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Qualité de l’air intérieur

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WoS, Google Scholar et Lens

Serrano, V. G., Lin, E. Z., Pollitt, K. J. G., Licina, D.
Adequacy of stationary measurements as proxies for residential personal exposure to gaseous and particle air pollutants.
Environmental Research, Vol. **231**, (2023)

People are exposed to myriad of airborne pollutants in their homes. Owing to diverse potential sources of air pollution and human activity patterns, accurate assessment of residential exposures is complex. In this study, we explored the relationship between personal and stationary air pollutant measurements in residences of 37 participants working from home during the heating season. Stationary environmental monitors (SEMs) were located in the bedroom, living room or home office and personal exposure monitors (PEMs) were worn by the participants. SEMs and PEMs included both real-time sensors and passive samplers. During three consecutive weekdays, continuous data were obtained for particle number concentration (size range 0.3-10 mu m), carbon dioxide (CO2), and total volatile organic compounds (TVOC), while passive samplers collected integrated measures of 36 volatile organic compounds (VOCs) and semi volatile organic compounds (SVOCs). The personal cloud effect was detected in >80% of the participants for CO2 and >50% participants for PM10. Multiple linear regression analysis showed that a single CO2 monitor placed in the bedroom efficiently represented personal exposure to CO2 (R2 = 0.90) and moderately so for PM10 (R2 = 0.55). Adding a second or third sensor in a residence did not lead to improved exposure estimates for CO2, with only 6-9% improvement for particles. Selecting data from SEMs when participants were in the same room improved personal exposure estimates by 33% for CO2 and 5% for particles. Out of 36 detected VOCs and SVOCs, 13 had at least 50% higher concentrations in personal versus stationary samples. Findings from this study aid improved understanding of the complex dynamics of gaseous and particle pollutants and their sources in residences, and could support the development of refined procedures for residential air quality monitoring and inhalation exposure assessment.

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Bhui, K., Newbury, J. B., Latham, R. M., Ucci, M., Nasir, Z. A., Turner, B.*, et al.*
Air quality and mental health: evidence, challenges and future directions.
BJPsych Open, Vol. **9** n°(4), (2023)

BackgroundPoor air quality is associated with poor health. Little attention is given to the complex array of environmental exposures and air pollutants that affect mental health during the life course.AimsWe gather interdisciplinary expertise and knowledge across the air pollution and mental health fields. We seek to propose future research priorities and how to address them.MethodThrough a rapid narrative review, we summarise the key scientific findings, knowledge gaps and methodological challenges.ResultsThere is emerging evidence of associations between poor air quality, both indoors and outdoors, and poor mental health more generally, as well as specific mental disorders. Furthermore, pre-existing long-term conditions appear to deteriorate, requiring more healthcare. Evidence of critical periods for exposure among children and adolescents highlights the need for more longitudinal data as the basis of early preventive actions and policies. Particulate matter, including bioaerosols, are implicated, but form part of a complex exposome influenced by geography, deprivation, socioeconomic conditions and biological and individual vulnerabilities. Critical knowledge gaps need to be addressed to design interventions for mitigation and prevention, reflecting ever-changing sources of air pollution. The evidence base can inform and motivate multi-sector and interdisciplinary efforts of researchers, practitioners, policy makers, industry, community groups and campaigners to take informed action.ConclusionsThere are knowledge gaps and a need for more research, for example, around bioaerosols exposure, indoor and outdoor pollution, urban design and impact on mental health over the life course.

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Mandin, C., Glorennec, P., Keirsbulck, M., Kêdoté, N. M., Le Bourhis, J.-P., Marchand, D.*, et al.*
Chapitre 22. Environnements intérieurs.
In: Environnement et santé publique. 2023. 575-596 p.

Si quelques problématiques spécifiques au bâtiment sont très anciennes (peintures au plomb, amiante), la pollution intérieure ou, de façon plus positive, la qualité des environnements intérieurs s'est invitée dans l'arène scientifique puis le débat public depuis les années 1970. Du fait notamment de la prise de conscience du temps passé dans des environnements intérieurs et donc de l'importance de ces environnements en termes d'exposition, de nombreux travaux ont été menés pour améliorer les connaissances et définir des mesures de gestion et de prévention.

