Bulletin de veille QAI
N° 01-2025

Objectif : *Qualité de l'air intérieur*

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Google Scholar, Lens, WoS

Almeida, M. L., Gonçalves, F. D., Martins, J. M., Magalhães, F. D., Ramos, R. M., Carvalho, L. H.

Addressing formaldehyde emissions in wood-based panels: evaluation of production processes, measurement strategies, and novel solutions.

The Journal of Adhesion, Vol., (2024), 1-23 p.

Due to their significant environmental and health impacts, formaldehyde emissions (FE) from Wood-Based Panels (WBPs) have been a critical area of study. This review focuses on assessing FE from WBPs, examining production processes, measurement strategies, and exploring novel solutions for emission reduction. A comprehensive overview of WBPs is provided, detailing their production, industrial applications, and the role of formaldehyde-based resins such as urea-formaldehyde (UF), melamine-formaldehyde (MF), and phenol-formaldehyde (PF) as key sources of emissions. Additionally, alternative bio-based resins and non-formaldehyde adhesives are discussed for their potential to reduce FE. The review also evaluates several international standards and regulations for FE, particularly in Europe, Japan, and the United States, while comparing standard testing methods including the chamber, gas analysis, perforator and desiccator methods. Emerging testing innovations, such as gas-diffusion microextraction and laser absorption spectroscopy, are highlighted for their efficiency and accuracy. Finally, the paper explores current efforts to mitigate FE, including advancements in adhesive formulations, the incorporation of formaldehyde scavengers, and new panel manufacturing technologies, emphasizing the importance of meeting global regulatory standards to improve indoor air quality.

https://doi.org/10.1080/00218464.2024.2447718

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Amarjit, S.

Aerodynamic and energy modeling of ventilation systems to optimize indoor air quality and reduce energy losses.

Journal of Asian Scientific Research (JASR), Vol. **14** n°(6), (2024), 7-11 p.

Indoor air quality (IAQ) plays a critical role in public health, productivity, and energy efficiency. Ventilation systems are integral to maintaining IAQ but often operate inefficiently, leading to significant energy losses. This paper investigates aerodynamic and energy modeling of ventilation systems to optimize IAQ while minimizing energy consumption. By integrating computational fluid dynamics (CFD) simulations with energy models, this study highlights novel strategies for balancing air circulation effectiveness and energy efficiency. The findings suggest that design modifications, combined with real-time monitoring, can enhance system performance.,

https://joasr.com/index.php/home/article/view/JASR2024140602

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Akhai, S.

Air Conditioning for Healthier Living.

In: Managing the Health Risks of Climate Change. IGI Global; 2025. 135-154 p.

The chapter explores the role of air conditioning technology in promoting healthier living environments amid climate change. It discusses the impact of climate change on indoor air quality (IAQ) and its implications for human health. It suggests a multifaceted approach, including ventilation, source control, air purification, and

moisture regulation. It also proposes climate change adaptation strategies, such as advanced air conditioning systems and early warning systems. The chapter highlights risks associated with traditional cooling methods, particularly for vulnerable populations. Technological advancements like HEPA filters and solar-powered systems are suggested for improving IAQ while minimizing environmental impact. Green construction techniques, photocatalytic oxidation, and green roofs/walls are also discussed. The chapter acknowledges challenges like data privacy and integration complexity but emphasizes the convergence of air conditioning technology, climate change adaptation, and sustainable design for healthier indoor environments.

10.4018/979-8-3693-4183-4.ch006

https://services.igi-global.com/resolvedoi/resolve.aspx?doi=10.4018/979-8-3693-4183-4.ch006

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Xing, X., Kang, S., Li, S., Luo, M.

Analysis of the source of abnormal odor components in medium-density fiberboard (MDF).

Wood Material Science & Engineering, (2024), 1-8 p.

To investigate the cause of the abnormal odor emitted by medium-density fiberboard (MDF) when formaldehyde-free diphenylmethane diisocyanate (MDI) adhesive is used, a comparative study of three types of MDF was conducted: MDF made with masson pine wood and MDI adhesive (PW-MDI), MDF made with masson pine wood and urea-formaldehyde resin (PW-UF), and MDF made with mixed hardwoods and MDI adhesive (HW-MDI). Volatile organic compounds (VOCs) emitted were collected and analyzed using gas chromatography-mass spectrometry (GC-MS), identifying 86 VOCs. Results reveal that the PW-MDI specimen contains a higher concentration of acid substances, comprising 56% of the specimen. These acid mainly octanoic and nonanoic acids, were the primary contributors to its abnormal odor. In contrast, the PW-UF and HW-MDI specimens were predominantly composed of alcohol substances, accounting for 33% and 36% respectively. Gas chromatography-ion mobility spectrometry (GC-IMS) was used to obtain VOC fingerprints. Analysis revealed that acids and aldehydes are the primary contributors to the relative odor activity value (ROAV). These compounds are known for their abnormal odor that impact the indoor air quality. This research successfully identified the source of the abnormal odor and provided technical support for the effective control of low abnormal odor VOC emissions from MDF.

https://doi.org/10.1080/17480272.2024.2434885

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Li, Q., Feng, F., Jiang, C., Song, S., Peng, H., Liao, Z.

Carboxyl graphene oxide/graphene composite structure for the chemiresistive detection of acetaldehyde at room temperature.

Sensors and Actuators B: Chemical, Vol. **427**, (2025)

The work systematically investigates the sensing performance of the carboxyl graphene oxide/graphene sensor (GO-COOH/Graphene) for acetaldehyde (CH3CHO). Firstly, carboxylated graphene oxide was prepared by employing sodium hydroxide and chloroacetic acid to convert epoxy and hydroxyl groups into carboxyl functional groups. Subsequently, the GO-COOH solution was uniformly deposited on the graphene film to fabricate the GO-COOH/Graphene sensor. Under the test conditions of 100 ppm CH3CHO, the response of the GO-COOH/Graphene sensor was 86.29 times that of graphene and 5.44 times that of GO-COOH, with a response of 177.76 %, response time of 23 seconds, recovery time of 296 seconds, and theoretical limit of detection (LOD) is 42.3 ppb, indicating that the GO-COOH/Graphene sensor exhibits a rapid and highly sensitive response to CH3CHO at room temperature and high humidity. Additionally, the GO-COOH/Graphene sensor demonstrates outstanding selectivity, repeatability, and long-term stability in CH3CHO sensing. By capitalizing on the abundant functional groups of GO-COOH and the excellent electrical conductivity of graphene, the GO-COOH/Graphene sensor effectively resolves the

issues of poor response, slow response, and slow desorption of graphene in CH3CHO sensing. The composite structure proposed in this work holds significant application potential in domains such as human respiratory detection and environmental monitoring of CH3CHO.

https://doi.org/10.1016/j.snb.2024.137179

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Faizah, A. U., Raharjo, M., Setiani, O., Sulistiyani, S., Darundiati, Y. H.

A Comparative Study: Indoor Air Quality (PM10, Ammonia, Airborne Total Bacteria) in Different Types of Broiler Chicken Farm.

Universal Journal of Public Health, Vol. **12** n°(5), (2024), 867 - 877 p.

Broiler chickens, one of Indonesia's promising ventures for food security, also serve as a livelihood for many people. Numerous workers engage in activities at these locations, with some dedicating up to 24 hours. This type of workplace carries various health risks, particularly concerning air quality. In Indonesia, there are three types of broiler chicken coops: Open, Semi-Enclosed, and Closed. The Closed type is claimed to be more promising and environmentally friendly. However, studies addressing these differences are still minimal. Air quality parameters such as temperature (℃), relative humidity (RH), PM10 (mg/m3), Ammonia (NH3), and total bacterial count (CFU/m3) were examined in 30 chicken coops in Banyumas Regency, Central Java, in close proximity. There were 11 open-type broiler chicken farms, 9 semi-enclosed farms, and 10 enclosed ones. The average values for temperature, relative humidity, and airborne bacterial count exceeded the limits set by the Indonesian government. As for PM10 and NH3 in all observed coops, they remained below this limit. There was a significant difference ($\propto$=0.05) for the RH parameter (p = 0.017), PM10 (p = 0.023), and total airborne bacterial count (p = 0.018) among the three coop types. The Spearman Rank test indicated a significant correlation between the number of chicken and PM10 (p = -0.62) and Airborne Bacterial Count (p = 0.46), as well as temperature and RH (p = -0.56), temperature and NH3 (p = -0.394), RH and NH3 (p = 0.392). With values above the recommended limits, poultry farm managers must consider indoor disinfection and administratively regulate working hours. These efforts also aim to minimize the health risks to workers.

https://doi.org/10.13189/ujph.2024.120510

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Varol, A., Motlagh, N. H., Leino, M., Tarkoma, S., Virkki, J.

