Rapport de veille n° 11-24

Qualité de l’air intérieur

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WoS, Google Scholar et Lens

Li, J., Zhao, H., Russell, M. L., Delp, W. W., Johnson, A., Tang, X., *et al.*
Air pollutant exposure concentrations from cooking a meal with a gas or induction cooktop and the effectiveness of two recirculating range hoods with filters.
Indoor Environments, Vol. **1** n°(4), (2024)

This study compares air pollutant concentrations resulting from cooking with gas or induction cooktops, with or without either of two recirculating range hoods with filters. A meal of pasta, plant-based “meat” sauce and stir-fried broccoli was cooked three times for each cooktop and hood combination in a 158 m3 room. Time-resolved measurements were made of nitrogen oxides (NOX), carbon dioxide (CO2), size-resolved particles, and speciated volatile organic compounds (VOCs) during cooking and 30 minutes after cooking. Cooking with induction used half as much energy, produced no discernible NOX, and significantly reduced ultrafine particles (UFP, diameter < 100 nm) and CO2 compared to gas cooktops. Induction produced statistically higher PM2.5 when calculated using size-resolved particle measurements from one pair of instruments, but the difference was not discernible when calculating from another pair. With gas cooktops, roughly half of the PM2.5 was in particles smaller than 0.3 µm and thus below the lower quantitation threshold for many optical particle instruments; optical devices may thus substantially under-report PM2.5 from gas cooking. VOCs did not significantly differ between gas and induction. Both recirculating range hoods substantially reduced all particle sizes when cooking with either fuel, and the reductions were larger for gas cooking. One of the range hoods also substantially lowered some of the VOCs.

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Garcia-Gonzalez, H., Lopez-Pola, T., Fernandez-Rubio, P., Fernandez-Rodriguez, P.
Analysis of Volatile Organic Compound Emissions in 3D Printing: Implications for Indoor Air Quality.
Buildings, Vol. **14** n°(11), (2024)

This study provides a comprehensive analysis of volatile organic compound (VOC) emissions in the context of 3D printing, a rapidly advancing technology that is transforming manufacturing processes. As the adoption of 3D printing grows, concerns regarding its potential impact on indoor air quality have emerged. This research addresses these concerns by investigating the risks associated with VOC emissions and proposing effective mitigation strategies. Using a robust methodology, filament and resin-based 3D printers were employed alongside VOC sampling equipment (Tenax tubes and personal pumps) to assess emissions. A detailed analysis of 49 VOCs revealed variable concentrations across different printing materials, with ethyl acetate being the dominant compound in resin printing and decanal in filament printing. While individual VOC levels were below 1% of occupational exposure limits, total VOC concentrations frequently exceeded the recommended indoor threshold of 200 µg/m3, particularly in resin-based processes. This raises concerns about the combined effects of multiple VOCs, some of which are known carcinogens. These findings underscore the need for further investigation into the cumulative health impacts of prolonged exposure to multiple VOCs. The study also emphasises the importance of accounting for both facility-specific conditions and material emissions to fully understand the environmental and health consequences of 3D printing. Preventative measures, such as enclosing 3D printers and equipping them with extraction systems, are recommended to safeguard user health.

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Explorelab, A. E., Heusen, S., Van Oel, C., Stoutjesdijk, P.
Architectural characteristics that contribute to well-being and experienced safety for innovative healthcare centres.
Delft University. Architecture and the Built Environment, Architecture and the Built Environment. Thèse 2024

Urban healthcare centres face considerable pressure due to the negative health impacts associated with cities and increasing urban density. These challenges add strain to healthcare providers already dealing with imbalances in care provision. Research indicates that environmental factors play an important role in physical recovery and stress reduction, yet many outpatient care facilities lack these beneficial features, presenting an opportunity for enhancement. By integrating healing architectural characteristics, patients can be encouraged to communicate openly about their health concerns, experiencing reduced mental and physical stress during examinations or treatments. Implementing such features not only reduces reliance on pain medication but also reduces aggression toward

healthcare providers and diminishes the need for recurrent visits. This paper hypothesizes that patients' stress levels have escalated since the COVID-19 pandemic, primarily due to concerns about airborne diseases in healthcare settings. Architectural features can mitigate the risk of contracting such diseases, potentially enhancing the perceived safety within these environments. Through a review of existing literature, this paper identifies current and future hurdles in healthcare centres, including airborne diseases, and proposes evidence-based design solutions aimed at enhancing patients' visiting experiences.

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Larcher, M., Leonardi, E., Troi, A., Stefani, A., Nerobutto, G., Herrera-Avellanosa, D.
Assessing the impact of moisture buffering properties of materials on indoor environmental quality: A study on a recycled material plaster.
Building and Environment, Vol. **267**, (2025)

This study examines Moisture Buffer Value (MBV) of interior finishing layers, which impacts buildings internal relative humidity, thus indoor environmental quality. The MBV depends on material's moisture capacity and vapour diffusion resistance factor, both of which depends on relative humidity. The paper aims to (i) characterize a new recycled material plaster that includes construction and food industry waste through laboratory measurements, (ii) use dynamical building simulations to quantify the impact of the MBV of existing and the new interior plaster on relative humidity in real design scenarios, and (iii) evaluate how changing the definition of the MBV to consider its dependence on indoor air relative humidity can improve its accuracy. Results show that the plaster's moisture buffering properties significantly reduce the variations of the relative humidity of interior climates compared to a vapour-tight finishing layer. The performances of the new plaster made with recycled materials are comparable to those of the other plasters. The new MBV definitions (“Dynamical MBV” and “Summer/Winter MBV”) show a significantly improved correlation with the relative humidity variations of indoor climates of buildings, observed in dynamic simulations, with respect to the typically used practical MBV. The new definitions are therefore promising for practical applications.

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Elangovan, U., Rani Hemamalini, R., Partheeban, P., Sridhar, M.
Assessment of harmful gases emission and its impact using IoT and geospatial technology.
Measurement, Vol. **242**, (2025)

Numerous industries in our daily lives use a variety of dangerous chemical gases, and workers are frequently exposed to these gases. The losses due to harmful gases can be reduced by developing an automatic harmful gases detection and alerting system. This study aims to design, develop, and implement an automatic warning system using series of gas sensors to deduct. The designed system is implemented to monitor 3 locations to detect the hazardous pollutions parameters, namely Large-Scale industries, wood burning sites and residential housings and analysed to understand the pollution level. This study observed elevated temperatures (35–45 °C) and heat index (30–50 °C) in large-scale industries, along with higher harmful gases compared to wood-burning sites and homes. Interestingly, wood-burning sites exhibited higher humidity (60–70 %) and peak ozone and methane levels compared to other locations. These variations underscore the unique environmental characteristics of each site, emphasizing the need for tailored monitoring and safety measures.

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Wei, W., Song, S., Meng, C., Li, R., Feng, Y., Chen, X.*, et al.*
Bacterial cellulose/polyethylene glycol composite aerogel with incorporated graphene and metal oxides for VOCs detection.
Chemical Engineering Journal, Vol. **499**, (2024)

It is important to monitor and detect volatile organic compounds (VOCs) for environmental protection, occupational safety and human health. Portable and compact VOC sensing devices with a fast response are needed for real-time monitoring and simple analysis. Using solvent exchange and freeze-drying techniques, an ultralight 3D bacterial cellulose (BC) aerogel is prepared and modified by polyethylene glycol with the functionalization of graphene and metal oxides to detect VOC gases. Unlike commercially available flat VOC sensors, the 3D structure of our VOC sensor with high permeability of BC composite provides superior sensing characteristics for acetone, formaldehyde and ethanol in a wider range of scenarios. The portable BC composite sensor exhibits remarkable sensitivity and selectivity toward VOCs

detection. The BC composite with TiO2 has a response time of about 20 s to 1 ppm acetone and can detect as low as 1.43 ppm at room temperature. In addition, BC composites with ZnO are suitable for detecting formaldehyde in indoor air.

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Mohamad Farid Sies, Jamiluddin Jaafar, Norzelawati Asmuin, Winardi Sani
A Bibliometric Review of Local Exhaust Ventilation (LEV) Culture Studies.
International Journal of Mechanical and Sustainability Engineering Technology, Vol. **1** n°(1), (2024), 1-21 p.

Local exhaust ventilation (LEV) systems are critical in maintaining air quality and ensuring safety in industrial and laboratory settings. However, a comprehensive review article needs to be published covering all aspects of local exhaust ventilation (LEV) research. This study presents a comprehensive bibliometric analysis of LEV research from 2020 to 2024, aiming to elucidate the current state, trends, and collaborative patterns in this field. Utilising the Scopus database, we employed various bibliometric techniques, including temporal analysis, author productivity assessment, subject classification, citation analysis, keyword co-occurrence, co-authorship network analysis, and co-citation network mapping. The results reveal a fluctuating publication trend, with a peak of 67 publications in 2022 and a decline in subsequent years. Engineering, Environmental Science, and Medicine emerged as the dominant subject areas, collectively accounting for 52.2% of the publications. The analysis identified key contributors, with Logachev, K.I., Averkova, O.A., and Wang, Y. as the most productive authors. Geographically, the United States, China, and the Russian Federation led in research output. Keyword analysis focused on specific industrial contexts, such as construction, welding, and occupational exposure concerns. Co-authorship network analysis revealed solid international collaborations, while co-citation mapping identified influential authors and research clusters. This study provides valuable insights into the interdisciplinary nature of LEV research, its key contributors, and collaborative networks. The findings can guide future research directions, resource allocation, and policy formulation to enhance occupational health and safety through effective LEV system implementation.

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Shojaei, A., Rostami, R.
BTEX concentration and health risk assessment in automobile workshops.
Atmospheric Pollution Research, Vol. **15** n°(12), (2024)

This study focused on the measurement of BTEX (benzene, toluene, ethylbenzene, and xylene) concentrations in the air of indoor and outdoor environments of automobile workshops in Damghan, Iran. Air samples from twenty-five workshops were actively collected and analyzed using Gas Chromatography-Flame Ionization Detection (GC-FID). The results showed that the concentrations of BTEX were higher in the indoor air compared to the outdoor air. The highest mean concentration of benzene (153.22 ± 34.21 μg m−3), toluene (94.41 ± 25.25 μg m−3), and xylenes (385.38 ± 34.21 μg m−3) was found in auto paint (AP) workshops, while the highest mean concentration of ethylbenzene (43.39 ± 12.57 μg m−3) was observed in auto body (AB) workshops. The significant negative correlations between benzene, ethylbenzene, xylene isomers, and relative humidity (RH) indicated that controlling humidity is an effective strategy. The mean inhalation lifetime cancer risk (LTCR) for benzene in both indoor and outdoor air of all automobile workshops exceeded the EPA (Environmental Protection Agency) recommended limits. The highest mean LTCR values for benzene and ethylbenzene were observed in the AP (3.24E10-4) and AB (2.95E10-5) workshops, respectively. The hazard quotient (HQ) of benzene and Xylene in the indoor air of the AP and AB workshops was >1, which indicates that the non-carcinogenic risks associated with exposure to these compounds are considerable. This study underscores the need for international attention to BTEX pollution in automobile workshops, highlighting the global health risks. The findings provide crucial data for developing strategies to mitigate these risks and protect workers' health.

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Costarramone, N., Le Bot, B., Le Cann, P., Plaisance, H., Raffy, G., Surget, E., *et al.*
Caractérisation de la qualité de l'air dans des salles de sport de différentes typologies (projet QAI-Sport).
Atmos'Fair 15e édition - Qualité de l'Air : de la recherche aux solutions opérationnelles. Octobre 2024. Lyon, France

La qualité de l'air intérieur des salles de sport est encore peu connue et étudiée, notamment en France,en comparaison de celle des logements et d'autres Etablissements Recevant du Public (ERP). Pourtant,avec le nombre croissant

d'amateurs de sport, les installations sportives intérieures ont connu une forteaugmentation au cours des dernières décennies. Avec des niveaux de pollution qui peuvent être plusélevés à l'intérieur qu'à l'extérieur, l'activité physique intense pratiquée dans les salles de sport peutcontribuer à augmenter le risque d'exposition aux contaminants en suspension dans l'air.Le projet QAI-SPORT a pour objectif de caractériser l'exposition aux polluants organiques volatils (COV)et semi-volatils (COSV) et aux contaminants microbiologiques (moisissures, virus et bactéries) autravers de l'étude de 10 de salles de sport d'activités différentes (fitness, dojos, salles de motricité pourjeunes enfants).

