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WoS, Google Scholar et Lens

Song, K., Yang, X. P., Wang, Y. J., Wan, Z. C., Wang, J. F., Wen, Y.*, et al.*
Addressing new chemicals of emerging concern (CECs) in an indoor office.
Environment International, Vol. **181**, (2023)

Indoor pollutants change over time and place. Exposure to hazardous organics is associated with adverse health effects. This work sampled gaseous organics by Tenax TA tubes in two indoor rooms, i.e., an office set as samples, and the room of chassis dynamometer (RCD) set as backgrounds. Compounds are analyzed by a thermal desorption comprehensive two-dimensional gas chromatography-quadrupole mass spectrometer (TD-GC x GCqMS). Four new chemicals of emerging concern (CECs) are screened in 469 organics quantified. We proposed a three-step pipeline for CECs screening utilizing GC x GC including 1) non-target scanning of organics with convincing molecular structures and quantification results, 2) statistical analysis between samples and backgrounds to extract useful information, and 3) pixel-based property estimation to evaluate the contamination potential of addressed chemicals. New CECs spotted in this work are all intermediate volatility organic compounds (IVOCs), containing mintketone, isolongifolene, beta-funebrene, and (5 alpha)-androstane. Mintketone and sesquiterpenes may be derived from the use of volatile chemical products (VCPs), while (5 alpha)-androstane is probably human-emitted. The occurrence and contamination potential of the addressed new CECs are reported for the first time. Non-target scanning and the measurement of IVOCs are of vital importance to get a full glimpse of indoor organics.

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Fromme, H.
Basic Exposure Information and Special Exposure Situation.
In: Indoor Air Quality: Occurrence and Health Effects of Contaminants. Springer Nature Switzerland; 2023. 37-91 p.

Exposure science has developed alongside epidemiology and toxicology as a field that aims to describe qualitatively and, in particular, quantitatively the contact of an individual or a population group with a chemical, physical, and biological stressor. Therefore, this chapter describes the basics of the exposure assessment process, its procedure and helpful sources to find data on human exposure factors like the US EPA Exposure Factors Handbook. Overall, the exposome is understood as the comprehensive—cumulative—description of the lifelong exposure history of individuals to changing exogenous and endogenous influences. In addition, the inclusion of human biomonitoring in exposure assessment and the importance of textiles as a source of indoor air pollution expands our scientific knowledge. Indispensable for understanding the health effects is the behavior of volatile and semi-volatile organic compounds, as well as particulate matter in the lungs. Many exposure and risk assessment strategies take their starting point from the exposure of sedimented dust indoors and its uptake through, e.g., hand-to-mouth contact. Nevertheless, some critical points like sampling conditions, type of analytical method, intake rates, bioaccessibility, and bioavailability have to be taken into account.

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Janjani, H., Yunesian, M., Yaghmaeian, K., Aghaei, M., Yousefian, F., Alizadeh, B.*, et al.*
BTEX in indoor air of barbershops and beauty salons: Characterization, source apportionment and health risk assessment.
Chemosphere, Vol. **345**, (2023)

Background Volatile organic compounds, mainly BTEX, are among the pollutants of concern in beauty salons and barbershops that threaten both staff personnel and clients' health. This study aimed to determine the concentration of BTEX in barbershops and beauty salons and assess the carcinogenic and non-carcinogenic risks based on the actual risk coefficients. Also, possible sources of BTEX were determined. Method Samples were collected by passive sampling. Quantitative and qualitative measurements of BTEX compounds were performed using gas chromatography-mass spectrometry (GC-MASS). Subsequently, the health risks were assessed according to the US Environmental Protection Agency. SPSS24 software and positive matrix factorization (PMF) analysis were used for statistical analysis and source apportionment respectively. Results Toluene is the most abundant compound in beauty salons, with a maximum

concentration of 219.4 (µg/m3) in beauty salons. Results indicated that the mean ELCR value estimated for benzene regarding female staff exposure (1.04 × 10−5) was higher than that for men (4.05 × 10−6). Also, ELCR values of ethylbenzene for staff exposure were 2.08 × 10−6 and 3.8 × 10−6 for men and women, respectively, and possess possible carcinogenesis risks. Conclusion Use of solvents and cosmetic products, improper heating systems, and type of service are the sources that probably contribute to BTEX emissions in beauty salons. It is necessary to follow health guidelines and conduct continuous monitoring for their implementation, in addition to setting a mandated occupational regulation framework or air quality requirements, to improve the health conditions in beauty salons.

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Liu, N., Liu, W., Deng, F., Liu, Y., Gao, X., Fang, L.*, et al.*
The burden of disease attributable to indoor air pollutants in China from 2000 to 2017.
The Lancet Planetary Health, Vol. **7** n°(11), (2023), e900-e911 p.

Background
High-level exposure to indoor air pollutants (IAPs) and their corresponding adverse health effects have become a public concern in China in the past 10 years. However, neither national nor provincial level burden of disease attributable to multiple IAPs has been reported for China. This is the first study to estimate and rank the annual burden of disease and the financial costs attributable to targeted residential IAPs at the national and provincial level in China from 2000 to 2017.
Methods
We first did a systematic review and meta-analysis of 117 articles from 37 231 articles identified in major databases, and obtained exposure–response relationships for the candidate IAPs. The exposure levels to these IAPs were then collected by another systematic review of 1864 articles selected from 52 351 articles. After the systematic review, ten IAPs with significant and robust exposure–response relationships and sufficient exposure data were finally targeted: PM2·5, nitrogen dioxide, sulphur dioxide, ozone, carbon monoxide, radon, formaldehyde, benzene, toluene, and p-dichlorobenzene. The annual exposure levels in residences were then evaluated in all 31 provinces in mainland China continuously from 2000 to 2017, using the spatiotemporal Gaussian process regression model to analyse indoor originating IAPs, and the infiltration factor method to analyse outdoor originating IAPs. The disability-adjusted life-years (DALYs) attributable to the targeted IAPs were estimated at both national and provincial levels in China, using the population attributable fraction method. Financial costs were estimated by an adapted human capital approach.
Findings
From 2000 to 2017, annual DALYs attributable to the ten IAPs in mainland China decreased from 4620 (95% CI 4070–5040) to 3700 (3210–4090) per 100 000. Nevertheless, in 2017, IAPs still ranked third among all risk factors, and their DALYs and financial costs accounted for 14·1% (95% CI 12·3–15·6) of total DALYs and 3·45% (3·01–3·82) of the gross domestic product. Specifically, the rank of ten targeted IAPs in order of their contribution to DALYs in 2017 was PM2·5, carbon monoxide, radon, benzene, nitrogen dioxide, ozone, sulphur dioxide, formaldehyde, toluene, and p-dichlorobenzene. The DALYs attributable to IAPs were 9·50% higher than those attributable to outdoor air pollution in 2017. For the leading IAP, PM2·5, the DALYs attributable to indoor origins are 18·3% higher than those of outdoor origins.
Interpretation
DALYs attributed to IAPs in China have decreased by 20·0% over the past two decades. Even so, they are still much higher than those in the USA and European countries. This study can provide a basis for determining which IAPs to target in various indoor air quality standards and for estimating the health and economic benefits of various indoor air quality control approaches, which will help to reduce the adverse health effects of IAPs in China.