Creation of AI-driven Smart Spaces for Enhanced Indoor Environments--A Survey.

arXiv preprint arXiv:2412.14708, (2024)

Smart spaces are ubiquitous computing environments that integrate diverse sensing and communication technologies to enhance space functionality, optimize energy utilization, and improve user comfort and well-being. The integration of emerging AI methodologies into these environments facilitates the formation of AI-driven smart spaces, which further enhance functionalities of the spaces by enabling advanced applications such as personalized comfort settings, interactive living spaces, and automatization of the space systems, all resulting in enhanced indoor experiences of the users. In this paper, we present a systematic survey of existing research on the foundational components of AI-driven smart spaces, including sensor technologies, data communication protocols, sensor network management and maintenance strategies, as well as the data collection, processing and analytics. Given the pivotal role of AI in establishing AI-powered smart spaces, we explore the opportunities and challenges associated with traditional machine learning (ML) approaches, such as deep learning (DL), and emerging methodologies including large language models (LLMs). Finally, we provide key insights necessary for the development of AI-driven smart spaces, propose future research directions, and sheds light on the path forward.,

https://doi.org/10.48550/arXiv.2412.14708

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Aghili, S. A., Khanzadi, M., Rezaei, A. H. M., Rahbar, M.

Data-driven approach to fault detection for hospital HVAC system.

Smart and Sustainable Built Environment, (2024)

Purpose

Hospital heating, ventilation and air conditioning (HVAC) systems are essential to patient safety and wellness. System malfunctions, however, may result in energy waste and even pose health dangers. This project aims to provide a fault detection and diagnostics framework designed primarily for HVAC systems in hospitals.

Design/methodology/approach

In order to identify problems in hospital air handling units, the study uses a data-driven methodology that makes use of Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRU) models. To address the problem of uneven data, the dataset is balanced. Other machine learning classifiers, such as Logistic Regression, Multilayer Perceptron, Support Vector Machine, Random Forest, Gradient Boosting and eXtreme Gradient Boosting, are compared to see how well the LSTM and GRU models perform.

Findings

Regarding defect detection, the LSTM and GRU models outperform traditional classifiers in terms of both accuracy and computation speed, with high accuracy rates surpassing 90%. Due to its simpler design, GRU achieves higher accuracy and performs faster calculations than LSTM. These recurrent models work well to identify temporal relationships in time-series data, which is crucial for detecting HVAC system problems.

https://doi.org/10.1108/SASBE-05-2024-0169

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Hosamo, H., Mazzetto, S.

Data-Driven Ventilation and Energy Optimization in Smart Office Buildings: Insights from a High-Resolution Occupancy and Indoor Climate Dataset.

Sustainability, Vol. **17** n°(1), (2025)

This paper explores innovative approaches to reducing energy consumption in building ventilation systems through the implementation of adaptive control strategies. Using a publicly available high-resolution dataset spanning a full year, the study integrates real-time data on occupancy, CO2 levels, temperature, window state, and external environmental conditions. Notably, occupancy data derived from computer vision-based detection using the YOLOv5 algorithm provides an unprecedented level of granularity. The study evaluates five energy-saving strategies: Demand-Controlled Ventilation (DCV), occupancy-based control, time-based off-peak reduction, window-open control, and temperature-based control. Among these, the occupancy-based strategy achieved the highest energy savings, reducing power consumption by 50%, while temperature-based control yielded a significant 37.27% reduction. This paper's originality lies in its holistic analysis of multiple dynamic control strategies, integrating diverse environmental and operational variables rarely combined in prior research. The findings highlight the transformative potential of integrating real-time environmental data and advanced control algorithms to optimize HVAC performance. This study establishes a new benchmark for energy-efficient building management through offering practical recommendations and laying the groundwork for predictive models, renewable energy integration, and occupant-centric systems.

https://doi.org/10.3390/su17010058

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Estaquio, R. P., Astrologo, N., Montecillo, S. M., Gasacao, H., Immanuel, J.

Determination of Optimal Placement of Indoor CO2 Sensors Using Computational Fluid Dynamics.

24th Australasian Fluid Mechanics Conference (AFMC) , Canberra, Australia, 1-5 December 2024

Indoor air quality (IAQ) is an important factor in ensuring that indoor environments such as the workplace, home, places of leisure, do not lead to reduced productivity, comfort, or sickness. Maintaining good indoor air quality begins with assessing contaminant concentrations with carbon dioxide being the norm as an indicator of IAQ. Accuracy of IAQ measurements may be achieved through placing multiple sensors throughout a room but this comes with a cost. This may be remedied by analyzing the optimal placement of a single sensor to accurately represent the mean concentration within a room, with probable indication of the distribution within the same room. Computational Fluid Dynamics (CFD) offers a numerical method to determine this optimal location along with a probable distribution of carbon dioxide relative to known emission sources and locations of ventilation. The present study aims to develop a verified and validated carbon dioxide dispersion model within a fan-ventilated bedroom, then apply the model to investigate the impact of room geometry and ventilation on indoor air quality. Validation against experimental data yields root mean square errors of 0.26 m/s and 22.09 ppm for airflow and CO2 concentration, respectively. Results indicate that mechanical ventilation effectively homogenized the CO2 concentration within the room, with no signs of vertical stratification. Approximately 97.1% of the room's volume exhibits carbon dioxide concentrations within +-10 ppm of the mean concentration.

https://doi.org/10.5281/zenodo.14213367

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Fissore, V. I., Barbaro, A., Chiavassa, P., Espinosa, G. a. R., Giusto, E., Puglisi, G. E.*, et al.*

Development and In-field Application of a System for Indoor Environmental Quality Monitoring and Occupants' Feedback Collection.

Multiphysics and Multiscale Building Physics. 25-27 July Toronto, Canada

Indoor Environmental Quality (IEQ) affects occupants' health, well-being and comfort, making its assessment increasingly required. This work presents a system designed to collect subjective and objective data on IEQ, referred to as PROMET&O (PROactive Monitoring for indoor EnvironmenTal quality & cOmfort). It is built on a survey and a low-cost and accurate multi-sensor device. The former was developed to collect feedback on occupants' comfort perception and personal and behavioural information. The latter was developed to monitor the thermal, lighting, acoustic and air quality conditions in indoor environments. The monitored parameters (air temperature, relative humidity, carbon dioxide, carbon monoxide, nitrogen dioxide, particulate matter, volatile organic compounds, formaldehyde, illuminance and sound pressure level) were selected based on international standards. A three-step calibration of the device is applied to ensure the measurements' reliability. The monitored data is transferred and processed on an open-source platform and the thermal comfort, visual comfort, acoustic comfort, indoor air quality and IEQ indexes are calculated and displayed on a user-friendly interface. This interface was designed to inform both building managers and occupants on IEQ trends and to provide them with more information on monitored parameters and hints on actions to improve their comfort. Preliminary tests in laboratory and in-field have shown the validity and scalability of the system's design.

https://doi.org/10.1007/978-981-97-8317-5_18

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Mahesh, N., Mrunalini, T., Dhanush, M., Prabu, P. D., Janadharshini, V., Ashok, S.

Development of Airborne Particle Filtering System Using IoT.

2024 8th International Conference on Electronics, Communication and Aerospace Technology (ICECA)

Design and development of an innovative air-borne particle filtering system integrated with Internet of Things (IOT) technology. The proposed system is an automated device that filters dust particles from the atmosphere using an embedded system approach. It comprises two main components: the filtering unit and the embedded control system with IOT connectivity. The embedded control system incorporates a Arduino uno, which regulates the speed of the DC motors based on real-time air quality data obtained from a dust sensor. The system leverages IOT technology to enable remote monitoring and control of the air quality. The microcontroller interfaces with an IOT module or a Wi-Fi/Ethernet interface, allowing data logging, monitoring, and remote control through a cloud-based platform or local network. Real- time air quality data, including dust particle concentrations, can be accessed and monitored remotely, enabling facility managers and environmental health and safety personnel to track air quality conditions effectively. By implementing this air-borne particle filtering system with IOT integration, textile facilities can proactively address the issue of dust particles in the workplace, promoting a healthier and safer environment for employees while ensuring compliance with occupational health and safety regulations.

https://doi.org/10.1109/ICECA63461.2024.10800917

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Changpradub, K., Threrujirapapong, T.

Development of hybrid plasmonics and metal oxide nanostructure chips for VOCs optical sensing device.

(2025)

In this study, a Localized surface plasmon resonance (LSPR)- based sensor for volatile organic compounds (VOCs) detection is developed. The sensors are fabricated as a hybrid nanostructure of gold nanoparticles (Au NPs) coated with a tantalum oxide (TaO) and Tungsten oxide (WO3) thin film on a glass slide substrate through magnetron sputtering and thermal solid-state dewetting techniques. The thickness of the TaO and WO3 film varies between 10 and 70 nm. The optical properties of samples are characterized by UV-Vis-NIR spectrophotometry, while their morphologies are confirmed via transmission electron microscopy. The results show the shift of the minimum optical transmittance related to the TaO and WO3 thickness. Electrical field simulations are performed to predict the sensitivity of the prepared samples for VOC detection. In addition, the sensors are tested with different VOCs, including formaldehyde, isopropanol, acetone, methanol and Toluene which show good potential for practical applications.,

http://202.44.33.99/dspace/bitstream/123456789/58/1/s6501062810010.pdf

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Cheniti Derradji, C. M.

Développement d'un système d'amélioration de la qualité d'air dans les espaces fermés.