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Eftekhari, A., Won, Y., Morrison, G., Ng, N. L.
Chemistry of Indoor Air Pollution.
American Chemical Society; Book 2023

Indoor air pollution is a growing concern as people spend more time indoors. Evaluating indoor air quality (IAQ) is complex because numerous processes affect IAQ. Indoor chemistry also has unique features compared to outdoor atmospheric chemistry.

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Lim Joo Kit, P.
Comparison of indoor air quality in nail salons served by central air-conditioning system and split air-conditioning system.
National University of Singapore.Thèse 2023

Nail products used at nail salons may include toxic chemicals in high concentrations, which can have a negative impact on a person's health if they are exposed to them. High levels of toxic chemicals in the air could result in poor indoor air quality (IAQ) in the salon. Having the right type of air-conditioning system could help with the ventilation and dispersion of the contaminated air. Thus, this study focuses on the comparison of indoor air quality in nail salons served by a central air-conditioning system and a split air-conditioning system. A field study was conducted in two salons, Agnes.G Nails which adopts a centralised air-conditioning system and Dawn Star Nail Salon which uses a split air-conditioning system. Spot measurements were used to acquire objective data, and the following parameters were assessed: temperature, humidity, air velocity, formaldehyde, carbon dioxide, particulate matter with a diameter of 2.5 microns, and total volatile organic compounds (TVOCs). One sampling point was established in each nail salon and readings were taken at different levels of occupancy – 0%, 25% and 50%. The collected data were then compared with SS554:2016 +A1:2021 to see if the recommended limits for IAQ were met by the nail salons. The results showed that the nail salon served by the centralised air-conditioning system had better IAQ than that of the nail salon served by the split air-conditioning system. However, despite that, the nail salon with centralised air-conditioning only met the requirements by SS554:2016 +A1:2021 for four out of seven of the tested parameters. The data gathered indicated that the IAQ levels in both nail salons were subpar, so recommendations to improve the IAQ of nail salons were made.

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Astolfi, A., Carullo, A., Fissore, V., Puglisi, G. E., Arcamone, G., Shtrepi, L.*, et al.*
Development and Metrological Characterization of a Multi-sensor Device for Indoor Environmental Quality (IEQ) monitoring.
2023 IEEE International Workshop on Metrology for Living Environment (MetroLivEnv). 29-31 May 2023. Milano, Italy

Indoor Environmental Quality (IEQ), which affects people's health, comfort, well-being and productivity, combines thermal, visual, acoustic and air quality conditions. This work deals with design, development and metrological characterization of a low-cost multi-sensor device that is able to detect the quality conditions of indoor environments for IEQ purposes. The device, hereafter referred as PROMET&O (PROactive Monitoring for indoor EnvironmenTal quality & cOmfort) embeds a set of low-cost sensors that measure air temperature and relative humidity, illuminance, sound pressure level, carbon monoxide, carbon dioxide, particulate matter, formaldehyde, and nitrogen dioxide. The basic architecture of the device is described and the design criteria that are related to the measurement requirements are highlighted. Particular attention has been paid towards the traceability assurance of the measurements provided by PROMET&O by means of specifically conceived calibration procedures, which have been tailored to the requirements of each measurement quantity. The calibration is based on the comparison to reference standards following commonly employed or ad-hoc developed technical procedures. The defined calibration procedures can be applied both for the single sensors and for the set of sensors integrated in the multi-sensor case. For the latter, the effects of the percentage

of permeable case surface and the sensors allocation are also investigated. A preliminary uncertainty evaluation of the proposed multi-sensor device is reported for the carbon dioxide and the illuminance sensors taking the defined calibration procedures into account.

