.

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Tan, H., Othman, M. H. D., Kek, H. Y., Chong, W. T., Nyakuma, B. B., Wahab, R. A., *et al.*

[Revolutionizing indoor air quality monitoring through IoT innovations: a comprehensive systematic review and bibliometric analysis.](#)

*Environmental Science and Pollution Research*, (2024)

Indoor air quality (IAQ) in the built environment is significantly influenced by particulate matter, volatile organic compounds, and air temperature. Recently, the Internet of Things (IoT) has been integrated to improve IAQ and safeguard human health, comfort, and productivity. This review seeks to highlight the potential of IoT integration for monitoring IAQ. Additionally, the paper details progress by researchers in developing IoT/mobile applications for IAQ monitoring, and their transformative impact in smart building, healthcare, predictive maintenance, and real-time data analysis systems. It also outlines the persistent challenges (e.g., data privacy, security, and user acceptability), hampering effective IoT implementation for IAQ monitoring. Lastly, the global developments and research landscape on IoT for IAQ monitoring were examined through bibliometric analysis (BA) of 106 publications indexed in Web of Science from 2015 to 2022. BA revealed the most significant contributing countries are India and Portugal, while the top productive institutions and researchers are Instituto Politecnico da Guarda (10.37% of TP) and Marques Goncalo (15.09% of TP), respectively. Keyword analysis revealed four major research themes: IoT, pollution, monitoring, and health. Overall, this paper provides significant insights for identifying prospective collaborators, benchmark publications, strategic funding, and institutions for future IoT-IAQ researchers.

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Kumar, P., Singh, S., Tyagi, E., Pathak, V. M., Gupta, S., Singh, R.

[Role of Gases, VOC, PM2.5, and PM10 in Biological Contamination in Indoor Areas.](#)

In: *Airborne Biocontaminants and Their Impact on Human Health*. 2024. 89-107 p.

Summary Indoor air quality (IAQ) has a significant impact on human health and well-being, considering that individuals spend most of their time indoors. Gases, volatile organic compounds (VOCs), and particulate matter (PM) are well-known contributors to poor IAQ. Currently, there is lack of proper guidelines and regulations to control indoor air pollutants and associated risks. This chapter explores the role of gases, VOCs, fine PM (PM2.5), and coarse PM (PM10) in contributing to biological contamination in indoor areas. It provides an overview of their sources, mechanisms of transport, health effects, and strategies for mitigation. To complete the objective of the study, we reviewed relevant literature, highlighted potential sources of contamination, examined the effects on human health, and discussed strategies to mitigate and improve IAQ. Understanding these factors is essential for developing effective strategies to improve IAQ and protect occupants' health.

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Beniwal, D. K., Kumar, D.

[Scenario of Green Building in India: Development of Sustainable approach.](#)

*IOP Conference Series: Earth and Environmental Science*, Vol. **1326** n°(1), (2024)

This article furnishes a conceptual framework for applying principles of sustainability to the construction industry, The framework is established on sustainable parameters, which include economic, social, and environmental factors. The framework includes resource conservation, Building Bye-Laws, and design for building optimization. Each theory is explained after a thorough bibliographical review, and some initiative steps taken by the central government in India are



presented to clarify the methods and strategies exercised during the life span of construction projects. The development of new technology is changing the way construction professionals think about the information they use to evaluate construction projects. This is because new technology provides a better way to collect and analyze information about construction projects. This enables construction professionals to make more efficient and effective decisions that can save time and money, thus improving the overall performance of the construction industry. The steps needed to be followed from applying to building assessment agencies to get certified according to the points achieved based on building performance. The objective of this paper is to analyze different parameters of sustainable construction, and the steps taken by the Government to embrace the Green Building concept nationwide, This paper also critically evaluates the amendment made in building bye-laws since their introduction in 2004 on both the center and state levels. These green building standards will result in strong political support to help create ecologically sensitive urbanism.

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Selvi, H., Capan, I., Capan, R., Acikbas, Y.