University Mohamed El Bachir El Ibrahimi of Bordj Bou Arreridj. Faculté des sciences et de la technologie. Thèse 2024

Les travaux présentés dans ce mémoire démontrent la faisabilité et l'efficacité d'un système de détection de gaz intelligent conçu pour protéger les espaces fermés contre les risques liés à la pollution atmosphérique. Grâce à une combinaison de capteurs de gaz avancés, de systèmes de ventilation réactifs et de dispositifs d'alerte, le prototype développé a prouvé sa capacité à détecter rapidement des concentrations dangereuses de gaz et à activer des mécanismes de protection adéquats. Ces résultats prometteurs ouvrent des perspectives intéressantes pour une future optimisation des performances du système, en particulier en termes de précision des capteurs, d'optimisation énergétique et de réduction des coûts. Ce projet s'inscrit dans une démarche plus large d'amélioration des technologies de gestion de la qualité de l'air intérieur, avec l'ambition de contribuer à la création d'environnements plus sûrs, plus sains et plus durables.

https://dspace.univ-bba.dz/handle/123456789/5882

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Rapone, L., Li Castri, G., Lavilletta, M., Favoino, F., Perino, M., Serra, V.

Double-Skin Façade with Air-PCM Latent Heat Exchanger: First Results from Experimental Campaign.

Multiphysics and Multiscale Building Physics

In the context of a European project aimed at developing, upscaling, and testing innovations in building envelope materials and technical systems to reach Nearly Zero Energy Buildings (nZEB) balance, a novel advanced glazing component was conceived to improve energy efficiency while ensuring occupant comfort in terms of thermal comfort and indoor air quality. The aim of this work is to present preliminary results from the experimental characterisation of this technology carried out on a full scale prototype in a South oriented façade of an outdoor test facility. The experimental characterisation presents first results for winter season, in terms of single component and whole system performance. To this sake both conventional performance metrics (i.e. U-value, g-value) and more advanced metrics considering the dynamicity of the components operations (i.e. pre-heating and dynamic insulation efficiencies) are taken into account, considering also the effect of the LHEX as compared to more traditional ventilation strategies (i.e. natural ventilation, decentralised heat recovery).

https:/doi.org/10.1007/978-981-97-8305-2_61

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Soriano, D. I. M.

The Effect of Indoor Air Quality on Respiratory Health in Office Environments: An Occupational Health and Safety Literature Review.

2024

Indoor air quality (IAQ) is an important factor of respiratory health and productivity in office environments, where individuals spend a significant portion of their time. This systematic literature review explores the relationship between IAQ and respiratory health, focusing on common pollutants such as volatile organic compounds (VOCs), particulate matter, and carbon dioxide (CO2). It synthesizes findings from recent studies to identify key challenges, technological advancements, and effective mitigation strategies. The review brings importance to IAQ management through real-time monitoring systems, adaptive ventilation technologies, and sustainable building designs. Despite notable progress, gaps in research, policy enforcement, and global standardization remain significant barriers to achieving healthier office environments. The findings describe the need for integrated engineering, regulatory, and behavioral approaches to optimize IAQ and enhance occupational health.

http://dx.doi.org/10.13140/RG.2.2.34431.62887

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Gunes, G., Undar, O. T.

Effect of natural ventilation on indoor air quality parameters in different microenvironments.

International Journal of Environmental Science and Technology, (2024)

In this study, the effect of natural ventilation on indoor air quality was investigated in different microenvironments and possible sources of pollutants were estimated. Particulate matter with an aerodynamic diameter less than 2.5 µm and less than 10 µm, total volatile organic compounds, formaldehyde, temperature and humidity values were measured. Carbon dioxide was measured with PCE CMM5, other parameters with PCE- RCM 11. It was determined that the winter season concentrations of both particulate and gas phase compounds were higher than other seasons. The results indicated that the increase in human numbers and activity can cause the resuspension of dust accumulated on indoor

surfaces. It was determined that frying/cooking processes and disinfectant use may cause an instant increase in total volatile organic compounds and formaldehyde concentrations. Additionally, total volatile organic compounds and formaldehyde concentrations may be affected printers, personal computers, potted plants, wooden cabinets, tables, wooden flooring, personal care products (perfume, cream, hand sanitizer, etc.) and citrus fruits. Indoor particle matter concentration increased during natural ventilation, especially in windy weather. The average values determined for quality parameters (except carbon dioxide) before natural ventilation did not show any significant difference according to the sampling points ($p > 0.05$). Nevertheless, the difference between the concentrations of total volatile organic compounds total volatile organic compounds, formaldehyde and carbon dioxide compounds before and during natural ventilation was statistically significant ($p < 0.05$).

https://doi.org/10.1007/s13762-024-06251-x

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Vecchiarelli, V., Scott, M., Piche, T., Milton, J., Putnam, B., Heywood, P.*, et al.*

Enhancing indoor air quality in ice arenas: Insights from a survey of operators.

Environmental Health Review, Vol. **67** n°(4), (2024), pp. 85-91

Abstract There are significant challenges to indoor air quality (IAQ) in indoor ice arenas due to fossil fuel-powered equipment. This research explores the air quality management practices in Ontario?s ice arenas, focusing on pollutants like carbon monoxide (CO) and nitrogen dioxide (NO2), which pose health risks to arena workers and the public. A survey was conducted among directors/managers/operators of ice arenas in Ontario, revealing key concerns such as aging ventilation systems, inadequate monitoring, and budget constraints. The findings highlight that while many arenas are transitioning to electric equipment and implementing regular maintenance, significant gaps remain in IAQ monitoring, particularly for NO2. This research advocates for enhanced training, consistent inspection practices, and better resource allocation to ensure the safety of arena users.

There are significant challenges to indoor air quality (IAQ) in indoor ice arenas due to fossil fuel-powered equipment. This research explores the air quality management practices in Ontario?s ice arenas, focusing on pollutants like carbon monoxide (CO) and nitrogen dioxide (NO2), which pose health risks to arena workers and the public. A survey was conducted among directors/managers/operators of ice arenas in Ontario, revealing key concerns such as aging ventilation systems, inadequate monitoring, and budget constraints. The findings highlight that while many arenas are transitioning to electric equipment and implementing regular maintenance, significant gaps remain in IAQ monitoring, particularly for NO2. This research advocates for enhanced training, consistent inspection practices, and better resource allocation to ensure the safety of arena users.

https://doi.org/10.5864/d2024-021

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Salas, A. F., Igualada, L., Farré, J., Serrano, M., Montes, T.

Enhancing user comfort in smart buildings though operational optimization.

2024 3rd International Conference on Energy Transition in the Mediterranean Area (SyNERGY MED). 21-23 October 2024. Limassol, Cyprus

This paper presents a multi- objective operational model for smart buildings, integrating Heating, Ventilation, and Air Conditioning (HVAC) systems, electrical storage, Light-Emitting Diode (LED) lighting, and photovoltaic (PV) devices. The model addresses the challenges of HVAC system non-linearity, optimizing both economic efficiency and occupant comfort. Designed for scalability and real-time applications, the model minimizes energy costs while ensuring thermal comfort, optimal lighting, and maintaining air quality within healthy CO 2 levels. Additionally, the study includes a Pareto frontier, offering a range of optimal solutions that balance energy savings with comfort requirements. This approach

enhances both cost-effectiveness and occupant well-being in smart buildings, providing decision-makers with flexibility in prioritizing between economic and comfort objectives.

https://ieeexplore.ieee.org/document/10799299

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Sugahara, E. S., Dias, A. M. A., Botelho, E. C., Campos, C. I., Dias, A. M. P. G.

Feasibility of using eucalyptus wood and castor oil adhesive to produce OSB panels.

Research square, (2024)

Among the products that help in the industrialization of construction with technological and sustainable characteristics, wood panels stand out, which are related to a possible lower environmental impact associated with carbon fixation and replacement of non-renewable materials. Worldwide consumption of OSB (Oriented Strand Board) panels has increased, proving the relevance and consolidation of the use of this product. Therefore, it is necessary to study viable alternatives for traditionally used raw materials so that the composites produced present final properties compatible with regulatory specifications and meet the required technological requirements so that they can be safely applied as a construction component. In this context, OSB panels were produced with eucalyptus wood and castor-based polyurethane adhesive. Eucalyptus wood is a reforestation hardwood, with fast-growing and diverse species. Considering that traditional adhesives are among the main environmental hotspots in OSB production, castor oil-based adhesive is a potential alternative, as it is not produced using formaldehyde and comes from renewable sources. In this study, the physical and mechanical properties of the panels were evaluated (density, moisture content, swelling in thickness − 24h, water absorption, modulus of elasticity and strength in bending, internal bond, and resistance to axial withdrawal of screws). The average results were compared with the use classes indicated by Standard EN 300:2006, demonstrating that the panels produced are compatible with the classification as OSB/4 according to EN 300:2006 (Heavy-duty load-bearing boards for use in humid conditions), confirming the viability of production and presenting excellent structural performance.

https://doi.org/10.21203/rs.3.rs-5454928/v1

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Handady, G., Dsouza, A., Nayak, V., Abraham, J.

Formaldehyde Levels and the Indoor Air Quality of an Anatomy Dissection Hall with Different Ventilation Setups.