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Jangra, R., Ahlawat, K., Dixit, A., Prakash, R.
Efficient deactivation of aerosolized pathogens using a dielectric barrier discharge based cold-plasma detergent in environment device for good indoor air quality.
Scientific Reports, Vol. **13** n°(1), (2023)

Air pollution is one of the top 5 risks causing chronic diseases according to WHO and airborne transmitted pathogens infection is a huge challenge in the current era. Long living pathogens and small size aerosols are not effectively dealt with by the available indoor air purifiers. In this work, a dielectric barrier discharge (DBD) based portable cold-plasma detergent in environment device is reported and its disinfection efficiency has been analyzed in the indoor environment of sizes up to 3 × 2.4 × 2.4 m3. The deactivation efficiency of total microbial counts (TMCs) and total fungal counts (TFCs) is found to be more than 99% in 90 min of continuous operation of the device at the optimized parameters. The complete inactivation of MS2 phage and Escherichia coli bacteria with more than 5 log reduction (99.999%) has also been achieved in 30 min and 90 min of operation of the device in an enclosed environment. The device is able to produce negative ions predominantly dominated by natural plasma detergent along with positive ions in the environment similar to mother nature. The device comprises a coaxial DBD geometry plasma source with a specially designed wire mesh electrode of mild steel with a thickness of 1 mm. The need for feed gas, pellets and/or differential pressure has been eliminated from the DBD discharge source for efficient air purification. The existence of negative ions for more than 25 s on average is the key advantage, which can also deactivate long living pathogens and small size aerosols.

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Lafleur, J., Francisco, P. W., Sun, Y., Merrin, Z., Gilleade, K., Graham, M.*, et al.*
Energy Savings With Acceptable Indoor Air Quality Through Improved Airflow Control in Residential Retrofits.
Building America. Gas Technology Institute Report 2023

The Partnership for Advanced Residential Retrofit (PARR) has been a U.S. Department of Energy (DOE) Building America team since 2009, with a primary focus on upgrading the performance of existing buildings to reduce energy loads. In this project, PARR's work explored the integration of airflow-focused measures in residential retrofit homes with the goal to maximize energy savings while ensuring acceptable indoor air quality (IAQ) using a systems approach to controlling four contributing air streams: • Building air leakage (natural, uncontrolled infiltration) • Forced-air distribution system static pressure and airflow rate • Distribution system duct leakage • Mechanical ventilation. This project addressed airflows in houses, their combined impact on energy use and IAQ, and the comparative effects of typical insulation and air sealing practices versus integrated system-level retrofits. Additionally, practical considerations for contractors taking either approach were addressed. Finally, the effects of supply ventilation and exhaust ventilation on IAQ were compared in occupied homes.

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Msr, N. K.
Fabrication of Natural Fiber Mixed Natural Matrix Composite Infused Indoor Air Purifier with Health Impact Simulation.
Research square, (2023)

The inhalation of airborne particles can endanger the health of any human being. Natural fiber and natural fiber reinforced with natural matrix material are employed in this work to create an indoor air purifier. Various natural fiber and natural composite combinations are used to purify the interior environment by eliminating particulate matter of various sizes and volatile organic chemicals. An air purifier is created using four distinct natural fibers, including hemp, jute, silk cocoon, and coir fibers, as well as neem and alovera gel as natural filler materials. An air quality-monitoring instrument is used to validate the performance of the designed natural fiber/natural plant-based filler material-equipped air purifier. Particulate matter of various sizes and volatile organic compounds in the indoor environment are detected at various time intervals. The efficacy of the air purifier is afterwards determined in human lungs of various

ages utilizing health impact simulation studies. The current product is utilized to effectively purify indoor air by eliminating particulates and volatile organic chemicals.

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Saffell, J., Nehr, S.
Improving Indoor Air Quality through Standardization.
Standards, Vol. **3** n°(3), (2023), 240-267 p.

Human beings experience a large fraction of their exposure to air pollutants in indoor environments. Air pollution is a large environmental health risk, and exposure to ambient air pollution and indoor air pollution contribute equally to the total number of fatalities worldwide. Although legislative authorities have established limit values for ambient outdoor air and stack emissions, there are inconsistent and variable national and regional limit values for gaseous substances and airborne particulate matter in the built environment (schools, homes, healthcare facilities, offices, and other public spaces). This lack of regulation is unsurprising, because indoor spaces are characterized by complex air chemistry, and their construction materials and types of activities vary significantly. The current understanding of indoor pollutants, including short-lived oxidants, degradation of VOCs, particle formation, and particle composition, is incomplete. It is necessary to identify and assess emerging pollutants and their toxicity, and to consider new consumer products and green construction materials and their impact on indoor air quality (IAQ). Learning from IAQ surveys and audit protocols, research methodologies should be regularized for cross-research comparisons. Some indoor air quality guidance and standards have been written, and several more are in development, with the international ISO 16000 series of indoor standards leading the way for improving indoor air data quality. The WHO has established some ambient air limit values which can mostly be translated into indoor limit values. The built environment needs to harmonize energy efficiency, thermal comfort and air quality standards and guidance. In this review, we discuss the next steps for improving international, regional and national standards and guidance, leading to better and more complete indoor air quality regulations.