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Moazami, T. N., Sterud, T.
The combined effect of indoor climate and psychosocial stressors on subsequent headaches: A prospective study of the general working population in Norway.
Indoor and Built Environment, (2024)

This prospective panel study explores the link between indicators of poor indoor climate and psychosocial stressors in the work environment with subsequent headaches. A random sample of the Norwegian working population (18 to 66 years) was examined, using self-reported health symptoms and work exposures collected in 2009, 2013 and 2016. This study included repeated measurements of 6681 workers attending at least two consecutive interviews (16,493 observations). The results were analysed using generalized estimating equations (GEEs), adjusting for sex, birth year, occupation, education, baseline mental health and the presence of headache at baseline. Headaches were prevalent in 25.4% of cases, with odds ratios (ORs) increasing with poor indoor climate (ORcontinuous = 1.14, 95% CI: 1.08?1.19) and number of psychosocial stressors (ORcontinuous = 1.09, 95% CI: 1.04?1.14). The OR amongst individuals concurrently exposed to both poor indoor climate and psychosocial stressors was 1.49 (95% CI: 1.26?1.75). Approximately one in five headache cases were attributable to this combined exposure. Measures implemented to reduce the prevalence of headaches in the work environment should consider the combined impact of a poor indoor climate and psychosocial stressors.

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Pullani, C., Pavithran, S.
Data-Driven Optimization of Smart Cleaning Processes in Buildings: Integrating Internal and External Data Sources.
Halmstad University, School of Information Technology. Thèse 2024

Smart cleaning technologies powered by data integration are revolutionizing building management by optimizing cleaning processes for efficiency and sustainability. This research explores how internal and external data sources can be integrated to optimize smart cleaning processes in buildings, addressing the research question: "How can internal and external data sources be used to optimize the process of smart cleaning in buildings?" The study identifies relevant data types, examines their integration into cleaning processes, and evaluates their impact on operational efficiency, resource optimization, and occupant well-being. A qualitative approach was employed, utilizing semi-structured interviews with key stakeholders in building management and smart cleaning. The findings reveal that internal data, such as occupancy and environmental sensor data, is vital for real-time cleaning adjustments, while external data, including weather forecasts and public health information, improves the responsiveness of cleaning strategies. The integration of these data sources leads to more efficient cleaning operations, reduced resource wastage, and greater occupant satisfaction. The research concludes that data-driven smart cleaning processes offer significant advantages in maintaining building hygiene and operational efficiency. The study recommends further investment in advanced data integration platforms and training for cleaning staff to maximize the effectiveness of data-driven cleaning strategies.

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Sy, W., District, T. B.
Data-driven prediction of indoor airflow distribution in naturally ventilated residential buildings using combined CFD simulation and Machine Learning (ML) approach.
Journal of Building Physics, Vol.**47** n°10, (2024)

Predicting indoor airflow distribution in multi-storey residential buildings is essential for designing energy-efficient natural ventilation systems. The indoor environment significantly impacts human health and well-being, considering the substantial time spent indoors and the potential health and safety risks faced daily. To ensure occupants' thermal comfort and indoor air quality, airflow simulations in the built environment must be efficient and precise. This study

proposes a novel approach combining Computational Fluid Dynamics (CFD) simulations with machine learning techniques to predict indoor airflow. Specifically, we investigate the viability of employing a Deep Neural Network (DNN) model for accurately forecasting indoor airflow dispersion. The quantitative results reveal the DNN's ability to faithfully reproduce indoor airflow patterns and temperature distributions. Furthermore, DNN approaches to investigate indoor airflow in the residential building achieved an 80% reduction in the time required to anticipate testing scenarios compared with CFD simulation, underscoring the potential for efficient indoor airflow prediction. This research underscores the feasibility and effectiveness of a data-driven approach, enabling swift and accurate indoor airflow predictions in naturally ventilated residential buildings. Such predictive models hold significant promise for optimizing indoor air quality, thermal comfort, and energy efficiency, thereby contributing to sustainable building design and operation.

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Shen, Y.
Development and investigation of a solar-driven indoor CO2/H2O capture system for low-carbon buildings.
Hong Kong Polytechnic University. Department of Building Environment and Energy Engineering. Thèse 2024

Overall, in this thesis, we proposed a novel SICC system as an innovative strategy for achieving low-carbon buildings, and demonstrated its feasibility in capturing indoor CO2, maintaining IAQ, and saving building energy in a wide spectrum of indoor environments and climate conditions. We also provide a new modeling-optimization framework to untangle the performances' interplay and help generate contextual SICC designs. The proposed SICC system is poised to offer a paradigm shift in the way we achieve low-carbon buildings for urban sustainability.

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Huang, C., Chuang, T.-K., Gomes, I., Ajala, L., Cram, E., Jung, N.*, et al.*
Development of a New Laboratory Test Methodology for Rapid Ageing of HVAC Filters.
8th International High Performance Buildings Conference at Purdue. 2024

Air filters installed in residential and commercial HV AC systems encounter a complex mixture of aerosols of outdoor and indoor origin during their service life. Standardized laboratory test methodologies are important for evaluating the loading behavior ofHV AC filters. Loading aerosols commonly used to age HV AC filters include various test dusts (ISO12103-l-A2, ISO-12103- l-A4, ASHRAE Test Dust) that are primarily composed of coarse mode particles (1 to 100 µm). However, urban aerosol mass size distributions often feature a prominent accumulation mode between 0.1 and 1 µm that is not well represented by traditional loading aerosols. The aim of this study is to develop a new laboratory test methodology for rapid ageing of HVAC filters with a representative urban aerosol mass size distribution at a high concentration to better predict long-term changes in HVAC filter performance. A HVAC filter test rig was custom designed and built following ASHRAE 52.2 specifications to artificially age HV AC filters with sub-micron potassium chloride (KCl) aerosol produced by a thermal aerosol generator. The KCl aerosol is formed by burning KCl sticks in a high temperature oxygen-propane flame and is delivered to the test rig via a damper-controlled intake duct. The results demonstrate that the new sub-micron KCl loading aerosol is a time- and cost-effective technique to artificially age HV AC filters with a particle mass size distribution representative of that found in HV AC installations in buildings.

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Laurence, T.
Drastic Energy and Carbon Reductions in Office Headquarters.
ASHRAE Journal, Vol. **66** n°(10), (2024), p. 48-51

The article discusses the energy and carbon reductions achieved in the Liberty Mutual Tower in Boston. The tower, which was completed in 2013, has undergone ongoing commissioning and energy conservation projects to improve its HVAC systems' operation and efficiency. These efforts have resulted in continuous decreases in energy use and operating costs. The building has implemented various energy-efficient control strategies, optimized ventilation, and incorporated innovative HVAC control strategies. As a result, the tower has achieved a 60% reduction in energy consumption and $4.5 million in utility savings since 2014. The owner is committed to further reducing the building's carbon footprint and has set a goal of a 50% reduction in greenhouse gas emissions by 2030.

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Iffa, E., Kunwar, N., Salonvaara, M., Hun, D.
Enhancing Commercial Building Energy Efficiency through Automated Air Sealing.
International Building Physics Conference (IBPC 2024) - Toronto, , Canada. 7/25/2024 -7/27/2024

Air leakage impacts commercial buildings' energy consumption significantly. Air leakage represents about 4 quadrillion Btu annually in the US. The other consequences of air leakages include moisture damage, lack of thermal comfort, degraded indoor air quality, and affecting the operation of mechanical ventilation systems. This study addresses the issue by demonstrating the advantages of an automated air sealing technology in a commercial building environment. The technology uses a modified blower door to pressurize and distribute the sealing aerosol to achieve the required building airtightness in an accurate, time-efficient, and cost-efficient manner. By measuring the airtightness levels post-application, we computed the building's overall energy consumption under various parameters, thereby revealing the technology's contribution to energy savings. The analysis based on energy simulation included the total energy use intensity (EUI) and separated the savings into natural gas and electricity consumption. Findings revealed that the greatest energy savings were observed in buildings in colder climates, particularly those with higher levels of air leakage and larger exposed surface areas. Energy savings of up to 41% in electricity and 81% in natural gas were found, underscoring the potential of automated air sealing in enhancing building energy efficiency.

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Selitrennikoff, C. P., Sylvia, C., Sanchez, M., Lawrence, P., Trosch, K., Carenza, A., *et al.*
Evaluate the safety of a novel photohydrolysis technology used to clean and disinfect indoor air: A murine study.
PLOS ONE, Vol. **19** n°(10), (2024)

There is a pressing need to develop new technologies that continuously eliminates harmful pollutants and pathogens in occupied indoor spaces without compromising safety. This study was undertaken to test the safety of a novel air cleaning and disinfection technology called Advanced Photohydrolysis. Advanced Photohydrolysis generates a complex mixture of ions and molecules that are released into the air and has been shown to reduce airborne and surface pathogens. Mice (6–8-week-old) were exposed to therapeutic levels of Advanced Photohydrolysis for 90-days. During the study, the Advanced-Photohydrolysis-exposed and control mice were monitored for food consumption, body weight gain, and any overt adverse effects. In addition, at the conclusion of the study, the blood chemistry and hematology values of both groups were determined. Finally, the tissues of the conduction and respiratory portions of the airways of mice from both groups were examined for any pathological changes. The mice of both groups were found to be normal and healthy throughout the 90-day study; there were no differences in the behavior, food consumption and weight gain. Analysis of clinical chemistry values found no differences in hepatocellular function or other markers of cellular and organ function, and clinical hematology values were also unremarkable. Finally, and importantly, histopathology of the upper and lower airway tissues showed no deleterious effects. These results are the first to demonstrate directly the safety of Advanced Photohydrolysis on live mammals and encourage additional studies.

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Haruna, U., Mohammed, M. A., Ajibade, Y. A.
Evaluating the impacts of printing operations on indoor air quality in a printing press.
Facilities, Vol. **ahead-of-print** n°(ahead-of-print), (2024)

Purpose Building operations and human activities indoors continuously affect air quality, contaminating the air and sometimes exceeding permissible limits which can be health threatening either in the short or long time. This implies a need for strict awareness and compliance with air quality standards, particularly in workplaces prone to air contaminants emissions. This study aims to evaluate printing-related pollutant concentrations and their effects on indoor air quality (IAQ). The study investigated a printing press's total volatile organic compounds (TVOC), particulate matter (PM), carbon monoxide and carbon dioxide emissions. Design/methodology/approach This study used mainly an experimental research design supported by physical assessment by identifying the major printing-related pollutants, assessing the existing situation and measuring pollutant concentration levels using literature reviews, walkthrough inspections and experiments, respectively. The measurements were conducted in two scenarios: with and without printing activities, and the results were compared with relevant standards and guidelines. Findings The outcomes indicate that TVOC concentration reaches 120 ppb during printing and binding activities, exceeding the 75 ppb acceptable limit based on the time-weighted average. The PM2.5 concentrations reach 49 µg/m3 and PM10 up to 150 µg/m3, exceeding acceptable levels given by the US Environmental Protection Agency (EPA), which are 35 µg/m3

and 150 µg/m3 for PM2.5 and PM10, respectively. These high concentrations of TVOC and PM indicate a significant risk to the health of building occupants, particularly those with respiratory conditions. PM concentrations do not exceed permissible levels when no printing or bookbinding occurs, suggesting that printing-related activities can contribute to elevated TVOC and PM concentrations. Social implications The social implication of the study lies in its ability to promote awareness among workers and improve their well-being which in turn relates to productivity. The study outcome could also encourage businesses to adopt more responsible environmental and social practices as part of corporate social responsibility practices. Originality/value The study's findings, which highlight the need for improved ventilation in printing halls, have the potential to significantly benefit building system designers, facility managers, policymakers and decision-makers. By providing information and theoretical support, the research can help integrate policies that regulate IAQ by reducing pollutant concentrations. This protects workers' health and helps update and enforce stricter IAQ regulations for industrial operations.