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Sun, W., Yan, W. D., Huang, K. L., Song, J. S., Liu, G. Q.
Characteristics Analysis of Volatile Organic Compounds Pollution in Residential Buildings in Northeast China Based on Field Measurement.
Atmosphere, Vol. **14** n°(10), (2023)

A total of 8 mechanically ventilated residential buildings and 8 naturally ventilated residential buildings were selected to analyze the pollution characteristics of indoor VOCs under different ventilation modes in the severe cold area of northeast China. On typical meteorological days in each season, VOCs were detected on site, and ventilation modes were investigated by long-term online monitoring. The test results showed that the TVOC (total volatile organic

compounds) concentrations varied greatly in different seasons or different functional rooms, and the TVOC concentration was the highest in winter, with a value of 0.994 mg/m3. The kitchen was the place with the most serious VOC pollution, and the TVOC concentration could reach 1.403 mg/m3. Benzene series and methylsiloxane had the highest detection rates, but the detected concentrations were low, and the average concentrations were 0.025 mg/m3 and 0.013 mg/m3 respectively. Among the VOC types with a detection rate greater than 50%, the average proportions of aldehydes, alkanes, and benzene series were 18.7%, 15.39%, and 14.38%, respectively. And their mass ratios were also high, which were 14.90%, 30.85%, and 15.70%, respectively. The annual daily average ventilation duration of mechanically ventilated residential buildings was 7.84 h longer than that of naturally ventilated residential buildings. The median TVOC concentrations of mechanically ventilated residential buildings and naturally ventilated residential buildings were 0.621 mg/m3 and 0.707 mg/m3, respectively. The fresh air system was applicable in the severe cold area of northeast China.

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Urrutia, A. R., Stawicki, S. P., Kimble, C. N., Worrilow, K. C.
The clinical and environmental effects of an advanced air purification technology in multiple healthcare settings.
Science and Technology for the Built Environment, (2023)

Many facility acquired infection (FAI) causing pathogens are airborne and controlling them is critical to preventing illness. An advanced air purification technology (AAPT) was designed to inactivate the genetic material of pathogens and remediate volatile organic compounds (VOCs). This study explores the effect of the AAPT on critical metrics in multiple healthcare settings. The AAPT was installed in the heating, ventilation, and air conditioning (HVAC) ductwork of a hospital's medical surgical floor (ACH-MSF), a second hospital's post-anesthesia care unit (PACU), intensive care unit (ICU), and medical surgical (MS) unit, and in a senior living facility's (SLF) memory support unit. In all installations, the control area(s) were protected only by high efficiency particulate air (HEPA) filtration. The measured airborne fungal levels, airborne and surface bacterial levels, and VOC levels decreased with the installation of AAPT. The AAPT removed infectious airborne pathogens and reduced surface pathogens and VOCs. The ACH-MSF and SLF protected by the AAPT documented improved clinical and economic metrics including a 39.5% decrease in patient length of stay, 23% in cost savings improvement, and a 39.6% decrease in FAIs. The current findings support the hypothesis that indoor environmental quality impacts wellness and has potential applications in diverse indoor environments.

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Wang, H., Feng, D., He, Y., Jin, X., Fu, S.
Comprehensive interventions to reduce occupational hazards among medical staff in the pathology department of five primary hospitals.
BMC Public Health, Vol. **23** n°(1), (2023)

To explore comprehensive interventions to reduce occupational hazards among medical staff in the pathology department of five primary hospitals.

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Wang, Y., Wang, B., Wang, R.
Current Status of Detection Technologies for Indoor Hazardous Air Pollutants and Particulate Matter.
Aerosol and Air Quality Research, Vol. **23** n°(12), (2023)

The application of modern gaseous pollutant detection techniques to monitor harmful gases and particulate matter in the indoor environment can effectively control air pollution and reduce accidents. Accurate, timely and economical monitoring of indoor concentrations of harmful gases and particulate matter in industrial production processes is still a great challenge. In recent years, there has been a gradual increase in research on detection methods for harmful gases and particulate matter.
A number of researchers have published reviews of research on detection methods for hazardous gases, which are generally organized in terms of the detection of specific hazardous gases. In order to provide a more comprehensive overview of the latest research advances in detection methods for hazardous gases and particulate matter, this paper provides a categorized summary of research on detection methods for nitrogen dioxide, sulfur dioxide, hydrogen sulfide, formaldehyde, methane, and particulate matter. Through a comprehensive analysis of various detection methods, this paper discusses the current research progress of detection technology of indoor harmful gases and

particulate matter, which is of great significance for timely and accurate monitoring of harmful gases and particulate matter in the environment for judging the content of pollutants in the air and controlling atmospheric pollution.

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Tarvydaite, I.
Determination of volatile emissions from indoor wood surfaces.
Norwegian University of Life Sciences. Thèse 2023

Wood is an important material widely utilised in construction, furniture manufacturing as well as for floor and wall coating in indoor environments. To improve material durability and for preservation purposes, wood materials are often modified with different additives and coatings that can affect indoor air quality (IAQ). Therefore, there was an interest in uncovering if treated wood surfaces emit anthropogenic volatile organic compounds (VOCs) such as xylene, toluene, and ethylbenzene, commonly found in different wood finishes. At the same time, wood naturally emits diverse groups of fatty acid derivatives, aldehydes or/and terpenes that can elevate VOC levels in indoor environments. Hence, the biogenic VOCs such as α-pinene, β-pinene, hexanal, d-limonene, and 3-carene, were quantified to determine the magnitude of the biogenic emissions.
The object of this project was to develop and validate an analytical method suited for the GC-HR-QTOF-TDU system. Acknowledging that VOC emissions from wood are not sufficiently characterised, the project aimed to determine emission profiles based on targeted compound quantification and non-targeted screening of unknown compounds. The project analysed three different Norway spruce samples (Picea abies): untreated interior panel (USP), cross-laminated timber (CLT) and stained interior panel (SSP). The test parameters utilised for this project were based on European Standard NS-EN 16516:2017+A1. The climate chamber method was used to determine the VOCs emitted from the laboratory samples, and the air samples were collected three days after the test specimens were placed in the chambers.
Results for three laboratory samples demonstrated that hexanal had the highest emissions (80.07-3.00µg/m3) followed by α-pinene (45.4-1.9µg/m3), β-pinene (15.4-0.32µg/m3), 3-carene (7.3-0.04µg/m3) and d-limonene (3.9-0.007µg/m3). The concentration of the compounds was highest in the USP and CLT samples. Concentrations of the VOCs were noticeably variating between the duplicates of the same laboratory sample, demonstrating that chambers used for the analysis could have had contamination issues or that variations were caused by the loss of analyte due to insufficient vacuum chamber sealing. Lower concentrations of hexanal and α-pinene were determined in the SSP, suggesting that treating the wood surface can contribute to lower biogenic monoterpene and aldehyde emissions. However, further investigation should be conducted to confirm the assumption.
The Suspect and Non-target screening (SUS and NTS) revealed that alkanes were the most dominant chemical group identified in SSP (29%), CLT (31%) and USP (37%). The most abundant alkanes identified were 2,3-dimethylpentane, 2-methylhexane, methylcyclohexane, 3-metylhexane and heptane. The compounds were not identified in chamber blanks implying that the alkane emissions could be caused by contamination of the sample surface from anthropogenic sources. Terpenes contributed to 7-10% of VOC emissions, and the most abundant terpenes identified were the targeted β-pinene, α-pinene, d-limonene, 3-carene, and non-targeted β-myrcene and o-cymene. Aldehydes contained 5-8% of total VOC emissions in laboratory samples. The most abundant aldehydes identified by the unknown analysis were heptanal, nonanal, decanal, pentanal and targeted hexanal.