[Sensing volatile organic compounds with CVD graphene: insights from quartz crystal microbalance and surface plasmon resonance studies.](#)

*Journal of Materials Science: Materials in Electronics*, Vol. **35** n°(18), (2024)

This study explores the sensing capabilities of chemical vapor deposition (CVD)-grown graphene in detecting volatile organic compounds (VOCs) through quartz crystal microbalance (QCM) and surface plasmon resonance (SPR) techniques. Two distinct sensing devices were developed, each tailored for QCM and SPR transducing mechanisms, utilizing CVD graphene as the sensing element. The sensors demonstrated consistent and reproducible responses when exposed to various concentrations of dichloromethane, chloroform, carbon tetrachloride, benzene, toluene, and m-xylene. Notably, both sensors exhibited unparalleled sensitivity to dichloromethane, with the graphene-coated SPR sensor displaying a sensitivity value of  $294 \times 10^{-3} \text{ ppm}^{-1}$  and a limit of detection (LOD) value of 10.62 ppm. Additionally, the SPR sensor showcased remarkably swift response and recovery times, both under 3 sec. Results indicate that the adsorption of VOC molecules on the CVD graphene surface increases with the rising dipole moments and vapor pressure values of the molecules. The utilization of CVD graphene in both sensing approaches demonstrates good reproducibility in detecting ultralow concentrations of VOCs at room temperature.

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Meng, J., Balendhran, S., Sabri, Y., Bhargava, S. K., Crozier, K. B.

[Smart mid-infrared metasurface microspectrometer gas sensing system.](#)

*Microsystems & Nanoengineering*, Vol. **10** n°(1), (2024)

Smart, low-cost and portable gas sensors are highly desired due to the importance of air quality monitoring for environmental and defense-related applications. Traditionally, electrochemical and nondispersive infrared (IR) gas sensors are designed to detect a single specific analyte. Although IR spectroscopy-based sensors provide superior performance, their deployment is limited due to their large size and high cost. In this study, a smart, low-cost, multigas sensing system is demonstrated consisting of a mid-infrared microspectrometer and a machine learning algorithm. The microspectrometer is a metasurface filter array integrated with a commercial IR camera that is consumable-free, compact ( $\sim 1 \text{ cm}^3$ ) and lightweight ( $\sim 1 \text{ g}$ ). The machine learning algorithm is trained to analyze the data from the microspectrometer and predict the gases present. The system detects the greenhouse gases carbon dioxide and methane at concentrations ranging from 10 to 100% with 100% accuracy. It also detects hazardous gases at low concentrations with an accuracy of 98.4%. Ammonia can be detected at a concentration of 100 ppm. Additionally, methyl-ethyl-ketone can be detected at its permissible exposure limit (200 ppm); this concentration is considered low and nonhazardous. This study demonstrates the viability of using machine learning with IR spectroscopy to provide a smart and low-cost multigas sensing platform.

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Johari, M. H. H., Abdul Rahman, M. F.

[Study on Indoor Air Quality \(IAQ\) Level and Sick Building Syndrome \(SBS\) at Dato' Muhamad Salleh Perang Office Building.](#)

*Progress in Engineering Application and Technology*, Vol. **5** n°(1), (2024), 635-645 p.

This study focuses the significant impact of poor Indoor Air Quality (IAQ) on the health and productivity of office building occupants, particularly in relation to Sick Building Syndrome (SBS), emphasizing the need for comprehensive research, adherence to IAQ regulations, and a focus on multiple IAQ parameters to create healthier work environments. This study aimed to assess Indoor Air Quality (IAQ) in the Dato' Muhamad Salleh Perang Building, identifying Sick Building Syndrome (SBS) symptoms, measuring IAQ parameters, and proposing practical solutions for a healthier office environment. The study employs quantitative methods, including IAQ measurements and SBS questionnaires, to thoroughly assess Indoor Air Quality (IAQ) and determine the prevalence of Sick Building Syndrome (SBS) symptoms among occupants in the Dato' Muhamad Salleh Perang Office Building. The findings showed that temperatures and RH were generally within acceptable ranges, air velocity and gaseous pollutants remained within permissible limits in all offices with low frequency of SBS-related symptoms. These symptoms were categorized into General discomfort, Throat and Chest problems, Nose problems, Skin complications, and Eye-related concerns. However, SBS symptoms highlighted the need for continuous monitoring and improvement efforts. Overall, this study contributes to the understanding of IAQ and SBS issues, offering insights that can inform practices for creating comfortable, safe, and productive workspaces. Future research recommendations include exploring additional IAQ parameters, assessing climate change impacts, and incorporating advanced monitoring tools for more accurate results.