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Bhoonah, R., Maury-Micolier, A., Jolliet, O.
Integration of Indoor Air Quality to the Life Cycle Assessment of Buildings.
IOP Conference Series: Earth and Environmental Science, Vol. **1196** n°(1), (2023)

Pollutants – gases or particles – are emitted in indoor air by different sources such as building materials, furniture, occupants and their activities. Spending over 80 % of our time indoors, we are directly exposed to substances that are potentially harmful to our health. Through measurements and simulation tools, the concentrations of these substances in air can be evaluated. However, today, Indoor Air Quality (IAQ) is not taken into account in the Life Cycle Assessment of buildings (LCA). The aim of this study is to calculate and compare the damage of IAQ on occupants' health with the damage over the whole building life cycle, expressed in the same unit as in LCA: Disability-Adjusted Life Years (DALY), in order to propose a decision-making tool. Volatile organic compounds (VOCs) are emitted by building materials or furniture and then are assimilated by occupants. A model describing their emissions including unknown or uncertain parameters is calibrated using existing emission data. Secondly, emission data on occupants and their activities are used to simulate indoor concentrations of VOCs. The assimilation and consequent health damages are then calculated. According to a case study of an office, health damages related to the emissions of gypsum-covered walls were of 1.32 x 10−6 DALY.year−1, about 2 orders of magnitude lower than those of the other life stages of the building (from fabrication and transport of products, construction, use, until end-of-life processes) which correspond to 1.2 to 4.5 x 10−3 DALY.year−1. Those related to regular office activities were of 3.7 x 10−26 DALY.year−1. This methodology can help in eco-design of buildings by identifying main sources of impacts. It can help to choose between materials or to dimension the ventilation for the evacuation of pollutants.

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Gabriel, M., Auer, T.
LSTM Deep Learning Models for Virtual Sensing of Indoor Air Pollutants: A Feasible Alternative to Physical Sensors.
Buildings, Vol. **13** n°(7), (2023)

Monitoring individual exposure to indoor air pollutants is crucial for human health and well-being. Due to the high spatiotemporal variations of indoor air pollutants, ubiquitous sensing is essential. However, the cost and maintenance

associated with physical sensors make this currently infeasible. Consequently, this study investigates the feasibility of virtually sensing indoor air pollutants, such as particulate matter, volatile organic compounds (VOCs), and CO2, using a long short-term memory (LSTM) deep learning model. Several years of accumulated measurement data were employed to train the model, which predicts indoor air pollutant concentrations based on Building Management System (BMS) data (e.g., temperature, humidity, illumination, noise, motion, and window state) as well as meteorological and outdoor pollution data. A cross-validation scheme and hyperparameter optimization were utilized to determine the best model parameters and evaluate its performance using common evaluation metrics (R2, mean absolute error (MAE), root mean square error (RMSE)). The results demonstrate that the LSTM model can effectively replace physical indoor air pollutant sensors in the examined room, with evaluation metrics indicating a strong correlation in the testing set (MAE; CO2: 15.4 ppm, PM2.5: 0.3 μg/m3, VOC: 20.1 IAQI; R2; CO2: 0.47, PM2.5: 0.88, VOC:0.87). Additionally, the transferability of the model to other rooms was tested, with good results for CO2 and mixed results for VOC and particulate matter (MAE; CO2: 21.9 ppm, PM2.5: 0.3 μg/m3, VOC: 52.7 IAQI; R2; CO2: 0.45, PM2.5: 0.09, VOC:0.13). Despite these mixed results, they hint at the potential for a more broadly applicable approach to virtual sensing of indoor air pollutants, given the incorporation of more diverse datasets, thereby offering the potential for real-time occupant exposure monitoring and enhanced building operations.