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Kim, J. H., Moon, N., Heo, S. J., Kwak, J. M.
Effects of environmental health literacy-based interventions on indoor air quality and urinary concentrations of polycyclic aromatic hydrocarbons, volatile organic compounds, and cotinine: A randomized controlled trial.
Atmospheric Pollution Research, Vol. **15** n°(1), (2024)

Indoor air pollution (IAP) caused by particulate matter (PM), aromatic and volatile chemicals is one of the leading causes of adverse reproductive health effects, such as infertility, decreased gestational age, and low birth weight. It is well documented that environmental health literacy (EHL) can promote reductions in IAP and the level of environmental pollutants in the body. We conducted randomized control trial to evaluate the effect of EHL-based intervention on the indoor air quality and urinary levels of polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and cotinine in reproductive aged women in Korea. The concentration of indoor PM2.5, PM10, CO2, and total VOCs (measured with a personal air quality monitoring device) as well as the urinary concentrations of PAHs, VOCs, and cotinine were measured in an experimental (n = 32) and control group (n = 31). The geometric mean concentrations of

2-NAP, tt-MA, and cotinine were 4.74, 82.82, and 0.60 μg/L respectively. The EHL intervention resulted in significant differences between experimental and control groups in the level of tt-MA ($z = -1.44$, $p = .031$), cotinine ($z = -1.07$, $p = .015$) in urine and PM2.5 ($z = 56.39$, $p < .01$), PM10 ($z = 57.85$, $p < .01$), CO2 ($z = 8.92$, $p < .01$), and total VOCs ($z = 10.11$, $p < .01$) of indoor air, and the mean score of EHL ($z = 6.30$, $p < .01$). Our results show the value in developing EHL interventions to reduce exposure to air pollutants originating from indoor activity and daily-life materials. Further studies are required to find ways to optimize general EHL for use in populations around the world.

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Bawa, J. A.
Evaluation of the Indoor Air Quality in the Production Area of Pharmaceutical Factory Buildings in Southwest Nigeria.
TWIST, Vol. **18** n°(4), (2023), 37-41 p.

The factory building houses people, equipment, materials, and circulation spaces. These features contain various types of matter, and because the pharmaceutical factory building is active, these characteristics can have an impact on the workers' health and performance. This paper investigated the indoor air quality of the production area in order to compare it to the established data for the normal built environment. The air quality was measured using the Multifunctional Air Quality Detector, the KXL-801 LCD CO Gas Carbon Monoxide Detector, and the HABOTEST HT625A Digital Anemometer, and the results were compared to established data from published literature relating to indoor air quality on the ground from fourteen (14) sampled PFBs in the study area. In this study, regression analysis was used to analyse the data obtained, while tables and figures were used for presentation. It was discovered that 60% of the parameters exceeded the globally accepted limits, indicating the need for more IAQ consideration in the design and operation of PFBs. The study suggests that smart technology be used to control the excessive presence of IAQ.

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Zhang, Q., Black, M. S.
Exposure hazards of particles and volatile organic compounds emitted from material extrusion 3D printing: Consolidation of chamber study data.
Environment International, Vol. **182**, (2023)

Ultrafine particles and volatile organic compounds (VOCs) have been detected from material extrusion 3D printing, which is widely used in non-industrial environments. This study consolidates data of 447 particle emission and 58 VOC emission evaluations from a chamber study using a standardized testing method with various 3D printing scenarios. The interquartile ranges of the observed emission rates were 109–1011 #/h for particles and 0.2–1.0 mg/h for total VOC. Print material contributed largely to the variations of particle and total VOC emissions and determined the most abundantly emitted VOCs. Printing conditions and filament specifications, included printer brand, print temperature and speed, build plate heating setup, filament brand, color and composite, also affected emissions and resulted in large variations observed in emission profiles. Multiple regression showed that particle emissions were more impacted by various print conditions than VOC emissions. According to indoor exposure modeling, personal and residential exposure scenarios were more likely to result in high exposure levels, often exceeding recommended exposure limits. Hazardous VOCs commonly emitted from 3D printing included aromatics, aldehydes, alcohols, ketones, esters and siloxanes, among which were various carcinogens, irritants and developmental and reproductive toxins. Therefore, 3D printing emits a complex mixture of ultrafine particles and various hazardous chemicals, exposure to which may exceed recommended exposure limits and potentially induce acute, chronic, or developmental health effects for users depending on exposure scenarios.

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Abulude, F. O., Oluwagbayide, S. D., Akinnusotu, A., Elemide, O. A., Gbotoso, A. O., Ademilua, S. O.*, et al.*
Indoor Air Quality in a Tertiary Institution: The Case of Federal College of Agriculture, Akure, Nigeria.
Aerosol Science and Engineering, (2023)

The Federal College of Agriculture in Akure, Nigeria, was the site of this study, which aimed to monitor indoor air quality (PM2.5 and PM10) and toxicity potential. The novelty of the study is: it is the first one in Africa to employ a cheap sensor called the Canāree A1 to measure the indoor air quality of a tertiary institution in Nigeria. The study offers baseline data for the next investigations and the formulation of policies regarding indoor air quality in Nigeria. Five distinct places were selected for the preliminary investigation, which lasted for 1 month. The protocols from the manufacturer were

strictly followed. The findings revealed that while PM10 levels were 2.3–13.1 times greater than 2021 World Health Organization (WHO) standards, PM2.5 readings were 5.8–20.3 times higher. Additionally, it exceeded The National Environmental Standards and Regulations Enforcement Agency (NESREA) guidelines by 1.2–6.6 times for PM2.5 and 0.7–3.9 times for PM10, respectively. Other findings include the following: Toxicity Potential (TP) ranges from 5.28 to 33.14 for PM2.5 and 2.30–8.33 for PM10; Indoor air quality index (IAQIndex) ranges from 1.16 to 6.63 for PM2.5 and 0.69–3.91 for PM10; and PM size distribution is from 0.31 to 0.34 for PM1.0/PM2.5, 0.34–0.84 for PM2.5, and 0.25–0.34 for PM10, respectively. The findings indicated that the study's study sites were contaminated, since the TP levels were higher than 1. An attempt should be made to lessen anthropogenic and non-anthropogenic activities' indoors. It is crucial that all parties involved in environmental issues comprehend the causes, effects, and mitigations of climate change.

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Elsharkawy, M. F.
Indoor air quality in Saudi residential homes.
Indoor and Built Environment, (2023)

This study aimed to assess the level of IAQ (indoor air quality) through monitoring of several air pollutants inside selected homes in the Eastern Province of Saudi Arabia, and to study the most affecting factors on IAQ. Continuous 8-hour monitoring at each home during six months of 2019?2020 was conducted for six air pollutants inside and outside 200 homes, representing three main Saudi cities (Dammam, Al-Hofuf and Qatif). Measurements of six air pollutants were conducted in the kitchen, the living room and the bedroom inside each home and simultaneously outside these homes in their immediate vicinity. The highest mean levels of PM10 (50.3 ± 20.0 μg/m3), CO2 (822.9 ± 195.1 ppm) and NO2 (0.044 ± 0.009 ppm) were found in kitchens, while the highest mean level of CO (1.27 ± 0.25 ppm) was found in living rooms. As for total volatile organic compounds (TVOC) and SO2, their levels were nearly the same at three sites (0.21 ± 0.04 ppm and 0.018 ± 0.002 ppm, respectively). Levels of PM10 exceeded their air quality guidelines (AQGs) in homes that are located near industrial and agricultural areas, while levels of other air pollutants were lower than their AQGs in all regions. The increase in concentrations of air pollutants outdoors was accompanied by an increase in concentrations indoors.

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Severac–Advancion, R.
Indoor air quality with amino alcohols.
Surface Coatings International, Vol. **106** n°(1), (2023)

Amino alcohols based on ANGUS chemistry can assist formulators in creating more environmentally-friendly paints and coatings. Multifunctional additives from ANGUS can be used to create low- and zero-VOC waterborne formulations, as well as low emissive coatings that qualify for green label certification programs. Amino alcohols are also highly effective formaldehyde scavengers that can be used to create functional coatings that improve indoor air quality.The level of hazardous air pollutants can be five times higher in indoor air than outdoor air and chronic exposure to these invisible indoor toxins, such as formaldehyde, can create long-term health problems. An attractive solution to reducing indoor formaldehyde levels is through a chemical remediation or scavenging system, and one of the emerging trends for the effective removal of indoor air contaminants is the use of functional coatings. We demonstrate how the unique functionality of amino alcohols can help improve indoor air quality by providing high-efficiency formaldehyde scavenging performance when used in waterborne architectural paints. Amino alcohol additives are highly effective at low dosages and do not require major reformulation work, enabling the creation of functional coatings to improve indoor air quality.