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Zhao, C., Dong, Z., Pan, S., Wu, X., Tang, X.

[Surface Modification of CuFe<sub>2</sub>O<sub>4</sub> Nanotubes with Well-Dispersive Au Nanoparticles for Sensitive and Selective Xylene Gas Detection.](#)

[ACS Applied Nano Materials](#), (2024)

Au-modified CuFe<sub>2</sub>O<sub>4</sub> nanotubes (Au-CuFe<sub>2</sub>O<sub>4</sub> NTs) were synthesized through a combination of electrospinning and liquid precipitation methods, resulting in the uniform surface modification of well-dispersive Au nanoparticles (NPs) with an average diameter of 3.4 nm. Gas-sensing results demonstrated that the Au-CuFe<sub>2</sub>O<sub>4</sub> sensors (0.5–5 wt % Au) exhibited significantly enhanced responses to xylene gas. Specifically, the 2 wt % Au-modified sensor displayed the highest response (38.1 @ 100 ppm xylene) and excellent selectivity at 260 °C. The comprehensive influences of ambient humidity and Au content on the detection capability of xylene using Au-CuFe<sub>2</sub>O<sub>4</sub> NTs were discussed systematically. The superior activity of Au-modified sensors compared to pristine CuFe<sub>2</sub>O<sub>4</sub> NTs was confirmed by their improved recovery characteristics in the presence of a high concentration of xylene. These enhanced sensing performances can be mainly attributed to electronic sensitization of Au and the synergistic catalytic effect of Au and CuFe<sub>2</sub>O<sub>4</sub>, indicating the great potential of Au-CuFe<sub>2</sub>O<sub>4</sub> NTs for sensitive and selective xylene detection.

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El Ashmawy, R. A., Ragheb, A. A., Ragheb, G., Marouf, O.

[Sustainable Design Principles for Green Office Buildings: A Comprehensive Review.](#)

[Planning](#), Vol. 19 n°(6), (2024), 2069-2077 p.

This manuscript addresses the imperative for sustainable building practices, particularly focusing on office buildings, which exhibit high energy consumption rates. Conventional building methods contribute significantly to environmental degradation through energy, water, and raw material usage, alongside waste generation and pollution. In contrast, green buildings offer a paradigm shift towards healthier, resource-efficient models, promoting sustainability and environmental stewardship. Green architecture, a global trend, emphasizes harmonizing building-environment interactions. Architects play a pivotal role in implementing advanced strategies to reduce energy consumption in office buildings, including the integration of renewable energy sources like solar and wind power. This paper highlights sustainable indicators and principles crucial for transforming office buildings into green structures. It underscores the urgency for architects to prioritize energy reduction through renewable sources and electric energy rationalization. Ultimately, the research contributes to advancing the discourse on green building practices, offering practical guidance for architects, policymakers, and stakeholders invested in fostering sustainable development within the built environment.

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Alsamrai, O., Redel-Macias, M. D., Pinzi, S., Dorado, M. P.