Environmental Health Insights, Vol. **18**, (2024)

During anatomy dissection, the release of formaldehyde (FA) from cadavers and embalming fluids can negatively affect the well-being of students and staff. The exposure of students, staff, and technicians to FA in the dissection hall is a concern. To address this issue, a study measured the FA and air quality (CO2 and Total Volatile Organic Compounds- TVOC) with different ventilation setups: natural, fan-based, and air-conditioned. The FA levels and the indoor air quality at the breathing zone were estimated using an air conditioning (AC), fan-based, and naturally ventilated setup. The FA, CO2, and TVOC levels were calculated at the cadavers? head and toe ends, in the pathway, and between the dissection tables. The FA, CO2, and TVOC levels were higher near the cadaver and lower in the pathway and between the tables, regardless of the type of ventilation used. Fan-based ventilation had the lowest mean FA, CO2, and TVOC levels compared to AC and natural ventilation. However, there was no significant difference in these levels between the ventilation types, except for the toe-ends of the cadavers (P?<?.05), where the toe-end farther from the AC vents had higher levels. The study suggests that areas away from the source of ventilation in the anatomy dissection hall are at risk of having lower air quality. Therefore, in addition to selecting an appropriate ventilation system, placing the donor bodies near the source of ventilation would help optimize FA levels and improve indoor air quality for better working conditions suitable for students and staff.

https://doi.org/10.1177/11786302241301590

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Kara, B., Kaymakamzade, B., Tulbentci, T., Savasan, A., Amilo, D., Hosseini, K.

A fractional-order model for the effects of expansions in hospitals on the applicability of performance certificate programme.

Applied Mathematics in Science and Engineering, Vol. **33** n°(1), (2025)

This study explores the impact of the Leadership in Energy and Environmental Design (LEED) certification system on healthcare services in private hospitals in North Cyprus using a fractional-order system of equations. The Near East Hospital (NEH) earned Gold-level certification with 79 points, while Burhan Nalbanto?lu Hospital (BNH) obtained 31 points. Through sensitivity analysis of indoor air quality and sustainable land criteria, the study demonstrates that hospitals adopting LEED certification provide superior service quality. The findings suggest that government hospitals could benefit from aligning with green certification criteria, potentially improving patient outcomes. Data collected from NEH and BNH support a positive relationship between green certification and increased patient and employee satisfaction, with significant evidence ($p<0.05$) distinguishing LEED-certified hospitals from non-certified ones. The study also evaluates how hospital expansions affect the applicability of certification programs and the management of COVID-19, focusing on criteria such as sustainable sites, water efficiency, and indoor environmental quality. The analysis provides insights for healthcare administrators and policymakers seeking to enhance hospital infrastructure to meet certification standards, improve healthcare services, and better manage future pandemics. The research underscores the importance of green certification in improving patient care, employee satisfaction, and overall hospital performance.

https://doi.org/10.1080/27690911.2024.2438769

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Bahrar, M., Aldakheel, J., El Mankibi, M.

In-Situ Assessment of Indoor Air Quality Through Monitoring Key Environmental Indicators.

Multiphysics and Multiscale Building Physics

Indoor air quality (IAQ) has become vital as it significantly influences human health and well-being. Given that people spend most of their lifetime indoors, assessing and maintaining an optimal IAQ is essential for ensuring the well-being of occupants. Numerous interrelated triggers influence Indoor Air Quality (IAQ): outdoor air quality, occupant behavior, building materials, heating, ventilation, and air conditioning (HVAC) systems, contaminant sources, temperature, and humidity. To better assess IAQ, the development of efficient methodologies and tools is necessary. This study evaluates indoor air quality (IAQ) in office environments through advanced mechanical ventilation strategies at the HYBCELL facility, ENTPE, France. The facility was instrumented with sensors to track various elements affecting indoor and outdoor air quality, such as temperature, humidity, air velocity, particulate matter (PM2.5, PM5, and PM10), CO2, and volatile organic compounds (VOCs). Moreover, the facility is equipped with mechanical ventilation systems to assess the impact of different ventilation strategies on pollutant levels. The results demonstrate the importance of adaptive ventilation strategies for maintaining optimal indoor environments. The findings underscore that a Demand-based Ventilation Control strategy can effectively regulate CO2 concentrations within desired limits, thus promoting a healthier workspace. On the other hand, fixed fan speeds provided valuable insights into the direct relationship between ventilation rates, pollutant concentrations, and energy consumption.

https://doi.org/10.1007/978-981-97-8317-5_39

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Gökdeniz, K., Bostanci, E.

Indoor Air Quality Predictions For Automation.

The Journal of Artificial Intelligence and Human Sciences, Vol. **1** n°(1), (2024), 56-66 p.

This study examines the implementation of home automation systems to predict indoor air quality using real-time data such as temperature, humidity, pressure, occupancy status, energy consumption, and window conditions. Due to the superior pattern recognition performance of recurrent neural networks, the study employs deep learning techniques for air quality prediction. A comparative analysis of GRU, LSTM and BiGRU models highlights GRU's superior performance across various metrics, emphasizing its generalization capability. The study also introduces an Air-Smart Control Device, enabling users to monitor predictions and control home automation systems. In conclusion, the research underscores the potential of home automation in air quality prediction, provides insights into neural network architectures, and contributes to advancements in automation technology and air quality management.,

https://doi.org/10.1234/dwr63f51

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Goodman, N., Rajagopalan, P., Francis, M., Nematollahi, N., Vardoulakis, S., Steinemann, A.

Indoor Volatile Organic Compounds in Prefabricated Timber Buildings—Challenges and Opportunities for Sustainability.

Buildings, Vol. **14** n°(12), (2024)

Prefabricated timber buildings offer a low-carbon approach that can help reduce the environmental impact of the building and construction sectors. However, construction materials such as manufactured timber products can emit a range volatile organic compounds (VOCs) that are potentially hazardous to human health. We evaluated 24 years (2000–2024) of peer-reviewed publications of VOCs within prefabricated timber buildings. Studies detected hazardous air pollutants such as formaldehyde, benzene, toluene, and acetaldehyde (indoor concentration ranges of 3.4–94.9 µg/m3, 1.2–19 µg/m3, 0.97–28 µg/m3, and 0.75–352 µg/m3, respectively), with benzene concentrations potentially exceeding World Health Organization indoor air quality guidelines for long/short term exposure. Most studies also detected terpenes (range of 1.8–232 µg/m3). The highest concentrations of formaldehyde and terpenes were in a prefabricated house, and the highest of benzene and toluene were in a prefabricated office building. Paradoxically, the features of prefabricated buildings that make them attractive for sustainability, such as incorporation of manufactured timber products, increased building air tightness, and rapid construction times, make them more prone to indoor air quality problems. Source reduction strategies, such as the use of low-VOC materials and emission barriers, were found to substantially reduce levels of certain indoor pollutants, including formaldehyde. Increasing building ventilation rate during occupancy is also an effective strategy for reducing indoor VOC concentrations, although with the repercussion of increased energy use. Overall, the review revealed a wide range of indoor VOC concentrations, with formaldehyde levels approaching and benzene concentrations potentially exceeding WHO indoor air quality guidelines. The paucity of evidence on indoor air quality in prefabricated timber buildings is notable given the growth in the sector, and points to the need for further evaluation to assess potential health impacts.

https://doi.org/10.3390/buildings14123858

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Peltason, V., Melin, J., Jung, B.

Initial steps toward a metrological model for assessing well-being in office spaces.

Measurement: Sensors, (2024)

A model is being proposed to aid in an investigation of a method for measuring well-being in offices using a classical metrological approach tailored to the unique challenges of measuring human perceptions. In this case, the measurand is well-being in an office space as characterized by specific environmental parameters determined using a sensor setup that collects data about variables such as temperature, illuminance, and air quality. The decisive feature of the model is that the human is taken to be the measurement instrument whose evaluation of the conditions in the room provides the raw data for the analysis. The model will offer insights into challenges that face human-based measurements and possible ways of overcoming them, including identifying the numerous parameters that act on the respondents and attempting to quantify them. The aim is that the novel metrological model developed for this study will exhibit flexibility, allowing it to be applied to other non-traditional metrics.

https://doi.org/10.1016/j.measen.2024.101505

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Xu, Y., Zhu, S., Cai, J., Chen, J., Li, S.

A large language model-based platform for real-time building monitoring and occupant interaction.

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

Effective management of indoor environments requires a comprehensive evaluation of health, energy consumption, and thermal comfort. However, real-time assessment of these factors is challenging due to the lack of integrated applications that combine IoT technology, real-time simulation, and user-friendly interfaces for communication. To address these challenges, this research introduces a novel platform specifically designed to manage health, energy consumption, and thermal comfort in smart buildings, leveraging IoT-based building information modeling (BIM), cloud computing, and an AI-powered conversational suggestion system based on the large language model (GPT). The platform integrates real-time monitoring, simulation, alerting, and persuasion capabilities to manage health, energy consumption, and thermal comfort, enabling responsive building environment controls by assessing tradeoffs among these dimensions and providing timely recommendations. Additionally, it employs persuasive techniques to encourage occupants to adopt environmentally-friendly practices. A case study in a university building demonstrated the platform's functionality and visualization capability. A survey assessing the persuasive system revealed high adoption rates—95.59 % for switching rooms to improve indoor air quality and health, and 79.90 % for adjusting clothing to enhance thermal comfort—indicating strong participant willingness to adopt sustainable practices through the platform's strategies. The key contribution of this research is the development of a comprehensive, real-time platform that enhances indoor environmental quality and sustainability through advanced monitoring, analysis, and social interaction.

https://doi.org/10.1016/j.jobe.2024.111488

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Barenghi, L., Barenghi, A., Scribante, A., Pellegrini, M., Spadari, F.