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Mohd Hannas, H., Noor Anilizawatima, S., Abang Annuar, E., Khairul Nisha Mohd, K.
Indoor Environmental Quality in Micro & Nanoelectronics Laboratories at IMEN, Research Complex, UKM.
Journal of Advanced Research in Applied Sciences and Engineering Technology, Vol. **32** n°(3), (2023), 342-354 p.

The National University of Malaysia's Micro and Nanoelectronics laboratories were examined to ascertain their comfort levels. Eight laboratories were chosen as the study locations. This study aims to assess the interior air quality at six locations by measuring CO2, formaldehyde CHOH, total volatile organic compound TVOC, PM2.5, indoor temperature,

and relative humidity. The thermal comfort evaluation for labs 1, 2, 3, 4, 5, and 7 is between 20.45 and 22.47 °C, which is below the range of DOSH and Ashrae. While the average readings in laboratories 6 and 8 are within the limits allowed at 23,21 °C and 23,75 °C, respectively. Five laboratories were exceeding the upper limit of RH (30–60%) but only three laboratories were still within the maximum level mentioned by the Ashrae standard. RH exceeded the ICOP limit (60%) at 70.3%, 63.7%, 75.4%, 60.6%, 62.8% and 65.5%, at Lab 1, 2,3,6,7 and 8, respectively, whereas temperature exceeded it (22.5- 26 °C) at 20.45, 22.2, 21.9, 22.43, 21.58 and 22.47 at Lab 1, 2, 3, 4, 5, 7 and 8, respectively. While the average air velocities for all laboratories are 0.17, 0.13, 0.10, 0.16, 0.12, 0.14, 0.15 and 0.09 ms-1, respectively. All the data that has been measured is found to be below the maximum level as recommended by the ASHRAE Standard 55 (2004) of 0.25 ms-1. The indoor air contaminants (CO, CHOH, TVOC, PM2.5, and PM10) met the standard level of ICOP and DOSH except for CHOH approaches ICOP (0.1ppm) at 0.1 and 0.09, at Point 9 and Point 10 for laboratory 3 compared to other laboratories where the concentration obtained is lower. The highest laboratories average concentration of PM2.5 was 13 µg/m3 determined in Lab 3, which was the most actively utilized one because the research activity in this laboratory was working more intensively than the others. As in the study of PM2.5, the highest average PM10 concentration was evaluated in Lab 3 as 36 µg/m3. Based on observations and studies, we find that fresh outdoor air with a complete and good purifier/filter should be used to reduce the concentration of indoor pollutants.

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Domhagen, F.
Influence of building envelope on indoor air quality.
Department of Architecture and Civil Engineering. Chalmers University Of Technology.Thèse 2023

The ventilation system should provide occupants with fresh air while removing excess pollutants from the building. However, increasing ventilation may inadvertently draw more pollutants into the occupant area or prove ineffective in altering emission rates from building materials and furnishings. If not addressed properly, this can make raising the ventilation rate inefficient, resulting in unnecessary heat losses or, in the worst case, reduced indoor air quality. This thesis addresses two previously insufficiently understood situations of contaminant transport within buildings, both manifested as unpleasant indoor smells: contaminant transport from adjacent compartments and early-stage emissions of air pollutants in new buildings. The former, inspired by school buildings in Sweden demolished due to 'moldy' smells, was thoroughly explored in my Licentiate thesis, Contaminant Transport by Air Infiltration from Crawl Space to Occupant Area-Numerical Simulations and Field Measurements in Swedish schools, and is presented here as a summary. The latter focuses on indoor air quality in new buildings, which often have initial high volatile organic compound (VOC) levels, typically perceived as a 'new smell.' In Sweden, it is common to run the ventilation system at full rate for several months as a remedy due to the negative effects of high VOC levels on occupants. However, the drawback of this strategy is the risk for over-ventilation with unnecessary energy losses. Two methods, ‘VOC-passport’ and ‘Ventilation threshold’, are developed to assess how ventilation can improve indoor air quality in more energy-efficient ways. Results show that with VOC-passport, it is possible to simulate dynamic variations in VOC concentrations in new buildings based on passive VOC measurements and building physics modeling. With this method, it is possible to find an optimal ventilation strategy for low VOC concentrations and minimal energy losses. In addition, an analytical analysis of the diffusion of VOCs in materials shows that if ventilation rates exceed a certain threshold, further increases will not affect the emission rate. A quantified ventilation threshold is useful for setting the ventilation rate regarding optimal off-gassing and an important complement to the VOC-passport.

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Chang, P. K., Chuang, H. H., Hsiao, T. C., Chuang, H. C., Chen, P. C.
Investigating the invisible threat: An exploration of air exchange rates and ultrafine particle dynamics in hospital operating rooms.
Building and Environment, Vol. **245**, (2023)

The air exchange rate (AER), defined as the number of times the air is fully replaced per hour in an indoor space, is an important parameter affecting indoor air quality (IAQ). Hospital operation rooms (ORs), one of the indoor environments with relatively high health risks, should maintain high AERs to quickly remove surgical smoke during surgery. This study aimed to investigate the characteristics and transmission of pollutants in ORs through on-site measurements and numerical simulations. To determine actual AER (AER(actual)), both exponential decay and concentration variations, resulting in a more precise representation of indoor air pollutant residence time, were considered. Our results revealed that gaseous pollutants exhibited lower AER(actual) values compared to particulate pollutants due to their higher

diffusibility. Notably, the AER(actual) of total volatile organic compounds (TVOC) was found to be greater than that of carbon dioxide (CO2) due to the higher reactivity of TVOC. Furthermore, this study also investigated the characteristics of surgical smoke particles and observed variations in emission factors (EF) depending on the surgical procedure, ranging from approximately 1010 to 1011 particles per minute. Moreover, coarse particles (>2.5 mu m) were primarily influenced by drag forces, resulting in lower AER(actual) values. Additionally, the AER(actual) of ultrafine particles (UFPs) was examined, revealing that smaller particles exhibited lower AER(actual) values, potentially due to stronger Brownian motion. By combining measurement and simulation analysis, the spatial distribution of lung deposited surface area (LDSA) concentrations could be evaluated, providing accurate exposure concentrations for health risk assessments.

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Petruleviciene, M., Savickaja, I., Juodkazyte, J., Ramanavicius, A.
Investigation of WO3 and BiVO4 Photoanodes for Photoelectrochemical Sensing of Xylene, Toluene and Methanol.
Chemosensors, Vol. **11** n°(11), (2023)

Volatile organic compounds (VOCs) are a notable group of indoor air pollutants released by household products. These substances are commonly employed as solvents in industrial operations, and some of them are recognized or suspected to be cancer-causing or mutagenic agents. Due to their high volatility, VOCs are typically present in surface waters at concentrations below a few micrograms per liter. However, in groundwater, their concentrations can reach levels up to thousands of times higher. This study analyses the applicability of the photoelectrochemical (PEC) sensing of VOCs in aqueous medium. Tungsten oxide and bismuth vanadate photoanodes were tested for PEC sensing of xylene, toluene, and methanol in sodium chloride and sodium sulfate electrolytes. The crystalline structure and morphology of coatings were analyzed using XRD and SEM analyses. Photoelectrochemical properties were evaluated using cyclic voltammetry, chronoamperometry, and electrochemical impedance spectroscopy. The results of the study show that aromatic compounds tend to block the surface of the photoelectrode and interfere with the PEC sensing of other substances. WO3 photoanode is found to be suitable for the PEC sensing of methanol under the mild conditions in aqueous electrolytes; however, electrode engineering and assay optimization are required to achieve better detection limits.