[A Systematic Review for Indoor and Outdoor Air Pollution Monitoring Systems Based on Internet of Things.](#)

[Sustainability](#), Vol. 16 n°(11), (2024)

Global population growth and increasing pollution levels are directly related. The effect does not just apply to outdoor spaces. Likewise, the low indoor air quality is also having a negative impact on the health of the building residents. According to the World Health Organization, indoor air pollution is a leading cause of 1.6 million premature deaths annually. Tackling this public health issue, due to the direct relationship between air pollution levels and mortality and morbidity rates as well as overall comfort, is mandatory. Many companies have begun to build inexpensive sensors for use in Internet of Things (IoT)-based applications to pollution monitoring. The research highlights design aspects for sustainable monitoring systems including sensor types, the selected parameters, range of sensors used, cost, microcontrollers, connectivity, communication technologies, and environments. The main contribution of this systematic paper is the synthesis of existing research, knowledge gaps, associated challenges, and future recommendations. Firstly, the IEEE database had the highest contribution to this research (48.51%). The results showed that 87.1%, 66.3%, and 36.8% of studies focused on harmful gas monitoring, thermal comfort parameters, and particulate matter levels pollution, respectively. The most studied harmful gases were CO<sub>2</sub>, CO, NO<sub>2</sub>, O<sub>3</sub>, SO<sub>2</sub>, SnO<sub>2</sub>, and volatile organic compounds. The cost of the sensors was suitable for people with limited incomes and mostly under USD 5, rising to USD 30 for specific types. Additionally, 40.35% of systems were based on ESP series (ESP8266 and ESP32) microcontrollers, with ESP8266 being preferred in 34 studies. Likewise, IoT cloud and web services were the preferred interfaces (53.28%), while the most frequent communication technology was Wi-Fi (67.37%). Indoor environments (39.60%) were the most studied ones, while the share for outdoor environments reached 20.79% of studies. This is an indication that pollution in closed environments has a direct impact on living quality. As a general conclusion, IoT-based applications may be considered as reliable and cheap alternatives for indoor and outdoor pollution monitoring.

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Tan, H., Kek, H. Y., Van Fan, Y., Sheng, D. D. C. V., Lee, C. H., Tan, K. Y., *et al.*

[Systematic Review on Indoor Microplastics: Unveiling Sources, Exposure Pathways, and Human Health Implications.](#)  
*Journal of Advanced Research in Micro and Nano Engineering*, Vol. **20** n°(1), (2024)

Indoor microplastics present a noteworthy and all-encompassing environmental issue that requires careful attention and contemplation. This comprehensive review navigates the intricate landscape of indoor microplastics, investigating their potential sources, pathways of exposure, and implications for human health. Commencing with an exploration of the origins and varieties of polymers within indoor environments, the review dissects commonplace products and manufacturing processes, identifying them as substantial contributors. Subsequent sections elucidate the diverse ways individuals encounter indoor microplastics, encompassing airborne dissemination, ingestion via dust and food, and skin contact with subsequent absorption. The critical evaluation of advancements in detection and measurement techniques addresses the complexities associated with accurately quantifying indoor microplastics. The review scrutinizes potential health risks linked to exposure, emphasizing cumulative effects and the vulnerability of specific populations. Prolonged contact with heightened concentrations of microplastics can bring about various consequences, including oxidative stress, DNA damage, organ dysfunction, metabolic disorders, immune responses, neurotoxicity, and reproductive and developmental toxicity. In the mitigation segment, strategies are outlined to curb microplastic presence at its source, manage indoor air quality, and advocate for policy and regulatory interventions. Identifying future directions and research gaps, the review serves as a roadmap for ongoing investigations. In summary, this study consolidates crucial discoveries, offers suggestions for future research initiatives, and emphasizes the critical need to understand and tackle the intricate network of indoor microplastics to safeguard both human health and environmental well-being.

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Rebekha, M., Anamika, N., Samantha, C., Pratibha, D.

[A systematic review on phytoremediation of indoor air pollution.](#)  
*Journal of Air Pollution and Health*, Vol. **9** n°(2), (2024)