Laser-assisted dentistry, safety, and cross-infection control: A narrative review.

Journal of Applied Pharmaceutical Science, (2024)

The rapidly expanding use of laser-assisted care in dentistry requires exploring all aspects of safety. The acronym laser stands for “light amplification by stimulated emission of radiation”. The laser produces a very narrow beam of electromagnetic radiation (light) and has been exploited for some innovative dental care technologies. So far, regulatory framework and laser safety issues mainly concern the prevention of some tissue damages (eye, non-target oral tissue, and non-target skin), and laser hazards (chemical, fire, and electric shock), but minimal on cross-infection prevention and control. Concerning infection prevention, it is important to remember that the outlook for infectious risk is alarming, dental patients are potentially infectious, and as with any other innovative oral-dental health technology, laser-assisted dentistry cannot

claim to be free of healthcare-associated infections. The narrative review focuses on cross-infection prevention of laser-assisted dental care and includes 158 references. The search was adopted using some essential keywords from documents in databases (PubMed, Scopus) from 2010 to 2023. This study focuses on 10 important areas in results and discussion: a) international guidelines and recommendations; b) pre-procedural mouthwash before LD; c) indoor air quality during laser dentistry and recommendations for indoor air quality in dentistry; d) use of personal protective equipment; e) hand hygiene; g) reconditioning of laser safety eyewear; f) standards for the reconditioning of laser accessories; g) clinical contact surface disinfection and the use of transparent barriers; h) limitations; and i) perspectives. To ensure safety and cross-infection prevention, the study highlights the need for sound research and updated international guidelines, and better information for users with detailed recommendations for dental practitioners.

https://dx.doi.org/10.7324/JAPS.2025.210316

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

Method of Experimental Evaluation of MOx Sensors for Real-Time Indoor VOCs Monitoring.

Multiphysics and Multiscale Building Physics

This study is specifically aimed at evaluating commercially available metal oxide (MOx) sensors for real-time monitoring of volatile organic compounds (VOCs) in typical indoor environments. To evaluate MOx sensors' performance, we used a 50 L environmental chamber system to provide a well-controlled testing environment. The VOC types and test concentrations were based on relevant indoor air quality (IAQ) standards and guides in the literature. Test VOCs included toluene, formaldehyde, m-Xylene, phenol, benzene, naphthalene, acetaldehyde, acetone, dichloromethane, tetrachloroethylene, 1,1,1-trichloroethane. The evaluation tests are categorized into individual VOC tests, mixture VOCs tests, temperature and relative humidity dependence tests, short-term stability tests, and long-term drifting tests to investigate the sensitivity to specific VOC, mixture co-influence under realistic condition, moisture compensation, and reliability. This paper focuses on the procedures and results of the toluene test, identifying necessary improvements in the algorithm through comparisons between raw signals and TVOC readings. Results of this study will help provide guidance on the selection and utilization of MOx VOC sensors for VOC monitoring and IAQ control.

https:/doi.org/10.1007/978-981-97-8317-5_36

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Brun, R., Gaudion, V., Verriele, M., Romanias, M. N., Chenal, M., Soisson, A.*, et al.*

Mitigation of indoor pollution events by lime-cement plasters: Full-scale assessment.

Atmospheric Environment, Vol. **343**, (2025)

The assessment of the impact of passive remediation approaches to improve indoor air quality requires the real-scale investigation of technologies. Plasters are identified as relevant materials to mitigate indoor pollution. Interestingly, lime-cement plasters can be formulated with activated carbon sorbent to expand their uptake properties. This work provides a full-scale and replicable evaluation methodology to address the passive remediation properties of materials with regard to experimental facilities and the diversity of pollution scenarios. This methodology is applied to lime-cement plaster formulated or otherwise with activated carbon and subsequently set in IRINA experimental room (40 m3). Both materials are successively submitted to CO2, ozone and VOC transient pollution events. Specific attention is paid to the behaviour of formaldehyde. First, both fresh plasters demonstrate high mitigation capacities towards CO2. This behaviour has to be compared to the ageing of materials. Similarly, excellent decomposition capacities are evidenced towards ozone. Both pollution scenarios highlight a higher mitigation of lime-cement compared to activated carbon. Regarding VOC pollution scenarios, the effective removal of formaldehyde is evidenced. However, formaldehyde decay follows second-order kinetics, due to surface reactive

processes, preventing the calculation of the clean air delivery rate (CADR). Mitigation of other VOCs is considerably promoted by activated carbon in the plaster. Abatement of different classes of pollutants is discussed taking CADR into consideration. Results evidence the effectiveness of combining carbon-based sorbent with plaster in order to benefit from complementary uptake properties. Finally, the CADR of selected pollutants are compared with classically determined equivalent data for active remediation technologies. This full-scale comparison demonstrates that passive mitigation approaches offer equivalent remediation capacities compared to widespread active and destructive air treatment technologies.

https://doi.org/10.1016/j.atmosenv.2024.120997

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Østerstrøm, F. F., Carter, T. J., Shaw, D. R., Abbatt, J. P. D., Abeleira, A., Arata, C.*, et al.*

Modelling indoor radical chemistry during the HOMEChem campaign.

Environmental Science: Processes & Impacts, (2025)

In the indoor environment, occupants are exposed to air pollutants originating from continuous indoor sources and exchange with the outdoor air, with the highest concentration episodes dominated by activities performed indoors such as cooking and cleaning. Here we use the INdoor CHEMical model in Python (INCHEM-Py) constrained by measurements from the House Observations of Microbial and Environmental Chemistry (HOMEChem) campaign, to investigate the impact of a bleach cleaning event and cooking on indoor air chemistry. Measurements of the concentrations of longer-lived organic and inorganic compounds, as well as measured photolysis rates, have been used as input for the model, and the modelled hydroxyl (OH) radicals, hydroperoxyl radicals, and nitrous acid (HONO) concentrations compared to the measured values. The peak modelled OH, , and HONO concentrations during cooking and cleaning activities are about 30%, 10%, and 30% higher than the observations, respectively, within experimental uncertainties. We have determined rates for the rapid loss of HONO formed through cooking activities onto a wet surface during the cleaning events and also for the subsequent slow release of HONO from the cleaned surface back into the gas-phase. Using INCHEM-Py we have also predicted peak concentrations of chlorine (Cl) atoms, (0.75–2.3) × 105 atom per cm3 at the time of cleaning. Model predictions of the Cl atom and OH radical reactivities were also explored, showing high Cl atom reactivity throughout the day, peaking around 5000–9000 s−1. The OH reactivity was found to increase from a background value close to urban outdoor levels of 20–40 s−1, to levels exceeding observations in outdoor polluted areas following cooking and cleaning activities (up to 160 s−1). This underlines the high oxidation capacity of the indoor atmospheric environment through determining the abundance of volatile organic compounds.

http://dx.doi.org/10.1039/D4EM00628C

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Lee Min, J., Zhang, R.

Multimodal Data Fusion and Deep Learning for Occupant-Centric Indoor Environmental Quality Classification.

Journal of Computing in Civil Engineering, Vol. **39** n°(2), (2025)

Amidst the growing recognition of the impact of indoor environmental conditions on buildings and occupant comfort, health, and well-being, there has been an increasing focus on the assessment and modeling of indoor environmental quality (IEQ). Despite considerable advancements, existing IEQ modeling methodologies often prioritize and limit to singular comfort metrics, potentially neglecting the comprehensive factors associated with occupant comfort and health. There is a need for more inclusive and occupant-centric IEQ assessment models that cover a broader spectrum of environmental parameters and occupant needs. Such models require integrating diverse environmental and occupant data, facing challenges in leveraging data across various modalities and time scales as well as understanding the temporal patterns, relationships, and trends. This paper proposes a novel framework for classifying IEQ conditions based on occupant self-reported comfort and health levels to address these challenges. The

proposed framework leverages a multimodal data-fusion approach with Transformer-based models, aiming to accurately predict indoor comfort and health levels by integrating diverse data sources, including multidimensional IEQ data and multimodal occupant feedback. The framework was evaluated in classifying IEQ conditions of selected public indoor spaces and achieved 97% and 96% accuracy in comfort and health-based classifications, outperforming several baselines.

https://doi.org/10.1061/JCCEE5.CPENG-6249

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Saleem, S. N. a. N., Zulkafli, N. I., Tee, B. T., Sukri, M. F., Tahir, M. M., Muhajir, A.*, et al.*

Multiple Linear Model Analysis of Indoor Air Quality for Air Conditioning System in Office Building.

Chemical Engineering Transactions, Vol. **113**, (2024), 127-132 p.

The building performance is measured through the power consumption of the air conditioning system and indoor air quality (IAQ) of the building spaces to provide sufficient cooling while at the same time satisfying thermal comfort. The multiple linear model of Piecewise linear (PWL) and Multiple Linear Regression (MLR) model is used to accurately estimate the power consumption of the air conditioning system considering IAQ parameters such as carbon dioxide concentration, indoor air temperature, and humidity. The IAQ parameters are usually modelled individually for the building without proper correlation with the power consumption of the air conditioning system. This problem makes the modelling results unrealistic to the building performance solutions. This paper focuses on identifying the relationship between power consumption with integrated IAQ parameters of CO2 concentration, air temperature, and humidity for Air Conditioning Mechanical and Ventilation (ACMV) system in the office building. The results demonstrate the power consumption estimation model considering IAQ parameters for different time zones is accurate and acceptable with a percentage difference of less than 1 % from the real data. The power consumption estimation model can be used to predict future power consumption with optimum range values for IAQ parameters for sustainable utilisation of energy.

https://doi.org/10.3303/CET24113022

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Majić, I., Krivohlavek, A., Andrić, E. K., Godec, R.