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Lapuente, C. S., Herrada, H., Jiménez, M. J., Sánchez, M. N.
Long-Term Assessment of a Set of CO2 Concentration Sensors in an In-Use Office Building.
Sensors, Vol. **22** n°(23), (2022)

The measurement of the CO2 concentration has a wide range of applications. Traditionally, it has been used to assess air quality, with other applications linked to the experimental assessment of occupancy patterns and air renewal rates. More recently, the worldwide dissemination of COVID-19 establishing a relationship between infection risk and the mean CO2 level has abruptly led to the measurement of the CO2 concentration in order to limit the spread of this respiratory disease in the indoor environment. Therefore, the extensive application of this measurement outside of traditional air quality assessment requires an in-depth analysis of the suitability of these sensors for such modern applications. This paper discusses the performance of an array of commercial wall-mounted CO2 sensors, focusing on their application to obtain occupancy patterns and air renovation rates. This study is supported by several long-term test campaigns conducted in an in-use office building located in south-eastern Spain. The results show a spread of 19–101 ppm, with a drift of 28 ppm over 5 years, an offset of 2–301 ppm and fluctuations up to 80 ppm in instantaneous measurements not related to concentration changes. It is proposed that values averaged over 30 min, using a suitable reference value, be used to avoid erroneous results when calibration is not feasible.

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Shen, J.
Monitoring and controlling of the micro-environment in a special exhibition in the Shanghai Museum.
SN Applied Sciences, Vol. **5** n°(11), (2023)

Monitoring and controlling of the showcase environment in a special exhibition in Shanghai Museum are described in this work. The long show time started on March 2022 and ended on January 2023. Various items were shown in this exhibition with different combination modes. Air conditioners, humidifiers and three kinds of passive humidity controlling methods were applied to this exhibition. Massive raw monitoring data are given and some series of data are transformed into specific values to conduct various analyses. Factors including outdoor climate, exhibition hall

structure, attendance, showcase structure, tightness and volume, monitor position and object combination modes are discussed in order to assess their effect on monitoring and controlling of temperature and relative humidity. The relation between the average value of temperature (or relative humidity) fluctuation in the whole exhibition period and the corresponding range of maximum temperature (or relative humidity) fluctuation in any 24 h is analyzed in order to obtain the probability of abnormally high fluctuation. The results show that the temperature control target is reached in general, while some unreasonable showcase structures and settings are responsible for the difficulty in monitoring and controlling of relative humidity. By conducting the analysis of big continuous historical data and learning the average values and the ranges reached, it is possible to assess the current environmental risk and predict the future risk in a simple way.

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Xu, Y., Hui, L., Zheng, P., Liu, G., Yu, J. Z., Wang, Z.
Monitoring techniques of airborne carbonyl compounds: Principles, performance and challenges.
TrAC Trends in Analytical Chemistry, Vol. **169**, (2023)

Airborne carbonyls are a significant class of indoor and outdoor air pollutants, and their accurate and timely measurement is critical for protecting human health. This article reviews the existing analytical techniques for monitoring atmospheric carbonyl compounds. We categorize the methods into real-time measurements and time-integrated measurements and compare the commonly used methods, including proton transfer reaction-mass spectrometry (PTR-MS), liquid chromatography (LC) and gas chromatography (GC) coupled with different detectors and various derivatization methods. The operation theory, normal working conditions, and instrument performance in detecting carbonyls, are summarized and compared. The advantages and limitations of each technique are also discussed, along with the challenges and solutions for measurement bias. The review concludes with recommendations for selecting a suitable technique based on selectivity, sensitivity, time-resolution, and operability, as well as the need for improving accuracy and optimization to reduce influences.

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Moorchilot, V. S., Aravind, U. K., Aravindakumar, C. T.
Occurrence of azo-dyes, plasticizers, and PAH-bound microplastics: an emerging source and sink for hazardous compounds in indoor environments?
Air Quality, Atmosphere & Health, (2023)

Indoor environments act as significant reservoirs for a wide range of potentially harmful substances, with microplastics (MPs) gaining increased attention in recent years. This study offers valuable insights into the role of MPs as both source and sink for hazardous contaminants within indoor environments. The analytical techniques employed encompass micro-Raman spectroscopy and high-resolution mass spectrometry. The results revealed a strong correlation between the levels of MPs with the size of the residential population. The dominant shape, colour and polymer type of MPs were fibre, white/transparent and polyamide, respectively. The risk of exposure to microplastics through ingestion was 22.5 times higher for infants compared to adults. In settlements where inhabitants utilized firewood as supplementary cooking fuel, an interesting observation was made: pyrene, which is a specific type of polycyclic aromatic hydrocarbon (PAH), was observed to be adsorbed by polystyrene (PS) MPs. This finding illustrates the capacity of MPs to serve as reservoirs for PAHs within indoor environments. Furthermore, the observation of PAH absorption onto MPs in households using firewood highlights a previously underexplored interaction between microplastics and pollutants in indoor settings. Organic micro-pollutants like di-ethyl hexyl phthalate (DEHP), monobutyl phthalate (MBP), 1,2-dihydro-2,2,4-trimethylquinoline and benzisothiazolone (BIT) were detected in both dust and MPs. It underscores the potential for organic micro-pollutants to move between settled dust and MPs within indoor settings, emphasizing the need for further research in this area.

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Mansouri, K.
Optimisation du confort thermique et de l'efficacité énergétique dans les établissements scolaires: cas d'un climat chaud et aride.
Université Mohamed Khider Biskra. Mémoire 2023

Actuellement, et avec le grand développement technologique dans le monde, le besoin en énergie a augmenté notamment dans le secteur du bâtiment. Cependant pour remédier à cette situation, une nouvelle discipline a vu le jour sous l'appellation de bâtiment passif, ce dernier est caractérisé par l'utilisation des matériaux de construction passifs. Son objectif est le confort et la réduction de la consommation énergétique. Dans cette étude, on s'intéresse à l'efficacité énergétique d'un bâtiment, celle-ci est liée particulièrement au type de matériaux et des isolants utilisés

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Wang, X., Chan, A. W. H.
Particulate Matter and Volatile Organic Compound Emissions Generated from a Domestic Air Fryer.
Environmental Science & Technology, Vol. **57** n°(45), (2023)

Air frying has become a popular cooking method for domestic cooking, but the level of released indoor air pollutants is poorly understood. In this work, we compared particle and gas phase emission factors (EF) and particle size distributions between cooking with a domestic air fryer and a pan for a variety of foods. The PM10 EFs of air frying chicken wings and breast were higher than pan cooking by a factor of 2.1 and 5.4, respectively. On the other hand, a higher PM10 emission factor from air frying can be achieved by increasing the amount of oil to levels similar to or above those from pan-frying for French fries and asparagus. We propose that higher temperature and greater turbulence lead to higher PM10 EFs for cooking with the air fryer compared with the pan for the same mass of oil added. EFs of volatile organic compounds (VOCs) are also generally higher for cooking with the air fryer compared with the pan: 2.5 times higher for French fries and 4.8 times higher for chicken breast. Our study highlights the potential risk of higher indoor PM10 levels associated with domestic air frying under certain cases and proposes possible mitigation measures.