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Bhatti, O. S., Iftakhar, N., Aiou, I., Muhammad, H., Nadeem, A.
Evaluation Of LEED Certification Potential For Built Environment Pedagogy At Undergraduate Level In Pakistan. Case For Architecture & Design Domains.
INTERNATIONAL JOURNAL OF HUMAN AND SOCIETY, Vol. **4** n°(2), (2024)

Modern day life of human settlements mainly reside and spend their time in indoor spaces. A well-planned constructed environment is usable by individuals of diverse backgrounds, ages, and abilities. A well-designed built environment may promote wealth and economic progress. Built environment and Architecture have been a source of friend of mankind since human race history. Yet with the modern day development and construction shifting to non-renewable resources lead to production of green house gases leading to climate change. Objective: Lack of standardization in design and architecture domains raised concerns related to future challenges faced by the built environment based on the current challenges of climate change, energy & water crisis and lack of design practices to cope with these issues. Methodology: The research explored the current awareness and knowledge of LEED as the major standard accepted globally for Energy & Environmental Design to be used by future generation of designers in Pakistan. Results: The study identified existing awareness and sensitization of built environment professionals from architecture and design domains for future. Two way approach for data collection was used and sample comprised of 100 students from four different higher education institutions It was concluded that students are aware of the LEED and how important it is to the development of sustainable design in context of Pakistan. However average knowledge is low. Recommendations: It was proposed by the respondents that LEED should be considered not only an option but a must integrated part of the design as well as academia of the design industry.

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Mohd Abdullah, M. S., Rosli, M. A., Hariri, A., Muhamad Damanhuri, A. A., Berkah Fajar, T., Ebas, N. A.*, et al.*
Evaluation of Sick Building Syndrome (SBS) Symptoms and Measurement of Indoor Air Quality (IAQ) Parameter in One of Hospital Building in Johor.
Journal of Advanced Research in Applied Sciences and Engineering Technology, Vol. **52** n°(2), (2024), 139-147 p.

This study assesses Sick Building Syndrome (SBS) symptoms and Indoor Air Quality (IAQ) parameters among hospital ward staff. Utilizing a thorough methodology, a questionnaire survey and IAQ monitoring were conducted, aligning with Department of Occupational Safety and Health (DOSH) guidelines. IAQ parameters are generally within limits, except for relative humidity which recorded values of 73.09-75.23% for Ward 16 and 62.33-71.13% for Ward 18. Respondents expressed concerns about room conditions, including temperature variations, unpleasant odours, and noise. Fatigue, difficulties concentrating, and various respiratory symptoms were prevalent, suggesting potential health issues linked to indoor pollutants. The findings underscore the urgency of addressing IAQ concerns to improve the well-being of patients and healthcare workers.

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Shi, S., Miyata, S., Akashi, Y.
Event-driven model-based optimal demand-controlled ventilation for multizone VAV systems: Enhancing energy efficiency and indoor environmental quality.
Applied Energy, Vol. **377**, (2025)

Model-based optimal demand-controlled ventilation (DCV) for multizone variable air volume (VAV) systems has significant potential for reducing energy consumption and enhancing occupancy comfort. However, the complexity of ventilation duct networks, building thermal dynamics, and the high computational demand for optimization pose challenges for widespread deployment in real buildings. To address these issues, we propose an event-driven model-based optimal DCV control for multizone VAV systems. The ventilation duct network is represented by an artificial neural network model, and the building thermal dynamics are captured by a multizone thermal network model, both of which are integrated into the control scheme. Unlike conventional approaches, the proposed strategy features an event-driven mechanism that triggers optimization only when necessary, thereby reducing the overall computational load. The controller determines the optimal fan frequencies and damper openings, minimizing energy consumption while maintaining a satisfactory indoor environmental quality (IEQ). Simulation comparisons and case studies validate the proposed strategy against different control methods. Compared to the time-driven method, the proposed strategy achieves similar performance while reducing the optimization runs by 70.83% with a small threshold throughout the occupied period. Additionally, it reduces the total IEQ cost by over 90% compared to well-tuned proportional-integral algorithm-based control and by 70% compared to setpoint optimization. Furthermore, flexible tradeoffs can be made based on the priority of reducing the computational load or maintaining the IEQ.

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Lovrić, M., Gajski, G., Fernández-Agüera, J., Pöhlker, M., Gursch, H., The, E. C.*, et al.*
Evidence driven indoor air quality improvement: An innovative and interdisciplinary approach to improving indoor air quality.
BioFactors, (2024)

Indoor air pollution is a recognized emerging threat, claiming millions of lives annually. People are constantly exposed to ambient and indoor air pollution. The latest research shows that people in developed countries spend up to 90% of their time indoors and almost 70% at home. Although impaired Indoor Air Quality (IAQ) represents a significant health risk, it affects people differently, and specific populations are more vulnerable: children, the elderly, and people with respiratory illnesses are more sensitive to these environmental risks. Despite rather extensive research on IAQ, most of the current understanding about the subject, which includes pollution sources, indoor?outdoor relationships, and ventilation/filtration, is still quite limited, mainly because air quality monitoring in the EU is primarily focused on ambient air quality and regulatory requirements are lacking for indoor environments. Therefore, the EDIAQI project aims to improve guidelines and awareness for advancing the IAQ in Europe and beyond by allowing user-friendly access to information about indoor air pollution exposures, sources, and related risk factors. The solution proposed with EDIAQI consists of conducting a characterization of sources and routes of exposure and dispersion of chemical, biological, and emerging indoor air pollution in multiple cities in the EU. The project will deploy cost-effective/user-friendly monitoring solutions to create new knowledge on sources, exposure routes, and indoor multipollutant body burdens. The EDIAQI project brings together 18 organizations from 11 different European countries that provide interdisciplinary skills and expertise in various fields, including environmental science and technology, medicine, and toxicology, as well as policy design and public engagement.

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Misztal, T. J., Addasi, O., Albano, J., Liu, Y.
An Experimental Study on the Emission Dynamics in Fused Deposition Modelling (FDM) 3D Printing Process.
ASME 2024 Heat Transfer Summer Conference and the ASME 2024 18th International Conference on Energy Sustainability. July 15–17, 2024. Anaheim, California, USA

Fused Deposition Modeling (FDM) 3D printing is a manufacturing process that involves the melting and layering of thermoplastic to create 3D objects. Concerns have arisen from the volatile organic compounds (VOCs) emitted when 3D printing filaments are heated to their melting points, posing environmental and health risks. In the present study, a series of experiments were conducted to characterize the thermal flow phenomena during FDM 3D printing, specifically focused on investigating the VOCs emission dynamics along with the thermal flow during heating and melting in the printing processes. A high-speed Schlieren imaging system and an infrared thermal imaging system were temporally synchronized to both qualitatively and quantitatively characterize the thermal effects and the thermal-induced multiphase flows during the 3D printing process within an FDM 3D printer. In addition, the VOC emissions during the printing process were quantified by using a spatially-distributed-and-temporally-synchronized metal-oxide sensor array system, which can achieve fast spatial tracking of the VOC emissions. By correlating the data from the multiple

measurement systems, the VOC emission transport behaviors in the convective gas current were characterized in detail. The findings in this paper offer insights into off-gassing profiles of different filaments, aiding in the development of customized ventilation approaches.

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Li, Z.-H.
Exploration of HVAC Engineering Design and Construction.
Engineering Technology Trends, Vol. **2** n°(4), (2024)

With the continuous development of society and technological advancements, the design and construction of HVAC engineering are increasingly receiving attention and recognition. In terms of engineering design, the green concept and technologies for energy conservation and environmental protection are becoming mainstream. The design of effcient and energy-saving HVAC systems is crucial for improving building energy effciency and achieving sustainable development. In the construction feld, strengthening quality and safety control is essential for enhancing engineering quality, effciency, and safety. The exploration and practice of HVAC engineering design and construction aim to create more intelligent, energy-effcient, environmentally friendly, and comfortable indoor environments, meeting people's demands for high-quality living and sustainable development.

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Jiang, J., Liu, J., Wang, C., Yin, Y., Pei, J., Gao, Y.*, et al.*
Exploring the long-term performance of air purifiers in removing particulate matter and formaldehyde across different residential environments.
Environmental Research, Vol. **263**, (2024)

Household air purifiers are widely used to enhance indoor air quality. However, limited information exists regarding the factors that influence their long-term performance. This study investigates the impact of various residential environments on the long-term efficacy of air purifiers. We deployed household air purifiers in three distinct environments: oily fumes (Group A), non-oily fumes (Group C), and a mixture of oily and non-oily fumes (Groups B-I and B-II). The selected air filter consisted of melt-blown polypropylene and activated carbon, materials commonly employed in commercial applications. The results demonstrated that the control efficiency of air purifiers in non-oily fume environments surpassed that in oily fume environments. After 12 months of operation, particulate matter (PM) concentrations rose by 92.7% and 76.5% in oily and non-oily fume environments, respectively. This increase was primarily attributed to the loss of electrostatic attraction in the polypropylene material due to the organic matter in oily particulate matter. After operating for 1000 h, the clean air delivery rate (CADR) attenuation rates for particulate matter were 70.6%, 19.9%, 16.7%, and 12.5% in Groups A, B-I, B-II, and C, respectively. The CADR attenuation rates for formaldehyde were 80.6%, 48.4%, 38.9%, and 37.3% in the same groups. Additionally, we developed a real-time prediction model for the service life of air purifiers using data from online sensors. When operated for 12 h daily at varying PM concentrations, the filters had an expected service life of 29–97 days in non-oily fume environments and 66–220 days in oily fume environments.

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Linder, A., Zhu, A., Bruns, R., Olsiewski, P., Gronvall, G.
FAR-UV Technology and Germicidal Ultraviolet (GUV) Energy: A Policy and Research Review for Indoor Air Quality and Disease Transmission Control.
Preprints.org, (2024)

COVID-19 highlighted the challenges of public acceptance of public health measures, including mask-wearing and vaccination. which has spurred interest in engineered approaches to reduce infections. Germicidal Ultraviolet (GUV) Energy has been used for decades in hospital rooms to limit TB transmission, but it is expensive to install in the upper part of rooms where it may be used safely. In contrast, FAR-UV energy is a relatively new, flexible technology that can be set up in rooms for moderate costs, and studies thus far indicate it is efficacious and not damaging to eyes or skin. To examine the state of the field, experts in aerosol biology, infection control, and building engineering from academia, government, and industry were convened to inform policy recommendations for future investments, identify research required, and examine policy options for using these technologies. Despite its high efficacy for deactivating several types of microorganisms and pathogens of concern, before FAR-UV technologies may be widely deployed, additional

studies are needed to understand potential adverse effects, as well as the best approaches to use, standardize, and regulate the technology. In some environments, the use of FAR-UV can generate ozone, which can react with volatile organic compounds that may be hazardous to human health, such as respiratory tract irritation. Even with these concerns, the demonstrated effectiveness in disease control of both FAR-UV and longer wavelengths of GUV deserve increased policy attention to reduce risks of indoor disease transmission. While potentially useful to counter disease in high-risk indoor environments, further standardization and regulatory measures, as well as research into the production of oxidative compounds is necessary before broad adoption of FAR-UV.