Mycotoxins Present in the Indoor Air of a Music School Repurposed from an Atomic Shelter.

Research square, (2024)

Clean air is essential for human well-being, especially indoors. Indoor air quality has a significant impact on human health and there is concern about the health effects of exposure to airborne bacteria and fungi. The World Health Organization has warned of adverse health effects associated with building moisture and biological agents. Mold growth due to indoor moisture affects a significant percentage of buildings worldwide, leading to increased health risks, especially for children. It is crucial to work on implementing effective solutions to create healthier indoor environments for children worldwide.

This study investigates the adverse health effects of total indoor air bacteria and molds and potential exposure to mycotoxins, which are products of airborne molds, on school-aged children. The study was conducted in the Music School in Zagreb, where children spend a few hours a day in a space originally designed as a nuclear shelter, without external openings, and the findings strongly suggest that the airborne mold levels in the music classroom are consistently distributed due to the shared air conditioning and ventilation system shared with the outdoor environment.The presence of a few isolated molds, with lower concentrations than outdoors, may be attributable to the regular use of air dehumidifiers. Low concentrations of airborne mold may pose a health risk for atopic children who are particularly susceptible to fungal spores, especially in environments contaminated with mycotoxin-producing fungi, further contribute to indoor air pollution.

https://doi.org/10.21203/rs.3.rs-5632354/v1

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Kim, H., Oh, J., Lee, H., Jeong, S., Ko, S. H.

Next-generation air filtration nanotechnology for improved indoor air quality.

Chemical Communications, (2025)

Indoor air quality (IAQ) significantly affects human health, with pollutants such as organic, inorganic substances, and biological contaminants contributing to various respiratory, neurological, and immunological diseases. In this review, we highlighted the need for advanced air filtration technologies to mitigate these pollutants, which are emitted from household products, building materials, combustion processes, and bioaerosols. While traditional HVAC systems and mechanical filtration methods have been effective, they are often energy-intensive and limited in their ability to capture specific pollutants. To address these limitations, nanotechnology-based air filtration technologies, particularly those utilizing electrospinning processes, offer promising alternatives. This review classifies pollutants and details the working principles of next-generation filters, focusing on passive, self-powered, and externally powered mechanisms. These advanced filters achieve high filtration efficiency with minimal pressure drop, enhanced pollutant capture, and in some cases, health monitoring capabilities. This review emphasizes the significance of ongoing research into eco-friendly and sustainable filtration systems to enhance IAQ and minimize health risks linked to long-term exposure to indoor air pollutants.

http://dx.doi.org/10.1039/D4CC05437G

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Yee, J.-J., Yousaf, J., Harseno, R. W.

Next-Generation Indoor Air Quality Management: An Integrated Iot-and Deep Learning-Based Approach for Real-Time Monitoring and Prediction.

Available at SSRN 4916862, (2024)

This study proposed ICTAir, an innovative system approach that leverages Internet of Things (IoT) and deep learning for the real-time monitoring and prediction of indoor air pollutants. By employing low-cost sensors and a microcontroller connected to cloud computing, ICTAir tracks crucial parameters, such as temperature, humidity, CO2, PM2.5, and PM10, enabling comprehensive air quality monitoring across all seasons. Calibration and reliability assessments underscored the high accuracy of our sensors, with calibration tests yielding coefficients of determination (R2) of 0.9449, 0.6612, 0.6675, 0.6751, and 0.6428 for temperature, CO2, humidity, PM2.5, and PM10, respectively. For reliability, cross-correlation methods were used with peak values of 0.9751, 0.9321, 0.9465, 0.9719, and 0.9325 for temperature, CO2, humidity, PM2.5, and PM10, respectively. Continuous data collection allows real-time visualization and long-term analysis on an IoT cloud platform, revealing significant seasonal air quality fluctuations. Autumn and spring show high variability in particulate matter due to activities, whereas winter and summer face challenges of low humidity and high temperatures. Real-time pollutant predictions were made using a Long Short-Term Memory (LSTM) model that was updated every 5 min and processed time-series data for all parameters. Analysis across seasons showed that a 3-day training window with a 1-h prediction interval yielded optimal accuracy. The LSTM model achieved RMSEs of 9.74, 0.0002, 0.0192, 0.2237, and 1.1663 for CO2, temperature, humidity, PM2.5, and PM10, respectively. These findings highlight the effectiveness of real-time deep learning in enhancing indoor air quality management, which is crucial for advancing smart building technologies.

https://dx.doi.org/10.2139/ssrn.4916862

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Hu, N., Sadrizadeh, S.

Numerical study of a novel hybrid ventilation system in operating rooms.

18th Conference of the International Society of Indoor Air Quality and Climate, INDOOR AIR 2024, Honolulu, USA, 7-11 July, 2024

This study evaluated the performance of a newly proposed hybrid ventilation strategy, a temperature-controlled airflow system, in an operating room under different working conditions. The influence of obstacles and ventilation rates on air patterns and airborne contamination concentration is investigated. Numerical simulation based on computational fluid dynamics techniques was applied to obtain high-resolution whole-field flow movement and particle dispersion. The results show that obstacles like surgical lamps considerably weaken the central supply of air and introduce mixing air movement above the operating table. It is also found that due to the presence of surgical lamps, the air exchange rate should be increased to obtain a similar performance as in the ideal room configuration.

http://urn.kb.se/resolve?urn=urn:nbn:se:mdh:diva-69647

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Bhatia, A.

Optimizing Wind Wing Wall Ventilation in High-Rise Buildings Within Dense Urban Hot and Humid Climate.

Rochester Institute of Technology. Thèse 2024

his study investigates how wing walls can increase natural ventilation in high-rise structures, particularly in hot, humid locations such as Mumbai, India. Using wind flow simulations and computational fluid dynamics (CFD) modeling, the study investigates how wind direction and the installation of wing walls affect airflow throughout the building. The study examines four scenarios, each analyzing how airflow varies when a building is located near surrounding structures of differing heights. It uses comprehensive CFD simulations to assess how alternative wing wall depth design can affect ventilation, as well as how wall-to-window ratio variation can contribute to airflows. Following these simulations, the study compares airflow within the building to conventional ventilation benchmarks to identify which layouts provide the optimum comfort and air quality. It also compares the building's energy consumption without natural ventilation to the savings achieved by the most efficient wing wall designs. The purpose is to provide practical insights to architects, engineers, urban planners, and policymakers who design and build tall buildings in densely populated tropical cities. The study's goal is to promote greener urban development and more sustainable construction practices by demonstrating the potential of wing walls as a simple but effective architectural solution. Finally, this study seeks to inspire new ideas for improving energy efficiency, lowering costs, and fostering a more sustainable future in rapidly expanding cities.

https://repository.rit.edu/theses/11963/

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Kurniawati, N. D., Dewi, Y. S., Wahyuni, E. D., Arifin, H., Poddar, S., Alfaruq, M. F.*, et al.*

Overview of ICU Nurses' Knowledge and Need Assessment for Instrument to Detect Sick Building Syndrome.

SAGE Open Nursing, Vol. **10**, (2024)

IntroductionNurses in intensive care units (ICUs) are vulnerable to sick building syndrome (SBS), which can affect their health, performance, and patient safety. Understanding SBS is crucial in healthcare to protect both staff and patients. However, many ICU nurses lack knowledge about this condition and the necessary detection tools.ObjectivesThis study aimed to describe ICU nurses? knowledge about SBS and the need of an instrument to detect the signs and symptoms of SBS.MethodsA cross-sectional study was conducted with a sample of 100 ICU nurses, recruited through simple random sampling from the Critical Care Indonesia Nurse Association. The study focused on nurses? knowledge of SBS and the need for an

instrument to detect it. Research instruments included basic respondent characteristics, nurses? knowledge, and the need for an SBS detection tool. Data were analyzed using descriptive statistics.ResultsThe majority of respondents exhibited a good level of knowledge (66%), yet many answered questions incorrectly regarding SBS etiology, symptoms, and effects. This was exemplified by incorrect responses attributing noise and chemicals as causes of SBS, overlooking fatigue as a symptom, and inaccurately assessing the physical effects of SBS. Notably, nurses demonstrated strong knowledge regarding SBS prevention (71%) and treatment (94%). Respondents unanimously supported the necessity of an instrument capable of detecting SBS among ICU nurses (71%), with an electronic instrument being the preferred option over other forms.ConclusionICU nurses possess a good level of knowledge about SBS. It is recommended to develop and investigate an electronic-based instrument for detecting SBS. Additionally, implementing an e-learning educational program could further enhance the knowledge and management of SBS among healthcare professionals.

https://doi.org/10.1177/23779608241288716

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Siddiqui, M. A., Baig, M. H., Yousuf, M. U.

Performance and data acquisition from low-cost air quality sensors: a comprehensive review.

Air Quality, Atmosphere & Health, (2024)

The rapid increase in urban populations has led to escalating traffic and higher levels of air pollutants, posing significant threats to urban health. In response, there is growing demand for accessible, real-time, and widespread air quality monitoring systems. This review focuses on the potential of low-cost air quality sensors to meet this demand, with emphasis on their ability to provide high-density spatiotemporal data at a lower cost. The paper critically examines current low-cost air quality sensors, including Wireless Sensor Network (WSN) and Internet of Things (IoT)-based solutions, through both field experiments and laboratory studies. A key contribution of this review is the comprehensive evaluation of calibration methods, showing how factors such as temperature and humidity influence sensor performance. The review highlights common challenges like sensor accuracy, cross-sensitivity, and data quality, offering insights into effective strategies such as calibration against reference instruments and advanced data validation techniques. Ultimately, this review underscores the potential of low-cost sensors in revolutionizing air pollution monitoring, while also addressing the practical challenges that must be resolved to fully realize their capabilities.

https://doi.org/10.1007/s11869-024-01683-3

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Amin Beigh, F., Rasool Shah, S., Ahmad, K.

A Perspective on Indoor Air Quality Monitoring, Guidelines, and the Use of Various Sensors.

Environmental Forensics, (2024), 1-18 p.

Various air pollutants harm human fitness, like particulate matter (PM2.5 and PM10), NO2, O3, CO, and fully volatile chemical-free compounds. In the last decade, international organizations have continuously worked to keep the Air Quality (AQ) guidelines and standards updated and refined to synchronize AQ modeling and management. The present AQ standards and guidelines have been provided by different agencies, including the California Ambient Air Quality Standards (CAAQS), the National Institute for Occupational Safety and Health (NIOSH), the Ambient Air Quality Standards (NAAQS), the American Conference of Governmental and Industrial Hygienists (ACGIH), the World Health Organization (WHO), and others. Various existing sensors for AQ management and analysis, their corresponding specifications, supply current, response time, data resolution, typical detection domain, measurement repeatability, or tolerance are issues of concern. These parameters are discussed to inspect present data research techniques focusing on indoor AQ. This study aims to provide a quick overview of AQ monitoring systems.

These include portable, low-cost sensors and various international guidelines and standards for AQ management. Current trends and future scope are also presented after the discussion.

https://doi.org/10.1080/15275922.2024.2431330

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Azman, M. S. M., Mansor, A. A., Ahmad, A. N., Ismail, M., Jarkoni, M. N. K., Abdullah, S.

Physio-Chemical Indoor Air Quality Analysis and CO2 Ventilation Forecasting Using Artificial Neural Networks in Boat Manufacturing.

Natural and Life Sciences Communications, Vol. **24** n°(1), (2024)

This study presents a comprehensive analysis of indoor air quality within a boat manufacturing facility, focusing on the physio-chemical parameters and forecasting of CO2 levels using artificial neural networks (ANN). The investigation involved measuring key physical, chemical, and ventilation performance factors, including total volatile organic compounds (TVOC), particulate matter (PM10, PM2.5, PM1), formaldehyde (HCHO), carbon monoxide (CO), temperature, relative humidity (RH), and air movement. The ANN model, employing a multilayer perceptron (MLP) architecture optimized with the Levenberg-Marquardt algorithm, was developed to predict CO2 concentrations based on these inputs. The results revealed that indoor activities such as sanding, cutting, painting, and adhesive application significantly elevated levels of TVOC, particulate matter, and formaldehyde, often exceeding acceptable limits. The ANN model demonstrated high predictive accuracy, with correlation coefficients (R) ranging from 0.7556 to 0.8725 during training and 0.6798 to 0.8163 during validation and mean squared error (MSE) values as low as 0.0048 ppm. The optimal model architecture was identified as 8:15:1, providing a reliable forecast of CO2 levels with an accuracy of up to 87.25%. This study underscores the importance of monitoring indoor air quality in industrial environments and highlights the potential of ANN-based models for enhancing ventilation strategies. By enabling real-time prediction of CO2 concentrations, the model offers a practical approach to maintaining healthier indoor conditions and improving worker safety. The findings suggest that such predictive tools could be effectively implemented in similar industrial settings to mitigate air quality issues and ensure compliance with health standards.

https://lens.org/010-652-258-724-097

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Mu, D., Wang, R., Wu, Y., Yang, B., Zhu, T., Zhou, B.*, et al.*

Reduced scale experiment and numerical simulation study on different airflow organization modes in large ship painting workshop.

International Journal of Ventilation, Vol., (2024), 1-23 p.

Mechanical ventilation is a key means to improve indoor air quality in shipbuilding industry. Appropriate airflow organization will have a perceptible impact on environmental safety, personnel health, and energy conservation. Many ship painting workshops use fully mixed ventilation, making it difficult to meet indoor pollutant standards and save energy. Therefore, it is necessary to optimal design the airflow organization in the ship painting workshop reasonably. This article introduces three new air supply strategies for ship painting workshops, namely piston flow air supply, attached jet air supply, and side air supply, and compares them with the existing mixed air supply. Three operating scenarios have been established, including isothermal conditions in spring and autumn, cooling condition in summer, and heating condition in winter. The airflow and pollutant distribution of each airflow organization are compared through scale model experiments and numerical simulations. Finally, the most suitable strategy for the workshop in each season is selected and promoted for engineering applications. Three air supply strategies are introduced for improving air quality as alternatives to the traditional mixed ventilation approach.The effectiveness of different airflow organizations under various operating conditions are compared through scale model experiments and numerical simulations.Side air supply is the most efficient air distribution form in the isothermal condition in spring and autumn and the heating condition in winter.For summer cooling

condition, the top jet air supply is suitable. Three air supply strategies are introduced for improving air quality as alternatives to the traditional mixed ventilation approach. The effectiveness of different airflow organizations under various operating conditions are compared through scale model experiments and numerical simulations. Side air supply is the most efficient air distribution form in the isothermal condition in spring and autumn and the heating condition in winter. For summer cooling condition, the top jet air supply is suitable.

https://doi.org/10.1080/14733315.2024.2441066

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Bajagain, R., Kim, P.-G., Kwon, J.-H., Hong, Y.

The release of volatile and semi-volatile organic compounds from polyvinyl chloride consumer products under simulated solar light: Implications for indoor air quality.

Journal of Hazardous Materials, Vol. **485**, (2025)

This study investigated the effect of light on emission of various volatile and semi-volatile organic compounds (VOCs and SVOCs), from polyvinyl chloride (PVC) products using xenon lamp as a solar light simulator. The emission flux generally decreased over time, with the light-induced targeted ∑VOC flux being about 1.6-times higher than heat-induced flux during the initial 1-h exposure. The emission is less affected by air flow rate; however, it is increased with light intensity. In general, the ∑SVOC levels are 3–34 times higher than ∑VOC levels. Results indicate that the chemicals released from PVC might decompose into degradation products upon xenon-light irradiation, resulting in intermediate or low-molecular weight compounds. Furthermore, total daily intakes of targeted compounds for different age groups ranged 0.80–29.1 μg/kg/day, while total hazard quotient and cancer risks posed by targeted VOCs ranged 0.020.26; and 4.5×10^{-6}–5.3×10^{-5}, respectively, suggesting the probable risk. Besides, more than 700 peaks are recorded and characterized as non-targeted chemicals. Also, 65–80 % of total number of chemical peaks emitted from PVC are attributed to VOCs, while that for SVOCs is 20–35 %. The fraction of emitted VOC peaks to total peaks under heat and light exposure are found to be 65 and 80 %, respectively. Therefore, indoor air quality can be deteriorated by the presence of PVC-related plastic products.

https://doi.org/10.1016/j.jhazmat.2024.136846

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Sekhar, L., Govindarajan Venguidesvarane, A., Thiruvengadam, G., Sharma, Y., Venugopal, V., Rengarajan, S.*, et al.*

Respiratory symptoms and pulmonary function in paint industry workers exposed to volatile organic compounds: A systematic review and meta-analysis.

PLOS ONE, Vol. **19** n°(12), (2024)

Several epidemiological studies have examined the respiratory consequences of occupational exposure to volatile organic compounds (VOCs). However, their effects on paint industry workers in organised and unorganised occupational sectors vary. The present systematic review and meta-analysis aim at evaluating the respiratory symptoms and pulmonary function of paint industry workers from various occupational sectors exposed to VOCs. Relevant MESH terms were used for literature search in MEDLINE, Scopus, Web of Science, and Google Scholar till August 2023. The articles were independently retrieved and qualified by two reviewers and two subject experts arbitrated reviewer differences to establish relevant article inclusion. The systematic review comprised 23 observational studies that assessed respiratory symptom and pulmonary function tests (PFT) among paint industry worker from various occupational sectors. The meta-analysis included 12 studies on respiratory symptoms and 18 on PFT. Pooled meta-analysis was done using random effect model, and the crude odds of respiratory symptoms such as cough (OR: 2.72, 95% confidence interval [CI]: 1.74 to 4.25), dyspnoea (OR: 3.59, 95% CI: 2.13 to 6.05),

nasal/throat irritation (OR: 4.5, 95% CI: 1.7 to 12.1), and wheezing (OR: 2.28, 95% CI: 1.37 to 3.82) were significantly higher among paint industry workers exposed to VOC compared to unexposed population. PFT parameters, such as forced expiratory volume in one second (FEV1) (SMD: -0.88, 95% CI: -1.5 to -0.2) and FEV1/forced vital capacity (FEV1/FVC) (SMD: -0.97, 95% CI: -1.6 to -0.32) were found to be significantly reduced among the paint industry workers. The meta-analysis has helped in generating evidence regarding the effect of VOC on respiratory symptoms and pulmonary function and the strength of the association varied with geographical regions, and the type of occupational sectors. Despite the heterogeneity (I2 > 75%) of studies, statistical power of this analysis was significant. Trial registration: PROSPERO registration number: CRD42022311390.

https://doi.org/10.1371/journal.pone.0315464

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Bralewska, K., Rogula-Kozłowska, W., Białas, J.

Seasonal and spatial variability of volatile organic compounds and formaldehyde concentrations at the fire station.

Building Research & Information, (2024), 1-23 p.

The objective of this study was to determine the concentrations of volatile organic compounds (VOCs), including the BTEX group (benzene, toluene, ethylbenzene, xylene), and formaldehyde in the changing room, garage, alarm point, TV room and fire truck of a typical Polish fire station. The novel of this study was to identify and prioritize the sources of these pollutants in the specific indoor areas. Measurements were conducted at each point simultaneously during two different seasons: heating (08/01/2023?09/02/2023) and non-heating (24/05/2023?25/06/2023). The samples were collected passively and analysed using gas (VOCs, BTEX) and liquid (formaldehyde) chromatography. The highest concentrations of VOCs, BTEX and formaldehyde were observed in the TV room (176.7?µg/m?), garage (136.7?µg/m?) and alarm point (14.4?µg/m?), respectively. Conversely, the lowest concentrations were observed in the changing room (81.85?µg/m?), the alarm point (64.6?µg/m?) and the garage (3.8?µg/m?), based on the average results from both measurement seasons. The same sources of pollution, including cleaning products, cosmetics, fires, fuel combustion, vehicle maintenance equipment, combustion equipment, fire extinguishers, chemicals and finishing materials, were identified at all measurement points. The obtained results can be used in further studies to assess the health risks of firefighters exposed to poor air quality.

https://doi.org/10.1080/09613218.2024.2434262

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Sekar, B. M., Dheeraj, M., Abishek, T., Kumar, K. D., Adharsh, R., Dinesh, T.

Smart Air-Conditioner Monitoring by IOT Applications.

2024 8th International Conference on Electronics, Communication and Aerospace Technology (ICECA). 6-8 Nov. 2024. Coimbatore, India.

The main issue faced at these times is that the consumers have to manually remove and change the internal components manually in an air conditioner such as a rotor or compressor because of overheat that may result in the particular air conditioner malfunctioning. An air conditioner is made up of many components, but the major parts doing the heavy lifting of moving the air indoors and outdoors are the evaporator, condenser, expansion valve, and compressor. Advanced air conditioner air filtration systems are considered to be the latest innovation in air condition technology which help to improve indoor air quality and reduce allergens, as well as help with cooling efficiency. In this project, when one of the components of an air conditioner is overheated, a coolant system acquires the temperature as input and begins functioning when the temperature of the component exceeds the limit set in the Arduino code. This system helps in reducing the temperature of the component in the air conditioner and guarantees operation for a prolonged period of time. Also, the moisture content because of the refrigerant gas present inside the air conditioner is recorded using a humidity sensor. Both temperature and humidity readings are notified to

the administrator with the help of a GSM module. The coolant system for reducing the temperature of the component could be even an exhaust fan used in the central processing unit of a computer.

https://doi.org/10.1109/ICECA63461.2024.10801169

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Akyüz, M. K., Açıkkalp, E., Altuntaş, Ö.

Thermal Performance, Indoor Air Quality, and Carbon Footprint Assessment in Airport Terminal Buildings.

Buildings, Vol. **14** n°(12), (2024)

This study explores energy consumption, thermal performance, and indoor environmental quality (IEQ) in terminal buildings. Through detailed thermal analysis, this research identifies key sources of heat loss, such as thermal bridges in walls and windows, which significantly increase energy demands for heating. IEQ measurements show that the lack of mechanical ventilation, combined with high passenger densities, frequently leads to CO2 levels exceeding recommended thresholds, highlighting the urgent need for improved ventilation systems. Energy requirements were calculated based on the TS 825 standard and compared to actual consumption data, showing that optimizing boiler settings could save 22% of heating energy without any additional investment. Simulations and economic analyses further showed that adding thermal insulation to the building envelope and installing double-glazed windows with improved U-values could achieve significant energy savings and reduce CO2 emissions, all with favorable payback periods. A life cycle assessment (LCA) was conducted to evaluate the environmental impact of these interventions, demonstrating significant reductions in the airport's carbon footprint. The findings underscore the importance of aligning operational standards with international guidelines, such as ASHRAE and CIBSE, to ensure thermal comfort and optimize energy use.

https://doi.org/10.3390/buildings14123957

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Haverinen-Shaughnessy, U., Dudzinska, M. R., Clinchard, S., Dimitroulopoulou, S., Fan, X., Jacobs, P.*, et al.*

Towards equitable and sustainable indoor air quality guidelines − A perspective on mandating indoor air quality for public buildings.

Indoor Environments, Vol. **2** n°(1), (2025)

A recent article published in Science urges mandatory indoor air quality (IAQ) standards in public spaces, focusing on protecting public health, especially against diseases such as COVID-19, but also IAQ in general (1). Given the significance of this topic to our society, this short communication aims to provide commentary on the article and further discuss the importance of establishing IAQ standards. Citing a lack of legislated standards globally, the authors (1) propose numerical limits for four IAQ parameters: particulate matter (PM2.5), carbon dioxide (CO2), carbon monoxide (CO), and ventilation rate (VR). While recognizing that most of the countries do not have any mandatory IAQ standards, it is also noteworthy that IAQ regulations or guidelines exist in more than 40 countries. We like to emphasize that successful IAQ management requires recognizing, sharing, and reviewing openly available, existing regulations and guidelines, while adapting them to regional characteristics.

https://doi.org/10.1016/j.indenv.2024.100070

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Račić, N., Terzić, I., Karlović, N., Bošnjaković, A., Terzić, T., Jakovljević, I.*, et al.*

Volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs) in indoor spaces–a review and meta-analysis of field measurements in Europe.

Zenobo preprint, (2024)

Indoor air quality is a significant aspect of public health, yet it remains less studied than outdoor air pollution. Understudied indoor pollutants include volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). This review and meta-analysis focus on these two groups of compounds that are known for their potential health effects, including respiratory issues, neurological disorders, and carcinogenicity. This study synthesizes data from field measurements in various indoor environments, including residential homes, offices, and schools, over the last two decades in Europe. Meta-analytic techniques were used to determine the overall concentration ranges and to identify patterns and trends in the pollutants. Our findings reveal that VOC and PAH concentrations vary widely depending on the indoor setting and region. The most common sources identified include tobacco smoke, cooking emissions, eating systems, and certain building materials such as paints and varnishes. The results also show significant seasonal variation, with higher concentrations typically observed in the colder months due to increased indoor activity and reduced ventilation. This the need for improved indoor air quality management practices and regulatory standards to minimize the health risks associated with VOCs and PAHs. This review of 46 scientific publications aims to inform future studies, and guide future field measurements and risk assessments in epidemiological studies by providing a detailed overview of the current state of knowledge and identifying research gaps.

https://zenodo.org/records/13902745

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Maneelok, S., Juntaro, P., Ainthong, R., Kaoien, P., Noosai, N.

Workplace Environment and Health Effects of Ribbed Smoked Sheet Factory: A Case Study of Thung Yai Rubber Fund Cooperative.

Thai Environmental Engineering Journal, Vol. **38** n°(3), (2024), 45-54 p.

This study investigates environmental conditions and their impact on worker health within the Thung Yai Rubber Fund Cooperative, specifically focusing on the Ribbed Smoke Sheet factory. Working area temperature and wind velocity were systematically monitored at two locations using digital thermometers and anemometers, respectively. Air quality parameters, including total dust, carbon dioxide (CO2), and oxygen (O2) levels, were assessed using real-time monitoring equipment. A qualitative approach was adopted to evaluate adverse health effects experienced by workers, employing standardized questionnaires and comprehensive interviews. The results revealed significant health implications among workers exposed to total dust and an inappropriate working environment over the last three months. Specifically, 53.8% of workers experienced nose congestion and stuffy nose; 46.2% experienced a runny nose; 30.8% experienced sore eyes, itchy eyes, body rash, and body itching; 15.4% experienced red eyes; 38.5% experienced sore throat, coughing, mucus, and fatigue; 23.1% experienced difficulty breathing; and 7.7% experienced rapid heartbeat and wheezing. Furthermore, the study concluded that workplace temperatures exceeded prescribed standards, and oxygen concentration levels is slightly higher than Occupational Safety and Health Administration (OSHA) standards. These findings should provide the intervention to address hazardous working conditions, including regulating temperature to safeguard worker health and well-being. Continuous monitoring and enforcement of safety standards are imperative to prevent future respiratory ailments and ensure a safe working environment conducive to optimal productivity and employee welfare within the Thung Yai Rubber Fund Cooperative.

https://so05.tci-thaijo.org/index.php/teej/article/view/273374

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