Degradation of Indoor Air Quality (IAQ) due to confined spaces and insufficient ventilation has become a serious concern to human health. Published literature has established phytoremediation as an efficient removal mechanism of indoor air pollutants such as formaldehyde, Benzene, Toluene, Ethyl benzene, Xylene (BTEX), Volatile Organic Compounds (VOCs), and Particulate Matter (PM) using potted plants. This review discusses both conventional and enhanced phytoremediation for removing air pollutants and the parameters influencing the removal efficiencies. A literature review was conducted following the PRISMA guidelines to identify published literature on indoor air

phytoremediation. After eliminating duplicates and reviewing articles, the articles related to indoor air phytoremediation from 2011 to the present were selected. The database was managed using Mendeley reference manager. Indoor air pollutants can be removed efficiently through phytoremediation using potted plants. Chlorophytum comosum removed the broadest range of contaminants, whereas Epipremnum aureum is the frequently used plant species for pollutant removal. Adding enhancing factors to the plant enhances their ability to remove pollutants. Inoculation of plants with soil bacteria such as Bacillus cereus ERBP is the most common enhancement method reported. The present study highlighted advancements in phytoremediation and factors affecting the pollutant removal efficiencies of plants. The findings demonstrated that enhanced phytoremediation is more effective at removing pollutants than the conventional method. Depending on the plant species used, the removal of indoor air pollutants may vary. The findings suggested that a combination of various plant species could be used to remove indoor air pollutants more efficiently.

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Athanasakis, E., Pantelidou, K., Siopis, N., Bizopoulos, P., Lalas, A., Votis, K., *et al.*

[Towards safer indoor spaces: A machine learning based CO2 forecasting approach for smart systems.](#)

2024 IEEE International Conference on Evolving and Adaptive Intelligent Systems (EAIS). 23-24 May 2024. Madrid, Spain

Indoor Air Quality (IAQ) is a significant concern for public health, with indoor air pollution contributing to millions of deaths annually. This research proposes a machine learning (ML) based approach to forecast CO<sub>2</sub> levels indoors, a key indicator of IAQ. By utilizing timeseries forecasting and artificial intelligence (AI) techniques, the study aims to predict CO<sub>2</sub> concentrations in a short term horizon (five minutes) and enhance indoor air quality. Two ML methods, Long Short-Term Memory (LSTM) networks and dilated Convolutional Neural Networks (CNNs), were explored and compared to naive forecasting methods. The best performing model achieved a Mean Absolute Error (MAE) of 4.56 ppm. Results demonstrated the potential of ML-based approaches to accurately predict CO<sub>2</sub> levels, which can be utilized to optimize the use of Heating Ventilation and Air-Conditioning (HVAC) systems for safer indoor spaces.

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Chen, H., Liu, N., Guo, J., Wang, L., Zhang, Y., Wei, J., *et al.*

[Two-parameter C-history method: A fast and accurate method for determining the characteristic parameters of formaldehyde/VOC early-stage emissions from building materials.](#)

*Science of The Total Environment*, Vol. **946**, (2024)

With the worsening indoor air quality in developing countries, more and more attention is being paid to indoor air pollution, especially formaldehyde and volatile organic compounds (VOCs) emitted from indoor building materials. A series of methods, such as the C-history method, have been proposed to determine the mechanistic parameters of formaldehyde and other VOC emissions. However, these methods require a relatively long test duration (at least 3 days) and may yield a multi-solution problem for these parameters. Therefore, we have developed a novel method, the two-parameter C-history method, to overcome these limitations by measuring the two early-stage emission characteristic parameters for formaldehyde/VOCs. The experimental results validate the accuracy of this method for different building materials and showed that the test duration can be substantially shortened to within 12 h. Based on this, we propose a new method to quickly predict the two emission characteristic parameters at different temperatures. We optimize the experimental parameters and discuss their influence to further improve accuracy. This method will be useful in engineering applications.

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Joëlle Goyette, P.

[Unis pour un air sain. Observatoire romand et tessinois de la qualité de l'air intérieur \(ORTQAI\).](#)

*Environnement, Risques & Santé*, Vol. **23** n°(3), (2024), 174-175 p.

Fondé en 2022, l'Observatoire romand et tessinois de la qualité de l'air intérieur (ORTQAI) a pour principale mission de documenter et d'évaluer l'état de la qualité de l'air dans les bâtiments, en s'appuyant sur une approche globale et interdisciplinaire. La qualité de l'air dans les espaces clos, dans lesquels nous passons plus de 80 % de notre temps, est devenue un enjeu important de santé publique. Les logements, écoles, bureaux, lieux de loisirs de même que les moyens de transport sont autant d'espaces de vie considérés par cet observatoire, touchant ainsi l'ensemble de la population, et plus particulièrement les personnes fragiles et sensibles à la pollution de l'air.

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Kolokotroni, M.

[Urban Ventilation.](#)

In: Resilient Urban Environments: Planning for Livable Cities. Springer Nature Switzerland; 2024. 131-147 p.

This chapter focuses on ventilation to achieve satisfactory indoor air quality and provide thermal comfort in urban buildings. The impact of urban specific parameters of air and thermal (urban heat island (UHI)) pollution on building ventilation is outlined. Urban external pollutants are discussed, and simple equations to calculate their concentration indoors are given. The urban heat island is explained and methods to account for this in the design of buildings is outlined. The impact of climate change on urban parameters is presented with suggestions on how this can be considered during the design through the use of appropriate weather files to include climate change and urban microclimate modifications. Case studies are presented with measured and simulated performance of urban ventilation to indicate suitable solutions.

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Zhao, L., Sun, S., Zhang, S., Li, X.

[UV activated formaldehyde gas sensing based on gold decorated ZnO@ In2O3 hollow nanospheres at room temperature.](#)

Sensors and Actuators B: Chemical, Vol. **417**, (2024)

Using uniform carbon nanospheres as sacrificial templates, gold nanoparticle-modified ZnO@ In2O3 hollow nanospheres with controlled dimensions and porous architectures were successfully synthesized through water bath, hydrothermal and chemical reduction methods. Gas sensing evaluation revealed that the Au-decorated ZnO@ In2O3 hollow nanostructures exhibited a dramatically amplified response up to 14.8 when exposed to 10 ppm formaldehyde analyte at room temperature. Furthermore, multifaceted performance benefits of Au-decorated ZnO@ In2O3 over single-phase ZnO, Au-ZnO, ZnO@ In2O3 heterojunction-based composites were observed, including excellent selectivity towards formaldehyde even in complex gas mixtures; tremendous sensitivity enhancement stemming from synergies between efficient gas diffusion through hollow heterojunction nanospheres and accelerated surface reactions at catalytically-active Au sites; and rapid, fully-reversible response/recovery time of 32 s and 42 s, respectively. In-depth investigations were conducted into the fundamental sensing mechanisms enabling formaldehyde detection using AC impedance spectroscopy, in situ diffuse reflectance Fourier transform infrared spectroscopy (DRIFTS), and density functional theory (DFT) computational modeling analyses.

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Tepeneu, A., Chambre, D., Surdea-Blaga, T., Lupitu, A., Moisa, C., Copolovici, D. M., *et al.*

[The Variability of Indoor Air Pollutants in the Office and Their Impact on the Workers' Health.](#)

Polish Journal of Environmental Studies, (2024)

This study examines the dynamics of indoor air quality in an office environment within a metropolis, with a specific focus on particulate matter (PM), formaldehyde, and total volatile organic compounds (TVOCs). The levels of PM concentrations stay constant at a value of  $13.9 \pm 2.9 \mu\text{g}/\text{m}^3$  for PM<sub>2.5</sub> throughout working hours, with a significant impact on human activities. The formaldehyde concentration inside increases thrice during 8 hours, from  $9 \pm 5 \mu\text{g}/\text{m}^3$  to  $27 \pm 14 \mu\text{g}/\text{m}^3$ , primarily from furniture and electronics. The total volatile organic compounds (TVOCs) levels significantly increase from  $0.050 \pm 0.044 \mu\text{g}/\text{m}^3$  at 8.00 to  $0.14 \pm 0.11 \mu\text{g}/\text{m}^3$  at 15.00, which can be attributed to indoor contaminants such as plastics and consumer items. PM concentrations exhibit seasonal fluctuations, with higher levels observed during colder months ( $37 \pm 5 \mu\text{g}/\text{m}^3$  for PM<sub>2.5</sub> in December and  $8 \pm 1 \mu\text{g}/\text{m}^3$  for PM<sub>2.5</sub> in August in the office, mainly due to outdoor contribution. Analysis of settled dust indicates a varied composition, suggesting the presence of both building materials and human activity. Employees exhibit symptoms consistent with Sick Building Syndrome, with a higher prevalence among females. The results emphasize the significance of dealing with variations in indoor air quality and identifying the causes that affect the health of occupants and the well-being of the workplace.

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Schreck, C., Fouquier, A., Rouchier, S., Wurtz, É.

[Ventilation naturelle par ouverture de fenêtre: analyse d'incertitude et de sensibilité dynamique du taux de renouvellement d'air dans le cas d'un bâtiment résidentiel.](#)

Conférence IBPSA France-La Rochelle Oléron-2024.

La capacité d'un bâtiment ventilé naturellement à maintenir le confort thermique de l'occupant dépend du taux de renouvellement d'air atteignable à travers les ouvrants. Le modeler peut alors se demander quel est l'impact de l'incertitude des paramètres tels que les coefficients de décharge (Cd) et coefficients de pression (Cp) sur le résultat en renouvellement d'air. Dans cet article, nous simulons la réponse thermo-aéraulique d'une maison individuelle : deux configurations traversantes et une configuration mono façade sont testées. L'originalité de cet article réside en l'exploration du potentiel de la méthode d'analyse de sensibilité RBD-FAST sur l'étude de la sortie dynamique en renouvellement d'air. Dans notre cas d'étude, les incertitudes de +/-50% dans les coefficients de décharge et dans le choix des coefficients de pression engendrent des incertitudes du même ordre de grandeur sur le taux de renouvellement d'air (jusqu'à +/- 5,6 h<sup>-1</sup>, soit +/- 46% de la valeur). L'analyse des indices de Sobol et variances partielles mettent en évidence le lien entre sensibilité aux paramètres, et vitesses et directions du vent.

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Paolin, E., Strlic, M.

[Volatile Organic Compounds \(VOCs\) in Heritage Environments and Their Analysis: A Review.](#)

Applied Sciences-Basel, Vol. **14** n°(11), (2024)

In the recent years, there has been an increased interest in indoor air quality in heritage environments, specifically in relation to volatile organic compounds (VOCs). These could originate from objects, furnishings, visitors and staff, as well as from olfactory exhibitions. This interest led to a number of studies investigating the "typical" emissions for diverse materials and their impact on the surrounding environment. The analysis of volatile compounds emitted by objects helps in the characterization of the material composition, its conservation history or its degradation processes. This contribution reviews how volatiles are emitted from objects and the commonly used sampling techniques for heritage science applications. A variety of methods are available, from bulk air sample collection to preconcentration using samplers. The commonly studied object types contributing to indoor VOCs are discussed. These include emissions from heritage objects, conservation products, furnishing materials and display cases. Furthermore, olfactory exhibitions are discussed in terms of indoor air quality. Finally, the findings are compared with the current guidelines on indoor volatile concentrations.

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Roy, S., Pan, S., Choudhury, N., Sivaram, S., De, P.

[Water-soluble polymeric probe with tryptophan pendants for formaldehyde sensing.](#)

European Polymer Journal, Vol. **215**, (2024)

Formaldehyde (FA) is a grade-I carcinogen and the most reactive aldehyde in the carbonyl family, posing substantial health hazards. Herein, a water-soluble polymeric probe with side-chain tryptophan pendants is proposed that relies on an FA-induced Pictet-Spengler reaction for FA sensing in an aqueous medium. The polymeric probe shows cyan fluorescence in an aqueous medium after the interaction with FA due to the formation of a  $\beta$ -carboline derivative, confirmed by high-resolution mass spectrum analysis of the product from the model reaction between tryptophan methyl ester and FA. The copolymer's sensitivity to FA in aqueous solutions at the nanomolar level is estimated using the fluorescence titration method, where ~20-fold enhancement in fluorescence intensity is observed within 2 min when 200  $\mu$ M FA is added to the aqueous solution of the copolymer. The probe can selectively detect FA using colorimetric and fluorometric methods with a detection limit as low as 25 nM. The FA-sensing mechanism is studied from the model reaction of tryptophan methyl ester (TME) with FA, and density functional theory (DFT).

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Konstantinou, A.

[Investigation of the relation of ventilation with indoor air quality and energy consumption of the Royal Theater of Thessaloniki.](#)

The International Hellenic University (IHU). Thèse 2024

The Royal Theater of Thessaloniki, a historical landmark steeped in cultural significance, stands as a testament to the city's rich heritage and architectural splendor. Its grandeur and elegance have enraptured audiences for decades, hosting a myriad of performances ranging from classical operas to contemporary theatrical productions. However, amidst its majestic ambiance lies a pressing concern - the need to ensure optimal thermal comfort and indoor air quality for both performers and spectators alike. In this essay, entitled "Investigating Ventilation for Assessing Thermal Comfort and Air Quality in the Royal Theater of Thessaloniki," we embark on a journey to explore various ventilation scenarios aimed at enhancing the overall environmental conditions within this iconic venue. The Royal Theater of Thessaloniki, a historical landmark steeped in cultural significance, stands as a testament to the city's rich heritage and architectural splendor. Its grandeur and elegance have enraptured audiences for decades, hosting a myriad of performances ranging from classical operas to contemporary theatrical productions. However, amidst its majestic ambiance lies a pressing concern - the need to ensure optimal thermal comfort and indoor air quality for both performers and spectators alike. In this essay, entitled "Investigating Ventilation for Assessing Thermal Comfort and Air Quality in the Royal Theater of Thessaloniki," we embark on a journey to explore various ventilation scenarios aimed at enhancing the overall environmental conditions within this iconic venue. Ventilation plays a pivotal role in maintaining a conducive indoor environment, influencing factors such as temperature, humidity, and air purity. In the context of the Royal Theater, where a delicate balance between architectural heritage and modern comfort must be struck, the significance of effective ventilation becomes even more pronounced. As the theater welcomes patrons through its ornate doors, it undertakes a silent promise to provide an experience that transcends the boundaries of artistic expression, encompassing the realms of comfort and well-being. Against this backdrop, our investigation assumes paramount importance, seeking to evaluate the efficacy of different ventilation strategies in addressing the dual concerns of thermal comfort and indoor air quality. By analyzing various scenarios, ranging from natural ventilation methods to sophisticated mechanical systems, we endeavor to unravel the optimal approach tailored to the unique characteristics of the Royal Theater. Through meticulous observation, data collection, and analysis, we aspire to unveil insights that not only enhance the operational efficiency of the theater but also foster an environment conducive to creativity, enjoyment, and overall satisfaction. The Royal Theater's historical significance imbues our study with a sense of reverence and responsibility, compelling us to tread carefully while navigating the intricacies of its architectural heritage. In doing so, we acknowledge the need for a balanced approach that respects tradition while embracing innovation, ensuring that our quest for improved ventilation remains harmonious with the theater's storied past. Moreover, as stewards of environmental sustainability, we recognize the imperative to minimize energy consumption and mitigate ecological impact without compromising on comfort or air quality. Thus, our investigation transcends mere technical analysis, encompassing a broader ethos of responsible stewardship aimed at safeguarding both the cultural legacy of the Royal Theater and the natural world it inhabits. In the pages that follow, we delve into the intricacies of ventilation design, exploring its nuances, challenges, and opportunities within the context of the Royal Theater of Thessaloniki. Through empirical inquiry and theoretical discourse, we aim not only to unravel the mysteries of thermal comfort and indoor air quality but also to inspire a newfound appreciation for the symbiotic relationship between architectural heritage and environmental well-being. As we embark on this intellectual odyssey, guided by the spirit of inquiry and fueled by a passion for excellence, we invite readers to join us in this quest for knowledge, understanding, and innovation. Together, let us illuminate the path towards a brighter, more sustainable future for the Royal Theater and all who grace its hallowed halls.

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