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Li, J. A., Link, M. F., Pandit, S., Webb, M. H., Mayer, K. J., Garofalo, L. A.*, et al.*
The persistence of smoke VOCs indoors: Partitioning, surface cleaning, and air cleaning in a smoke-contaminated house.
Science Advances, Vol. **9** n°(41), (2023)

Wildfires are increasing in frequency, raising concerns that smoke can permeate indoor environments and expose people to chemical air contaminants. To study smoke transformations in indoor environments and evaluate mitigation strategies, we added smoke to a test house. Many volatile organic compounds (VOCs) persisted days following the smoke injection, providing a longer-term exposure pathway for humans. Two time scales control smoke VOC partitioning: a faster one (1.0 to 5.2 hours) that describes the time to reach equilibrium between adsorption and desorption processes and a slower one (4.8 to 21.2 hours) that describes the time for indoor ventilation to overtake adsorption-desorption equilibria in controlling the air concentration. These rates imply that vapor pressure controls partitioning behavior and that house ventilation plays a minor role in removing smoke VOCs. However, surface cleaning activities (vacuuming, mopping, and dusting) physically removed surface reservoirs and thus reduced indoor smoke VOC concentrations more effectively than portable air cleaners and more persistently than window opening.

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Grandjean, A., Bazin, D., Becker, A., Le Calvé, S.
Portable Microfluidic Analyser For Continuous Monitoring of Formaldehyde in Indoor Air.
Envirotech online, (2023)

At a time when pollution has become a major public health concern, reliable monitoring techniques for air quality must be available. Formaldehyde is a pollutant found mainly in indoor air. It is present in concentrations 2 to 15 times higher than those in outdoor air, with values typically ranging from 10 to 100 µg m-3 [1]. A wide variety of formaldehyde sources are present indoors: building and furnishing products, household products, domestic combustion, etc. Formaldehyde is also present in many products due to its disinfectant and conservation properties.

Formaldehyde has irritating effects on the respiratory system and eye mucosa, and its involvement in allergic asthma, is well known [2]. The International Agency for Research on Cancer classified it as carcinogen in 2004. Health agencies recommended thus to reduce exposure to lowest feasible concentration: values of 19.7 µg m−3 (16 ppb) (NIOSHa) and 30 µg m-3 (24.4 ppb) (ANSESb) for long term exposure while occupational exposure limits are set at 243 µg m-3 (300

ppb) (over 8 h) and 487 µg m-3 (600 ppb) (over 15 min) under EU Directive 2019/983. Rapid, sensitive, easy-to-use, and robust continuous analysis techniques need to be developed to democratise the formaldehyde monitoring.

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Stringari, G., Moraleda, N., Rosell, A., Rieradevall, J., Orsini, F., Durany, X. G.
Potential volatile organic compounds emission in indoor urban farming: a case study.
In: 31st International Horticultural Congress (IHC) - Horticulture for a World in Transition / International Symposium on Urban Horticulture for Sustainable Food Security (UrbanFood). Angers, FRANCE2022. pp. 117-125.

A possible solution to cope with climate change and food insecurity is city greening, through extensive adoption of green infrastructures and urban agriculture. Little consideration is given to potential impacts that could be derived from elevated biogenic volatile organic compounds (BVOCs) released by plants. BVOCs can account for up to 90% of global VOC emissions. In indoor spaces, their levels are still unknown, although they may raise as much concern as for GHGs. The study presents the monitoring BVOCs emitted by a mature crop of green beans (Phaseolus vulgaris L. 'Pongo') cultivated inside an integrated rooftop greenhouse (i-RTG) in the Mediterranean area. Long-term air measurements were taken by passively sampling the atmosphere inside the i-RTG and in an inner open chamber hosting plants to monitor physiological emissions, as well as from the external outdoor environment, as control. An additional short measurement was taken on four plants in static-head space conditions to check detected BVOCs. Among a wide range of different volatiles terpenes, methanol and acetic acid were always found (including in the control), suggesting that their origin should not be associated with i-RTG plants. However, the detected signals were below the analytical procedures' LLOQ (lower limit of quantitation). In the statichead space sample, most GC-MS signals could be identified as terpenoid compounds based on their MS spectra and by comparison of their chromatographic retention times with standards; though signals were faint, estimated values were below ppb. Accordingly, the results suggested passive sampling as a practical and easy-to-implement method to produce preliminary tracking of BVOC emissions. However, active sampling may improve the quantitative assessment of their levels inside the i-RTG.

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Jung, C., Abdelaziz Mahmoud, N. S., Al Qassimi, N., Elsamanoudy, G.
Preliminary Study on the Emission Dynamics of TVOC and Formaldehyde in Homes with Eco-Friendly Materials: Beyond Green Building.
Buildings, Vol. **13** n°(11), (2023)

This preliminary study investigates the emission characteristics of formaldehyde (HCHO) and total volatile organic compounds (TVOC) in indoor environments, comparing the effects of eco-friendly materials and general materials. The study analyzes the concentration changes over time in the living rooms of experimental units to assess the effectiveness of eco-friendly materials in reducing indoor air pollutants. The results show that eco-friendly materials exhibit lower initial emissions of TVOC than general materials, gradually decreasing over time. Compared to the eco-friendly material unit, the general material unit takes longer to reach acceptable TVOC concentrations. The emission pattern of HCHO differs from TVOC, with the highest peak occurring on the seventh day. Major individual VOCs, except for benzene, exhibit a similar decreasing trend for TVOC over time. Eco-friendly materials demonstrate significant reductions in emissions compared to general materials in various material applications, including parquet flooring, wallpaper, built-in furniture, and kitchen furniture. However, the difference in emissions for door and window frames using eco-friendly materials is minimal. These findings emphasize the effectiveness of eco-friendly materials in reducing indoor air pollutants and provide valuable insights for creating healthier living environments. Further research is needed to optimize the application of eco-friendly materials in specific components and investigate their long-term impact on indoor air quality and occupant health.

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Qu, Y. K., Zou, Z. W., Weschler, C. J., Liu, Y. J., Yang, X. D.
Quantifying Ozone-Dependent Emissions of Volatile Organic Compounds from the Human Body.
Environmental Science & Technology, (2023)

Ozone reactions on human body surfaces produce volatile organic compounds (VOCs) that influence indoor air quality. However, the dependence of VOC emissions on the ozone concentration has received limited attention. In this study, we conducted 36 sets of single-person chamber experiments with three volunteers exposed to ozone concentrations

ranging from 0 to 32 ppb. Emission fluxes from human body surfaces were measured for 11 targeted skin-oil oxidation products. For the majority of these products, the emission fluxes linearly correlated with ozone concentration, indicating a constant surface yield (moles of VOC emitted per mole of ozone deposited). However, for the second-generation oxidation product 4-oxopentanal, a higher surface yield was observed at higher ozone concentrations. Furthermore, many VOCs have substantial emissions in the absence of ozone. Overall, these results suggest that the complex surface reactions and mass transfer processes involved in ozone-dependent VOC emissions from the human body can be represented using a simplified parametrization based on surface yield and baseline emission flux. Values of these two parameters were quantified for targeted products and estimated for other semiquantified VOC signals, facilitating the inclusion of ozone/skin oil chemistry in indoor air quality models and providing new insights on skin oil chemistry.