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Shrivastava, A., Raj, P.
A review of different air filtration techniques.
International Research Journal of Modernization in Engineering Technology and Science, Vol. **05** n°(6), (2023)

A lot of research has been focused on the various methods of purifying air. The most harmful pollutants are PM2.5 particulates and NOx emissions. This paper presents a review of the study of the current scenario of the problems of air pollution and different air filtration methods for purifying air. The most common and significant methods of purifying air such as those employing HEPA filters, electrostatic smoke precipitators, activated carbon, and UV light have been presented and their use in air purifiers manufactured by OEMs has been mentioned. Some of the most modern methods of purifying air such as those using transparent PAN filters, photochemical materials, soy proteins, and silk nano-fibers have been studied and reviewed. These methods have been found to provide an attractive and economical pathway for filtering out PM 2.5 compared to conventional HEPA filters.

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Min, V. N. H.
User exposure to printer emissions under different ventilation scenarios: a case study approach.
National University of Singapore. Thèse 2023

Laser printing, with its emissions poses health risks to users. Although the types of pollutants that printers produce are well-researched, less is known about the impact of the types of ventilation on exposure to those pollutants. Given that humans spend up to 90% of their time indoors where laser printers are, it highlights the need to choose the most appropriate ventilation system that will keep printer emissions at a safe level. This study focuses on the National University of Singapore (NUS) School of Design and Environment 1 (SDE1) printing room to determine user exposure to printer emissions under different ventilation scenarios in the real environment. The scenarios include having the room without ventilation, with the ACMV system in normal operation, with cross-ventilation, single-sided ventilation and cross-ventilation with pedestal fan assisted. Real-time measurements of common printer pollutants and the overall indoor air quality of the room were carried out during printing for the evaluation of printer emissions and the ventilation systems. Specifically, 30 black and white pages with 5% toner coverage were printed during each round of air sampling. In this study, air pollutants were maintained at safe levels under all scenarios and it was concluded that exposure to printer pollutants is insignificant with light printing activity. This research found that different contaminants were best regulated by different methods of ventilation hence, there is no conclusive result as to which particular scenario is the most optimal for reducing printer emissions. However, formaldehyde appeared to be the most prominent emission by the printer used in this experiment and it was best regulated by cross-ventilation with fan.

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Fuczek, D., Czajka, M., Szuta, J., Szutkowski, K., Kwaśniewska-Sip, P.
VOC Emission from Lightweight Wood Fiber Insulation Board.
Forests, Vol. **14** n°(7), (2023)

The aim of the presented research work was to determine and analyze emissions of volatile organic compounds (VOCs) from experimental lightweight wood fiber insulation board produced in dry technology. Until now, there have been no rigid insulation materials made of wood fibers produced in such low density and made in dry technology. Among the typical parameters such as thermal conductivity and the mechanical performance of the lightweight board, attention was also paid to their influence on indoor air quality. Therefore, an attempt was made to determine the kind of substances emitting from wood fiber insulation boards produced at defined production parameters as well as the dynamics of emission reduction over time. Additionally, the influence of fire retardants used for protection against lightweight wood fiberboard fires on the emission of VOCs was analyzed. Tests on VOC emissions were carried out using the chamber method according to the applicable ISO 16000 standards. The main components emitting from lightweight insulation fiberboards were acetic acid and aldehydes such as pentanal, hexanal, heptanal, octanal, nonanal, decanal, furfural, and benzaldehyde. The percentage of acetic acid in total volatile organic compounds (TVOCs) was within the limits of 17% to 65%. From the aldehydes group, the most concerning substance was furfural due to a very strict limit value. In the presented research, depending on the variant, the emission of furfural was from 0 up to 10 µg/m3 after 28 days of measurement. Other substances such as terpenes or aromatic hydrocarbons were at a very low level. The reduction in VOCs over a period of 28 days was significant in most cases from 22% up to 61%. The tests carried out also showed a substantial impact of fire retardant, used in the production of lightweight insulation fiberboard, on the emission of VOCs from fiberboards, and thus on their quality.

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