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Shen, C., Pan, Z., Wei, T., Yu, C. W., Luo, X.
Feasibility and climate adaption of shallow geothermally driven direct ventilation.
Indoor and Built Environment, (2024)

Ground heat exchangers in ground source heat pump (GSHP) systems can provide low-temperature water, which has the potential to be utilized for pre-cooling in building ventilation. In this study, a novel shallow geothermally driven direct ventilation system was established. Experimental measurements were conducted to evaluate the effectiveness of the system. In addition, a TRNSYS software dynamic numerical model was developed to assess the long-term operational characteristics. The results of the long-term experiments indicated stable shallow soil temperatures, which were significantly lower than the outdoor temperatures in summer. Even when the outdoor temperature rose to 39.0°C, the system could provide an air supply temperature of 19.5°C, maintaining an average indoor temperature of 24.9°C. Numerical simulation results demonstrated that a shallow geothermally driven direct ventilation system could achieve an 88.9% rate of satisfaction for the cooling season. The system performed efficiently in dry and cold regions, such as Xi?an, and in severely cold regions, such as Shenyang. The results showed that two buried pipes exhibited optimal operational efficiencies. Therefore, installing a ventilation cooling system with buried pipes covering an effective cooling area of 18 m2 is recommended. These findings provide valuable reference data for effective promotion of shallow geothermal energy in low-energy buildings.

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Sana, D. P. R.
Harmonizing Innovation: Exploring the Future of Smart Spaces.
International Journal of Town Planning and Management, Vol. **10** n°(1), (2024)

The inception of the harmonizing innovation was fueled by a forward-thinking vision aimed at revolutionizing interior spaces through the seamless integration of adaptive design concepts and cutting-edge technological advancements. At the core of our approach lies an interactive dialogue between design creation and inhabitants, facilitated by the incorporation of Artificial Intelligence tools. Through case studies drawn from numerous projects, the evolution of integrating smart solutions into interior design emerges as more than just a passing trend. It showcases not only an enhancement of aesthetic appeal but also practical functionality and efficiency, with Artificial Intelligence emerging as a futuristic design tool that expands the horizons of creative expression. By shedding light on existing design challenges, the report underscores the significance of collaborative efforts among creative professionals in enhancing the overall quality of interior space design. It highlights the transformative potential of integrating smart technologies seamlessly into interior design, leveraging advancements in AI, IoT, and automation to create spaces that are not only visually captivating but also intuitive and responsive to the needs of occupants. In conclusion, this report consists into the integration of smart technologies into interior design and its practical application. It explores the myriad benefits of seamlessly blending smart technologies with design, from enhancing functionality to fostering creativity and innovation. Through collaborative efforts and a forwardthinking approach, Smart Interior Design Studios are poised to shape the future of interior design, creating spaces that are not just aesthetically pleasing but also intelligent, efficient, and responsive to the needs of modern living.

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Islam, R. U., Mazzei, P., Savaglio, C.
Healthiness and Safety of Smart Environments through Edge Intelligence and Internet of Things Technologies.
Future Internet, Vol. **16** n°(10), (2024)

Smart environments exploit rising technologies like Internet of Things (IoT) and edge intelligence (EI) to achieve unseen effectiveness and efficiency in every tasks, including air sanitization. The latter represents a key preventative measure–made even more evident by the COVID-19 pandemic–to significantly reduce disease transmission and create healthier and safer indoor spaces, for the sake of its occupants. Therefore, in this paper, we present an IoT-based system aimed at the continuous monitoring of the air quality and, through EI techniques, at the proactively activation of ozone lamps, while ensuring safety in sanitization. Indeed, these devices ensure extreme effectiveness in killing viruses and bacteria but, due to ozone toxicity, they must be properly controlled with advanced technologies for preventing occupants from dangerous exposition as well as for ensuring system reliability, operational efficiency, and regulatory compliance.

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Oosterhoff, J.
A healthy oasis in the centre of Apeldoorn: Taking care of the human wellbing by architectural interventions in the shopping mall.
Technical University of Delft. Thèse 2024

Without realising it, a building can have a lot of impact on user health. Using literature studies and interviews in two case studies, we looked at how physical elements in a building affect the user's experience. These physical elements are nature, material, air, light, dimensions, smell, sound and temperature. These interviews took place in shopping malls. As it happens, more and more shopping malls are becoming vacant. The design case for this project, the Oranjerie, also experienced this. Located in the city centre of Apeldoorn, this shopping mall has been battling this vacancy for ages. In this design, I propose adding more nature, applying healthy (bio-based) materials where necessary, reusing or recycling materials, connecting indoors with outdoors more, creating multiple meeting places and mixing different functions. By opening up the traffic area, but still keeping the roof, an adaptable space is created with a climate that changes throughout the seasons. Through these interventions, I hope to create a healthy environment where people feel comfortable and can meet. By creating multiple types of spaces, it creates a lively area where people can shop, live, eat or just unwind.

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Liang, Q., Lin, G., Gao, J., Li, Z., Feng, Q.
Highly selective detection of ppb-level formaldehyde realized by regulating the surface chemisorbed oxygen of Ga-doped In2O3 microspheres.
Journal of Alloys and Compounds, Vol. **1010**, (2025)

Formaldehyde is a ubiquitous indoor pollutant. Developing metal oxide semiconductors gas sensors for selective ppb-level formaldehyde detection is challenging. Therefore, developing gas sensors that can selectively detect indoor formaldehyde at ppb levels is important. In this study, outer-walled thin sheet-like microspheres of Ga-doped In2O3 (GaxIn2-xO3, x = 0, 0.1, 0.2, 0.3, and 0.4) were fabricated using a facile two-step synthetic method. The Ga0.3In1.7O3 based sensor shows the response (556 ± 25) to 100 ppm formaldehyde at 80 °C, which is around 6.5 times that of the pure In2O3 based sensor at 90 °C. Furthermore, it has fast response time (< 3 s), excellent selectivity (SFormaldehyde/SEthanol = 160, SFormaldehyde/SAcetone = 267), good stability (at least 60 days), and ultra-low limit of detection (10 ppb) for formaldehyde at 80 °C. The improved formaldehyde sensing performance of Ga0.3In1.7O3 microspheres is attributed to the optimization of surface chemisorbed oxygen, which is caused by Ga doping regulating the Fermi level of In2O3 as well as an increase in the specific surface area.

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Dash, S., Mojumder, S., Das, T., Saha, D., Pal, M.
Highly sensitive and selective rGO-LaFeO3 nanocomposite based formaldehyde sensors towards air quality monitoring.
Chemosphere, Vol. **367**, (2024)

Formaldehyde (HCHO), a ubiquitous volatile organic compound and recognized human carcinogen, is extensively used in industrial applications such as resin and adhesive production. Even minimal exposure to HCHO can induce serious health effects, including respiratory distress and dermal irritation. Thus, the advancement of highly sensitive and selective sensors for HCHO detection is imperative for safeguarding environmental and indoor air quality. Herein, we report the development of a very sensitive, highly selective, and stable HCHO sensor based on reduced graphene oxide (rGO) and

lanthanum ferrite (LaFeO3). LaFeO3 and rGO-LaFeO3 nanocomposites with different compositions were synthesized through an affordable and straightforward sol-gel process. Among them, the LFGO(50:1) sensor demonstrated the highest response and selectivity towards HCHO, with a detection limit (theoretically) as low as 19 ppb (1.5 fold). Notably, it exhibited approximately 15-fold p-type response to 1 ppm of HCHO, while operating at 260 °C. The sensor also showed quick response and recovery times of around 1.5 s and 36 s, respectively while having negligible response to other VOCs, including ethanol, methanol, and NH3. A synergistic effect of rGO and LaFeO3 is attributed to this improved sensing behavior. rGO offers a large surface area that facilitates the adsorption of HCHO molecules, while LaFeO3 acts as a catalyst for the oxidation of HCHO. The sensor also showed good selectivity, stability, and reproducibility, making the material a promising candidate for practical applications towards environment monitoring, indoor air quality control, and industrial safety.

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Gupta, N., Abd El-Gawaad, N. S., Mallasiy, L. O.
Hospital-borne hazardous air pollutants and air cleaning strategies amid the surge of SARS-CoV-2 new variants.
Heliyon, Vol. **10** n°(20), (2024)

Indoor air pollutants and airborne contamination removal have been challenging in healthcare facilities. The airborne transmission control and HVAC system may collapse in hospitals due to the highly infectious respiratory disease-associated patient surge, like COVID-19. Common air filtration systems and HVAC systems enhance the patients' comfort and support indoor hygiene, hitherto insufficient to control highly infectious airborne pathogens and hospital-borne pollutants such as radon, PM2.5, patient droplets, VOC, high CO2, and anesthetic gases. This review summarized important air cleaning interventions to enhance HVAC efficiency and indoor safety. We discussed efficient air cleaning and ventilation strategies including air filtration, air ionization, passive removal materials (PRM), and UVGI to minimize cross-contamination in hospital wards.

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Mohd Saupi, S. B., Tan, H., Rahim, R. A., Lubis, A., Vui Sheng, D. D. C., Lau, A.*, et al.*
How Different Ventilation System's Designs Affected Their Applications in Healthcare Facilities: A Comprehensive Review.
Journal of Advanced Research in Applied Sciences and Engineering Technology, (2024), 234-257 p.

Effective indoor ventilation systems are crucial in reducing airborne viruses in healthcare facilities which include significant sections such as OR, isolation room and emergency department. Infection control through indoor ventilation system can be done by manipulating the concentration of infectious particles to reduce airborne infections. This review article highlighted different types of indoor ventilation strategies including mechanical ventilation system, natural ventilation system and hybrid ventilation system that have been integrated into different healthcare facilities. The overview, advantages, and limitations of each strategy were discussed in detail. The utilization of mechanical was deemed more suitable for better air quality control, while a vertical (ceiling-mounted) airflow ventilation system was found to promote higher air cleanliness in the desired zone in healthcare facilities. However, many ventilation systems face limitations when attempting to maintain both thermal comfort, indoor air quality, and energy efficiency simultaneously. The findings of this review are useful for the researchers who design appropriate ventilation strategies in healthcare facilities to ensure good indoor air quality meanwhile reduce the risk of disease dissemination.

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Bhoonah, R., Mendez, M., Maury-Micolier, A.
Human health impacts and indoor chemical reactions of VOCs from cleaning products and occupants.
Atmospheric Environment, Vol. **338**, (2024)

Occupants and indoor activities are sources of volatile organic compounds (VOCs). We propose a framework to simulate the pollutant pathway using the INCA-Indoor© model and VOC emission rates to derive dynamic concentrations, and the USEtox model to evaluate health impacts in DALYs (Disability-Adjusted Life Years). The applicability of the framework is tested on a case study, and the effect of indoor chemical reactions on health impacts is assessed. In this case study, health impacts were of 0.3 µDALY/day without and 0.4 µDALY/day (13 s/day) with indoor air chemistry (+28 %) out of which 12 % were linked to occupant breath and skin emissions. Cleaning activities led to the highest impacts without chemical reactions (terpinolene, responsible for 0.14 µDALY/day), but indoor air chemistry led to high impacts

linked to formaldehyde formation (0.18 µDALY/day). These reactions led to the formation of more formaldehyde, hence leading to 20% more impacts, in summer than in winter. Occupants' contribution to CO2 concentrations exceeded recommended limits under the given occupancy and ventilation scenario. Secondary organic aerosol (SOA) formation affected indoor particulate matter mass concentrations by up to a factor 1.2 and their number concentrations by up to a factor 25,000 in the presence of VOC emissions. Results of this study indicate that chemical reactions and SOA formation are important factors to consider in indoor air quality impact assessment. A larger number of activities and scenarios can be tested to improve the robustness of the conclusions, since, under different scenarios (for e.g. activities with lower emission rates) and with more complete toxicity data, these conclusions are likely to change.