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Christianson, C. D., Baylis, J. B., Komisar, V., Brinkerhoff, J.
Quantifying Ventilation Design, Room Layout, and Occupant Activity Parameters during Aerosol-Generating Medical Procedures in Hospitals.
Indoor Air, Vol. **2023**, (2023)

The risk of airborne disease transmission in hospital rooms during aerosol-generating medical procedures is known to be influenced by the size of the room, air ventilation rate, input-to-output flow ratio, vent surface area, and vent location. However, quantitative recommendations for each ventilation design parameter are scarce. Moreover, room layout and occupant activity parameters, such as furniture locations and healthcare worker movement, are often omitted from studies on airborne disease transmission in hospital settings. As a result, the development of policies and technologies aimed at mitigating airborne disease transmission in hospitals has been limited. To address this shortfall, this study is aimed at first characterizing existing ventilation, room layout, and occupancy parameters in hospital rooms where aerosol generation medical procedures (AGMPs) occur and then testing the hypotheses that ventilation, room layout, and occupancy parameters vary significantly between hospital rooms and, in some cases, with time. Information on AGMPs was collected via a survey circulated to healthcare workers within British Columbia 2019's Interior Health Authority (IHA), while hospital room and ventilation system information was collected by reviewing drawing packages of 37 IHA hospital rooms. The survey results indicate that AGMPs commonly occur in trauma, ICU, or general ward rooms with positive or negative pressure ventilation systems. Statistical tests, with room type (trauma, ICU, or general), room pressure (positive or negative), and/or time as independent variables, show that variables relating to ventilation (number of supply vents, supply and exhaust vent location, ventilation rate, and supply and exhaust area) and room layout (congestion score, room volume, light area, and number of lights) vary with room type but not with room pressure. Occupant activity variables (number of workers, number of moving workers, and speed score) also vary with room type, although to differing extent with room pressure and time. The survey and drawing review data presented in this study can help guide systematic comparisons of mitigative technologies as well as parametric investigations on how room layout, ventilation, and operational parameters influence airborne disease spread. This is a crucial first step in achieving quantitative and clinically relevant recommendations for mitigating airborne disease transmission in healthcare settings.

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Yang, Y., Kang, X., Yang, Y., Ye, H., Jiang, J., Zheng, G.*, et al.*
Research progress in green preparation of advanced wood-based composites.
Advanced Composites and Hybrid Materials, Vol. **6** n°(6), (2023)

Since ancient times, humans have used wood as a building material due to its unique properties including porosity, anisotropy, biodegradability, and easy processing. Wood-based composites have been extensively studied in order to meet the performance requirements of the wood during use. However, the environmental burdens are steadily increasing due to the pollution in the synthesis of wood-based composites. At present, it has become a mainstream development trend to use environmentally friendly materials as raw materials and use adhesive-free bonding technology to prepare wood-based composites. Based on this green production, various environmentally friendly functional additives are widely mixed into raw materials to endow advanced wood-based composites with new practical functions such as electromagnetic shielding, antibacterial, and flame retardant. Hence, this paper summarizes the types of traditional wood-based composites and the pollution problems that exist in the preparation and application process, focusing on the green preparation technology and performance advantages of advanced wood-based composites.

Among them, the adhesive-free hot-pressed technology is the most environmentally friendly method in the green preparation technology. Meanwhile, this paper looks forward to the development direction of advanced wood-based composites with new functions processed by green preparation technology. Furthermore, it will be upgraded towards the research of multi-functional integrated advanced wood-based composites in the future.

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Li, S. M.
Review of Engineering Controls for Indoor Air Quality: A Systems Design Perspective.
Sustainability, Vol. **15** n°(19), (2023)

This paper aims to review the engineering controls for indoor air quality (IAQ) from a systems design perspective. As a result of the review, we classify the literature content into three categories: (1) indoor air treatments, (2) dissemination control strategies, and (3) information technology. Indoor air treatments can be generally interpreted as the "cleaning" aspect, which covers ventilation and contaminant removal techniques. Dissemination control focuses on how contaminants generated in an indoor space can be transmitted, where four types of dissemination are classified. The category of information technology discusses IAQ sensors for monitoring, as well as the applications of the Internet of Things and IAQ data. Then, we further analyze the reviewed engineering controls by performing systems and functional analysis. Along with a discussion of IAQ functions, we suggest some systems design techniques, such as functional decoupling and design for flexibility/resilience, which are expected to promote more systems thinking in designing IAQ solutions.

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Otuyo, M. K., Nadzir, M. S. M., Latif, M. T., Din, S. a. M.
A review of personal exposure studies in selected Asian countries' public transport microenvironments: lessons learned and future directions.
Environmental Science and Pollution Research, (2023)

This comprehensive paper conducts an in-depth review of personal exposure and air pollutant levels within the microenvironments of Asian city transportation. Our methodology involved a systematic analysis of an extensive body of literature from diverse sources, encompassing a substantial quantity of studies conducted across multiple Asian cities. The investigation scrutinizes exposure to various pollutants, including particulate matters (PM10, PM2.5, and PM1), carbon dioxide (CO2), formaldehyde (CH2O), and total volatile organic compounds (TVOC), during transportation modes such as car travel, bus commuting, walking, and train rides. Notably, our review reveals a predominant focus on PM2.5, followed by PM10, PM1, CO2, and TVOC, with limited attention given to CH2O exposure. Across the spectrum of Asian cities and transportation modes, exposure concentrations exhibited considerable variability, a phenomenon attributed to a multitude of factors. Primary sources of exposure encompass motor vehicle emissions, traffic dynamics, road dust, and open bus doors. Furthermore, our findings illuminate the influence of external environments, particularly in proximity to train stations, on pollutant levels inside trains. Crucial factors affecting exposure encompass ventilation conditions, travel-specific variables, seat locations, vehicle types, and meteorological influences. The culmination of this rigorous review underscores the need for standardized measurements, enhanced ventilation systems, air filtration mechanisms, the adoption of clean energy sources, and comprehensive public education initiatives aimed at reducing pollutant exposure within city transportation microenvironments. Importantly, our study contributes to the growing body of knowledge surrounding this subject, offering valuable insights for policymakers and researchers dedicated to advancing air quality standards and safeguarding public health.

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Gu, W., Li, G., Xiermaimaiti, A., Ma, T.
A review of recent techniques in performance augmentation and evaluation metrics of Trombe walls.
Energy and Buildings, Vol. **301**, (2023)

Trombe walls are attracting considerable attention from researchers and engineers on account of their potential ability for addressing environmental and energy crisis. However, reviews on the current situation and challenges of Trombe walls are limited. Therefore, it is necessary to present an overview on recent development of Trombe walls from various perspectives and provide some potential directions for further research. This review mainly focuses on the latest techniques on passive solar heating (represented by Trombe walls). In detail, various and novel Trombe walls are

introduced according to structural improvement and technological innovation. In addition, different assessment indicators of Trombe walls are summarized from four points of view: energy, exergy, economy and environment (4E). In the end, the outlook, including challenges and future perspectives of Trombe walls are summarized and proposed. We hope that this article would be valuable for academic researchers and can provide related engineering designers in the field of passive buildings with a reference for further research.

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Parra, M., Knowlton, T.
School exposure to air pollution in the UK and Ireland: Indoor-Outdoor air quality assessment.
European Journal of Public Health, Vol. **33** n°(Supplement_2), (2023)

Globally, 93% of children under the age of 15 (1.8 billion) are exposed to fine particulate matter (PM2.5) levels that might cause respiratory/cardiovascular disorders, impaired neuro/cognitive development, and cancer. Air pollution causes 1/10 deaths in children under the age of 5.The purpose of this observational study was to collect data on indoor and outdoor air quality in 24 schools over 10 school days and compare it with city-wide average air quality levels reported in rural/urban areas in the UK and Northern Ireland. Nitrogen dioxide, volatile organic compounds (VOCs) and PM10,2.5,1 were monitored inside the classrooms and school surroundings with personal pollution monitors. City-wide averages were taken from local reference air quality and ground-source monitoring stations. Data was expressed using the Plume Labs Air Quality Index (PAQI) thresholds [low (0-20), moderate (21-50), high (51-100), very high (101+) pollution level] aligned with WHO's exposure recommendations.Despite both AQIs being in the moderate threshold, the school's average indoor AQI was ~44% higher than the city-wide average. Only 27% of schools' indoor air quality indexes matched the city-wide average, 59% were higher and 14% were lower. Rural schools had a marginally higher average indoor AQI than urban schools. The primary classroom pollutants observed were VOCs, followed by PM10. The average walk-exposure AQI of 33% of total schools was higher than the city's average. The school reporting the highest average walk AQI was seven times higher than the lowest.Poor indoor air quality and higher levels of pollutants were found inside the majority of the schools across the regions. There is a need for mitigation strategies to identify responsible factors for indoor air pollution. A regulatory framework for school ventilation and behavior interventions like nasal washes may reduce pollution exposure and its impact on children's health outcomes and mortality. Poor indoor air quality (~44% higher than the city-wide average) and higher levels of pollutants (volatile organic compounds and PM10) were found inside the majority of the schools across the regions. A regulatory framework for school ventilation and behavior interventions like nasal washes may reduce air pollution exposure and its impact on children's health outcomes and mortality.

