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Google Scholar et WoS

Letellier, N., Gutierrez, L.-A., Pilorget, C., Artaud, F., Descatha, A., Ozguler, A.*, et al.*
Association Between Occupational Exposure to Formaldehyde and Cognitive Impairment.
Neurology, (2021)

Objective: To our knowledge, no study has investigated the effect of exposure to formaldehyde on cognition in the general population. Our objective was to examine the association between occupational exposure to formaldehyde and cognitive impairment in middle-aged and young- old adults (≥45 years).Methods: In the French CONSTANCES cohort, cognitive function was assessed with a standardized battery of seven cognitive tests to evaluate global cognitive function, episodic verbal memory, language abilities and executive functions (e.g., Digit Symbol Substitution Test, DSST). A global cognitive score was created using principal component analysis. Cognitive impairment was assessed in reference to norms of neuropsychological battery according to age, sex and education. Lifetime exposure to formaldehyde was assessed using a French job-exposure matrix created in the framework of the Matgéné project. After performing multiple imputation, separate modified Poisson regression models were used to evaluate the association between cognitive impairment (<25th percentile) and formaldehyde exposure (exposed/never exposed), exposure duration, cumulative exposure index (CEI), and combination of CEI and time of last exposure.Results: Among 75 322 participants (median age: 57.5 years, women: 53%), 8% were exposed to formaldehyde during their professional life. These participants were at higher risk of global cognitive impairment (for global cognitive score: adjusted relative risk, aRR, 1.17, 95% confidence interval, CI: 1.11-1.23), after adjusting for confounders (age, sex, education, income, solvent exposure, Effort–Reward Imbalance, night-shift, repetitive, and noisy work). They were at higher risk of cognitive impairment for all cognitive domains explored. Longer exposure duration and high CEI were associated with cognitive impairment, with a dose-effect relationship for exposure duration. Recent exposure was associated with impairment in all cognitive domains. Time did not fully attenuate formaldehyde-associated cognitive deficits especially in highly exposed individuals (for DSST: high past exposure aRR 1.23, 95%CI: 1.11-1.36; high recent exposure: aRR 1.24, 95%CI: 1.13-1.35).Conclusion: Our findings highlight the long-term detrimental effect of formaldehyde exposure on cognitive health in a relatively young population.

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Apel, E. C., Asher, E. C., Hills, A. J., Hornbrook, R. S.
ATom: Volatile Organic Compounds (VOCs) from the TOGA instrument, Version 2.
ORNL Distributed Active Archive Center 2021

This dataset provides concentrations of volatile organic compounds (VOCs) measured by the Trace Organic Gas Analyzer (TOGA) during the four ATom campaigns. These data are relevant to the impact of human-produced air pollution on greenhouse gases and on chemically reactive gases in the atmosphere. Specific data were obtained for radical precursors, tracers of anthropogenic and biogenic activities, tracers of urban and biomass combustion emissions, products of oxidative processing, precursors to aerosol formation, and compounds important for aerosol modification and transformation. TOGA measures a wide range of VOCs with high sensitivity (ppt or lower), frequency (2-minutes), accuracy (often 15% or better), and precision (<3%).

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Liao, C., Zhang, M., Gao, N., Tian, Q., Shi, J., Chen, S.*, et al.*
Based Vapor Detection of Formaldehyde: Colorimetric Sensing with High Sensitivity.
Chemosensors, Vol. **9** n°(12), (2021), 11 p.

We report on a novel colorimetric sensor system for highly sensitive detection of formaldehyde (FA) in the gas phase. The sensor is constructed with paper towel as a substrate coated with the sulfuric acid salt of hydroxylamine ((NH2OH)2·H2SO4) together with two pH indicators, bromophenol blue and thymol blue. Upon exposure to FA, the hydroxylamine will react with the absorbed FA to form a Schiff base (H2C=N-OH), thus releasing a stoichiometric amount of sulfuric acid, which in turn induces a color change of the pH indicator. Such a color change was significantly enriched by incorporating two pH indicators in the system. With the optimized molar ratio of the two pH indicators, the color change (from brown to yellow, and to red) could become so dramatic as to be visible to the eye depending on the