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Tianning, Y., Sun, L., Geng, L., Xu, Y., Hu, K., Chen, X.*, et al.*
Human-Centred Perception as a Mediator of Environmental Decision-Making: A Study on the Suitability Parameters of Public Underground Spaces – a Case Study of Wujiaochang, Shanghai.
Preprints, (2024)

With the acceleration of urbanisation and the increase in underground space use, how to provide a comfortable and healthy environment in underground space has become an important research topic. This study constructed an environmental decision-making model for underground space by integrating human perception evaluation and physical environment factors. The study analysed the influence of physical environment parameters on users' perceived experience through field data collection and questionnaire surveys. The data were in-depth analysed using single-indicator fitted regression analysis and XGBoost machine learning model. The results reveal the significant influence of physical parameters such as temperature, humidity, illuminance and wind speed on the comfort of users of underground spaces and determine the range of appropriateness of these physical environment parameters. The results provide a reliable theoretical basis for optimising the design and management of underground spaces and help to enhance the environmental quality and user experience of underground spaces.

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Petrov, D., Tesfamaryam, L. J.
Impact of material reuse on indoor air quality: Exploring the impact of reuse carpet tiles on indoor air quality.
NTNU. Faculté d'économie. Thèse 2024

Good indoor air quality (IAQ) is vital in individual performance, health, and well-being, as it is closely linked to the quality of air inhaled. As reuse becomes more and more popular it is starting to become necessary to evaluate the impact reused building materials have on IAQ. IAQ is directly tied to human health since we spend 90\% our time indoors. Therefore, this becomes a rather important properly evaluate this topic. Consequently, this thesis examines the impact of carpet tile reuse on IAQ.

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Kajjoba, D., Kasedde, H., Kirabira, J. B., Wesonga, R., Mugwanya, R., Lwanyaga, J. D.*, et al.*
Impact of natural ventilation and outdoor environment on indoor air quality and occupant health in low-income tropical housing.
Energy Reports, Vol. **12**, (2024), 4184-4194 p.

Ventilation is pivotal in mitigating indoor pollutants and ensuring comfortable Indoor Air Quality (IAQ) levels globally. The outdoor environment and ventilation mechanisms significantly impact indoor air quality and occupant health. This research investigated the impact of natural ventilation (NV) and outdoor environment (OE) on indoor air quality (AQ) and occupant health (HI) in low-income housing in Kampala City, Uganda. The study followed a mixed methodology approach by employing self-administered questionnaires and statistical modeling using IBM® SPSS® Amos V24 to analyze the relationships between Natural Ventilation (NV), indoor Air Quality (AQ), Outdoor Environment (OE), and occupant health (HI). The research reveals a strong correlation (0.76) between NV and AQ. In contrast, correlations between AQ and OE (0.16) and NV and OE (0.08) are weak. Model comparative fit indices (CFI: 0.984, SRMR: 0.029, RMSEA: 0.053) indicate an excellent fit. Reliability is high with Cronbach's alpha (NV: 0.800, AQ: 0.862, OE: 0.782) and AVE values (NV: 0.832, AQ: 0.869, OE: 0.786). Significant positive relationships were found between NV and AQ and AQ and HI, highlighting the importance of natural ventilation in improving indoor air quality and occupant health. The study

supports SDGs 3, 11, and 13, promoting sustainable building practices and promoting health, enhanced living conditions, and lower greenhouse gas emissions.

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Ngamsritrakul, T., Panyametheekul, S., Rachdawong, P., Ahmad, M.
Indoor air pollutants and microbes in mass rapid transit (MRT) trains of north-western area of Bangkok, Thailand: Impact on indoor air quality and human health.
Environmental Challenges, Vol. **17**, (2024)

Most modern cities suffer from urban air pollution caused by human activity such as traffic and other sources. Various pollutants in the environment may pose a threat to the health of commuters. The objective of this study is to assess the indoor air quality (IAQ) in MRT purple line trains serving the north-western area of Bangkok in order to determine any potential impacts on human health. The monitored parameters include total volatile organic compounds (TVOCs), temperature, relative humidity, carbon monoxide (CO), carbon dioxide (CO2), ozone (O3), formaldehyde (CH2O), and fine particulate matter (PM2.5). The indoor air pollutant concentrations in the MRT remained within the permissible thresholds. The results of the correlation analysis reveal that relative humidity (RH) and PM2.5 are positively correlated in both the wintertime and summertime measurement campaigns. In contrast, CO2 correlated with temperature in the wintertime and CO in the rainy season. Bacterial and fungal loads were estimated during various measurement campaigns in MRT. Fungi and bacterial loads were higher in the MRT trains during the wintertime and rainy season campaigns. The IAQ of MRT train in Bangkok is within the satisfactory and excellent category of air quality index (AQI). The inhaled doses of PM2.5, CO, and VOCs were also estimated to identify their health effects on commuters. The inhaled dose of PM2.5 was comparatively higher than other pollutants. In this study, a general perspective of the IAQ in the MRT system was provided. It is recommended to conduct more research studies on various MRT lines in Bangkok to further investigate the levels of bacteria, fungi, TVOCs, O3, and PM. Additionally, the ventilation mode in MRT needs to be investigated as it is the main factor affecting the IAQ.

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Gaber, A., Mahmoud, H., Kagi, N., Shokry, H.
Indoor air quality improvement using developed polymeric membrane filter.
Journal of Physics: Conference Series, Vol. **2857** n°(1), (2024)

Carbon dioxide (CO2) levels must be controlled to protect the environment and human health. Previous studies focused on improving indoor air quality (IAQ) by reducing these negative impacts with electrical equipment such as mechanical ventilators and air purifiers; however, passive techniques were lacking. This work develops a prototype membrane filters to improve IAQ by capturing and separating indoor CO2 levels. These filters use polyvinyl alcohol (PVA) membranes and activated carbon (AC) as innovative and effective passive materials at four concentrations. Scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), and X-Ray diffraction (XRD) were employed to characterize the materials. The effectiveness of CO2 absorption across the four filter types was then assessed through tests conducted in a controlled environment. Subsequently, site monitoring was undertaken to evaluate the most effective filter. The absorption rates of CO2 levels indoors of the developed filters are 17.5%, 8.1%, 4.5%, and 3.4%, respectively, for four filters. The most efficient filter increased absorption efficiency by 47.8% in an unoccupied space and 35.5% in an occupied one. This passive material can be applied in various indoor spaces, including office buildings, residential buildings, and educational facilities, due to its benefits in saving energy and enhancing indoor environmental quality.

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Mena-Martinez, A., Alvarado-Uribe, J., Molino-Minero-Re, E., Ceballos, H. G.
Indoor occupancy monitoring using environmental feature fusion and semi-supervised machine learning models.
Journal of Building Performance Simulation, Vol. **17** n°(6), (2024), 695-717 p.

Smart buildings optimize energy consumption and occupant comfort through Heating, Ventilation and Air Conditioning, and lighting management. Nevertheless, large venues require data fusion techniques to improve analysis and forecasting. This study aims to evaluate the effectiveness of using different feature fusion techniques, environmental sensors, and semi-supervised learning to estimate indoor occupancy in a 230 m2 office. Using five Internet of Things devices measuring air temperature, relative humidity, and barometric pressure, data was collected for 99 days with

6800 entries (on average) and only 14% labeled. Eight feature selection methods were evaluated along with three supervised and two semi-supervised classification methods. Results indicate that the Chi-squared-based approach for feature fusion outperformed others. Similarly, the semi-supervised Self-Training model achieved better performance than the supervised methods. This research shows that combining semi-supervised learning and data fusion allows for estimating the occupancy level in large indoor spaces with high accuracy and low labeling costs. Highlights This study pioneers in exploring semi-supervised learning and distinct feature fusion methods for estimating indoor occupancy levels in a 230?m 2 open office using only Internet of Things (IoT) environmental sensors (air temperature, relative humidity, and barometric pressure).A comprehensive comparison of statistical methods, feature selection, and dimensionality reduction techniques are conducted to determine their ability to generate robust feature fusion sets.The feature fusion selected through the Chi-squared test stood out with a high accuracy F1-score (average of 0.95) and an average accuracy of 0.99.The Self-Training model reached the best performance from semi-supervised learning, with an average F1-Score of 0.90 and an average accuracy of 0.97, based on a dataset with a large proportion of unlabelled data (16,847 entries) and only 9367 labels. For supervised learning, Random Forest achieved a high accuracy (average of 0.98) and F1-score (average of 0.93) across various feature sets. This study pioneers in exploring semi-supervised learning and distinct feature fusion methods for estimating indoor occupancy levels in a 230?m 2 open office using only Internet of Things (IoT) environmental sensors (air temperature, relative humidity, and barometric pressure). A comprehensive comparison of statistical methods, feature selection, and dimensionality reduction techniques are conducted to determine their ability to generate robust feature fusion sets. The feature fusion selected through the Chi-squared test stood out with a high accuracy F1-score (average of 0.95) and an average accuracy of 0.99. The Self-Training model reached the best performance from semi-supervised learning, with an average F1-Score of 0.90 and an average accuracy of 0.97, based on a dataset with a large proportion of unlabelled data (16,847 entries) and only 9367 labels. For supervised learning, Random Forest achieved a high accuracy (average of 0.98) and F1-score (average of 0.93) across various feature sets.

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Selinheimo, S., Eidstø, E., Lampi, J., Salmela, A., Pekkanen, J.
Institutional distrust and levels of functional impairment related to indoor air-associated symptoms: A Finnish population-based study.
Indoor Environments, Vol. **1** n°(4), (2024)

Introduction While distrust in social institutions has been linked with poor health outcomes, this association has not been examined in relation to indoor air (IA). We investigated the relationship between functional impairment due to IA-associated symptoms and distrust in social institutions, both in general and distrust particularly in IA-related questions. Methods The Finnish population-based Indoor Air and Health survey (n=1750) was utilized to assess any IA-associated symptoms and functional impairment due to these symptoms within the past 12 months. The associations between levels of functional impairment and distrust in social institutions (health care, juridical system, government officials, construction business, media, and social media) were analyzed using multinomial logistic regression adjusted for gender, age, and education. Results Of the respondents with symptoms (23.1 %), the level of functional impairment varied from severe (1.8 %) to no impairment (4.9 %). Distrust in social institutions was more common in IA-related questions than in general. Higher levels of functional impairment were associated with increased distrust particularized in IA-related questions in other institutions except for media and social media: higher levels of functional impairment were associated with increased trust in these institutions. The strongest associations were observed with distrust in health care and government officials (aOR 4.10, 95 %CI 1.97–8.53, and aOR 3.35, 95 %CI 1.62–6.94, for those with severe impairment compared to those with no IA-associated symptoms). Conclusions Higher levels of self-reported functional impairment due to IA-associated symptoms were associated with decreased trust in most social institutions, but with increased trust in media and social media. These findings should be considered in communication on and prevention of IA-associated health issues.

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Chuthong, W., Surawattanasakul, V., Sapbamrer, R., Sirikul, W.
Investigating exceedances of formaldehyde levels and source identification in offices of an academic medical institute.
Journal of Occupational Health, Vol. **66** n°(1), (2024)

Objectives: To investigate factors associated with indoor formaldehyde levels in office settings within an academic medical institute.Methods: This cross-sectional study was conducted in 25 offices (261 workers) at a medical university in Thailand. Questionnaires gathered data on demographics, work patterns, and office equipment usage (printers, photocopiers, air fresheners, liquid paper, glue, cleaning agents, and marker pens). The building environment was assessed by a multidisciplinary team. Formaldehyde levels and relevant parameters (temperature and relative humidity) were measured in each room both indoors and outdoors. A multiple linear regression model investigated the relationship between formaldehyde and office factors, controlling for room conditions.Results: Median office formaldehyde levels were 442.1 µg/m3 (interquartile range: 343.8-908.7 µg/m3), exceeding World Health Organization and Thai guidelines. Photocopier use was significantly associated with higher levels of indoor formaldehyde (β = .20; 95% CI, 0.30-0.37; P = .02). Air freshener use also showed a significant association (β = .56; 95% CI, 0.30-0.81; P< .001). No correlation was found between the use of liquid paper, glue, printers, cleaning agents, or marker pens and indoor formaldehyde levels.Conclusions: Indoor formaldehyde levels in these offices exceeded the established guidelines. Use of photocopiers and air fresheners was associated with increased formaldehyde levels. Implementing interventions such as improved ventilation and regular screening is essential for creating healthier office environments.