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Zaporozhets, A., Babak, V., Kostenko, G., Sverdlova, A., Dekusha, O., Kornienko, S.
Some features of air pollution monitoring as a component of the microclimate of the premises.
System Research in Energy, Vol. **75** n°(4), (2023), 65-73 p.

The quality of living space largely depends on the quality of indoor air. The physical and chemical properties of the air people breathe can affect their health and comfort. Indoor air pollution in residential and workplace environments can occur due to various activities of occupants or employees, such as cooking, smoking, and using electronic devices, as well as emissions of pollutants from building materials and the use of certain products. Pollutants that can be present indoors include carbon monoxide, formaldehyde, volatile organic compounds, particulate matter, aerosols, biological contaminants, and more. To effectively monitor the quality of atmospheric air, it is necessary to determine the main sources of air pollution, which is the purpose of this study. Naturally, the quality of indoor air cannot be clearly separated from the ambient air quality. The first factor affecting the microclimate is the level of air pollution near the building. Air from the street enters the room through windows, doors, or the building's ventilation system. If the state of the surrounding environment is unfavorable, the concentration of harmful substances indoors may also exceed the norm. However, indoor sources of air pollution in any building can have a much greater impact on the health and comfort of the people inside it. Materials used in construction, such as concrete or mineral insulation, may contain ammonia, formaldehyde, and other substances that are released from building structures over time and deteriorate indoor air quality. Ensuring control and monitoring of indoor air quality is an extremely important task. This includes measuring concentrations of pollutants and identifying their sources. It is also important to adhere to standards and recommendations developed by health and environmental organizations to ensure safety and comfort indoors. To

reduce indoor air pollution, various measures can be implemented, such as selecting appropriate building materials, and ventilation, installing purification systems, controlling sources of pollution, and limiting the impact of human activity.

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Dong, X. Y., Wang, J., Wang, X. L., Li, T. T., Wang, Q., Xu, D. Q.
[Study on formulation and revision of standard limit for formaldehyde in the "Standards for indoor air quality in China].
Zhonghua yu fang yi xue za zhi [Chinese journal of preventive medicine], Vol. **57** n°(11), (2023), 1748-1751 p.

Formaldehyde, as an important pollutant in indoor air, has always been of great concern. In the newly issued "Standards for indoor air quality (GB/T 18883-2022)", the standard limit of formaldehyde has been restricted to 0.08 mg/m³. In order to better promote the implementation and application of this new standard, this study reviewed and interpreted the relevant technical content for determining the standard limit, including the indoor concentration and human exposure levels of formaldehyde, the health effects of formaldehyde, and the derivation of safety reference values. It also proposed prospect for the future development and revision of quality standards for formaldehyde in indoor air.

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El-Leathey, L. A., Anghelita, P., Constantin, A. I., Circiumaru, G., Chihaia, R. A.
System for Indoor Comfort and Health Monitoring Tested in Office Building Environment.
Applied Sciences-Basel, Vol. **13** n°(20), (2023)

The use of smart technologies and the Internet of Things (IoT) is becoming more and more popular in order to enhance the overall building performance by monitoring parameters related to occupants' comfort and health in the built environment. A new modular, custom-made and replicable IoT system is proposed based on an Arduino development board (MKR WiFi 1010) connected to the Arduino IoT Cloud. An Application Programming Interface (API) enables the integration of this system with other possible ones, thus making the system modular, custom-made and replicable. A series of parameters were simultaneously monitored over a 7-day period in two office spaces and a photovoltaic (PV)-testing laboratory. While the meteorological and comfort parameters (temperature, relative humidity, CO2) were monitored in all three spaces, the health parameters (total volatile organic compounds-TVOCs; formaldehyde-HCHO; particulate matter-PM; and radon-222Rn) were monitored only in an office setup located right next to a Chemical Analysis and Testing Laboratory. Generally, the registered values of the health parameters fell within the recommended thresholds. However, the thermal comfort parameters were constantly exceeded: over 90% of the working time in the two office spaces and 83.33% in the PV-testing laboratory. Still, the optimal relative humidity values in the monitored spaces contributed to the discomfort reduction in the occupants. Also, CO2 and TVOCs had some exceptions in particular conditions. CO2 values of up to 1500 ppm due to poor ventilation and TVOC levels of up to 1000 ppb related to chemical experiment development were registered. Also, several other peaks were recorded when monitoring HCHO as well as PM. Thus, special attention must be paid to natural ventilation or to the improvement of building characteristics. Also, the time intervals when experiments in the Chemical Analysis and Testing Laboratory are carried out should be communicated to other personnel from the nearest offices. The testing of the monitoring system over a one-week period showed that the proposed solution operated adequately, representing a reliable tool for data acquisition via the Arduino IoT Cloud.

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Link, M. F., Li, J. A., Ditto, J. C., Huynh, H., Yu, J., Zimmerman, S. M.*, et al.*
Ventilation in a Residential Building Brings Outdoor NOx Indoors with Limited Implications for VOC Oxidation from NO3 Radicals.
Environmental Science & Technology, Vol. **57** n°(43), (2023), 16446-16455 p.

Energy-efficient residential building standards require the use of mechanical ventilation systems that replace indoor air with outdoor air. Transient outdoor pollution events can be transported indoors via the mechanical ventilation system and other outdoor air entry pathways and impact indoor air chemistry. In the spring of 2022, we observed elevated levels of NOx (NO + NO2) that originated outdoors, entering the National Institute of Standards and Technology (NIST) Net-Zero Energy Residential Test Facility through the mechanical ventilation system. Using measurements of NOx, ozone (O-3), and volatile organic compounds (VOCs), we modeled the effect of the outdoor-to-indoor ventilation of NOx

pollution on the production of nitrate radical (NO3), a potentially important indoor oxidant. We evaluated how VOC oxidation chemistry was affected by NO3 during NOx pollution events compared to background conditions. We found that nitric oxide (NO) pollution introduced indoors titrated O-3 and inhibited the modeled production of NO3. NO ventilated indoors also likely ceased most gas-phase VOC oxidation chemistry during plume events. Only through the artificial introduction of O-3 to the ventilation duct during a NOx pollution event (i.e., when O-3 and NO2 concentrations were high relative to typical conditions) were we able to measure NO3-initiated VOC oxidation products, indicating that NO3 was impacting VOC oxidation chemistry.

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Fromme, H.

Volatile Organic Compounds and Very Volatile Organic Compounds.

In: Indoor Air Quality: Occurrence and Health Effects of Contaminants. Springer Nature Switzerland; 2023. 93-156 p.

In this chapter, the large group of volatile organic compounds (VOC) like formaldehyde, other aldehydes, glycol ethers, isothiazolinone, methyl methacrylate, emerging PFAS, oximes, and naphthalene as well as the very volatile organic compounds (VVOC) are presented individually in detail. In addition to a brief description of the chemical–physical characteristics and the use of the substance, an overview of main health risks and, in particular, references to further scientific literature are given. In the foreground, however, are extensive presentations of the occurrence of the substances in indoor air and in sedimented dust.

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