concentration of FA. In particular, under 80 ppb of FA (the air quality threshold set by WHO) the color of the sensor substrate changes from brown to yellow, which can even be envisioned clearly by the naked eyes. By using a color reader, the observed color change can be measured quantitatively as a function of the vapor concentration of FA, which produces a linear relationship as fitted with the data points. This helps estimate the limit of detection (LOD), to be 10 ppb under an exposure time of 10 min, which is much lower than the air quality threshold set by WHO. The reported sensor also demonstrates high selectivity towards FA with no color change observed when exposed to other common chemicals, including solvents and volatile organic compounds. With its high sensitivity and selectivity, the proposed paper-based colorimetric sensor thus developed can potentially be employed as a low-cost and disposable detection kit that may find broad application in detecting FA in indoor air and many other environments.

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Stinson, B.
Determining Airflows and VOC Source Strengths for an Occupied School.
MCNAIR SYMPOSIUM 2021

Volatile organic compounds (VOCs) are a group of air pollutants that can adversely impact human health, engage in chemistry indoors, and meaningfully degrade indoor and outdoor urban air quality. While extensive research with regard to VOC emission rates from indoor sources has been conducted, it was not until recently that this work began to focus on characterizing emissions from humans and human activity in depth. As buildings are constructed to be increasingly airtight, and the materials utilized are chosen to reduce VOC emissions, it follows that human contributions are poised to become increasingly important indoor sources of VOCs. Utilizing data extracted from a three-month campaign conducted at Harriet Tubman Middle School in Portland, Oregon—an institution built near a busy roadway—this study modeled airflows through the school and quantified source strengths for VOCs over the course of one week in May 2019. We developed an approach to estimate occupant density, outdoor air ventilation rates, and supply air flow rates through the school by analyzing the decay, steady-state, and accumulation periods of CO2 measured in return air. In total, emission rates for 249 compounds were calculated. Emission rates for seven compounds that are traditionally associated with human metabolism and activity became the study's primary focus, as did source strengths for BTEX compounds (benzene, toluene, xylenes, and ethylbenzene), which are typically associated with traffic-related air pollution (TRAP). Calculated per-person emission rates for VOCs that are associated with human activity or metabolism, e.g., monoterpenes and isoprene, were consistent with estimates in the literature and indicate humans and their activities are an important indoor source of reactive VOCs. This study provides new data concerning VOC source strengths of indoor and outdoor origin to a building, which can enable the modeling of air pollution exposures in schools.

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Liu, R., Liang, M., Xu, J., Wang, J., Long, L., Ni, Y.
Dialdehyde starch reinforced polyacrylate-polyethylene glycol resin for impregnated decorative paper with improved toughness and ultra-low formaldehyde emission.
Industrial Crops and Products, Vol. **176**, (2022)

To solve the problems of brittleness and formaldehyde emission of melamine-formaldehyde (MF) impregnated decorative paper, a polyacrylate-polyethylene glycol (PEG)-dialdehyde starch (DAS) was used to modify MF. The impregnation adhesive was characterized and the properties of impregnated decorative paper and laminated to plywood were tested. DAS showed better dispersion in the compound resin and higher reactivity with MF compared to the control. The MF can react with active aldehyde groups of DAS by Schiff base reaction and hydroxyl groups of polyacrylate, PEG, and DAS. Thus, the cross-linked structure was formed in the impregnated decorative paper interlayer. At mass ratio of polyacrylate-PEG-DAS:MF= 2:1, the abrasion value, surface bonding strength, fouling capacity of plywood was comparable to MF impregnated decorative paper bonded plywood, improved with crack resistance. In addition, the formaldehyde emission was sharply lowered down with ultra-low value of 0.03 mg/L, which was classified as F* ** * for very high JAS 234:2003 standard (≤0.3 mg/L).

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Hu, D., Tobon, Y., Agostini, A., Grosselin, B., Chen, Y., Robin, C.*, et al.*
Diurnal variation and potential sources of indoor formaldehyde at elementary school, high school and university in the Centre Val de Loire region of France.

Science of The Total Environment, Vol. **811**, (2022)

Formaldehyde (HCHO) is one of the abundant indoor pollutants and has been classified as a human carcinogen by the International Agency for Research on Cancer (IARC). Indoor HCHO at schools is particularly important due to the high occupancy density and the health effects on children. In this study, high time resolved measurement of formaldehyde concentration was conducted in the classrooms at elementary school, high school and university under normal students' activities in three different locations in the Region Centre Val de Loire-France. Indoor average formaldehyde concentrations at those three educational institutions were observed to be in the range 10.96–17.95 μg/m3, not exceeding the World Health Organization (WHO) guideline value of 100 μg/m3. As expected, ventilation was found playing an important role in the control of indoor formaldehyde concentration. After opening windows for 30 min, formaldehyde level decreased by ~25% and 38% in the classroom at the elementary school and the high school, respectively. In addition to the primary sources, the objective of this study was also to determine potential secondary sources of indoor formaldehyde in these schools by measuring the other volatile organic compounds (VOCs) present in the classrooms by a Proton Transfer Reaction Time-of-Flight Mass Spectrometry (PTR-ToF-MS). The measurements suggest that the release of residue from tobacco smokers is one of the major sources of indoor HCHO at the high school, which increases HCHO by ~55% averagely within 1 h. Moreover, the control experiments conducted in the university suggests that VOCs such as that released from cleaning products like terpenes, can contribute to the increase of indoor formaldehyde levels through chemical reactions with ozone. This study confirms simple recommendations to reduce the indoors HCHO concentration in schools: use ventilation systems, limit the emissions like cigarette smoke or cleaning products. It also points out that the secondary sources of formaldehyde must be also considered in the classroom.

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Tang, Y., Han, Z., Qi, Y., Yang, Z., Han, H., Jiang, Y.*, et al.*
Enhanced ppb-level formaldehyde sensing performance over Pt deposited SnO2 nanospheres.
Journal of Alloys and Compounds, Vol. **899**, (2022)

Formaldehyde is one of the most serious threats to human health in modern interior decoration. Thereby, online detection of indoor formaldehyde concentration has become an urgent problem. In this work, the Pt deposited porous SnO2 nanospheres were synthesized as the formaldehyde sensing materials, which were prepared by hydrothermal and chemical reduction methods. The diameter of as-synthesized Pt-SnO2 were centered in the range of 30–50 nm, with the dominant pore size of ~10 nm and the specific surface area of 89.79 m2 g−1, which provided a raft of passages and active sites for gas molecules to diffuse and interact mutually. Moreover, the experimental results demonstrated that the 1 wt.% Pt-SnO2 exhibited higher response (16.03), high-speed response time (9 s) and outstanding selectivity with exposure to low-concentration formaldehyde compared with original SnO2. The porous structures and catalytic effect of Pt nanoparticles were jointly responsible for the enhancement of SnO2 on sensing performance towards formaldehyde.

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Hearth, H., Sondarangalla, S. D. A.
Enhancing Air Quality and Controlling Indoor Air Pollution by Using Low-Cost Air Purification Strategy.
INTERNATIONAL RESEARCH SYMPOSIUM 2021 University of Vocational Technology, pp. 36-43

Air pollution is a major environmental concern these days, and it's more than just a fact; it's a painful fact that causes problems for humans, such as serious health problems According to WHO data on indoor air pollution and health, indoor air pollution causes 3.8 million premature deaths each year, including stroke, chronic, ischemic heart disease, obstructive pulmonary disease and lung cancer. As a result, the majority of research has focused on various air purification methods. The most dangerous pollutants are PM 2.5 particles. The majority of these can be found both inside and outside of buildings. Because effective air filtration is an expensive process, the solution is to cut costs while maintaining efficiency. This paper discusses the current state of human air pollution problems, low-cost and effective air purification methods like HEPA filters, activated carbon, and ultraviolet light, and how they developed this system. In addition to that, the benefits of air purification in improving indoor air quality are discussed.

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Exploitation des données de la base nationale Capt'air pour le recensement des experimentations de capteurs pour la qualite de l'air.
Laboratoire Central de Surveillance de la Qualité de l'Air 2021

Ce rapport présente une synthèse des informations disponibles dans la base de données Capt'Air mise en place depuis 2019 pour recenser des systèmes capteurs utilisés pour l'évaluation de la qualité de l'air et des expérimentations menées en laboratoire ou sur le terrain avec ces derniers.

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Saleh, I. A., Ezzo, A. A., Abdel-Latif, N. M. M., Mohammed, A. M. F.
Formaldehyde Risk Assessment in Indoor/Outdoor Environment in Cairo, Egypt.
Egyptian Journal of Chemistry, (2021)

Acute and chronic health problems are expected due to exposure to high levels of formaldehyde. The aim of the current study was to evaluate the outdoor and indoor levels of formaldehyde in Cairo in order to assess the carcinogenic and non-carcinogenic risks as a result of exposure to formaldehyde. Formaldehyde concentrations were measured outdoors and indoors at five residential sites in Cairo, Egypt. The samples were taken during the day (8 AM to 6 PM) and at night (8 PM to 6 AM) for 10 hours during winter and summer seasons of 2018/2019. Chronic daily intakes (CDI), cancer risk (R) and hazard quotient (HQ), were estimated to assess health risks from exposure to formaldehyde. Outdoor average concentrations of formaldehyde at the selected sites were 24.6 and 22.8 µg/m³ in summer and winter, respectively, which exceeded the value of 15 ppb (18.3 µg/m3) set as an indicator for urban environment. Indoor HCHO concentrations are still far lower than the effective short-term exposure levels of HCHO between 0.5 and 1 ppm (0.62-1.23 mg/m3) which could lead to irritation of throat, nose and eyes. Newly apartments with newly furnished can be a stronger source for formaldehyde emissions than the ambient sources.The I/O ratios of formaldehyde were above one which demonstrated that the sources in the indoor environment are prevalent at the investigated sites.The outdoor cancer risk values did not exceed the "alarm level" (R > 1 × 10–4) for formaldehyde, while in living rooms and kitchens they exceeded the "alarm level" by 30% and 55% in winter and summer, respectively. The results indicated that the levels of airborne and inhaled formaldehyde in Cairo residences should not be underestimated. The current study can help regulatory agencies to establish guidelines for formaldehyde concentration in indoor air.

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Pan, S., Roy, S., Choudhury, N., Behera, P. P., Sivaprakasam, K., Ramakrishnan, L.*, et al.*
From Small Molecules to Polymeric Probes: Recent Advancements of Formaldehyde Sensors.
Science and Technology of Advanced Materials, (just-accepted),(2021)

Formaldehyde is a well-known industrial material regularly used in fishery, vegetable markets, and fruit shops for maintaining their freshness. But due to its carcinogenic nature and other toxic effects, it is very important to detect it in very low concentrations. In recent years, amine-containing fluorescent probes have gained significant attention for designing formaldehyde sensors. However, the major drawbacks of these small molecular probes are low sensitivity and long exposure time, which limits their real-life applications. In this regard, polymeric probes have gained significant attention to overcome the aforementioned problems. Several polymeric probes have been utilized as a coating material, nanoparticle, quartz crystal microbalance (QCM), etc., for the selective and sensitive detection of formaldehyde. The main objective of this review article is to comprehensively describe the recent advancements in formaldehyde sensors based on small molecules and polymers, and their successful applications in various fields, especially in situ formaldehyde sensing in biological systems.

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Yin, Y., He, J., Zhao, L., Pei, J., Yang, X., Sun, Y.*, et al.*
Identification of key volatile organic compounds in aircraft cabins and associated inhalation health risks.
Environment International, Vol. **158**, (2022)

The identification of key VOCs during flights is important in creating a satisfactory aircraft cabin environment. Two VOC databases for the building indoor environment (from 251 occupied residences) and the aircraft cabin environment (from 56 commercial flights) were compared, to determine the common compounds (detection rate (DR) > 70%) in the two environments and the characteristic VOCs (only those with high DR during flights) in aircraft cabins. Possible VOC emission sources in flights were also discussed. As TVOC is usually viewed as a general indicator of air quality, the prediction of TVOC concentration was carried out using BP neural network algorithm, and the average error between the predicted and measured values was 55.35 µg/m3 (R2 = 0.80). Meanwhile, the VOCs' inhalation cancer/non-cancer

risks to crew members and passengers were calculated on the basis of detection rates, exposure concentrations, and health risk assessments. Six compounds (i.e., formaldehyde, benzene, tetrachloroethylene, trichloromethane, 1,2-dichloroethane, and naphthalene) were proposed as the key VOCs in the existing aircraft cabin environment, presenting a risk to crew members that is higher than the US EPA proposed acceptable level (evaluated mean value > 1E-06). The estimated lifetime excess cancer/non-cancer risks for passengers were all below the assessment criteria. Based on a summary of various VOC limits in five built environments, hierarchical design of VOC concentration limits is recommended for the aircraft environment.

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Zhu, L., Wang, J., Liu, J., Xu, Z., Nasir, M. S., Chen, X.*, et al.*
In situ enrichment amplification strategy enabling highly sensitive formaldehyde gas sensor.
Sensors and Actuators B: Chemical, Vol. **354**, (2022)

Rapid detection of hazardous trace gas is critical to protect humans from health threats. The current gas sensors, however, suffer from insufficient sensitivity and selectivity, which limits their use in the application of real-time monitoring for low concentration gas. Herein, a versatile “in situ enrichment amplification” (IEA) strategy is proposed, aiming to integrate the in situ formed adsorption-functional material for target gas enrichment and the backbone sensor-functional material for gas response. The IEA-based gas sensors exhibit high sensitivity and selectivity toward the detection of HCHO gas. The calculated detection limit of the IEA sensor to HCHO gas is 63 ppb, much lower than that of the conventional HCHO sensor (183 ppb). Furthermore, a wireless cloud HCHO detection system is developed to achieve sustainable remote monitoring of the HCHO gas. Application of this IEA strategy to other metal oxide sensing materials generates similarly successful results.

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Alwi, N. S., Hassim, M. H., Hamzah, N. A.
Indoor Air Quality and Sick Building Syndrome among Garment Manufacturing Workers in Kota Bharu, Kelantan.
Malaysian Journal of Medicine and Health Sciences, n°(October), (2021), pp. 51-58

Introduction: Sick Building Syndrome (SBS) is an illness that occurs among occupants that linked to time spent in a building. The causes of SBS can be various but it has a significant relation to the Indoor Air Quality (IAQ) of the building itself. This study aimed to investigate the Indoor Air Quality (IAQ) and symptoms of Sick Building Syndrome (SBS) among garment manufacturing workers. Methods: The IAQ Parameters (air velocity, temperature, relative humidity, carbon dioxide, carbon monoxide, formaldehyde, PM10, and PM2.5) were measured using specified instruments. The SBS symptoms were assessed by a questionnaire adopted from the Industry Code of Practice (ICOP) of Indoor Air Quality (IAQ) 2010 among 173 employees from the production section Results: Temperature, PM10, and formaldehyde concentration levels exceeded the threshold values of ICOP IAQ 2010. The prevalence of SBS was high (82.1%). There was a significant association between relative humidity and scalp’s itchiness ($\chi 2 = 5.601$, $p=0.018$) while formaldehyde level with skin’s itchiness ($\chi 2 = 4.425$, $p=0.039$), scalp’s itchiness $\chi 2 = 4.668$, $p=0.031$), and eye irritation ($\chi 2=9.663$, $p=0.002$). Age, gender, smoking status, and years of employment were predictors for few symptoms of SBS such as fatigue, dizziness, stuffy nose, and eye irritation ($p<0.05$). Conclusion: This study showed a significant association between poor IAQ of certain parameters and SBS symptoms. Regular maintenance of ventilation and control measures are important for maintaining good indoor air quality to avoid further health problems to the occupants.

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Jia, L.-R., Han, J., Chen, X., Li, Q.-Y., Lee, C.-C., Fung, Y.-H.
Interaction between Thermal Comfort, Indoor Air Quality and Ventilation Energy Consumption of Educational Buildings: A Comprehensive Review.
Buildings, Vol. **11** n°(12), (2021)

Thermal comfort and indoor air quality (IAQ) of educational buildings can affect students’ academic performance and well-being and are closely related to ventilation energy consumption. Demands of the indoor environmental quality within the classroom generally vary with the education levels and result in ventilation energy consumption accounting for a considerable proportion of the total energy use in bulk educational buildings. Its huge energy-saving potential is attracting worldwide attention from scholars and governments. Therefore, appropriate operation strategies of ventilation systems should be adopted to effectively reduce energy consumption without sacrificing thermal comfort

and IAQ. However, the absence of relevant standards and guidelines for designing a quality classroom environment considering the special features of educational buildings remains an important research question. This study conducts a comprehensive review to determine research gaps and identify future directions for the interaction between thermal comfort, IAQ and ventilation energy consumption for educational buildings. The review results show that: (1) The thermal comfort prediction model should consider the influences of genders, ages and socioeconomic backgrounds; (2) The mixed-mode ventilation coupling the natural and mechanical approaches is preferred given its advantage of lower energy consumption and improved thermal comfort, but its control strategies need further exploration; (3) Optimizing passive design parameters of buildings (e.g., window to wall ratios, window orientations and sun shading installations) can significantly reduce the ventilation demands while maintaining indoor thermal comfort; (4) More studies are required for investigating thermal comfort in educational buildings during the heating period; and (5) IAQ of university buildings clearly requires further studies, especially on bacterial and fungal aerosol pollutants, for a more comprehensive assessment of the built environment.

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Justo Alonso, M., Wolf, S., Jørgensen, R. B., Madsen, H., Mathisen, H. M.
A methodology for the selection of pollutants for ensuring good indoor air quality using the de-trended cross-correlation function.
Building and Environment, Vol. **209**, (2022)

CO2 is customarily used to control ventilation as it is a proxy for bio-effluents and pollutants related to the presence and activity of people in the room. However, CO2 could not be a satisfactory indicator for pollutants that do not have a metabolic origin, i.e., emissions from building materials or emissions from traffic. A methodology to select pollutants besides or instead of CO2 is presented in this article. This methodology sets to study (i) the suitable location to measure air pollutants and (ii) which parameters to measure. The answers to these two questions are based on correlation analysis between pollutants and indoor/outdoor ratios. Measurements of CO2, air temperature, relative humidity, formaldehyde, and particulate matter have been taken in an office, an industrial kitchen, and a gym and are used to show how to apply the methodology. Correlations were studied in detrended (pre-whitened) time series. Studying correlations in detrended time series via cross-correlation functions is recommended because correlation coefficients may be overestimated because of the trends in the time series. In contrast to Pearson's correlation coefficient, the cross-correlation function studies the correlation between pollutants concurrently (as Pearson) but also at different time lags. From the measurements we can conclude on the need to measure at least one parameter representing: 1)pollutants related to human activities 2)pollutants that infiltrate from processes like combustion or traffic outdoors, 3)pollutants related to combustion indoors, 4)pollutants related to degassing from building materials, 5)pollutants related to other “non-combustion-related activities” indoors and moisture loads.

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Adeoye, A. O., Tokede, C. A., Olagoke, M. A.
Perceived Indoor Air Quality of Fresh Cement-sand Screeded Camp Dormitory in Osun State Nigeria.
Technology (ICONSEET), Vol. **6** n°(26), (2021), pp. 195-203

Building materials and construction products constitute potential sources of indoor pollutants especially when they are still fresh in construction or new in installation. Studies have affirmed the possibility of emission of toxic substances into such spaces. Occupying a building of this status might impact user’s health and comfort negatively. This study seeks to understand the perception of the occupants with respect to the indoor air quality within fresh cement-sand screeded camp dormitory. Structured questionnaire was administered on 50% of the respondents residing in the religious dormitory during a week long program in early April 2021. The result of the analysis shows that the overall assessment of ventilation of the dormitory to be good, to the tune of 37 (41.6%). 15 (16.9%) adjured the air flow to be very good while 19 (21.3%) were neutral in their opinion. Other indoor air quality parameters were mostly adjured neutral. It is therefore recommended that Ventilation design for residential dormitory and any other similar scheme is of paramount importance and as such Architects should consciously address it based on the users’ population per floor area and the expected indoor activities.

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Yao, B., Wang, H., Zhang, W., Feng, L.

Research Progress in Determination Methods of Formaldehyde Content in Indoor Air.
Architecture Engineering and Science, Vol. **2** n°(4), (2021), pp. 109-113

The detection methods of formaldehyde content in indoor air, including traditional laboratory detection methods (AHMT spectrophotometry, phenol reagent spectrophotometry, acetyl acetone spectrophotometry and gas chromatography) and rapid detection methods (electrochemical sensor method, photoelectric spectrophotometry, etc.), were introduced and described. This paper systematically analyzes and compares the detection principle, applicable environment medium, detection flux and the advantages and disadvantages of each detection method. The future detection methods of formaldehyde content in indoor air were prospected.

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Zhang, H., Zheng, Z., Yu, T., Liu, C., Qian, H., Li, J.
Seasonal and diurnal patterns of outdoor formaldehyde and impacts on indoor environments and health.
Environmental Research, Vol. **205**, (2022)

Formaldehyde is concerned as an important indoor carcinogen. While contribution of outdoor formaldehyde to indoor concentration is recognized, long-term measurement about its impact on indoor environments remain missing. We measured both outdoor and indoor formaldehyde concentrations for over one year in Nanjing (east-central China) and calculated the outdoor/indoor (O/I) ratios. 64.8% of the measured outdoor concentration have exceeded the chronic reference exposure criteria of 0.009 mg/m3 set by Office of Environmental Health Hazard Assessment (OEHHA). The outdoor concentration was highest in summer with median value of 0.020 mg/m3 and lowest in spring with median value of 0.009 mg/m3. Diurnally, outdoor formaldehyde concentration was highest at noon with median value of 0.013 mg/m3 and lowest at night with median value of 0.01 mg/m3. Health analysis revealed that cancer risk by exposure to this concentration level is 1.6 × 10−4, higher than threshold limit of 10−6. In addition, the median O/I ratios are 0.18 and 0.27 in two offices, indicating that outdoor formaldehyde contributes to indoor concentrations by about one quarter. The change of O/I ratio also shows a similar seasonal and diurnal trend as outdoor concentrations (highest in the summer in a year and at noon in a day). Outdoor formaldehyde concentration is therefore not negligible as a contributor to indoor concentration, especially as indoor concentration limit gets continuously lowered. This factor should be taken into account in indoor air quality design and maintenance.

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Arias, A., Entrena-Barbero, E., Feijoo, G., Moreira, M. T.
Sustainable non-isocyanate polyurethanes bio-adhesives for engineered wood panels are revealed as promising candidates to move from formaldehyde-based alternatives.
Journal of Environmental Chemical Engineering, Vol. **10** n°(1), (2022)

The main driving forces on the development of eco-friendly wood adhesives are based on environmental sustainability, costs savings, recyclability, reusability and health benefits, in comparison with synthetic resins. Lignin, tannin, proteins and carbohydrates are the main renewable raw materials being studied. Taking as a premise the technical performance of different bio-based alternatives, in comparison with formaldehyde-based resins, it is necessary to evaluate the environmental profile of such products in order to assess the pros and cons. In this regard, this manuscript addresses the industrial-scale design and environmental evaluation, through the Life Cycle Assessment methodology, of four formaldehyde-free bio-adhesives. For this purpose, the use of renewable resources such as Organosolv (OSL) and kraft (KL) lignins, soy (SPI) and tannins (MT)), crosslinked and hardened with NIPU (non-isocyanate polyurethanes) were considered. The impact results obtained showed that OSL-NIPU bio-adhesive, with a single environmental score of 35.27 mPa, has the best environmental profile, followed by SPI-NIPU, with a value of 63.36 mPa. Therefore, both could be considered as potential substitutes for synthetic resins. On the other hand, it has been identified that hexamethylenediamine (HDMA), used as crosslinking agent for the formulation of the bio-adhesives, is one of the main hotspots of the environmental profiles of OSL, KL and MT NIPU bio-adhesives. In the case of SPI-NIPU adhesives, it is the soy protein isolation process that leads to a higher environmental contribution. Thus, future research should focus on trying to reduce the dose of HMDA and on improving the soy protein isolation process.

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