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Shaheen, F.
IoT Air Monitoring and Reporting System for Residential Environments.
University of Bahrain 2024

The impact of indoor air quality is a growing matter of concern due to its effects on the health, comfort and well-being of humans worldwide. People spend 80-90% of their routine time indoors [6], so IAP can directly impact the health and productivity of people worldwide. Sources of indoor air pollution include burning coal or charcoal, fireplaces, and inadequate ventilation in HVAC systems [1]. This project aims to provide indoor air quality monitoring for residential environments using the Internet of things (IoT), with the main objective of raising awareness to the risks caused by poor indoor air quality. Furthermore, this paper provides a review of two microcontrollers used for system design and challenges faced in the development of real time monitoring systems. This paper also presents a time series forecasting algorithm inorder to provide residents of the indoor environment a forecasting of their air quality and take further action when necessary.

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Jouda, M., Wadi, M.
IoT with LoRa Architecture for Indoor Air Quality Monitoring System.
8th International Artificial Intelligence and Data Processing Symposium (IDAP). 21-22 September 2024. Malatya, Turkiye

Human beings need clean air for good health. A monitoring system is essential to detect any potential threats to air purity. An indoor air quality monitoring system is designed to identify pollutants and notify users when their levels become too high. These systems can be tailored to meet specific needs and are commonly used in both homes and commercial buildings. This paper presents a system that uses LoRa technology, which enables communication up to 10 kilometers, so accurate readings on air quality are given and alerts are made when it drops below acceptable levels. This makes it ideal for monitoring large areas where proper ventilation would be required. The design of the system continuously monitors each of the parameters of temperature, humidity, volatile organic compounds (VOCs), carbon dioxide (CO2), and particulate matter (PM) through index-based measurements aligned with international environmental protection standards. It provides real-time data and keeps records of daily and monthly averages. Moreover, through the MQTT protocol, thousands of users can monitor air quality from anywhere using the Internet of Things (IoT).

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Flayyih, H. Q., Waleed, J., Ibrahim, A. M.
IoT-based AI Methods for Indoor Air Quality Monitoring Systems: A Systematic Review.
International Journal of Computing and Digital Systems, Vol. **16** n°(1), (2024)

This exploratory disquisition delves into the world of Indoor Air Quality(IAQ) monitoring systems, using the solidarity of Artificial Intelligence(AI) and Internet of Effects (IoT) technologies. Its overarching thing is to check the efficacity of these structures in regulating IAQ within structures, with a specific focus on mollifying pollutant degrees and their

dangerous results on inhabitants. The study undertakes a comprehensive review of present literature and exploration trials, which depend upon AI and IoT algorithms for border monitoring, records analysis, and contrivance evaluation. also, it delves into the complications of machine armature, deployment ways, and functional efficiency. Furthermore, the exploration attracts different instructional budgets, including clever detectors and IoT bias stationed within the ambient surroundings. It elucidates the functionality of those instruments to accumulate real-time statistics, encompassing variables together with unpredictable natural composites, temperature oscillations, and moisture ranges. A vital aspect of this study is the disquisition of AI, contrivance getting to know Machine Learning (ML), and Deep Learning (DL) algorithms, showcasing their prophetic prowess within shadowing fabrics. also, they have a look at delving into the symbiotic dating among those algorithms, expounding their function in enhancing machine delicacy and optimizing energy intake. Moreover, the studies trials to delineate personalized health tips knitter- made to character inhabitants, decided from the wealth of records accrued through these structures. By integrating present-day technologies with empirical perceptivity, this takes a look at trials to pave the manner for better IAQ control strategies, fostering more healthy and lesser sustainable lodging surroundings.

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Tabbal, S.
Les composés organiques volatils d'origine microbienne comme potentiels biomarqueurs d'exposition aux moisissures en milieux professionnels: développement de méthodes de quantification.
Université de Montréal. Ecole de santé publique. Thèse 2024

Les moisissures sont considérées comme un des facteurs affectant la qualité de l'air intérieur. L'exposition professionnelle aux moisissures peut affecter la santé des travailleurs. Selon l'espèce de moisissure, la dose d'exposition et la sensibilité individuelle, les effets peuvent être irritatifs, infectieux, immunologiques, toxiques ou cancérigènes. Les méthodes classiques, basées sur le bilan environnemental des moisissures cultivables dans l'air, souffrent d'inconvénients tels que le nombre élevé d'échantillons, les analyses coûteuses et la sous-estimation de l'exposition. La croissance des moisissures peut entraîner la production de métabolites, notamment des COVm. Ces derniers, lorsque inhalés, pourraient s'accumuler dans le corps et pourraient être détectés dans les matrices biologiques des travailleurs avant et après leur quart de travail. L'objectif principal de cette thèse est de développer une méthode permettant d'évaluer l'exposition aux moisissures en milieu de travail en exploitant les COVm comme biomarqueurs d'exposition.

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Bu, N., Yan, Y., Bai, X., Wang, M., Ma, Y., Jia, S*., et al.*
Liquid crystal gel-based acetone sensor using correlated laser speckles.
Sensors and Actuators B: Chemical, Vol. **423**, (2025)

Acetone, a common volatile organic compound (VOC), poses health risks even at low concentrations. Current acetone sensors are costly and require specialized equipment and expertize. This work develops a novel vapor sensor for determining acetone vapor concentration using the speckle patterns generated by liquid crystal gels (LCGs). The vapor sensor comprises a LCG film prepared by the phase separation of a mixture containing polystyrene microspheres and liquid crystals (LCs). The orientation of the LC molecules changes when the LCG film is exposed to an acetone vapor environment, altering the equivalent refractive indices of the LC domains. This leads to a change in the scattering state of the LCG film under laser illumination, forming different speckle patterns. The concentration of acetone vapor is determined by calculating the correlation coefficient of the speckle images, where the sensitivity and limit of detection of the sensor are 4 × 10−4 ppm−1 and 754.05 ppm, respectively. The developed correlated laser speckle-based optical system is simpler, less expensive, and more stable than traditional LC film vapor sensors. This acetone gas sensor has potential applications in industrial and indoor air quality testing.

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Shaberi, M., Hamzah, A., Dzulkifly, S., Li, W. S., Gaus, Y. F. A.
Machine Learning Approaches for Predicting Occupancy Patterns and its Influence on Indoor Air Quality in Office Environments.
International Journal of Advanced Computer Science & Applications, Vol. **15** n°(9), (2024)

It is normal for the modern population to spend 12 hours or more daily indoors where the level of comfort can be moderated. Yet, indoor occupants are similarly exposed to various air pollutants just as outdoors. Indoor air pollution

could be detrimental toward the occupant's health noted by the United Nation Environment Programme (UNEP) in the Pollution Action Note, published on 7th of September 2021. According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards, occupancy patterns could influence indoor air quality. Hence, this paper investigates the utilisation of machine learning algorithms in predicting occupancy patterns against indoor air quality (IAQ) variables such as humidity, temperature, light, and carbon dioxide (CO2). This study compares the performance of selected machine learning approaches, namely deep learning (LSTM, CNN), regression (ANN) and (SVR) models. In addition, it explores the diverse range of evaluation metrics utilized to evaluate the performance of machine learning in the specific context of Mean Squared Error (MSE) and Mean Absolute Error (MAE). In the training phase, the SVR model achieved the lowest MAE of 0.0826 and MSE of 0.0280 as compared to the other algorithms. The ANN model demonstrated slightly better generalization capabilities in the testing phase, while the LSTM model demonstrated robust performance in the test phase. Overall, the results highlighted the significant impact of occupancy behaviour on Indoor Air Quality (IAQ) variables and underscored the importance of advanced modelling techniques in IAQ monitoring and management, emphasizing the need for tailored approaches to address the complex relationship between occupancy patterns and IAQ variables.

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Sohail, A., Ahmad, N.
Machine Learning Empowered IoT Devices, Analysis of Indoor and Outdoor Temperature and Health Risks.
In: IoT Sensors, ML, AI and XAI: Empowering A Smarter World. Springer Nature Switzerland; 2024. 35-51 p.

The Internet of Things (IoT) is a widely used technology due to its high applicability. Since it is capable of generating data at high velocity, this data can also be beneficial in machine learning. This paper pre-processed data about temperature generated through IoT devices, followed by analysis, consequences on health, and ML applications. In order to establish a maximum indoor and outdoor temperature threshold for health, this study aims to identify and evaluate the evidence regarding the direct and indirect health effects of Indoor and Outdoor temperatures, as well as the temperature thresholds at which those effects are noticed. Additionally, the data generated by IoT devices are fed into machine learning models for classification as indoor or outdoor based on the given temperature and comparative analysis of predictability for the given dataset. The analysis of data generated by the IOT device is done using available tools in Python. Some valuable insights about data related to temperature and its associated parameters are extracted, and their effect is estimated. Different machine learning models have been applied to the given dataset and measured using available metrics. Overall, this paper contains the analytical part of the data to measure the health risks based on the indoor and outdoor temperature and their classification using the best supporting Machine Learning models.

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Mohebbi, M., Jafari, A. J., Gholami, M., Baghani, A. N., Shahsavani, A., Kermani, M.
Measurement and health risks assessment of BTEX compounds exposure in beauty Lahijan City salons.
Scientific Reports, Vol. **14** n°(1), (2024)

The presence of BTEX (Benzene, Toluene, Ethylbenzene, and Xylene) compounds in beauty salons has raised concerns about potential health risks. This study aimed to measure the levels of BTEX compounds in the air of beauty salons in Lahijan, Iran and assess the associated health risks. Air samples were collected from 15 beauty salons, and the concentrations of BTEX compounds were measured according to 1501 NIOSH standard method. The results showed that the mean concentrations of benzene (20.62 µg/m3), toluene (18.3 µg/m3), ethylbenzene (38.36 µg/m3), and O and P-xylene (27.35, 23.6 µg/m3) were above the recommended levels. The indoor to outdoor ratios for benzene, toluene, ethylbenzene, O and P-xylene were 3.04, 2.36, 3.75, 4.89, and 6.54, respectively. Also, the toluene/benzene (T/B) ratio in indoor and outdoor was 20.9 and 2.68 respectively. Almost half of the technicians (49.12%) reported adverse health effects, including joint pain, itchy eyes and nose, and respiratory allergies. The IARC guideline suggests that there is a potential risk of cancer development for individuals in all salons with LCR values exceeding 10−6, but the HQ index values indicate no non-carcinogenic risk. The findings suggest that beauty salon workers and customers are at risk of developing health problems from exposure to BTEX compounds. Effective risk management strategies, such as proper ventilation, use of personal protective equipment, and substitution of harmful chemicals with safer alternatives, to minimize exposure and protect the health of salon workers and customers recommended.

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Farshchi, F., Ghaffarzadeh, S., Hasanzadeh, M., Shadjou, N.

Microfluidic paper-based colorimetric chemo-sensing of formaldehyde using tetramethylbenzidine-conjugated gold nanoflowers: A point-on-demand approach for efficient chemosensing of volatile organic compounds.
Journal of Photochemistry and Photobiology A: Chemistry, Vol. **459**, (2025)

The presence of formaldehyde, a common environmental aldehyde and a recognized carcinogen, poses a significant health risk to humans. Monitoring its levels in environmental samples and human biofluids is crucial for both pollution control and advancements in health science. This study introduces an effective colorimetric method utilizing UV–Vis spectroscopy to identify formaldehyde in real samples. Various types of gold nanoparticles (AuNPs) with diverse sizes and structures were employed to develop a photochemical chemosensing device. The method exhibited high sensitivity in detecting formaldehyde, particularly through the use of gold nanoflowers (AuNFs) at a pH of 6.15, with a low quantification limit of 0.1 µM and a linear range of 0.6 µM to 1 M. Furthermore, the method was successfully utilized to assess formaldehyde in human biofluids. Additionally, a paper-based microfluidic colorimetric opto-device was incorporated for on-site and on-demand formaldehyde screening. This study showcases the application of AuNPs for the precise and sensitive detection of formaldehyde in human biofluids, offering potential for advanced analytical methods targeted at formaldehyde and other volatile organic compounds (VOCs). The practicality, affordability, and portability of the microfluidic paper-based colorimetric device (µPCDs) make it a promising choice for point-of-care VOC testing. This represents the first demonstration of µPCDs for the selective photochemical sensing of toxic substances, and its one-step process that does not rely on novel sorbents, membranes, or external stimuli, making it easily scalable. The potential for µPCDs to be broadly applicable to the selective monitoring of formaldehyde from complex bio-matrices is evident. This method demonstrated robust performance in terms of accuracy, sensitivity, reproducibility, and selectivity.

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Conceição, E., Gomes, J., Conceição, M. I., Conceição, M., Lúcio, M. M., Awbi, H.
Modelling of Indoor Air Quality and Thermal Comfort in Passive Buildings Subjected to External Warm Climate Conditions.
Atmosphere, Vol. **15** n°(11), (2024)

Air renewal rate is an important parameter for both indoor air quality and thermal comfort. However, to improve indoor thermal comfort, the air renewal rate to be used, in general, will depend on the outdoor air temperature values. This article presents the modelling of indoor air quality and thermal comfort for occupants of a passive building subject to a climate with warm conditions. The ventilation and shading strategies implemented for the interior spaces are then considered, as well as the use of an underground space for storing cooled air. The indoor air quality is evaluated using the carbon dioxide concentration, and thermal comfort is evaluated using the Predicted Mean Vote index. The geometry of the passive building, with complex topology, is generated using a numerical model. The simulation is performed by Building Thermal Response software, considering the building's geometry and materials, ventilation, and occupancy, among others. The building studied is a circular auditorium. The auditorium is divided into four semi-circular auditoriums and a central circular space, with vertical glazed windows and horizontal shading devices on its entire outer surface. Typical summer conditions existing in a Mediterranean-type environment were considered. In this work, two cases were simulated: in Case 1, the occupation is verified in the central space and the four semi-circular auditoriums and all spaces are considered as one; in Case 2, the occupation is verified only in each semi-circular auditorium and each one works independently. For both cases, three strategies were applied: A, without shading and geothermal devices; B, with a geothermal device and without a shading device; and C, with both shading and geothermal devices. The airflow rate contributes to improving indoor air quality throughout the day and thermal comfort for occupants, especially in the morning. The geothermal and shading devices improve the thermal comfort level, mainly in the afternoon.

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Pepi, W. M.
Moss and Air: Biofiltration and Moss as a Fresh Air Generator.
Rensselaer Polytechnic Institute.Thèse 2024

This thesis addresses both indoor air quality (IAQ), the top environmental risk to human health, and building energy consumption, a principal driver of climate change. Plants can enhance both IAQ and building energy efficiency. Botanical biofilters host microbial populations that remediate a diversity of contaminants while plant photosynthesis may provide CO2-O2 balance of occupant respiration, enabling continuous clean air recirculation and HVAC energy savings – by

reducing the supply and conditioning of outdoor air. In other words, beyond hosting microbial biofiltration, plants may be complete fresh air generators.

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Mughal, H., Rana, A.
Natural Ventilation for Transitional Spaces: Case Study of an Airport Terminal.
In: Proceedings of the ICSDI 2024 Volume 3. 2024.

Transitional public spaces, such as airport terminals, consume considerable energy resources and induce a large carbon footprint. The application of passive strategies, particularly the use of natural ventilation, to reduce operational energy use can be an effective strategy to reduce the environmental impacts of these spaces and reduce the capital, maintenance and replacement costs associated with these large spaces. This work investigates the feasibility of natural ventilation as a passive cooling strategy in an airport terminal. This preliminary study identifies opening sizes for a hypothetical airport terminal in Kinmen County, China. It is observed that large openings are required in June compared to July and August. Detailed computational simulations and field measurement studies can help provide more tailored natural ventilation solutions for airport terminal buildings.

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Lee, W.-C., Hong, Z.-S., Chen, Y.-H., Liou, A.-Y., Hsieh, P.-H., Chen, C.-H.*, et al.*
Novel DABCO-Derived Ionic Liquids for Liquid Desiccant Air Conditioning.
ACS Sustainable Chemistry & Engineering, Vol. **12** n°(44), (2024), 16249-16259 p.

Conventional air conditioners are inefficient, especially in hot and humid areas, to take water away from the moisture-rich air since this causes higher energy consumption. Liquid desiccant air-conditioning (LDAC) systems represent a promising alternative due to their effective temperature- and humidity-independent control with energy-saving potential. Ionic liquids (ILs) are considered desiccant substitutes for traditional halide salts with better performance and no metal corrosion. This study introduced the synthesis and structure characterization of novel ILs with cations based on 1,4-diazabicyclo[2.2.2]octane (DABCO) and anions derived from trialkylphosphate. The corrosion behavior of copper and aluminum in these IL solutions was studied with an electrochemical test. The resulting ionic liquids were strongly hygroscopic and antimicrobial while showing much lower corrosivity with no risk of crystallization. These advantages made DABCO-derived ILs the potential liquid desiccants of the next generation.

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Wang, Y., Ding, D., Yu, C. W.
Numerical simulation of bioaerosol deposition and mildew risk under transitional seasonal ventilation in workshop with wet source.
Indoor and Built Environment, (2024)

In this study, a typical workshop with internal water vapour sources was selected as the research object. A coupled Computational Fluid Dynamics model was established to simulate bio-particle diffusion, dry and wet collision and deposition. The study investigated the indoor humidity field and bioaerosol deposition distribution under different supply air parameters in transitional seasons when using a fresh air ventilation system. Additionally, quantitative analysis was conducted on the Mildew Risk Index (MRI) in the workshop under different airflow patterns and supply rates. The main findings of this study are as follows: 1) Higher indoor humidity led to larger MRI, with Beijing having an MRI of only 0.59% compared to Guangzhou?s 56.4%. Correlation analysis showed that MRI had a positive correlation with Absolute Humidity (AH) of supply air (coefficient = 0.92), while it had a negative correlation with Particle Removal Efficiency (PRE) (coefficient = ?1.0). 2). There was a negative correlation between PRE and AH (coefficient = ?0.93) which indicated that a higher humidity in the supply air could promote bioaerosol deposition indoors and would increase MRI. 3) The regression equations between MRI and PRE were also established in this study, and a variance analysis was performed on them.

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Vass, W. B., Shirkhani, A., Washeem, M., Nannu Shankar, S., Zhang, Y., Moquin, T. L.*, et al.*
Occupational exposure monitoring of airborne respiratory viruses in outpatient medical clinics.
Aerosol Science and Technology, (2024), 1-21 p.

Exposure to airborne respiratory viruses can be a health hazard in occupational settings. In this study, air sampling was conducted from January to March 2023 in two outpatient medical clinics—one primary care clinic and one clinic dedicated to the diagnosis and treatment of respiratory illnesses—for the purpose of assessing airborne respiratory virus presence. Work involved the operation of a BioSpot-VIVASTM as a stationary air sampler and deployment of NIOSH BC-251 bioaerosol samplers as either stationary devices or personal air samplers worn by staff members. Results were correlated with deidentified clinical data from patient testing. Samples from seven days were analyzed for SARS-CoV-2, influenza A H1N1 and H3N2 viruses, and influenza B Victoria- and Yamagata-lineage viruses, with an overall 17.5% (17/97) positivity rate. Airborne viruses predominated in particles of aerodynamic diameters from 1–4 µm and were recovered in similar quantities from both clinics. BC-251 samplers (17.4%, 15/86) and VIVAS (18.2%, 2/11) collected detectable viruses at similar rates, but more numerous BC-251 samplers provided greater insight into virus presence across clinical spaces and job categories. 60% of samples from reception areas contained detectable virus, and exposure to significantly more virus ($p = 0.0028$) occurred at reception desks as compared to the “mobile” job categories of medical providers and nurses. Overall, this study provides valuable insights into the impacts of hazard mitigation controls tailored to reducing respiratory virus exposure and highlights the need for continued diligence toward exposure risk mitigation in outpatient medical clinics.

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Chaudhari, Y. D., Shembade, R., Pawar, A. R., Patil, V. V., Patil, P. S., Songire, J.
Optimizing HVAC Systems for Pharmaceutical Manufacturing Facilities.
Asian Journal of Pharmaceutical Analysis, Vol. **14** n°(3), (2024)

This text provides an extensive overview of Heating, Ventilation, and Air Conditioning (HVAC) systems, their components, functions, and impact on energy consumption and building sustainability. It highlights the significance of HVAC systems in maintaining indoor comfort levels and discusses various techniques for enhancing energy efficiency. Additionally, it covers topics such as air handling units (AHUs), temperature and relative humidity testing, energy efficiency regulations, ventilation systems, air conditioning methods, and the effects of building behavior on HVAC energy consumption. The abstract also outlines advantages and disadvantages of HVAC systems, emphasizing their role in indoor air quality, energy savings, and environmental impact.

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Lazaridis, M.
Particulate matter concentrations and human exposure approaches in the world microenvironments.
Air Quality, Atmosphere & Health, (2024)

Particulate matter (PM) constitutes an important environmental exposure. The quantification of human exposure at different indoor microenvironments and outdoors is crucial for refining exposure estimates to inform potential human health hazard using state-of-the-art data derived from field measurements. The overall aim of the current work is to review PM concentrations encountered at different microenvironments such as domestic houses, traffic, offices, schools and outdoors. Measurements of PM concentration characteristics in different microenvironments is the first step for the evaluation of the actual human exposure. In the quantification of the actual human exposure is also necessary to determine the exposure of humans at different microenvironments spent during the day and their activities (activity patterns) in combination to source apportionment analysis. Information derived of the exposure population characteristics can be further used as inputs to dosimetry models, to health risk assessment analysis and epidemiological studies.

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Binti Ahmad, Z.
Portable Dust Remover for Construction Sites: Improving Air Quality and Worker Safety.
Jurnal Amalan Pengajaran dan Penyelidikan Lestari, Vol. **2** n°(2), (2024), 71-80 p.

Construction activities generate substantial airborne dust, posing significant health risks to workers and nearby communities. This study focuses on the development and evaluation of the Portable Construction Site Dust Remover (PCSDR) to improve air quality by measuring particulate matter (PM2.5), total volatile organic compounds (TVOCs), and carbon monoxide (CO) levels at construction sites. The development process, guided by the CDIO (Conceive, Design,

Implement, and Operate) approach, included interviews and observations at Politeknik Port Dickson workshops and construction sites in Port Dickson and Malacca. Integrating principles from fluid mechanics, occupational health and safety engineering, and environmental engineering, the PCSDR prototype was designed to enhance air quality and ensure compliance with health and safety standards. The PCSDR features a transparent, heavy-duty plastic casing with robust wheels, an adjustable airflow suction system, an air filtration system, and a water recycling system. Testing its effectiveness over seven days at a Malacca construction site demonstrated that the PCSDR could reduce PM2.5 by nearly 30%, TVOCs by approximately 38%, and CO concentrations by nearly 48%, significantly improving indoor air quality. These results underscore the PCSDR's potential as a practical solution for sustainable construction practices, contributing to safer working environments and aligning with global health, safety, and environmental protection initiatives. The PCSDR system significantly advances construction site air quality management with its portable design, water-efficient technology, and rapid installation, promoting environmental sustainability, reducing costs, enhancing workplace safety, and aligning with sustainable construction practices.

