Rapport de veille n° 02-2021

Aéraulique

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Google Scholar et WoS

Rojas, G.
3.14 Simplifying Mechanical Ventilation with Heat Recovery systems: Assessing the extended cascade ventilation and active overflow concept.
2020. 76 p.

The objective of Subtask 4 in the IEA EBC Annex 68 was to integrate knowledge and results from remaining Subtasks and present them in the context with current knowledge. The focus of the Subtask 4 was on practitioners dealing with ensuring high Indoor Air Quality (IAQ) in modern low-energy residences, the demands and challenges they meet during daily work. This especially includes architects and ventilation designers, facility managers, property developers and employees of public authorities. This publication is a result if Subtask 4's work. It brings a collection of 24 "case studies" related to IAQ design and control in Low-Energy Residential Buildings. By a "case study" we mean a real life construction project, laboratory investigation or a simulation study that provides innovative approach. The case studies were selected to give the practitioners new insigts, inspiration and motivation to go along new paths leading to sustainable and comfortable homes of the future. The report is organized into three main chapters: "Ways to design residential ventilation in the future" and "Towards better performance and user satisfaction". The descriptions of case studies are accompanied by "lessons learned" sections aiming directly at practical utilization of results as well as recommended future reading section providing the most important references.

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Reddy, M., Heidarinejad, M., Stephens, B., Rubinstein, I.
Adequate indoor air quality in nursing homes: An unmet medical need.
Science of The Total Environment, Vol. **765**, (2021)

A small but growing body of literature indicates that concentrations of indoor particulate and gaseous pollutants in long-term care facilities (i.e., skilled nursing facilities) for older adults, hereafter referred to nursing homes, often exceed those recorded in nearby, comparable outdoor environments. Unlike the outdoors, indoor air quality (IAQ) in nursing homes is not regulated by legislation and is seldom monitored. To that end, residents of nursing homes commonly spend the vast majority of their time indoors where they are exposed to indoor air pollutants for long periods of time. Given that many nursing home residents, especially those of advanced age, are more susceptible to the effects of air pollutants, even at low concentrations, this prolonged exposure may adversely affect their health, well-being, quality of life and increase medical expenditures due to frequent, unscheduled acute care visits and hospitalizations. We propose an action plan for assessing IAQ in nursing homes, understanding the impacts of IAQ on adverse health outcomes of nursing home residents, and addressing vulnerabilities in these facilities to safeguard health, well-being, and quality of life of nursing home residents and minimizing unscheduled acute care visits and hospitalizations. We propose that IAQ should be regularly monitored in nursing homes to proactively identify and address vulnerabilities in these facilities and that resources should be provided for remedial interventions to improve IAQ in nursing homes, including but not limited to source control, improving ventilation and filtration, and deploying air cleaners where appropriate. This proactive approach may pave the way for establishing enforceable standards for indoor air quality in nursing homes that will promote health, well-being, and quality of life of nursing home residents and reduce medical expenditures.

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Zong, Z., Chen, D., Zhao, C., Tang, G., Ji, Y., Zhang, H.*, et al.*
Application of Ce–Eu/TiO2 phase change material as the wall material to improve the indoor environment.
Journal of Materials Research, (2021)

Walls of buildings fitted with functional materials are beneficial for saving energy and increasing the comfort level. The Ce–Eu/TiO2 phase change material mixed with gypsum as wall plaster materials could purify indoor air, store heat energy, and also control air humidity. This paper studied the thermal-photocatalytic-humidity performance of gypsum based functional materials for residential walls and evaluated the effects of its application. The latent heat of gypsum based functional materials was 23.57 J/g, whereas the phase transition temperature of 16.81–24.97 °C, which was a

comfortable temperature range for humans. After 11 h of testing the formaldehyde concentration decreased from 1.0 to 0.3144 mg m−3 and the degradation rate reached 68%. The maximum temperature difference between the experiment room and the contrast room could reach 3.9 °C. The relative humidity indoors of the experiment room was 38.40–62.30%, which was much more stable than that of the contrast room.

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Kozielska, B., Kaleta, D.

Assessment of Indoor Benzene and Its Alkyl Derivatives Concentrations in Offices Belonging to University of Technology (Poland).

Atmosphere, Vol. **12** n°(1), (2021)

Indoor air contamination in office rooms is regarded as one of the most important issues in the protection of workers' health, because contaminants, even those occurring at low concentrations, can cause health problems for the office staff in view of the long exposure time. This paper presents the results of measurements of benzene and its alkyl derivatives (toluene, ethylbenzene, xylenes, styrene, and 1,3,5-trimethylbenzene) - known indicators of human exposure to volatile organic compounds (VOCs) in the air in newly renovated offices at University of Technology (Upper Silesia, Poland). Monthly samples of indoor and outdoor air were collected during the years 2018-2019 by passive methods and analyzed by thermal desorption-gas chromatography with flame ionization detector (TD-GC/FID). In the first month of measurements average concentrations of the sum of five VOCs under consideration was 127.7 µg/m3, then in subsequent months between 15.1 µg/m3 to 87.3 µg/m3. The average concentration of carcinogenic benzene was below 1.5 µg/m3. Toluene had the highest concentration among studied VOCs, accounting for as high as 60 % and 84 % of the total indoor and outdoor VOCs, respectively. High indoor-to-outdoor (I/O) ratios for ethylbenzene (7.1), m,p-xylene (9.8), and styrene (12.5) indicate the dominant role of indoor sources.

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Saadun, N., Mt, P., Roseley, A., Lee, S., Juliana, A., Adnan, A.

Awareness, knowledge and perception of formaldehyde emission from wood composite products among design professionals.

THE MALAYSIAN FORESTER, Vol. **84** n°(1), (2021), 120-136 p.

Given the rising concern over the potential health effects of formaldehyde in indoor environment released from wood composite products bonded with formaldehyde-based resin, this study examines the awareness, knowledge, and perception of formaldehyde emission from wood based-based composite products and its effect on health among design professionals. Using a mixed-mode survey design, a total of 7 architects, 49 interior designers, 15 furniture designers, and 5 structural engineers had participated in the survey. The results showed that a majority (72%) of the respondents has never heard about formaldehyde and about 22% of the respondents were aware that formaldehyde can cause harmful effect on their health. The level of understanding of formaldehyde among respondents who were aware of formaldehyde was good based on the correct answers given on statements related to the concept of formaldehyde. Only a small percentage (25%) of the respondents has always taken the efforts to recommend low-formaldehyde wood composite products to their clients. This study highlights the urgent need for awareness program to educate the designers on making a conscious choice in the selection of less hazardous materials to be used in their design. Information from this study also provides a basis for policy makers to design technical regulation related to formaldehyde emission standards from wood composite products.

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Sadkovyi, V., Pospelov, B., Andronov, V., Rybka, E., Krainiukov, O., Rud, A.*, et al.*

Construction of a method for detecting arbitrary hazard pollutants in the atmospheric air based on the structural function of the current pollutant concentrations.

2020, Vol. **6** n°(10 (108)), (2020), 9 p.

This paper reports the construction of a method for calculating the structural function within a moving window of the fixed size, based on measuring the vector of current concentrations of arbitrary air pollutants. The use of a moving window makes it possible to reveal the current moments of the emergence of inhomogeneities in the polluted atmosphere. In this case, the time shift of the structural function reveals the corresponding time scale of this heterogeneity. It has been shown that, in contrast to the known method, the proposed method makes it possible to

reveal the dynamics of the levels and scales of local inhomogeneities of the polluted air using only the current measurements of concentration for an arbitrary number of pollutants. It is noted that the method does not use information about the current meteorological conditions of the atmosphere and the features of urban infrastructure near a pollution control point. Therefore, the method is universal; it could be applied to arbitrary control points of atmospheric pollution across various territories of states. The efficiency of the proposed method was tested using the example of actual measurements of the concentrations of urban air pollutants involving formaldehyde, ammonia, and nitrogen dioxide. The reported results generally indicate the applicability of the proposed method. It has been experimentally established that the method makes it possible to identify, in real time, the areas of local inhomogeneities characteristic of hazardous air pollution associated with the absence of dispersion and accumulation of pollutants in the air. In addition, the method makes it possible to detect in real time both the levels and the scale of inhomogeneities in the polluted atmosphere. It has been experimentally established that before the occurrence of the tested reliable emergency in a polluted atmosphere, the level of local heterogeneity was 0.015 units at its time scale corresponding to 8 counts. Next, by the time of the emergency, the level of heterogeneity decreased to 0.0025 units at the time scale corresponding to 2 counts. It has been experimentally established that for this case the forecast time of the occurrence of an emergency was 4 counts or 24 hours

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Rahman, M., Awang, M., Musa, M., Mustafa, M., Hamidon, N., Khamidun, M.*, et al.*
The Development of Indoor Air Quality Pre-Assessment Tool for Determining Risk Level at Pre-School Building.
Journal, (2020), 169-175 p.
Third International Conference on Separation Technology 2020 (ICoST 2020)

A tool is constructed for Indoor Air Quality (IAQ) pre-assessment of pre-school buildings on the basis of a methodology that incorporates structured expert judgment and analytic hierarchy process (AHP). The tool calculates the level of indoor air pollutants such as Carbon Dioxide (CO2), Carbon Monoxide (CO), Particulate Matter (PM10), Formaldehyde (HCHO), Nitrogen Dioxide (NO2) and Volatile Organic compound (VOC) based guidelines. In particular, structured expert judgment criteria used to provide the most significant chemical contamination on health-related risks to children of pre-school. In addition, the AHP approach used for the classification of possible risk index of good, marginal or poor results from direct monitoring measurements. Three selected pre-school are used to demonstrate the use of the proposed tool as case studies.

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Magalhães, R., Nogueira, B., Costa, S., Paiva, N., Ferra, J. M., Magalhães, F. D.*, et al.*
Effect of Panel Moisture Content on Internal Bond Strength and Thickness Swelling of Medium Density Fiberboard.
Polymers, Vol. **13** n°(1), (2021), 114 p.

Wood-based products usually have serious limitations concerning contact with water, both because wood is a hygroscopic material and because the commonly used binder has low moisture resistance. This paper studies the effect of panel moisture content (MC) on the physico-mechanical properties of medium density fiberboards (MDF). Several commercial MDF boards produced in Europe were stored at room temperature and relative humidity (RH) for 9 weeks (approx. range 15–20 °C and 50–85% RH). Every week, a strip of each MDF board was cut out, divided into 5 × 5 cm test pieces and its internal bond strength (IB) was measured. A strong influence of MDF moisture content on internal bond strength was observed and therefore IB test pieces were stored in a climatic chamber (either at 20 °C, 55% RH and at 20 °C, 70% RH). A decreasing linear relation was established between IB and MC. It was found that this effect is reversible: after drying, internal bond strength rises again (following a slight hysteresis). This work reinforces the importance of conditioned storage before board properties analysis, as described in European Standard EN 319.

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Phongphetkul, P., Mangkang, S., Praditsmanont, A., Intrachooto, S., Choruengwiwat, J., Treesubsuntorn, C.*, et al.*
Evaluation of indoor air quality in high-rise residential buildings in Bangkok and factor analysis.
Environmental Monitoring and Assessment, Vol. **193** n°(1), (2021), 23 p.

High-rise residential developments are rapidly increasing in urban areas. Smaller residential units in this high rise bring a reduction in windows, resulting in poor indoor air ventilation. In addition, materials used in interiors can emit volatile organic compounds (VOCs), which can significantly affect human health. Since people spend 90% of their time indoors,

an evaluation of indoor air quality is especially important for high-rise residential buildings with an analysis of determining factors. This study aims to measure the concentrations of VOCs, formaldehyde, and particulate matter (PM2.5 and PM10) in 9 high-rise residential buildings in Bangkok by using the accidental sampling method (n = 252) and to investigate possible important determining factors. The results show that the average concentrations of VOCs, formaldehyde, PM2.5, and PM10 in 9 high-rise residential buildings were at good to moderate levels in the indoor air quality index (IAQI) and that high pollutant concentrations were rarely found except in new constructions. Moreover, it was found that the age of buildings shows strong correlations with all pollutants (p value < 0.0001). Old buildings showed significantly lower pollutant concentrations than new and under-construction buildings at a 95% confidence level. The findings from this investigation can be used as part of sustainable well-being design guidelines for future high-rise residential developments.

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Even, M., Wilke, O., Kalus, S., Schultes, P., Hutzler, C., Luch, A.
Formaldehyde Emissions from Wooden Toys: Comparison of Different Measurement Methods and Assessment of Exposure.
In: Materials (Basel, Switzerland). 2021.

Formaldehyde is considered as carcinogenic and is emitted from particleboards and plywood used in toy manufacturing. Currently, the flask method is frequently used in Europe for market surveillance purposes to assess formaldehyde release from toys, but its concordance to levels measured in emission test chambers is poor. Surveillance laboratories are unable to afford laborious and expensive emission chamber testing to comply with a new amendment of the European Toy Directive; they need an alternative method that can provide reliable results. Therefore, the application of miniaturised emission test chambers was tested. Comparisons between a 1 m³ emission test chamber and 44 mL microchambers with two particleboards over 28 days and between a 24 L desiccator chamber and the microchambers with three puzzle samples over 10 days resulted in a correlation coefficient r² of 0.834 for formaldehyde at steady state. The correlation between the results obtained in microchambers vs. flask showed a high variability over 10 samples (r²: 0.145), thereby demonstrating the error-proneness of the flask method in comparison to methods carried out under ambient parameters. An exposure assessment was also performed for three toy puzzles: indoor formaldehyde concentrations caused by puzzles were not negligible (up to 8 µg/m³), especially when more conservative exposure scenarios were considered.

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Even, M.
Formaldehyde emissions from wooden toys: Method comparison and exposure assessment.
Indoor Air 2020: The 16th conference of the international society of indoor air quality and climate, Online meeting

This study shows that formaldehyde Emission results in micro-scale emission chambers are comparable with results in bigger chambers both for particle boards and wooden toys. On the contrary, the WKI flask method was leading to more variable results depending on sample geometry. Thus, microchambers could be used for reliable routine market surveillance. An exposure assessment led to noticeable formaldehyde indoor air concentration values, pointing out the need for an effective Surveillance of such samples.

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Canha, N., Teixeira, C., Figueira, M., Correia, C.
How Is Indoor Air Quality during Sleep? A Review of Field Studies.
Atmosphere, Vol. **12** n°(1), (2021), 22 p.

This review aimed to provide an overview of the characterisation of indoor air quality (IAQ) during the sleeping period, based only on real life conditions' studies where, at least, one air pollutant was considered. Despite the consensual complexity of indoor air, when focusing on sleeping environments, the available scientific literature is still scarce and falls to provide a multipollutants' characterisation of the air breathed during sleep. This review, following PRISMA's approach, identified a total of 22 studies that provided insights of how IAQ is during the sleeping period in real life conditions. Most of studies focused on carbon dioxide (77%), followed by particles (PM2.5, PM10 and ultrafines) and only 18% of the studies focused on pollutants such as carbon monoxide, volatile organic compounds and formaldehyde.

Despite the high heterogeneity between studies (regarding the geographical area, type of surrounding environments, season of the year, type of dwelling, bedrooms' ventilation, number of occupants), several air pollutants showed exceedances of the limit values established by guidelines or legislation, indicating that an effort should be made in order to minimise human exposure to air pollutants. For instance, when considering the air quality guideline of World Health Organisation of 10 µg·m−3 for PM2.5, 86% of studies that focused this pollutant registered levels above this threshold. Considering that people spend one third of their day sleeping, exposure during this period may have a significant impact on the daily integrated human exposure, due to the higher amount of exposure time, even if this environment is characterised by lower pollutants' levels. Improving the current knowledge of air pollutants levels during sleep in different settings, as well as in different countries, will allow to improve the accuracy of exposure assessments and will also allow to understand their main drivers and how to tackle them.

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Tran Le, A. D., Zhang, J. S., Liu, Z.
Impact of humidity on formaldehyde and moisture buffering capacity of porous building material.
Journal of Building Engineering, Vol. **36**, (2021)

The aim of this article is to present a validated model to study the influence of humidity on formaldehyde sorption of building material and the effect of formaldehyde and moisture buffering capacity of hygroscopic porous material on indoor air environment. New empirical formulas proposed to describe the diffusion and partition coefficients as functions of humidity based on previous experimental data are incorporated in a coupled moisture and pollutants transport simulation model. The numerical model that takes into account the effect of RH (or moisture) in building materials on VOC diffusion can be used to simulate VOC emissions/sorption from building materials. The developed model is implemented in the environment SPARK (Simulation Problem Analysis and Research Kernel) using finite difference technique. The model is then applied to study the hygric and formaldehyde (FOR, a water soluble VOC) behavior of calcium silicate (CS) subjected to different dynamic conditions of RH and formaldehyde. The results obtained in this paper help to emphasize the importance of moisture and formaldehyde buffering capacity as a new key parameter when selecting clean and hygroscopic building materials in building design because they can contribute to dampen indoor RH and formaldehyde variations. In addition, the impact of RH variation is significant and needed to be taken into account in the simulation to correctly predict the indoor formaldehyde concentration. The model developed in this paper can also be used to optimize the hygric performance and IAQ in building.

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Aung, W.-Y., Sakamoto, H., Sato, A., Yi, E.-E.-P.-N., Thein, Z.-L., Nwe, M.-S.*, et al.*
Indoor Formaldehyde Concentration, Personal Formaldehyde Exposure and Clinical Symptoms during Anatomy Dissection Sessions, University of Medicine 1, Yangon.
International Journal of Environmental Research and Public Health, Vol. **18** n°(2), (2021)

The formaldehyde (FA) embalming method, the world's most common protocol for the fixation of cadavers, has been consistently used in medical universities in Myanmar. This study was designed to examine the indoor FA concentrations in anatomy dissection rooms, an exposed site, and lecture theater, an unexposed control site, and to access personal exposure levels of FA and clinical symptoms of medical students and instructors. In total, 208 second year medical students (1/2019 batch) and 18 instructors from Department of Anatomy, University of Medicine 1, participated. Thirteen dissection sessions were investigated from February 2019 to January 2020. Diffusive sampling devices were used as air samplers and high-performance liquid chromatography was used for measurement of FA. Average indoor FA concentration of four dissection rooms was 0.43 (0.09-1.22) ppm and all dissection rooms showed indoor concentrations above the occupational exposure limits and short-term exposure limit for general population. Personal FA exposure values were higher than indoor FA concentrations and the instructors (0.68, 0.04-2.11 ppm) had higher exposure than the students (0.44, 0.06-1.72 ppm). Unpleasant odor, eye and nose irritations and inability to concentrate were frequently reported FA-related symptoms, and the students were found to have significantly higher risks ($p < 0.05$) of having these symptoms during the dissection sessions than during lecture.

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Fu, N., Wei, P., Jia, Y., Zheng, X., Guan, J.
Indoor volatile organic compounds in densely occupied education buildings of four universities: Target list, concentration levels and correlation analysis.

Building and Environment, Vol. **191**, (2021)

Although significant progress had been made in characterizing indoor volatile organic compounds (VOCs) during the past decades, much was unknown considering the impact of human emissions on indoor VOCs in actual densely occupied spaces. In this context, this study investigated the indoor VOCs in densely occupied education buildings of four universities to identify the species, target list, concentration levels and possible relevance. A total number of 89 VOC species with high detection rate (≥50%) were mostly detected, including 24 alkanes and alkenes, 20 esters and alcohols, 14 ketones and aldehydes, 5 halides, 22 aromatics and 4 other VOCs. Among them, 33 VOC species were categorized into a target list determined by individual detection rate, concentration level and potential significance. The main concentration range of most individual targeted VOCs was 0–7.6 μg/m³ with a few exceptions. Several actual scenarios, including occupied condition, season and function room type were analyzed for identifying targeted VOCs and their possible factors correlated with human related emissions. The univariate analysis indicates that occupied condition, season, and function room type may yield a significant concentration difference of some targeted VOC individuals. However, no consistent results of each targeted VOC can be obtained under those three actual scenarios due to the complex effects of indoor natural ventilation, sources and sinks, T/RH and so on. This study could be a better understanding of actual indoor human-related VOC pollution in densely occupied buildings.

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Tan, Y., Zhi, Y., Gao, M., Cheng, Z., Yan, B., Nie, L.*, et al.*
Influence of temperature on formaldehyde emission parameters of solvent-based coatings.
Journal of Coatings Technology and Research, (2021)

Temperature affects the emission behavior of formaldehyde from coatings. Initial emittable concentration (C0), diffusion coefficient (Dm) and partition coefficient (K) are three key parameters for characterizing the formaldehyde emission from coatings. However, recent research concerning temperature effect on volatile organic compound (VOC) emission from coatings mainly focused on the influence on gas-phase concentration or emission rate, and few studies were conducted on the correlation between temperature and key emission factors (C0, Dm and K). In this work, formaldehyde emission from a solvent-based coating was measured at 10, 15, 20 and 25°C in a 30 L environmental chamber. From 10 to 25°C, C0 increased by 2.35-fold, and positive linear correlation was observed between ln(C0*T0.5) and 1/T. An empirical equation characterizing temperature effect on K was derived. Temperature effects on Dm were negligible. Through the obtained equations that can characterize the correlation between temperature and the key parameters, C0 and K at different temperatures from this work can be easily calculated. This study would be useful for predicting emission behavior of formaldehyde from solvent-based coatings and better understanding the influence of temperature.

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Zhang, H., Srinivasan, R., Ganesan, V.
Low Cost, Multi-Pollutant Sensing System Using Raspberry Pi for Indoor Air Quality Monitoring.
Sustainability, Vol. **13** n°(1), (2021)

Deteriorating levels of indoor air quality is a prominent environmental issue that results in long-lasting harmful effects on human health and wellbeing. A concurrent multi-parameter monitoring approach accounting for most crucial indoor pollutants is critical and essential. The challenges faced by existing conventional equipment in measuring multiple real-time pollutant concentrations include high cost, limited deployability, and detectability of only select pollutants. The aim of this paper is to present a comprehensive indoor air quality monitoring system using a low-cost Raspberry Pi-based air quality sensor module. The custom-built system measures 10 indoor environmental conditions including pollutants: temperature, relative humidity, Particulate Matter (PM)2.5, PM10, Nitrogen dioxide (NO2), Sulfur dioxide (SO2), Carbon monoxide (CO), Ozone (O3), Carbon dioxide (CO2), and Total Volatile Organic Compounds (TVOCs). A residential unit and an educational office building was selected and monitored over a span of seven days. The recorded mean PM2.5, and PM10 concentrations were significantly higher in the residential unit compared to the office building. The mean NO2, SO2, and TVOC concentrations were comparatively similar for both locations. Spearman rank-order analysis displayed a strong correlation between particulate matter and SO2 for both residential unit and the office building while the latter depicted strong temperature and humidity correlation with O3, SO2, PM2.5, and PM10 when compared to the former.

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D'amico, A., Pini, A., Zazzini, S., D'alessandro, D., Leuzzi, G., Currà, E.
Modelling VOC Emissions from Building Materials for Healthy Building Design.
Sustainability, Vol. **13** n°(1), (2021)

The profound qualitative changes of indoor air and the progressive increase in the absolute number of pollutants, combined with the scientific awareness of the health impacts deriving from spending more than 90% of one’s time inside confined spaces, have increased the attention onto the needs of well-being, hygiene, and the health of users. This scientific attention has produced studies and analyses useful for evidence-based insights into building performance. Among the main pollutants in the indoor environment, Volatile Organic Compounds (VOCs) play a central role, and the use of box-models using the mass balance approach and Computational Fluid Dynamics (CFD) models are now consolidated to study their concentrations in an indoor environment. This paper presents the use of both types of modelling for the prediction of the VOC concentration in the indoor environment and the proposal of a guide value for the Indoor Air Quality (IAQ)-oriented building design, specifically related to the indoor VOC concentration due to building materials. Methodologically, the topic is addressed through environmental sampling, the definition of the parameters necessary for the numerical models, the simulations with the box-model and the CFD, and the comparison between the results. They show a good correspondence between the modelling tools used, highlighting the central role of ventilation and allowing a discussion of the relationship between regulatory limits of emissivity of materials and Indoor Air Guide Values for the concentration of pollutants.

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Richter, M., Horn, W., Juritsch, E., Klinge, A., Radeljic, L., Jann, O.
Natural Building Materials for Interior Fitting and Refurbishment—What about Indoor Emissions ?
Materials, Vol. **14** n°(1), (2021)

Indoor air quality can be adversely affected by emissions from building materials, consequently having a negative impact on human health and well-being. In this study, more than 30 natural building materials (earth dry boards and plasters, bio-based insulation materials, and boards made of wood, flax, reed, straw, etc.) used for interior works were investigated as to their emissions of (semi-)volatile organic compounds ((S)VOC), formaldehyde, and radon. The study focused on the emissions from complete wall build-ups as they can be used for internal partition walls and the internal insulation of external walls. Test chambers were designed, allowing the compounds to release only from the surface of the material facing indoors under testing parameters that were chosen to simulate model room conditions. The emission test results were evaluated using the AgBB evaluation scheme, a procedure for the health-related evaluation of construction products and currently applied for the approval of specific groups of building materials in Germany. Seventeen out of 19 sample build-ups tested in this study would have passed this scheme since they generally proved to be low-emitting and although the combined emissions of multiple materials were tested, 50% of the measurements could be terminated before half of the total testing time.

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Lin, N., Rosemberg, M.-A., Li, W., Meza-Wilson, E., Godwin, C., Batterman, S.
Occupational exposure and health risks of volatile organic compounds of hotel housekeepers: Field measurements of exposure and health risks.
Indoor Air, Vol. **31** n°(1), (2021), 26-39 p.

Abstract Hotel housekeepers represent a large, low-income, predominantly minority, and high-risk workforce. