
# Bulletin de veille QAI
# N°02-2025 – 11/02/2025

Objectif : *Qualité de l'air intérieur*

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# Google Scholar, Lens, WoS

Nulty, A. B.

**Assessing the Occupational and Environmental Risks of Resin-Based 3D Printing in Dental Clinics: Airborne Chemical Emissions and Mitigation Strategies.**

Medical Research Archives; Vol 12 No 12 (2024): Vol.12 Issue 12 December 2024, (2024)

Resin-based 3D printing has become a pivotal technology in digital dentistry, enabling the production of highly customised dental models, prostheses, and orthodontic devices. Despite its advantages, the adoption of this technology raises significant occupational and environmental concerns due to the emission of volatile organic compounds and particulate matter, which can negatively impact indoor air quality and the health of dental professionals. This literature review synthesises findings from existing research to assess the airborne hazards associated with resin-based 3D printing in dental clinics. It identifies the types and concentrations of emissions, explores their health implications, and evaluates strategies to mitigate associated risks. Recommendations include the implementation of enhanced ventilation systems, advanced air filtration technologies, and best practices for material handling and disposal. The review also highlights the need for safer printing materials and improved emission monitoring systems to further safeguard dental professionals and their work environments as the field evolves.

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Nor Haida Azwa Binti, M., J, N. R., Dewika, M., Sara, Y. Y., Norfatiha, I., Nur Aqilah, S.

**Environmental Influences on Microplastics and Particulate Matter Resuspension in Indoor Air: A Study of Office Settings with Air Conditioning.**

Malaysian Journal of Catalysis, Vol. **8** n°(2), (2024), 44-49 p.

<p>This study investigates airborne microplastics (MPs) in office environments, with a particular focus on spaces with air conditioning (AC), due to increasing health concerns. The research aims to analyze the physical characteristics, sources, distribution, and potential health risks of MPs. Despite growing awareness of MP pollution, comprehensive data on their specifics in office settings—such as shape, composition, and size—remains limited. Between November 2023 and January 2024, 42 air samples were collected under controlled conditions, both with and without AC, at the Air Resource Research Laboratory, Universiti Teknologi Malaysia Kuala Lumpur Campus. Stereomicroscopy was employed to identify the MPs' physical properties, revealing a dominance of bead-shaped MPs in air-conditioned spaces, with smaller particles (<50µm), often transparent or black, being the most prevalent. Environmental factors like wind speed and humidity were found to influence MPs' abundance. The study also noted a potential correlation between atmospheric MPs and particulate matter (PM) emissions, suggesting shared sources or accumulation mechanisms. Estimates of daily MPs intake through dust ingestion highlighted associated health risks. This research provides insights into the dynamics of MPs and PM in air-conditioned offices, emphasizing the need for further investigation into their environmental and health impacts. Effective mitigation strategies are crucial for reducing MP and PM exposure, thereby improving indoor air quality and protecting human health.</p>

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Izam, M. N., Razali, N., Yunus, F. a. N., Rahim, M. B., Kasiman, A. R.

**Development of an Integrated IoT-Based Sanitation System for Air Conditioning Split Units.**

Research and Innovation in Technical and Vocational Education and Training, Vol. **4** n°(2), (2024), 121-139 p.

The COVID-19 pandemic underscored the critical importance of effective sanitation methods, particularly in indoor environments where air quality and ventilation significantly influence viral transmission risks. This study introduces an innovative Integrated IoT-Based Sanitation System for Air Conditioning Split Units designed to enhance indoor air quality and reduce the transmission risk of airborne diseases, including COVID-19. The system automates sanitation by leveraging Internet of Things (IoT) technology, utilising real-time environmental data to optimise disinfection protocols. The system was conceptualised, designed, developed, and evaluated through a rigorous research methodology encompassing the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) and quantitative analysis for efficiency, safety, and user satisfaction. Key findings demonstrate the system's effectiveness in distributing sanitising agents through split unit air conditioning systems, significantly improving indoor air quality. The IoT-enabled features allow for remote monitoring and control, ensuring precise and timely activation of the sanitation process. Through expert analysis and Content Validity Index (CVI) methods, the evaluation revealed strong consensus on the system's design quality, functional efficacy, and potential for widespread application in various indoor settings. Despite the positive feedback, minor areas for improvement in design neatness and component arrangement were identified, offering directions for future enhancements. Integrating IoT technology with air sanitation significantly advances public health measures, providing a novel approach to mitigating airborne transmission risks in enclosed spaces. The system's scalability and adaptability underscore its potential in addressing current and future health challenges, positioning it as a crucial tool in the ongoing fight against airborne diseases.,

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Torriani, G., Torresin, S., Albatici, R., Babich, F.

**Influence of building- and occupant-related factors on perceived air quality (PAQ) in offices: A systematic review.**

Journal of Building Engineering, Vol. **100**, (2025)

Achieving good Indoor Air Quality (IAQ) in offices goes beyond protecting health; it also enhances comfort, enjoyment, and productivity. While much of the existing literature focuses on how environmental factors (e.g., contaminants, thermal, visual, and acoustic parameters) affect Perceived Air Quality (PAQ), fewer studies have comprehensively explored the influence of building-related (e.g., finishing materials) and occupant-related (e.g., socio-demographic) factors. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, this review critically analyses the existing evidence (39 field and laboratory studies) on building- and occupant-related factors that influence PAQ satisfaction in office buildings and their implications for building design and management. According to the review results, building-related factors affecting PAQ satisfaction include HVAC systems, personal comfort systems, operable windows, emissions from furniture and materials, building and office types, and workplace location within the building. Occupant-related factors include socio-demographics, building tenure, country, occupancy rates, and habits such as eating or cleaning. Moreover, the perceived and actual control over the indoor environment significantly influences PAQ satisfaction. Notably, non-IEQ factors like office layout and ventilation rates have a major impact on PAQ, with enclosed private offices increasing satisfaction by 88 % compared to open spaces without partitions and increasing ventilation rates from 3 to 20 L/s per person boosting satisfaction by 63 %. The study promotes a holistic approach to building design and management, empowering all professionals involved (e.g., mechanical engineers, architects, building managers) by highlighting the influence their individual choices can have on PAQ satisfaction.

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Riffat, S., Ahmad, M. I., Shakir, A.

**Zero-Energy and Low Carbon Buildings**.

In: Sustainable Energy Technologies and Low Carbon Buildings. Springer Nature Switzerland; 2025. 219-258 p.

As the global focus shifts toward combating climate change, zero-energy and low-carbon buildings have emerged as essential components of sustainable urban development. This chapter explores the innovative design and technological advancements driving the development of zero-energy and low-carbon buildings. It examines strategies aimed at reducing energy consumption while enhancing environmental sustainability, focusing on energy-efficient insulation, passive solar heating, and the integration of renewable energy systemsRenewable energy systems such as solar and wind power. Additionally, it highlights the role of smart grids and building energy management systems (BEMSBuilding Energy Management Systems (BEMS)) in optimizing energy use and enabling buildings to contribute to larger energy networks. The chapter provides a global perspective on the adoption of these buildings, particularly in North America, Europe, and Asia, where rigorous energy policies and incentives support their growth. Economic and health benefits, including lower operating costs, increased property value, and improved indoor air quality, are discussed, showcasing the comprehensive advantages of zero-energy and low-carbon buildings. As cities worldwide prioritize sustainable development, these buildings are becoming central to urban planning and the creation of resilient, energy-efficient infrastructures.

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Lesan, M., Chahardoli, S., Bhattacharya, A.

**HVAC energy saving through effective air distribution models based on occupancy patterns, exhaust positioning, and ceiling level in a large office**.

18th Conference of the International Society of Indoor Air Quality and Climate, INDOOR AIR 2024

HVAC systems play a crucial role in maintaining comfortable indoor conditions. Building regulations often set minimum standards for air change rates to ensure adequate ventilation and indoor air quality. However, increased ventilation leads to over-conditioning, higher energy consumption, and increased maintenance costs. This study aims to investigate the energy and ventilation performance of a mixing ventilation system for different occupancy patterns and air distribution strategies related to ceiling level and exhaust vent location for optimal indoor environmental quality (thermal comfort and air quality) by integrating CFD with energy simulation. This paper presents the simulation-based study of a large office building with different occupancy patterns in a hot and humid climate. First, models were simulated in CFD software. Then, the results were imported to Energy Plus for annual cooling energy simulations. The results indicate that effective air distribution models lead to 12% annual savings in energy consumption.,

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Álvarez Carpintero, J. D., Hernández, R. O., Camacho Tamayo, J. H.

**Improvement of the hygrothermal environment in non-centrifugal cane sugar production through ventilation systems using computational fluid dynamics.**

Advances in Building Energy Research, Vol., (2025), 1-17 p.

Non-Centrifugal Cane Sugar (NCS) production is an important economic and social factor for rural families who subsist with this activity. In Colombia, the implementation of industrial factories, called ?Centrales? has attempted to improve economy for people who do these activities without technification. Nevertheless, the characteristics of the factories show ventilation problems, generating risks for the workers and the product. Hence, the aim of this study was to assess the existing deficiency in workplace ventilation and its resultant implications, while also presenting an alternative approach to enhance ventilation systems utilizing a Computational Fluid Dynamics (CFD) model. Results show that it is possible to improve the indoor environment for both workers and the NCS product, through natural ventilation strategies. This approach resulted in a reduction of approximately 13% in both temperature and relative humidity levels.

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Paliulis, D., Grubliauskas, R.

**The Analysis of Parameters Affecting Indoor Air Pollution and Noise Levels Under the Applied Theory of Covariance Functions.**

Rocznik Ochrona Środowiska, Vol. **26**, (2024), 658-671 p.

Analysis variations in the intensity of vectors estimating indoor air pollution (PM2.5, PM10 and CO2) and noise levels are presented. The research was conducted in an office room during COVID-19. The theory of covariance functions was used to analyse changes in the intensity of the vectors of determined parameters. The estimates of the cross-covariance functions of digital vectors and the autocovariance functions of the individual vectors of air pollution and noise recording sensor parameters were calculated in line with the random functions of data arrays measuring the vectors of air pollution sensor parameters. The approximations of covariance functions were calculated by changing the quantisation interval on a time scale and applying software created based on the Matlab procedure package. The stochastic interdependence of the vectors of air pollution and noise level recording sensor parameters and variations in vectors on the time scale was established.

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Kuru, Z., Aksoy, K.

**A Review of Breathable Walls and Breathable Paints: Innovations and Sustainability in Building Materials.**

The European Journal of Research and Development, Vol. **4** n°(4), (2024), 58-100 p.

Today's construction industry, are continuous focus on well-designed buildings, with innovation and technology being embraced to meet the evolving demands of modern living standards. Challenges such as urbanization and resource depletion have made it imperative to develop innovative, eco-friendly solutions that not only reduce environmental impact but also enhance indoor environmental quality (IEQ). In this context, breathable walls (BWs) and breathable paints (BPs) have emerged as promising solutions.

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Parker, T., Craig, B., Smith, P., Larrañaga, M.

**Indoor carbon monoxide exposures in a retail occupancy.**

Journal of Occupational and Environmental Hygiene, Vol., (2024), 1-8 p.

In a two-story retail mall in the Southeastern United States, employees within Store A (located on the second level) began to feel headaches and general unease and discussed the symptoms among themselves. Approximately 1.5?hr later, an employee called 9-1-1. Upon arrival, the fire department discovered the presence of carbon monoxide (CO) within Store A and evacuated all employees and customers. As a result of this incident, 13 employees were treated for carbon monoxide poisoning that day, and an additional four employees sought medical attention in subsequent days. This work discusses the events leading up to this incident, which involved welders used for indoor construction on the first level of the mall inside Store B?situated directly below and adjacent to Store A?s east wall. It was determined that carbon monoxide was created by the use of liquified petroleum gas-fueled (LPG) welders on the first story of Store B, which migrated into Store A through unsealed floor penetrations within floor electrical receptacles. From the identified causes, this work proposes strategies to reduce the likelihood of similar incidents occurring in the future.

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Christakis, N., Drikakis, D., Kokkinakis, I. W.

**Advancing understanding of indoor conditions using artificial intelligence methods.**

Physics of Fluids, Vol. **37** n°(1), (2025)

This study presents a novel methodology for optimizing probe placement in indoor air-conditioned environments by integrating computational fluid dynamics simulations with artificial intelligence techniques in an unsupervised learning framework. The “Reduce Uncertainty and Increase Confidence” algorithm

identified spatially distinct thermal and velocity clusters based on temperature and velocity magnitude distributions. Optimization of probe positions within these clusters, guided by sequential least squares programing, resulted in an effective strategy to minimize probe redundancy while maximizing spatial coverage. The methodology highlights the interplay between temperature, relative humidity, velocity, and turbulence intensity, revealing critical insights into airflow behavior and its implications for occupant comfort. The findings of the presented study underscore the potential for targeted probe placement to provide a robust framework for advanced indoor climate control.

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Choi, Y. J., Choi, E. J., Byun, J. Y., Moon, H. J., Sung, M. K., Moon, J. W.

**CO2- and PM2.5-Focused Optimal Ventilation Strategy Based on Predictive Control.**

Indoor Air, Vol. **2025** n°(1), (2025)

This study developed and evaluated an optimal ventilation strategy for variable air volume (VAV) systems, targeting carbon dioxide (CO2) and particulate matter less than 2.5??m in diameter (PM2.5) concentrations. The strategy integrates system-level demand-controlled ventilation (DCV) based on real-time occupancy data and zone-level predictive control using indoor air quality (IAQ) prediction models. By predicting indoor CO2 and PM2.5 levels for the subsequent time step and dynamically adjusting control priorities, optimal airflow is determined. A co-simulation model integrating EnergyPlus, CONTAM, and Python was employed for model training and testing. The proposed strategy was compared with on?off control, CO2 predictive control, and PM2.5 predictive control, demonstrating superior prediction accuracy and stable IAQ maintenance. The optimal ventilation strategy achieved the highest performance, maintaining CO2 and PM2.5 levels below their respective upper limits of 100% and 97.33% of the time. Although this strategy resulted in slightly higher energy consumption compared to the other control algorithms due to its multivariable control approach, it effectively maintained IAQ standards. This method simplifies development and maintenance by circumventing the need for complex optimization, providing a flexible and cost-effective solution for IAQ management. Future research will focus on developing integrated VAV system control strategies that ensure comfort year-round, addressing both energy efficiency and thermal comfort.

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Aazami, R., Moradi, M., Shirkhani, M., Harrison, A., Al-Gahtani, S. F., Elbarbary, Z. M. S.

**Technical Analysis of Comfort and Energy Consumption in Smart Buildings With Three Levels of Automation: Scheduling, Smart Sensors, and IoT.**

IEEE Access, Vol. **13**, (2025), 8310-8326 p.

This paper presents a simulation of a residential building in Ilam, where energy consumption and occupant comfort levels are analyzed across various scenarios. The study identifies optimal conditions for both energy efficiency and resident well-being. By evaluating a residential building, this research compares energy consumption and comfort across basic scheduling, sensor-based control, and advanced IoT-enabled automation levels. Optimal configurations that improve energy savings and occupant comfort are identified, highlighting the effectiveness of IoT integration in HVAC management. The results demonstrate that advanced automation, particularly IoT-based control, offers significant advantages for energy management and comfort optimization in residential buildings.

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Borisov, B., Kuznetsov, G., Maksimov, V., Nagornova, T., Salikhov, F.

**Analysis of Air Exchange System Influence on Thermal and Concentration Modes in the Local Working Area under Radiant Heating Conditions.**

Frontiers in Heat and Mass Transfer, Vol. **22** n°(6), (2024), 1597-1612 p.

One of the effective options for energy saving in terms of heat costs for the formation of routine thermal conditions of working areas of large-sized industrial premises is the replacement of traditional convective (water) heating systems with systems, the main part of which are gas infrared emitters. But the mass introduction of such systems based on emitters was held back until recently by the lack of scientific and technical foundations for ensuring not only the routine thermal conditions of local working areas, but also ensuring acceptable concentrations of carbon dioxide, which is formed during the operation of a gas emitter. Solving the latter problem by the method of experimental selection of heating and air exchange modes is practically impossible due to the multivariate nature of possible solutions to this problem. Therefore, the purpose of the work is to analyze the results of theoretical studies of the possibility of ensuring an acceptable level of carbon dioxide concentrations in local working areas during the operation of gas infrared emitters and an air exchange system. Numerical modeling of heat and mass transfer processes under such conditions was performed in a fairly wide range of the main significant factors: air flow rate in the air exchange system from 0.01 to 0.04 kg/s, the position of the air inlet and outlet channels relative to the radiator and the local workplace (height from 0.3 to 4.1 m). It was found that by varying the numerical values of these factors, it is possible to ensure carbon dioxide concentrations in the local working area within the permissible limits of up to 1400 ppm.

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Breda, J., Tahmasebi, M., Singla, R., Gao, H., Feng, J. D., Casco, L.*, et al.*

**Commercial Building Duct Sealing Market Characterization**.

Report 2024

The California investor-owned utility San Diego Gas & Electric commissioned the research team to conduct a market characterization study evaluating duct sealing technologies in commercial buildings. The research team analyzed and compared a range of duct sealing solutions, from traditional methods like manual taping and mastic application to advanced technologies such as nontoxic aerosol sealant sprays, to identify cost-effective and impactful options to enhance energy efficiency in existing HVAC systems. The research team conducted data collection through literature reviews and interviews with industry experts. Several findings emerged as this study developed, supporting the main premise that HVAC airflow leakage contributes to poor energy performance in existing buildings and that effective duct sealing can help customers achieve energy consumption and cost savings. Conditioned supply air leaking from the ductwork wastes not only fan energy, but also cooling and heating energy in that additional air must be cooled and heated to compensate for leakage. Exhaust air leakage into ductwork impacts fan energy and leads to excess infiltration, in which the conditioned supply air equipment must work harder to overcome the unintended infiltration of warm air in the summer and cold air in the winter.

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Alabi, O. O., Aforolagba–Balogun, O. T., Fasina, A. O., Salisu, S. A., Ladigbolu, T. A., Oyedeji, O.

**Assessing Natural Ventilation Performance of a Lecture Hall.**

Journal of Engineering Research and Reports, Vol. **26** n°(12), (2024), 271-285 p.

The building industry faces growing challenges in improving energy efficiency and achieving environmental sustainability. This study explores the integration of natural ventilation with HVAC (heating, ventilation, and air conditioning) systems as a promising solution for sustainable building design. The primary objective is to evaluate how this integration can balance energy efficiency, indoor air quality, and occupant comfort. Through a review of existing research, real-world applications, and case studies, the study identifies key design strategies—such as building orientation, façade optimization, and intelligent control systems—that enhance the performance of integrated systems. Additionally, the research analyzes the benefits, such as reduced energy consumption and improved occupant well-being, alongside challenges like design complexity and climate adaptability. The findings demonstrate that integrating natural ventilation and HVAC systems can significantly reduce a building's energy use and environmental footprint while promoting healthier indoor environments. This work provides actionable insights for architects, engineers, and building

professionals aiming to design high-performance, sustainable structures that align with environmental and human needs.,

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Moujalled, B., Richieri, F., Mollard, A., Hostein, M.

**Assessment of thermal environment and thermal comfort in air traffic control towers.**

44th AIVC - 12th TightVent - 10th venticool Conference – Dublin, Ireland - 9-10 October 2024

Ensuring thermal comfort in air traffic control towers (ATCTs) is paramount, given the exacting demands of air traffic control, which require heightened levels of concentration and vigilance. ATCTs feature extensive glazed surfaces, leading to significant solar gains and heat loss within the indoor environment. To maintain thermally comfortable conditions throughout the year, air conditioning systems are employed to regulate the indoor climate, adjusting for varying thermal load. However, achieving uniform and stable thermal conditions poses a challenge due to the dynamic thermal loads inherent in the environment.

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Dhamodharan, P., Bakthavatsalam, A. K., Prabakaran, R., Choi, G. S., Kim, S. C.

**Experimental and exergy analysis of air-conditioning condensate energy recovery in HVAC and cold storage units.**

Thermal Science and Engineering Progress, Vol. **59**, (2025)

Air-conditioning (AC) condensate, a valuable source of chilled energy, holds significant potential for energy recovery. Preliminary assessments showed daily condensate collection rates of 0.8–1.1 L/h for split AC (1.5 TR), 34 L/h for packaged AC (88 TR), and 180–195 L for cold storage plants (5000 TR). This study investigates the use of an Air-Water Heat Exchanger (AWHX) and Thermal Energy Storage (TES) system for condensate energy recovery across different air-conditioning capacities. Theoretical analysis (energy and exergy) and pilot experiments were conducted to design an effective condensate energy recovery system. Exergy analysis performed in the AWHX system, reveals the efficiency was improved with increase in temperature from 15 to 20 °C. Likewise, TES-assisted recovery exhibited a decrease in exergy efficiency at high ambient temperatures. Experiments were carried out in packaged AC and cold storage units integrated with a condensate energy recovery system. Additionally, the usefulness of the packaged AC with AWHX and TES was assessed by measuring indoor air quality (IAQ). Condensate with 17 ℃ and 7.5 L/h effectively pre-cooled the air by 3–3.2 °C which significantly improved the IAQ. Similarly, experiments conducted in cold storage units with a TES-based condensate recovery system resulted in 3–4 °C reduction in product temperature. Economic analysis indicated annual energy cost savings of $40, $99, and $32 for systems of split AC, packaged AC, and cold storage, respectively. The packaged AC system exhibited a 57 % greater reduction in environmental impact compared to the cold storage plant, highlighting its environmental sustainability benefits.

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Honma, Y., Shimonosono, K., Azuma, K., Shimazaki, D., Kobayashi, K., Bando, M.*, et al.*

**Temperature, Relative humidity and Indoor Air Quality in office buildings and their subjective evaluation.**

44th AIVC - 12th TightVent - 10th venticool Conference – Dublin, Ireland - 9-10 October 2024

Long-term continuous measurements of temperature, humidity and CO2 concentrations were conducted in offices in three buildings of over 3,000 m² and three non-specified buildings of less than 3,000 m². These measurements were carried out to investigate the effect of the hygrothermal environment in winter and summer, with a particular focus on the impact of humidity in winter and the hot and humid environment when air conditioning is turned off in summer, on microbial contamination. The impact of temperature and

humidity conditions in winter and summer, particularly winter humidity and the high temperature and humidity environment in summer, on microbial contamination was examined.,

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Manikandan, P., Swedheetha, C., Mohan, R. L. R., Kumar, S. L., Reddy, P. D., Sai, P. a. S.

**Intelligent Monitoring System for Automatic Air Conditioning System**.

2024 International Conference on IoT Based Control Networks and Intelligent Systems (ICICNIS). 17-18 Dec. 2024. Bengaluru, India

In order to improve indoor air quality, optimize energy consumption and avoid the accidents due to gas leakage, this paper proposes an intelligent air conditioning system that integrates several sensors such as DHT11, PIR sensors, MG6 Gas sensor and PMS7003 sensor and control mechanisms. An Arduino Mega, the system's central component, synchronizes data from several sensors to efficiently control the air conditioner and other linked equipment. This system keeps track of how many people enter and leave the space, enabling the air conditioning system to modify its settings in real time according to occupancy. When the room is empty, this feature saves energy. If gas leakage is present, system notifies users through a buzzer and turn off the AC. Many users often forget to clean their AC filters regularly, which can lead to reduced efficiency, higher energy consumption, and poorer air quality. Our innovative AC system addresses this common issue. Once the dust level crosses a predefined threshold, the system triggers a clean filter alert, reminding to act before it affects performance. Also, the air conditioner kicks on to cool the room if the outside temperature is high and the inside temperature is higher than an acceptable level. In contrast, the air conditioner is shut off to avoid needless cooling if the inside temperature is low. A display unit shows temperature, humidity, occupancy, gas levels, and dust concentration. This integrated technique automatically modifies the system's operation based on conditions, ensuring not only a more hygienic and comfortable environment but also improved energy efficiency

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Rikalainen, M.

**Product safety of recycled construction and demolition waste plastics.**

LUT University, Finland. Thèse 2024

Finland is committed to the EU recycling goals, but recycling construction and demolition waste (CDW) plastics is challenging due to the variable quality of the material and the presence of potentially harmful substances. The main objective of this thesis was to evaluate the product safety of CDW plastics, focusing particularly on volatile organic compounds (VOCs) and heavy metals.

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Aekarrechai, P., Vongsoasup, N., Charoensin-O-Larn, R.

**Optimizing HVAC System Performance and Comfort: A Numerical Investigation of Air Inlet Placement**.

International Conference on Materials and Energy (ICOME2024). Bangkok, Thailand, October 30-November 1, 2024

Given the significant impact of indoor air quality (IAQ) on human health, regulations and standards have been imposed to maintain high air quality. Conformity with regulations necessitates ventilation, a process that significantly consumes energy. This study employs computational methods to analyze the temperature distribution inside the breathing zone and evaluate the effectiveness of the air supply setup in an office environment. The investigation relies on the widely utilized metric referred to as the age of air. This study analyzes three different inlet configurations while maintaining a constant airflow rate. The results indicate that the age of air decreases when the air inlet is situated in a central location. Conversely, positioning the supply air inlet at the lowest elevation results in the most uniform temperature distribution, which is crucial

for occupant comfort. The findings suggest that changing the airflow rate in systems with minimal air duration can enhance the energy efficiency of HVAC systems.,

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Rodriguez, C., Diaz De Mera, M. D. P., Morales, G., Yahyaoui, I., Cilleros, A.

**New Building Management Systems for Smart Cities: A Brief Analysis of Their Potential**.

In: Urban Pollution - Environmental Challenges in Healthy Modern Cities. IntechOpen; 2025. p.

As our cities continue to grow and develop, the issue of urban pollution has become a growing concern. This problem is causing several environmental challenges that require urgent attention. The rise in greenhouse gas emissions and other toxic pollutants generated by urban areas is damaging the quality of our air and water resources. This poses a severe threat to human health and the infrastructure of our cities. The book "Urban Pollution - Navigating New Frontiers in Healthy Modern Cities" will analyse the challenges posed by urban pollution and provide potential solutions for a sustainable future. The book will cover a wide range of topics on urban pollution, including the complexities of the issue. It will offer insights to policymakers, researchers, and citizens with ideas that can be used to collaborate and create a future where access to clean air and water is a fundamental human right. By implementing these solutions, we can work toward interventions to improve the built environment and promote healthy modern cities. It is our collective responsibility to address this issue and ensure a sustainable future for ourselves and future generations.

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Soonklang, P., Ketsakorn, A., Homkham, N., Chaikittiporn, C., Norkaew, S.

**Comparison of real-time instrument use and absorbent tube method for measuring formaldehyde in working environments: A health risk assessment for gross anatomy staff.**

Toxicology Reports, Vol. **14**, (2025)

Formaldehyde is widely used for the preservation of cadavers, exposing workers to potential risks of formaldehyde exposure in the workplace. This study compared the performance of real-time instruments (Gasmet) and absorbent tube methods in controlling formaldehyde levels in gross anatomy dissections with four working process areas. The concentrations of formaldehyde were determined over working periods ranging from 2 to 5 h. For the Gasmet results, a Monte Carlo simulation was applied in the uncertainty analysis to predict the formaldehyde concentration. Data collection involved questionnaires that included personal and work-related information. The Wilcoxon matched-pairs signed-rank test and intraclass correlation coefficients (ICC) were used to test–retest reliability between the two instruments. The results showed that the Gasmet direct reading and absorbent tube concentrations were not significantly different ($p > 0.05$) in all working areas and ICC was 0.939 indicating a highly reliable test result between the two measurements. The health-risk estimation indicated the hazard quotient and carcinogenic risk of formaldehyde. The carcinogenic risk was found to be unacceptable for all staff and processes, while the hazard quotient was found to be acceptable only in the body injection process. Future studies should employ a larger sample size and a greater number of sampling points to enhance the statistical power and precision of the results. The findings of this study can be used to improve work environments and develop strategies to reduce the risks for staff who work in gross anatomy dissections.

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Quang, T. V., Doan, D. T., Phuong, N. L., Zhang, T., Ghaffarianhoseini, A., Ghaffarianhoseini, A.

**Predicting indoor temperature and humidity in a naturally ventilated office room using long short-term memory networks model in a tropical climate.**

Architectural Engineering and Design Management, Vol., (2024), 1-21 p.

This study evaluates the efficacy of long short-term memory (LSTM) neural networks in predicting indoor temperature and humidity dynamics for naturally ventilated office environments in Ho Chi Minh City, Vietnam (10.8231°N, 106.6297°E). The tropical climate of this location, characterized by consistently warm temperatures year-round, provides a specific context for the model's performance and applicability. A simulated office room model with diverse window opening scenarios was developed using EnergyPlus simulations, generating a synthetic dataset of hourly indoor-outdoor conditions across varying seasons. An LSTM neural network, trained on 70% of the data and tested on the remaining 30%, was employed to forecast indoor temperature and humidity at multiple time horizons. Results indicate that the LSTM achieves near-perfect short-term (1?30 min) predictions, with performance degrading at longer horizons (60?120 min) while remaining competitive with existing approaches. The model effectively captured the strong influence of window opening area and solar irradiance on indoor conditions. A comparison of different window configurations revealed their significant impact on predicted thermal dynamics. Model accuracy was assessed using the coefficient of determination, root mean square error, and mean absolute error metrics. The study demonstrates that LSTM networks can effectively learn complex non-linear building physics to forecast climate in naturally ventilated spaces. With sub-second response times, this approach shows potential for supporting real-time control and optimization of natural ventilation strategies based on probabilistic forecasts, ultimately enhancing occupant comfort and energy efficiency in buildings.

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Roy, M., Bhattacharyya, S.

**Indoor Air Quality in a Tropical City Hospital and Associated Respiratory Infection Risk for Pacemaker Implant Patients.**

Aerosol Science and Engineering, (2025)

Hospitals are supposed to be places of healing, but poor indoor air quality (IAQ) can actually increase the risk of respiratory infections for both patients, care givers and staff. The objective of the study was to develop a respiratory risk index to ensure healthy IAQ of patients and health care workers fora city hospital. To fulfil this indoor air quality such as PM10, PM2.5, SOx, NOx, microbial load, relative humidity, air velocity and temperature were measured seasonally in three ward of cardiac unit where patient get admitted to implant pacemaker. Physiological data such as tidal volume and respiratory rate was also taken from the hospital records. Participants who are being admitted to the hospital for the first time and undergoing their first pacemaker implantation are included in this study and subjects with a known respiratory disease are excluded from this study. Using these data respiratory deposition dose (RDD), was measured separately for male and female patient, which was used to develop a linear equation of Potential Respiratory Risk Index (PRRI). The study found that PM10 and PM2.5 concentrations were highest in summer (65.23 and 42.82 µg/m3), with a bioaerosol load of 1254 CFU/m3 during rainy season. All data exceeded the World Health Organization's recommended standards. The PRRI can predict the risk of indoor air pollution for hospitalised patients over a specific time period. These findings can be applied to hospital management in developing countries located in tropical areas.

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Tian, Y., Zhao, Z., Loo, J. Y.

**An application of smart visual air conditioning controller to enhance control efficiency in office environments.**

Results in Engineering, Vol. **25**, (2025)

Innovative solutions for sustainability and energy efficiency are crucial in green building management. This study presents a novel approach to optimizing air conditioning (AC) system operations in commercial buildings, with a focus on real-time control aimed at reducing energy consumption. We propose the Smart Visual Air Conditioning Controller (SVACC), which utilizes computer vision and deep learning-based human detection to intelligently manage AC operation, minimizing unnecessary runtime. By detecting human presence in meeting rooms, the system dynamically adjusts AC activation based on occupancy, thereby

significantly reducing energy waste. A statistical analysis conducted over five months across ten conference rooms demonstrated that the SVACC reduced AC usage time by 33.60 %. We validate and optimize the SVACC across various building types, including commercial office spaces, industrial warehouses and laboratories, and residential apartments. The system achieved an optimal balance with 96.55 % precision and 93.33 % recall, resulting in an F1 score of 0.9492, demonstrating high performance across various environments. Our results underscore the effectiveness of the SVACC, which highlights the potential of integrating advanced deep learning models with HVAC systems to optimize energy consumption. This approach offers a promising solution for improving HVAC design and energy management across diverse building environments. Future work will focus on refining sensor technology and control algorithms to further optimize energy efficiency.

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Abdullah, A. Y., Salem, H., Ameri, H. M. a. Q. A., Alnahdi, M. M., Okasha, M., Shaban, I. A.

**A Proposed Maintenance 4.0 Model for Laboratory Ventilation Systems: An Industry 4.0 Approach to Air Quality Management**.

2024 IEEE Global Conference on Artificial Intelligence and Internet of Things (GCAIoT). 19-21 Nov. 2024

Air quality plays a crucial role in the health and well-being of workers, with poor conditions potentially leading to respiratory issues, headaches, fatigue, and decreased productivity. This study utilizes Industry 4.0 configuration to assess air quality in laboratory settings and develop an online maintenance planning model for ventilation systems, termed Maintenance 4.0. In a laboratory at UAE University, air quality monitoring devices were installed to measure parameters such as $\text{CO}_{2}$ emissions, humidity, PM1, PM2.5, PM10, and temperature. Several assessment procedures were employed to enhance the evaluation of ventilation system performance, referencing standards like ASHRAE 62.1, the World Health Organization (WHO) Air Quality Guidelines, and the Environmental Protection Agency (EPA) regulations. Additionally, predictive models were created using the collected data: one to forecast future air quality based on historical trends, and another-a Vector Autoregression (VAR) time series model-to predict air quality for the next 20 readings. The findings provide valuable insights into the current state of laboratory air quality and support the development of improvement strategies. By assessing ventilation performance and suggesting optimal maintenance times, this research benefits laboratory managers, maintenance personnel, and workers, enabling proactive measures through accurate air quality predictions and ultimately enhancing safety and productivity in laboratory environments.

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Da Silva Paula, V. M., De Moraes Bruna, C. Q., Ciofi Silva, C. L., De Souza Hajar, K., Eduardo Galvão, C., Uchikawa Graziano, K.

**Fractional exhaled nitric oxide and respiratory symptoms in central sterile supply department workers exposed to different ventilation systems.**

International Journal of Environmental Health Research, (2025), 1-10 p.

Objective: To verify the association between different types of ambient ventilation in Central Sterile Supply Department (CSSD), fractional exhaled nitric oxide (FeNO) values, and respiratory symptoms of workers . Methods: CSSD workers from five hospitals were evaluated in three different ventilation systems: negative air pressure, air conditioning, and natural ventilation. The prevalence of respiratory symptoms was evaluated by The European Community Respiratory Health Survey. The respiratory inflammatory response was evaluated utilizing FeNO level measurements. Results: There was a general prevalence of respiratory symptoms in 5% of the workers investigated; there was no association between respiratory symptoms and ventilation systems ($p = 0.170$). Of the total workers investigated, 22% had FeNO levels $\geq 25$ parts per billion (ppb), considered above the normal range, and there was a statistically significant difference between ventilation systems ($p = 0.009$) favoring natural ventilation. Conclusion: Exposure to the natural ventilation system reduced the chance of developing FeNO levels $\geq 25$ by 94.3%.

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Lakhiar, M. T., Sanmargaraja, S., Olanrewaju, A. L., Lim, C. H., Ponniah, V., Mathalamuthu, A. D.

**Thermal comfort in green Malaysian office: Objective versus subjective evaluation**.

International Symposium on Green and Sustainable Technology (ISGST 2024). Kampar, Perak, Malaysia, October 14-15, 2024

An office building in Malaysia with a green certification was examined in terms of objective and subjective evaluations of thermal comfort. In this study, thermal comfort data was collected objectively using specific instruments per the ASHRAE 55 standard, and the Predicted Mean Vote (PMV) values were computed. In addition, validated questionnaires were used to assess subjective perceptions of thermal comfort. It was found that, although the PMV model suggested a slightly cool atmosphere occupants experienced a cooler sensation than expected. The divergence highlights the inadequacies of measuring thermal comfort solely based on objective measures and stresses the necessity of incorporating occupant feedback into the assessment process. By focusing on environmental sustainability and occupant well-being, this research provides valuable insight for the management and development of future green office buildings.,

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Rosti, B., Jankovic, A., Goia, F., Mathisen, H. M., Alam, A. G., Cao, G.

**Impact of cable length on the performance of low-cost sensors in single-board computer monitoring systems**.

ROOMVENT Conference 2024. April 22-25, Stockholm, Sweden

The increasing adoption of low-cost monitoring devices in environmental systems is a testament to their cost-effectiveness, versatility, and reliability. These devices, when paired with host minicomputers such as Raspberry Pi or Arduino, form the backbone of modern, budget-friendly monitoring solutions. This study addresses a crucial question in the deployment of such systems: the effect of cable length on the integrity of sensor data. It meticulously evaluates three widely-used sensors—the MCP9808 for temperature, the BME280 for temperature, and humidity, and the SCD30 for temperature, humidity, and CO2 concentration—across varying cable lengths from 10 cm to 6 m, utilizing the I2C communication protocol for connectivity to the Raspberry Pi. Results indicate that extended cable lengths do not significantly affect the accuracy of sensor readings, with CO2 and RH measurements showing high correlation values (r2 > 0.98) and temperature readings displaying lower, yet reliable, r2 values (0.82 to 0.92). Time-series and error analysis further confirm the sensors' performance. This study provides critical insights into the design of cost-effective monitoring systems and suggests that data accuracy is maintained across varying cable length, offering flexibility for environmental monitoring in diverse and spatially challenging settings.,

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Speroni, S., Polizzi, E.

**Green Dentistry: State of the Art and Possible Development Proposals.**

Dentistry Journal, Vol. **13** n°(1), (2025)

Objectives: The objective of this narrative literature review was to highlight all dental procedures attributable to sectoral waste and to consider possible alternatives in line with the concept of sustainable development. Methods: An extensive search of electronic databases, including the Cochrane Oral Health Group Specialized Register, Cochrane Central Register of Controlled Trials (CENTRAL), Web of Science, PubMed, EMBASE, and Google Scholar. Search words included ‘Green Dentistry’, ‘Dental Pollution’, ‘Pollutants and Dentistry’, ‘Disinfectants and Dentistry’, and ‘High-tech Dentistry’. All of them allowed an assessment of the impact of dental practice on the external environment, and new frontiers currently applied or possibly applicable for green dentistry were included in the study. Non-full-text papers, animal studies, studies in languages other than English, and studies not related to the topic under consideration were excluded. Results: According to the inclusion criteria, 76 papers were selected for the study. The

topics analyzed were the impact of dental practice on the outdoor environment, currently applied and potentially applicable principles of green dentistry, and the 'Four Rs' model (Rethink, Reduce, Reuse, and Recycle). Conclusions: With the limitations of the present study, the concept of green dentistry could be applicable provided that the measures already taken to reduce indoor and outdoor risk factors are continued and improved.

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Bhise, S. L., Awale, M. B., Jadhav, S. A., Lokhande, S. D., Kathwate, L. H., Dake, D. V.*, et al.*

**Mn-Doped CuO Nanostructure Films Based Gas Sensor for High Sensitive and Selective Formaldehyde Detection at a Room Temperature.**

ChemistrySelect, Vol. **10** n°(3), (2025)

Abstract The development of an efficient gas-sensing materials is crucial for applications in healthcare, industry, environmental monitoring, and agriculture. In this study, Mn-doped CuO thin films were synthesized and evaluated for their gas-sensing properties. The fabricated films exhibited a monoclinic CuO structure with (002) and (111) orientations, and their morphology reveals a uniform, spherical-like crystalline distribution. Mn doping adjusts the optical bandgap from 2.11 eV to 2.03 eV. Compared with pure, 3% Mn-doped CuO-based sensor demonstrated a high response value of 82% to 20 ppm formaldehyde at room temperature with swift response and recovery times of 9 and 36 s, respectively. The high sensitivity and stability of these sensors make Mn-doped CuO films a promising candidate for practical gas detection applications.

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Wang, H., Wei, W., Wang, K., Kong, H., Zilli Vieira, C. L., Koutrakis, P.*, et al.*

**A global multidimensional analysis of air pollution in land, sea, and air transport cabins reveals substantial health risks.**

One Earth, Vol. **8** n°(1), (2025)

Air pollutants are ubiquitous in transport cabins, contributing significantly to the burden of disease, but exposure levels and related health effects remain largely unexplored at a global scale. To address this, we systematically reviewed studies from the past 20 years on 17 air pollutants across major means of transport over land, sea, and air globally. We evaluated concentration levels from the perspectives of transport type, country, and time, and analyzed primary influencing factors and health effects. Findings showed that land transport provided the highest pollutant exposure, with that to bus drivers topping the list, while high levels of certain pollutants were also detected in sea and air transport. Although energy transitions have helped partly reduce benzene, toluene, and NO2 exposures, levels of formaldehyde, black carbon, and particulate matter (PM2.5 and PM10) remain persistently high, indicating substantial health risks. This study enhances our understanding of cabin-related health effects and provides a foundation for effective exposure-reduction strategies.

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Islam, M. M., Shofiullah, S., Sumi, S. S., Shamim, C. M. a. H.

**Optimizing hvac efficiency and reliability: a review of management strategies for commercial and industrial buildings.**

Academic Journal on Science, Technology, Engineering & Mathematics Education, Vol. **4** n°(04), (2024), 74-89 p.

This study presents a comprehensive review of strategies to optimize HVAC systems in commercial and industrial buildings, focusing on enhancing energy efficiency, system reliability, and environmental sustainability. HVAC systems are major energy consumers, contributing significantly to operational costs in large buildings. With increasing energy costs, regulatory pressures, and the push for sustainability,

technological advancements and management strategies have emerged to improve HVAC performance. Following PRISMA guidelines, this review analyzed 58 high-quality peer-reviewed studies published between 2010 and 2023. Key findings show that energy management systems (EMS) can reduce energy consumption by up to 30%, while Building Management Systems (BMS) enhance system reliability through centralized control and predictive maintenance. The adoption of eco-friendly refrigerants and energy-efficient designs, such as heat recovery and variable refrigerant flow (VRF) technologies, further lowers energy usage and environmental impact. Additionally, integrating renewable energy sources like solar and geothermal into HVAC systems can reduce energy consumption by as much as 40%. Green building certifications, such as LEED and BREEAM, drive the adoption of optimized HVAC technologies, delivering both environmental and financial benefits. This review underscores the crucial role of HVAC optimization in reducing energy consumption, lowering carbon footprints, and improving the operational performance of buildings, offering valuable insights for building managers, engineers, and policymakers.

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Ma'bdeh, S. N., Hamasha, A. A., Al-Shawabkeh, M., Alali, R. O., Almomani, R. M., Obeidat, L. M.*, et al.*

**Enhancing office air quality: The role of window to wall ratio with window-wind catchers using CFD analysis.**

Energy Reports, Vol. **13**, (2025), 1508-1524 p.

This research paper delves into the optimization of window size and placement for window wind-catchers (WWCs) in office buildings using a Computational Fluid Dynamics (CFD) simulation approach. Recognizing the critical role of natural ventilation in sustainable building design, this study evaluates various window configurations to maximize airflow rates and indoor air quality (IAQ). CFD simulations were conducted on an office building model with varying window sizes and placements. The findings demonstrate that increasing the window size enhances the airflow rate, with larger windows achieving up to a 40 % increase compared to smaller configurations. Additionally, optimizing window placement reduced stagnation zones by approximately 30 %, improving airflow distribution. These results provide architects, engineers, and building designers with valuable insights into the most effective strategies for optimizing WWCs in office buildings to achieve superior indoor environmental conditions.

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Ting, D. S. K., Stagner, J. A.

**9 - Adaptive heating, ventilation, and air conditioning: energy-efficient thermal comfort for tomorrow.**

In: Adaptive Engineering. Woodhead Publishing; 2025. 197-211 p.

Buildings sheltering humanity, for dwelling, working, schooling, shopping, etc., consume approximately 40% of global energy. Therefore, to reduce energy consumption, we should invest effort into transforming how we provide thermal comfort for indoor occupants. One solution is to force tenants to sacrifice and adapt to a less-than-comfortable environment. However, experience tells us that this approach will not succeed universally. Building occupants often demand personalized thermal comfort, rather than making a lifestyle sacrifice. Providentially, a close examination of various studies in the literature reveals that personalized thermal comfort does not necessarily demand more energy. Air conditioning and heating that cater to the personal preferences of the dwellers can be achieved simultaneously with energy reduction and increased occupant comfort and productivity.

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Kairui, Z., Chandra, S., Lup, C. W.

**Effects of Nozzle Radius on Induction Ratio of Active Chilled Beams.**

5th Asia Conference of IBPSA. December 8th – 10th, 2024, Osaka, Japan

The global increase in building energy consumption necessitates the development of energy-efficient technologies to mitigate environmental impacts. Active Chilled Beam (ACB) systems are known for their lower energy consumption compared to traditional HVAC systems. In an ACB, the supply air jets induce the indoor air which passes through cooling coils and returns to the indoors with the supply air. The ratio of induced air to the supply air is called the entrainment ratio or induction ratio (IR). IR typically ranges between 2 and 6. A higher IR means more induced airflow under the same supply air flow rate. Therefore, understanding how ACB design affects IR is important to achieve high efficiency. This paper examines the impact of ACB nozzle radius on IR. Using computational fluid dynamics (CFD) simulations, a set of parametric study is conducted by varying the inlet velocity and nozzle radius. The CFD results reveal that IR remains around 4.2 when the supply air velocity is increased gradually from 0.75 m/s and 5.33 m/s, confirming that IR is independent of the supply air velocity. Decreasing the nozzle radius significantly increases the IR, where an IR of up to 9.0 can be achieved with a small nozzle radius of 2 mm. Guided by the findings that nozzle radius can significantly affect IR, Future work can focus on other geometrical parameters of the nozzle, such as nozzle length, nozzle angle, and the spacing between nozzles, to increase the efficiency of ACB systems.,

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Russ, J., Hammer, N.

**Departing from standard practices: Strategic application of value engineering in the anatomy laboratory to enhance formaldehyde extraction using high-impact, low-cost, and low-maintenance solutions.**

Anatomical Sciences Education, (2025)

Abstract This study describes the process of developing a high-impact, low-cost, and low-maintenance air ventilation system for anatomy facilities. It employed the strategic application of Value Engineering (VE), assuring that the air ventilation system meets contemporary threshold limit values (TLVs) for formaldehyde in the working zone of dissection tables. A creative?innovative construction methodology was used, combining the Theory of Inventive Problem Solving (TRIZ/TIPS) and VE for an anatomy laboratory air ventilation concept. The TRIZ/TIPS aimed to resolve conflicts that impeded progress toward higher ideality, while VE aimed to develop alternative approaches to fulfill required functions at a minimal cost. The findings were first trialed in a mockup while dissecting human tissues embalmed with two protocols. The experimental results were validated by computational fluid dynamics simulations, and then followed by a pilot and commissioning phase once the physical installation of the dissection laboratory concluded. The findings demonstrate the superiority of the combined TRIZ/TIPS and VE approach in terms of air distribution and efficient formaldehyde extraction within the breathing zone. A formaldehyde exposition below 0.1?ppm, lowered air exchange rates, and system usability proved that the given third-generation ventilation system complies with contemporary TLVs and potential changes in user requirements. The third-generation ventilation system offers a cost-effective, high-impact, and low-maintenance solution for state-of-the-art air ventilation systems in the anatomy dissection laboratory. The underlying design approach ensured that formaldehyde levels in the laboratory meet the TLV and indoor air guideline values for formaldehyde exposure, at which current knowledge indicates no increased risk of cancer.

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Joo, S., Yesildagli, B., Kwon, J.-H., Lee, J.

**Comparative analysis of indoor volatile organic compound levels in an office: Impact of occupancy and centrally controlled ventilation.**

Atmospheric Environment, Vol. **345**, (2025)

Understanding the effects of human occupancy and ventilation on indoor air quality, especially in the presence of volatile organic compounds (VOCs), is crucial for human health. We investigated VOC concentrations in an office environment with varying occupancy and ventilation in real-time via proton transfer reaction time-of-flight mass spectrometry by evaluating conditions across different ventilation

control scenarios. Among the 276 analyzed species, 113 VOCs were quantified, where 77.8% of the total emission rate is attributed to human occupancy, 12.9% to building sources, and 9.30% to supply air. The emissions rates of occupants and building were quantified by considering natural ventilation (Q = 117.36 m3 h−1) in the emission source, which increased their emission rate by 31.5%. A decrease in the ventilation recirculation ratio (RR = 0.5) reduced the total concentration of indoor VOCs by 55.1% owing to the introduction of fresh ambient air. Notably, daytime measurements with the half-open damper of the ventilation system highlighted the importance of controlled ventilation in mitigating VOC presence. Our findings suggest that considering natural ventilation is important in assessing indoor air quality, that HVAC system management is crucial in enhancing indoor air quality, and that building design and operational strategies must be optimized for the health of indoor environments.

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Fang, M., Yue, K., Hu, J., Wang, L., Yan, X., Guo, M.*, et al.*

**A Systematic Review of the Impact of Carbon Reduction Measures on Human Comfort: A Human Factors and Ergonomics Perspective.**

Environmental Research Communications, (2025)

This systematic review uniquely explores the impact of carbon reduction measures on human comfort from a human factors and ergonomics perspective, focusing on human comfort. An analysis of 30 papers identifies key environmental factors requiring attention in contemporary carbon reduction strategies and their implications for human comfort. The results reveal a growing emphasis on thermal comfort and air quality in carbon reduction retrofits, while other environmental factors such as light and noise receive insufficient attention. While optimal ventilation and local environmental adjustments can yield positive outcomes, adverse effects like significant indoor temperature fluctuations and heightened carbon dioxide levels may arise from certain modifications. Moreover, the findings from the analysis of human comfort assessment methods indicate a lack of focus on human comfort evaluation in carbon emission reduction initiatives, with predominant reliance on subjective questionnaires. Most studies superficially mention human comfort assessment without delving into comprehensive research or employing systematic evaluation techniques. The findings indicate that although the implementation of carbon reduction measures is extensively covered in academic literature, the limited literature addressing human comfort assessment post-implementation implies a need for further comprehensive exploration and development within the field. This study furnishes researchers, practitioners, and policymakers with a comprehensive insight into the current landscape and proposes prospective research avenues within the domain.

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Koshlak, H.

**Earth-Air Heat Exchangers: A Comprehensive Review.**

Preprints, (2025)

Earth Air Heat Exchangers (EAHEs) provide a compelling solution for improving building en-ergy efficiency by harnessing the stable subterranean temperature to pre-treat ventilation air. This comprehensive review delves into the foundational principles of EAHE operation, meticu-lously examining heat and mass transfer phenomena at the ground-air interface. The study me-ticulously investigates the impact of key factors, including soil characteristics, climatic condi-tions, and crucial system design parameters, on overall system performance. Beyond independ-ent applications, this review explores the synergistic integration of EAHEs with a diverse array of renewable energy technologies, such as air source heat pumps, photovoltaic thermal (PVT) panels, wind turbines, fogging systems, water spray channels, solar chimneys, and photovoltaic systems. This exploration aims to clarify the potential of hybrid systems in achieving enhanced energy efficiency, minimizing environmental impact, and improving the overall robustness of the system.

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Hii, D. J. C., Hasama, T.

**Towards the Digital Twinning and Simulation of a Smart Building for Well-Being.**

2024 Winter Simulation Conference (WSC). 15-18 Dec. 2024. Orlando, FL, USA

Smart cities and buildings are enabled by the Internet of Things (IoT) sensor infrastructures integration and monitoring in the current Industry 5.0 era. Environment sensing, people and robots counting enable the simulations of both digital twin and agent-based modelling (ABM). This enables the understanding of the impact between the built environment and humans. The movement analysis allows planning and design of spaces as well as utilizing machine learning methods to train the trajectories for space usage prediction. Human behavior and social interaction comprehension is important to generate people friendly spaces. The GEAR is a smart, green, and WELL certified building embedded with sensors as a living lab for research and development. The diverse workspace layouts create an ideal testbed to study human and built environment interactions. This pursuit is to achieve more sustainable and better designed spaces for human well-being in the fast-changing world.

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Biju, P., Sheta, W., Saumer, B.

**Towards healthier dining environments: evaluating indoor air quality in Dubai restaurants.**

J Build Des Environ, Vol. **2** n°(3), (2024)

This study investigates the indoor air quality (IAQ) of restaurants in Dubai with a focus on the impact of cooking-related pollutants on the health and comfort of both employees and patrons. Recognizing the release of particulate matter (PM), carbon oxides, and volatile organic compounds (VOCs) during cooking, the study highlights the importance of maintaining healthy IAQ in restaurants. The study includes a detailed case analysis, evaluating current air quality standards, identifying potential pollutants, and assessing their implications. A preliminary assessment, combined with a quantitative inspection of the kitchen and dining areas, set the foundation for a survey conducted among staff and customers. This survey identified key areas of concern and the variables essential for monitoring to maintain IAQ at optimal levels. The study measured parameters such as PM2.5, PM10, temperature, humidity, interior lighting, CO, and total VOCs using appropriate instruments. Results indicated that cooking activities contribute to elevated levels of particulate matter, suggesting a need for enhanced ventilation or air purification systems to ensure a healthy working environment. While some employees reported discomfort during working hours, customer feedback was largely positive, with around 90% expressing satisfaction with the restaurant's IAQ. The findings underscore the importance of continuous monitoring and improvement of IAQ in the hospitality industry to safeguard the well-being of both staff and patrons.

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Dimchev, I., Terziev, A., Ivanov, M., Vassilev, M.

**Climate change impact on the energy performance of an air handling unit with two-stage heat recovery.**

E3S Web Conf., Vol. **608**, (2025)

Climate change affects air handling units with two-stage recovery since these systems are used for heating, ventilation and air-conditioning. Their parameters are affected by changes in each of the seasons. The parameters analysed for each of the three climate zones (colder, average and warmer) are SCOP and annual COP of the entire AHU working in all available modes. Two factors - increase in global temperature and increase in CO2 concentration. Each of these factors has a different impact on seasonal coefficient of performance. The increase in global temperature leads to SCOP decrease by 2.3 to 3.7%. On the other hand, the increase of CO2 concentration in the outdoor air for the last 20 years by 50 ppm or 13.3% leads to an increase in SCOP by 5.5 to 6.9%. For the colder climate annual COP is increased by 2.4% due to climate change but for the other two climates (average and warmer) it is decreased with 1.7 and 3.4%. In the near future a large part of the existing air-conditioning and ventilations systems will not be able to maintain the same indoor air quality as now and this will lead to a deterioration in the quality people’s life.,

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Bawa, J. A., Abdullahi, M. L., Abdulrahman, N. J.

**Sustainable architecture and the impact of smart ventilation, air conditioning, and heating (vach) systems.**

Open Journal of Engineering Science (ISSN: 2734-2115), Vol. **5** n°(2), (2024), 19-31 p.

The advent of Smart Ventilation, Air Conditioning, and Heating (VACH) systems has markedly transformed sustainable architecture by improving energy efficiency, indoor environmental quality (IAQ), and occupant comfort. This paper underscores the critical role of Smart VACH systems as foundational elements in sustainable building design, promoting energy conservation and environmental stewardship within the built environment. Methodologically, a comprehensive literature review is adopted to examine how Smart VACH systems contribute to sustainability objectives in architectural design. Through a detailed analysis of performance metrics and environmental impacts, the study compares intelligent VACH systems to conventional alternatives, highlighting their superior contributions to energy conservation, reduced carbon emissions, and overall sustainability. Findings indicate that Smart VACH systems not only enhance indoor air quality but also substantially reduce operational costs and extend equipment lifespan, thus lowering maintenance requirements. Moreover, these systems improve occupant health and productivity by maintaining consistent indoor air quality and thermal comfort, factors shown to enhance well-being in built environments. This paper concludes by discussing the limitations of current research and suggests potential areas for further exploration, advocating for wider adoption of Smart VACH systems across diverse architectural settings to strengthen sustainable building practices.,

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Li, Y., Chen, Z., Wen, J., Fu, Y., Pertzborn, A., O'neill, Z.

**A framework for calibrating and validating an HVAC system in Modelica.**

Journal of Building Performance Simulation, (2025), 1-21 p.

Using Modelica to simulate the dynamic behaviours of building HVAC systems has gained popularity. Calibration of a Modelica model that represents large and complex HVAC systems involves elaborate and time-consuming determination of hundreds of parameters. This study proposes a systematic framework to calibrate and validate an HVAC system model in Modelica. The framework includes strategies to decouple the model and calibrate it with multi-source data, aiming to efficiently and accurately determine Modelica model parameters that provide a good match between the simulated and real system behaviours. To demonstrate the validity, the framework was applied to calibrate the parameters of a Modelica model representing a real AHU-VAV system with components such as fans, pumps, dampers, valves, chillers, etc. The results show that the simulated results match well with the real system measurement of VAV supply air condition and equipment power consumption within the acceptance criteria.

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Lee, M. J., Zhang, R.

**A self-attention fusion-based bi-lstm framework for occupant-centric prediction of indoor environmental factors.**

6th International Conference on Civil and Building Engineering Informatics, 8-11 January 2025, Hong Kong

The integration of occupant data into the management of indoor environment factors is gaining increasing attention for creating intelligent and inclusive built environments. Traditional approaches have mostly relied on static models, often failing to account for the ever-changing nature of occupant behavior and environmental factors across time and dimensions. Recent advancements in deep learning, especially deep sequential models capable of capturing both local and global dependencies between time steps, provide an opportunity to overcome these challenges. To address these challenges, the authors propose an LSTM-based model framework that utilizes self-attention-based multimodal fusion, real-time occupant

data, indoor environmental quality (IEQ) data, outdoor air quality data, and meteorological data to predict future IEQ conditions, preferred IEQ conditions, and classify current IEQ conditions based on collected occupant feedback. To develop and test the proposed framework, four key steps were followed: (1) collecting IEQ data through smart sensors, (2) collecting perceived occupant feedback, (3) collecting meteorological and Outdoor Air Quality (OAQ) data, and (4) developing an attention-fusion-based Bi-Directional LSTM(Bi-LSTM) model. The proposed framework was tested at the Virginia Tech Blacksburg campus, showing promising results.

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Lin, P.-S., Quellmalz, A., Parhizkar, S., Huang, P.-H., Negm, N., Suckow, S.*, et al.*

**Atmospheric-level carbon dioxide gas sensing using low-loss mid-IR silicon waveguides.**

Optics Express, Vol. **33** n°(2), (2025), 3511-3521 p.

Interest in carbon dioxide (CO2) sensors is growing rapidly due to the increasing awareness of the link between air quality and health. Indoor, high CO2 levels signal poor ventilation, and outdoor the burning of fossil fuels and its associated pollution. CO2 gas sensors based on integrated optical waveguides are a promising solution due to their excellent gas sensing selectivity, compact size, and potential for mass manufacturing large volumes at low cost. However, previous demonstrations have not shown adequate performance for atmospheric-level sensing on a scalable platform. Here, we report the clearly resolved detection of 500 ppm CO2 gas at 1 s integration time and an extrapolated 1σ detection limit of 73 ppm at 61 s integration time using an integrated suspended silicon waveguide at a wavelength of 4.2 μm. Our waveguide design enables suspended strip waveguides with bottom anchors while maintaining a constant waveguide core cross-sectional geometry. This unique design results in a low propagation loss of 2.20 dB/cm. The waveguides were implemented in a 150 mm silicon on insulator (SOI) platform using standard optical lithography, providing a clear path to low-cost mass manufacturing. The low CO2 detection limit of our proposed waveguide, combined with its compatibility for high-volume production, creates substantial opportunities for waveguide sensing technology in CO2 sensing applications such as fossil fuel combustion monitoring and indoor air quality monitoring for ventilation and air conditioning systems.

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Parkar, A., Yadav, R. S., Chopade, R., Dhavase, N., Dhumal, J. R., Mankar, S. P.*, et al.*

**Automating the Two-Dimensional Design of Heating, Ventilation, Air Conditioning, and Refrigeration (HVACR) Ducts using Computer Programming Language: An Algorithmic Approach.**

Journal of Mines, Metals and Fuels, Vol., (2025), 211-220 p.

This paper reports on designing an automated two-dimensional duct of Heating, Ventilation, Air Conditioning and Refrigeration (HVACR) using computer programming. The designed system uses an algorithmic approach attempting to accelerate the design process, decrease the human error of the designers and make the process of designing HVACR systems more efficient. It applies a system of interacting algorithms to solve duct sizing, routing and layout optimisation tasks. This facilitates both the saving of time and the increment of accuracy and consistency in the final design. By applying advanced computational techniques, it could analyse complex geometries of buildings and easily produce optimised designs for ducts. This research contributes to the field of HVACR engineering by providing a practical solution for automating a critical design phase. The automation system may be configured to work with existing Computer Aided Design (CAD) software, allowing for close collaboration between designers and engineers.

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Luo, Q., Wang, T.

**Clean-room Air Conditioning Control Based on Improved Min-Max Robust Model Predictive Control Algorithm.**

IEEE Access, (2025)

With the increasing demand for indoor environmental comfort, air conditioning has become an essential electrical device for modern life. To improve the comfort of indoor environment in clean-room and to reduce the operating cost of the equipment, the study proposes an improved Min-Max robust model predictive control algorithm for clean-room air conditioning control strategy. Firstly, for the comfort of indoor air conditioning, the MPC algorithm is investigated to regulate the air conditioning air supply based on indoor temperature and humidity ratio in order to control the indoor comfort of the clean-room. Subsequently, an improved Min Max robust model predictive control algorithm was proposed to control the parameters of the model, and compared and analyzed with the original algorithm. The simulation results indicated that the PMV index of the model predictive control algorithm was 0.66 at the lowest and 0.68 at the highest. The Min-Max robust model predictive control algorithm was 0.73 at the lowest and 4.3 at the highest. The improved Min-Max robust model predictive control algorithm was 0.45 at the lowest and 0.47 at the highest. The experimental data indicate that the improved Min-Max robust model predictive control algorithm has the best performance and has more obvious effect on the comfort control of clean room environment.,

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Rajendran, S., Ramesh, P., Sengottaiyan, P., Balasubramaniam, N. D.

**Clearing the Air: Nanotechnology's Role in Tackling Atmospheric Pollution**.

In: Breaking Boundaries: Pioneering Sustainable Solutions Through Materials and Technology. Springer Nature Singapore; 2025. 213-235 p.

The environment is getting degraded inadvertently with xenobiotic compounds which negatively impact the receptor ecosystem. Air pollution is emerging as a critical issue since it is directly involved in human health as well as other organisms. Many contaminants including carbon monoxide, hydrocarbons, nitrogen oxides, volatile organic compounds, and chlorofluorocarbons pose a major threat to the environment's quality. Both Indoor and Outdoor air pollution is raising a concern due to its influence on human health. The swift advancement of nanotechnology has sparked significant curiosity about the possible applications of nanomaterials in enhanced environmental monitoring and cleanup systems. It is largely employed in the domains of air filtration and purification, emission reduction, sensing and monitoring, carbon capture and storage, and industrial applications. Nanofiber filters, catalytic converters, photocatalysts, nanocoatings, fuel additives, nanosensors, nano adsorbents, electrospun nanofibers, and nanocatalysts play a major role in defending the environment against pollution. Since they have unique characteristics, for instance, higher surface area, nanomaterials can effectively absorb and break down airborne contaminants. Industries can improve ambient air quality and environmental protection by using nanotechnology to achieve cleaner processes, more proficient pollution tracking, and improved remediation. This chapter will address the concerns of air pollution in the environments, its sources, its effect on human health, different nanotechnology practices in controlling air pollution, and its future perspectives. The application of nanotechnology in air pollution control not only offers long-term solutions but also contributes to the development of reliable treatment plans for a sustainable future.

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Elsafty, A.

**The concept of green hospitals and sustainable practices (review article).**

Egyptian Journal of Occupational Medicine, Vol. **49** n°(1), (2025), 117-123 p.

Introduction: The concept of green hospital is crucial in promoting sustainable development within health care sector. The idea is to minimize their environmental impact parallel to enhancing health and wellbeing of patients and working staff. Achieving this goal is greatly considered and outlined in the United Nations Sustainable Development Goals (SDGs) [Goal 3, which is concerned with "Ensuring a healthy life and promoting well-being at all ages"]. Paradoxically, health care sector that is considered as health protector is in the same time the main emitter of environmental pollutants that negatively affects health. Sustainability became the key priority for the whole world, governments, leaderships and health care organizations,

aiming at optimizing the resources efficiently and being recognized in the community. Aim of Work: The aim of this review article is to provide and explore the research landscape in the field of green hospitals and highlight sustainable practices within the healthcare sector. Renewable energy integration, innovative practices, smart building management systems, benefits and challenges in implementing of sustainability practices will be explored. Green hospital certification requirements involve assessing healthcare facilities with specific environmental sustainability standards and practices that minimize resource consumption, lower carbon foot print along with maintaining high-quality patient care and staff satisfaction. In conclusion, adopting sustainability approaches and practices in health care facilities is essential for enhancing public health through reduction of environmental negative impacts, improving health outcomes, promote cost effectiveness, mitigate climatic changes, engage community and pose hospitals as leaders in health sector transformation. Green hospitals mark an inspiring step forward in how healthcare embraces sustainability.

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Zhang, H., Sun, C., Zhang, L., Yan, B., Liu, Y., Dong, Q.

**A field study on thermal comfort and adaptive behaviour of university open-plan offices in severe cold regions of China.**

Journal of Asian Architecture and Building Engineering, (2025), 1-19 p.

This study investigates the thermal comfort and adaptive behaviours of occupants in open-plan office spaces at a university located in Northeast China, a region characterized by severely cold winters with an average temperature ≤?10°C in the coldest month. The research focuses on the interaction between buildings and occupants from an indoor environmental quality perspective, contributing to the field of occupant-centric building design and operation by studying thermal comfort, adaptive behaviour, and energy-efficient heating strategies in severe cold regions. By employing field measurements and a subjective questionnaire survey, we summarized the environmental factors contributing to thermal discomfort and their respective weights. The results reveal that air temperature, radiant asymmetry caused by envelopes, and relative humidity are the three most significant factors, with weights of 0.376, 0.209, and 0.194, respectively. Furthermore, a fuzzy comprehensive evaluation method was employed to determine the thermal neutral operating temperature (22.5°C) and the acceptable operating temperature range (19.5°C to 25.5°C). Based on the analysis of occupant behaviour characteristics and preferences, a suitable winter heating setting is proposed for open-plan university offices. These findings support the development of more accurate building performance simulations and inform strategies for low-energy building management in severe cold regions.

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Christensen, M. S. F.

**Leveraging the Industrial Internet of Things (IIoT) for Real-Time CO2 Monitoring, Measurement and Visualization: Technologies, Applications and Future Directions**.

Global Internet of Things and Edge Computing Summit

Global CO2 emissions reduction requires industries to manage and understand their CO2 emission levels in real-time. This paper examines the Industrial Internet of Things (IIoT) for real-time monitoring, measurement, and visualization of reducing CO2 emissions in industrial and environmental domains.

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Sambhrant Srivastava, V. K., Pankaj Yadav, Vijay Kumar, Brihaspati Singh.

**CFD Simulation of Operation Theatre for Comfort of Patient**.

In. Technologies and Innovations for Sustainable Development; 2025. 16 p.

The purpose of this study was to enhance patient comfort during surgical procedures by simulating air flow and temperature distribution in an operating room using computational fluid dynamics (CFD). The

ventilation system was modelled, and its influence on the thermal environment was examined. CFD simulation is an effective tool for modelling and analysing the air flow and temperature distribution in a complex environment such as an operating theatre. Our study utilized this approach to investigate how the ventilation system affects the thermal environment and subsequently patient comfort. The outcomes demonstrated how air flow and temperature distribution can be optimized to reduce patient discomfort and ensure their wellbeing during surgery. This study's findings can be utilized to enhance the overall patient experience in the operating room and, ultimately, to improve the efficacy of surgical procedures. Air flow and temperature distribution in complex environments, such as operating rooms, can be effectively modelled and analyzed using CFD simulation. Utilizing this methodology, the study investigated the impacts of the ventilation system on patient comfort and thermal environment. Four cases of different height and position of cooling air in an operation theatre is modelled in SolidWorks and simulated in CFD for examining the most suitable position of inlet air. In this study, the velocity streamline and temperature are compared with human comfort conditions. A double inlet on two adjacent walls proves to be the most effective positions for maintaining human comfort conditions, according to operation theatre velocity 1–2m/sec and 23ºC Temperature.

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Gnecco, V. M., Kousis, I., Pigliautile, I., Pisello, A. L.

**Decoding Living Lab sensing system through Bayesian networks: The preferable working space targeting comfort and productivity.**

Journal of Building Engineering, Vol. **101**, (2025)

Workplace environmental conditions significantly influence workers' well-being, health, and productivity. The understanding of the interaction between environmental factors across multiple domains can improve occupants' satisfaction and indoor conditions. This study aims to identify optimal office environmental conditions by analysing comfort demands and multi-domain interplay in a dynamic context. A year-long experimental campaign was performed in a Living Lab comprising five offices, monitoring indoor and outdoor environmental parameters and gathering occupants' feedback through surveys. Gaussian Naïve Bayes technique was applied to develop probabilistic models that identified optimal conditions for comfort and satisfaction, including self-perceived productivity as combined effect analysis. Participants showed more acceptability of warmer conditions in cooling seasons. Probabilistic models aligned with the current standards, indicating optimal temperatures of 22°C-24 °C for heating seasons and 23°C-24 °C for cooling seasons. Visual comfort was affected by the balance of natural and artificial light, with higher visual discomfort when the former was limited during cooling seasons. Temperatures higher than 22 °C demonstrated increased "stale air" discomfort, potentially linked to respiration and sweating, even without elevated $CO_2$ levels. Self-perceived productivity decreased in temperatures higher than 24 °C and CO2 concentrations exceeding 800 ppm. Other factors and more comprehensive measurements, together with monitoring of physiological signals should be included in future studies, allowing the creation of guidelines for more comfortable office places. These findings offer valuable insights for enhancing workplace human-centric standards and regulations globally. They have the potential to shape policies that foster more sustainable productive environments for workers' wellbeing worldwide.

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Modaqeq, T., Joia, R., Tulepov, M.

**A Comprehensive Review on Understanding Car Air Filters: Structure and Mechanism of Operation.**

International Journal For Multidisciplinary Research, Vol. **7** n°(1), (2025)

Modern lifestyles necessitate adaptation to contemporary technologies, as approximately 80% of our time is spent indoors or in vehicles. This raises significant concerns about indoor air quality, including issues like particles, dust, volatile organic compounds (VOCs), harmful gases, unpleasant odors, and biological contaminants such as airborne viruses and bacteria. Car air filters play a crucial role in trapping dirt particles that can negatively impact engine performance and longevity. They also purify the air inside

the cabin, significantly enhancing passenger health. In developed countries, around 80% of cars utilize nanotechnology-based filters that effectively eliminate odors and trap fine particles. This study aims to examine the impact of air pressure on engine performance using both clean and dirty air filters. Research indicates that dirty air filters lead to increased fuel consumption and greenhouse gas emissions while diminishing engine performance. Specifically, fuel consumption rises and exhaust gas temperatures increase with dirty filters. In modern cars equipped with electronic pressure transducers, notable pressure differences between clean and dirty filters are observed. For carburetor engines, dirty filters markedly reduce acceleration performance. Consequently, maintaining clean air filters is vital for optimal engine performance, fuel efficiency, and reduced emissions, while nanotechnology filters enhance filtration and improve overall vehicle performance.

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Shanrui, S., Shohei, M., Yasunori, A.

**Model-Based Optimal Control for Multizone VAV Systems Considering Indoor Temperature, CO2, and Pressure Regulation**.

ASim Conference 2024: 5th Asia Conference of IBPSA. 8th-10th December 2024. Osaka, Japan

Conventional model-based optimal control strategies for multizone variable air volume systems often rely on optimizing the setpoints and neglecting the return air side, leading to unbalanced room pressure and air leakage. To address this issue, this study proposes a model-based optimal control strategy to concurrently regulate indoor air temperature, CO2 concentration, and room pressure while minimizing energy consumption. The proposed strategy directly optimizes fan frequencies and damper openings using a datadriven duct network model. Simulation results show that the proposed strategy maintains indoor air temperature and CO2 concentration and reduces air leakage without increasing energy consumption.,

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Yuan, Y., Song, C., Zeng, K., Gao, L., Huang, Y., Chen, Y.

**An occupant-centric control case study based on internet of things and data mining for an office space.**

Journal of Building Engineering, Vol. **101**, (2025)

Although research on Occupant Behavior (OB) and Occupant-Centric Control (OCC) is extensive, the actual application of OCC remains limited. This study addresses this gap by introducing a comprehensive OCC workflow and conducting a case study in an office building in Changsha, China. Firstly, three months of meteorological, indoor environmental, and energy interaction behavior data were collected by multiple IoT sensors from November 2023 to January 2024. In the second step, indoor comfort levels were analyzed according to ASHRAE standards, revealing that 15.3 % of the time during this period fell within uncomfortable intervals. Based on these findings, an OCC experiment was proposed to improve indoor comfort. A data-driven air-conditioning usage behavior model was developed. Subsequently, a two-week pre-heating experiment was conducted following the recommendations of the proposed model. For comparison, non-heating and pre-heating days were alternated. Finally, the experiment was evaluated using occupants' thermal comfort voting and energy consumption analysis. Participants' thermal comfort was recorded using five metrics and one behavioral metric via surveys. Five metrics include thermal sensation, comfort, preference and acceptance. The results indicated a significant improvement in occupant comfort levels, with acceptance ratings increasing from an average of 3.78–4.38. With pre-heating, the air conditioning energy consumption increased by 1.35 kWh per person per day, representing an increase of approximately 0.98 % overall energy usage. Additionally, a web-based platform named OBIoT was developed to integrate this workflow. These findings provide meaningful insights for improving indoor comfort and optimizing energy consumption.

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Deng, C., Niu, Z., Chen, C.

**Personal Air Cleaning by a User-Tracking Robot Equipped with a Nanofiber Air Cleaner in a Large Work Space.**

Indoor Environments, (2025)

In large work spaces, such as logistics warehouses, implementing whole-space air cleaning to protect the workers' health can be costly. To tackle this issue, the present study developed a user-tracking robot equipped with a nanofiber air cleaner to achieve personal air cleaning for a moving worker in a large work space. First, nanofiber air filters with low pressure drop were fabricated using the electrospinning technique. An air cleaner with a deflector for directing the airflow towards the user's breathing zone and the nanofiber air filters was assembled and then integrated into a user-tracking robot. Experiments were conducted to measure the clean air delivery rate (CADR) of the nanofiber air cleaner, evaluate the accuracy of the user-tracking algorithm, and determine the optimal deflector setup and user-to-robot distance. Field tests were conducted to evaluate the personal air cleaning performance of the proposed method by comparison with a stationary nanofiber air cleaner. The results show that the user-tracking algorithm of the user-tracking robot was accurate, with an average absolute error in the user-to-robot distance of 4cm. The user-tracking robot with nanofiber air cleaner outperformed the stationary nanofiber air cleaner by reducing the concentration of 0.3-0.4 μm particles in the breathing zone of the user by 16.4%. Furthermore, compared with commercial panel-type high-efficiency particulate air (HEPA) filters, the use of nanofiber air filters can extend the battery service life, consequently facilitating the practical application of the moving robot.

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Ogundiran, J. O., Nyembwe, J.-P. K., Ogundiran, J., Ribeiro, A. S., Gameiro Da Silva, M.

**A Systematic Review of Indoor Environmental Quality in Passenger Transport Vehicles of Tropical and Subtropical Regions.**

Atmosphere, Vol. **16** n°(2), (2025)

This systematic literature review (SLR) focuses on indoor environmental quality (IEQ) in passenger transport vehicles within tropical and subtropical regions. It specifically examines indoor air quality (IAQ), thermal comfort (TC), acoustic comfort (AC), and visual comfort (VC) of passenger vehicle cabins (PVCs) in auto rickshaws, sedans, trucks, bus rapid transits (BRTs), buses, trains, trams, metro systems, aircraft and ferries of tropical and subtropical regions. The SLR used the PRISMA approach to identify and review scientific studies between 2000 and 2024 on the IEQ of PVCs in the tropics. Studies reviewed were found in SCOPUS, Web of Science, Science Direct, and EBSCO databases including relevant citation references. Findings reveal a significant geographical imbalance in research, with most studies concentrated in tropical Asia (78.2%), while sub-Saharan Africa (8.2%), South America (11.8%), and Oceania (1.8%) are considerably underrepresented. In 113 studies, most addressed IAQ and TC but limited attention to AC and VC. Moreover, fewer studies have jointly addressed all the IEQ parameters, highlighting the need for a more comprehensive approach to IEQ for tropical PVCs. Several studies alluded to in-cabin commuter risk linked to PM2.5, PM10, carbon monoxide (CO), and volatile organic compounds (VOCs). These risks are exacerbated by traffic hotspots, poor ventilation, ambient pollution, overcrowding, and poor vehicle conditions. Additionally, thermal discomfort is compounded by extreme heat loads, inefficient HVAC systems, and high vehicle occupancy. Common gaps include a paucity of IEQ studies and inadequate IEQ regulations or adapted standards in developing tropics. Infrastructural and regulatory deficiencies have been identified, along with strategies for mitigation. Recommendations are for more holistic IEQ studies in the tropics, including exposure studies for emerging gaps in new indoor pollutants, integration of AI and IoT for sustainable ventilation strategies, and development of effective regulatory frameworks considering region-specific conditions. Finally, Policymakers are encouraged to establish localized IEQ standards, enforce regulations, and prioritize upgrades to transport infrastructure. The SLR findings emphasize the urgent need for targeted interventions in developing tropical regions to address disparities in IEQ, ensuring healthier and more sustainable transport environments that could be replicated across transport systems worldwide.

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Samsuddin, S. B., Abdull, N., Suhaimi, A. A., Suhaimi, N. S.

**Indoor Air Quality Level in Mass Rapid Transit (MRT) Train in Malaysia.**

In: Controlling Environmental Pollution: Practical Solutions.

Springer Nature Singapore; 2025. 85-102 p.

This study aims to determine the correlation between CO2 concentrations, CO concentration, relative humidity, and temperature to the number of train passengers. Even though the number of passengers is growing, some reports assert that the quality of the indoor air of Malaysian passenger trains is controversial, particularly during peak hours. The survey included 28 major stations and was carried out over 2 h on weekdays at peak and non-peak hour travel times. The direct-reading instrumentations were in the middle of the train compartment and used for temperature, humidity, air movement, carbon monoxide (CO), and carbon dioxide (CO2). The number of passengers in and out of the train was also counted manually. The finding indicates that the concentration of CO2 (up to 1380 ppm) during peak hours exceeded the standard limits (1000 ppm) set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), and Department of Occupational Safety and Health (DOSH) Malaysia. A positive correlation exists between the number of passengers and CO2 concentration. However, the other parameters such as relative humidity, temperature, air movement, and CO concentration have weak correlations to the number of passengers. This study can provide initial data to the train management team on the requirement to improve indoor air quality by applying suitable control measures such as a proper ventilation system.

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Jiang, J., Huang, J., Jung, N., Boor, B. E.

**Spatiotemporal Variations in Ozone and Carbon Dioxide Concentrations in a HVAC System of a LEED-Certified Office Building.**

Building and Environment, (2025)

Indoor air quality (IAQ) is crucial for the health, well-being, and productivity of office occupants. IAQ is strongly influenced by occupancy and the operational mode of the heating, ventilation, and air conditioning (HVAC) system. This study investigates the spatiotemporal variations in ozone (O3) and carbon dioxide (CO2) concentrations throughout the HVAC system of a LEED-Certified office building. A four-month field measurement campaign was conducted at the Ray W. Herrick Laboratories, employing an automated multi-point sampling system to monitor O3 and CO2 at eight locations throughout the HVAC system. The objectives of this study are to characterize the spatiotemporal distribution of these gases under different ventilation modes and occupancy, and to identify O3 loss mechanisms in the office and its HVAC system. Spatiotemporal variations in O3 and CO2 concentrations were observed throughout the HVAC system. Results indicate that outdoor air exchange rates (AERs) significantly impact indoor O3 levels, with higher AERs resulting in increased indoor O3 but reduced CO2 concentrations. The study reveals that HVAC filters and ducts contribute to O3 loss, with up to 18% O3 removal observed in the longest HVAC duct segment. Additionally, occupancy influences O3 deposition onto human skin and clothing. This research underscores the limitations of ventilation standards that focus on CO2, highlighting the need for ventilation strategies that consider the effects of occupancy and AERs on different gases. By integrating multi-point gas sampling into building automation systems, more effective control strategies can be developed to enhance IAQ and occupant health while reducing energy consumption.

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