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Shao, Z., Wu, C., Shao, Q., Yang, J., Xie, M.
Prevalence of Sick Building Syndrome Symptoms in Residents During the COVID-19 Pandemic—A Case Study of Suzhou City, China.
Buildings, Vol. **14** n°(11), (2024)

Quarantine policies during the coronavirus disease 2019 (COVID-19) pandemic prolonged time spent at home, leading to an unintended occurrence of sick building syndrome (SBS) symptoms. The aim of this study was to investigate the prevalence of SBS symptoms among residents in Suzhou, China, during the COVID-19 pandemic. A questionnaire survey was conducted online from February to May 2022. A total of 442 adults were included in this study. The prevalence of SBS symptoms was much higher during the COVID-19 pandemic, and the proportions of general, mucosal, and skin symptoms were 59.3%, 45.5% and 49.1%, respectively. The influences of building characteristics, occupant lifestyle, indoor environment and perception of indoor environment were analysed using a multivariate logistic regression model. Neighbourhood pollutant sources, older residences, non-ownership and humidity indicators were significant risk factors for SBS symptoms. Frequent use of air fresheners was significantly associated with general (adjusted odds ratio (AOR): 4.9, 95% confidence interval (CI: 2.4–10.0), mucosal (AOR: 5.3, 95% CI: 2.4–11.5), and skin symptoms (AOR: 4.6, 95% CI: 1.6–13.1), while the use of disinfectants was significantly correlated with skin symptoms (AOR: 4.0, 95% CI: 1.5–10.7). Residents' perception of an uncomfortable indoor environment was a significant predictor of general (AOR: 2.2, 95% CI: 1.2–4.0) and mucosal symptoms (AOR: 3.1, 95% CI: 1.6–6.0). The use of air cleaners can reduce the prevalence of general symptoms. An important finding of this study is that the psychological impact of staying at home for a long time was associated with general symptoms (AOR: 1.3, 95% CI: 1.1–1.7), which means that attention should also be paid to the mental health of residents during the COVID-19 pandemic. Although the quarantine period has now ended, our results can still serve as a reference for the impact of the indoor environment on the health of people with SBS, especially for those who stay at home for a long time, such as the elderly.

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Alnusairat, S., Abed, A. R., Alsous, J. I.
Quality of home-work environment and crises: a case study of call center employees.
Architectural Science Review, (2024), 1-16 p.

The home-work environment theme has received high attention post-COVID-19 pandemic. This suggested the need to assess the quality of the indoor home-work environment in terms of telecommuters' performance and satisfaction. The study investigated the performance of telecommuters in a call centre of a telecommunications company in Jordan based on the performance assessment data collected before, during, and after the COVID-19 period. A survey was conducted to examine telecommuters' satisfaction with the quality of the indoor home-work environment in the spatial, behavioural and environmental dimensions. A comparative analysis of key performance indicators was conducted. The results affirmed a relationship between indoor home-work environment quality, employee performance and satisfaction. The analysis demonstrated that behavioural and environmental changes could improve the three factors. Thus, recommendations were made to improve telecommuting settings to facilitate health, well-being, and sociocultural sustainability for new and existing housing by designing more resilient housing suites in several industries.

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Lis, A.
Quality of human functioning in study areas and workplaces in terms of the condition of the indoor environment.
Scientific Journals of the Maritime University of Szczecin, Vol. n°(79), (2024)

Due to necessity, people spend most of their lives in enclosed spaces. This creates the need to shape the indoor environment so as to form a state of satisfaction with their surrounding conditions. When shaping or assessing the quality of the indoor environment in buildings, we should primarily focus on its impact on the quality of life of users. Study and work environments are particularly important because attention needs to be paid to, among others, the significant relationship between the inappropriate quality of this environment and psychomotor skills, academic results, work efficiency, or increasing sickness absence and the associated high economic cost of these factors. This article presents the results of research on the condition of the study and work environment. It determines the factors influencing the shaping of indoor environmental conditions and presents the impact of the indoor environment on the quality of the people working there. The relationship between the basic parameters of the indoor microclimate and the level of satisfaction with the environmental conditions and its impact on the comfort of study and work is examined. Attention is paid to the impact of green solutions in buildings in order to improve the quality of life and efficiency in study areas and workplaces.

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Tolvaly-Roşca, F., Fekete, G., Bíró, I., Fekete, A.-Z., Forgó, Z.
Real-Time IoT Solution to Monitor and Control dMVHR Units in Real-Life Environment.
Acta Polytechnica Hungarica, Vol. **21** n°(6), (2024)

This paper presents an up-and-running control system, using IoT hardware, for multiple decentralized mechanical ventilation with heat recovery (dMVHR) units to enhance the overall performance of heat exchangers and the air quality of a real-life environment. The implemented control and monitoring system is able to measure the thermal efficiency of the complete ventilation system under real working conditions. Fan speed is automated based on the measured CO2eq levels in the bedrooms of the building, however, manual control is also possible. Temperature, relative humidity and CO2eq levels can be monitored live on the user's smart device, while data can be exported through Google cloud system. Data values can be stored and accessed any time by legit users. The thermal efficiency of the individual units and the whole ventilation system was investigated and experimentally verified under real-life conditions, using the implemented centralized control and monitoring system.

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Kim, K., Kim, J., Lee, Y. G., Wi, S., Kim, S.
Revitalizing subterranean spaces: a comprehensive study on enhancing air quality in underground shopping malls for sustainable urban living.
Sustainable Environment Research, Vol. **34** n°(1), (2024)

Cities worldwide are increasingly turning to underground spaces to address the challenges posed by high population density. These subterranean areas are now utilized for various purposes such as offices, shopping malls, subway terminals, and underground sidewalks. However, the semi-closed nature of most underground spaces presents difficulties in ensuring a comfortable environment due to the lack of natural ventilation. This study focuses on a representative underground shopping mall in South Korea, utilizing preliminary surveys and long-term sensor monitoring to identify existing problems. The aging ventilation system was retrofitted to enhance and assess indoor air quality. As a result, concentrations of carbon dioxide, total volatile organic compounds, and radon were reduced by over 33, 74, and 98%, respectively, while particulate matter with a diameter of 2.5 µm or less (PM2.5) concentrations remained the same as before. This not only contributed to maintaining proper indoor air quality, but also led to a reduction in total energy consumption. The goal of this project is to improve air quality in facilities located in underground spaces, such as underground shopping malls, where indoor air quality management is challenging, thereby creating a safe and healthy environment for users and enhancing the overall functionality of the facility.

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Bumpus, M. A.
A survey of machine learning applications in commercial building management.
Issues in Information Systems, Vol. **25** n°(2), (2024), 475-487 p.

Commercial building managers are faced with challenges in operating their facilities in an efficient and cost-effective manner. Energy and maintenance costs are large consumers of operational budgets and offer opportunity for improvement through machine learning and data analysis. From prediction and forecasting to outcome optimization, several machine learning techniques are uniquely suited for applications in building management. In addition to maintenance and operational improvements, machine learning, combined with sensors and intelligent environmental systems can help improve occupant satisfaction and worker productivity through improvements in air quality and lighting conditions. As enhancements in machine learning and artificial intelligence continue, the application for improvement in building operations will expand as well.

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Sundaramoorthy, S., Kumar, S. K. S., Chavhan, M. V.
Textile Materials for Good Health and Wellbeing.
Springer; 2024.

This book explores the application of latest technologies such as nanotechnology, composite technology, biotechnology in textile materials for health-related applications. It further discusses different types of textiles and their application in the areas of health, safety and well-being. Various topics covered in this book are, medical textiles, filtration textiles, protective textiles, thermal protective wear, intelligent textiles and many more. The book also deals with air and water filtration textiles and textile-based personal protective equipments. This book will be of interest for students, researchers and professionals working in the area of textile engineering, materials, biomedical engineering, defense, healthcare and other allied fields.

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Grimmer, C., Richter, M., Neuhaus, T., Prinz, C., Strzelczyk, R. S., Colakoglu, I.*, et al.*
Towards a multi-VOC emission reference material with temporally constant emission profile for QA/QC of materials emission testing procedures.
Chemosphere, Vol. **366**, (2024)

Emission reference materials (ERMs) are sought after to further control and improve indoor air quality. The impregnation of porous materials with volatile organic compounds (VOCs) is a promising approach to produce ERMs. Different VOCs were used to impregnate various porous materials (mainly zeolites, activated carbons and a metal organic framework). The influence of different methodological parameters and material properties were studied to optimize the impregnation procedure and to find the best material/VOC combination. The impregnation procedure remains quite irreproducible, nevertheless, very good ERM candidates were identified. Two materials (zeolite 4 and AC 1 impregnated with n-hexadecane) showed a very stable emission over 14 days (<10 % change). Another material (AC 1 impregnated with toluene) showed a declining emission profile but with a very good in-batch reproducibility and a storage stability of up to 12 months.

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Kiil, M., Mikola, A., Võsa, K.-V., Simson, R., Kurnitski, J.
Ventilation effectiveness and incomplete mixing in air distribution design for airborne transmission.
Building and Environment, Vol. **267**, (2025)

How ventilation should be arranged to be effective at reasonable air change rates is one key question as ventilation criteria and standard airborne disease transmission models are based on the well-mixed assumption, but air distribution patterns lead to non-uniform spatial concentrations. In this study a new method for ventilation effectiveness application in ventilation design for airborne transmission was developed and tested with tracer gas measurements in 22 rooms. Contrary to existing ventilation effectiveness values measured with distributed source, the developed method uses a couple of point source locations corresponding to an infector to quantify infection risk for each occupant. Novelty of the method is new ventilation effectiveness indicator that makes it possible to describe the effect of spatial variation of concentration and risk with single parameter. Quanta were used as input data to calculate the ventilation rate supplied by air distribution system corresponding to a specified risk level, but the differences between studied cases do not significantly depend on the quanta values. Application of the method to measured rooms showed that simple ventilation effectiveness calculation from average concentration at the breathing height, not requiring quanta data,

provided lower ventilation effectiveness and higher ventilation rate in all cases. In many cases the difference in required ventilation rates was only a few percent, but in some large spaces it exceeded 10% with maximum of 39% in large open plan office with high concentration differences. Measured ventilation effectiveness values ranging from 0.5 to 1.4 indicate a substantial improvement potential in many cases.

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Wu, L., Zhu, Y., Yuan, J., Guo, X., Zhang, Q.
Volatile Organic Compounds (VOCs) in China: Progress and Prospects of Research on Treatment Technologies and Policy Provisions.
Journal of Materials Science and Chemical Engineering, Vol. **12** n°(9), (2024), 1-43 p.

Volatile organic compounds (VOCs) are an atmospheric pollutant with a boiling point of 50˚C - 260˚C at room temperature and pressure. They are precursors of sulfur dioxide and ozone, which can seriously pollute the atmosphere and endanger human health. After the “14th Five-Year Plan”, VOCs, instead of SO2, became one of the five indicators of China’s atmospheric governance. As a result, the government’s efforts to control VOCs have increased significantly. VOCs governance mustn’t be delayed. This paper provides a comprehensive summary and analysis of VOCs governance, covering the classification of VOCs, analysis of VOC governance technology (with a focus on end-of-pipe governance technology), national policy regulations, current governance shortcomings, and a forward-looking perspective on the future direction of VOCs governance, emphasizing healthy and sustainable development.

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Astrologo, N., Estaquio, R. P., Montecillo, S., Gasacao, H., Galido, A. C., Eslit, J. J., *et al.*
A Wireless Sensor Network-Based Testbed for Characterizing the Dispersion of Total Volatile Organic Compounds in an Enclosed Space.
2024 IEEE International Conference on Omni-layer Intelligent Systems (COINS). August 2024. London, United Kingdom

An indoor air quality monitoring system can provide information about the air quality in enclosed spaces such as offices, and potentially prevent occupants from suffering illnesses due to staying in enclosed spaces, more commonly known as Sick Building Syndrome (SBS). Experiments were conducted to characterize the spread of Total Volatile Organic Compounds (TVOC) in a room, using ESP32-based sensor nodes were equipped with SGP30 and CCS811 TVOC sensors. This setup was used as a testbed to monitor pollutant concentrations at different points in 3D space. Discrepancies in the measurements between points showed that airflow has a large effect in reducing pollutant concentrations.

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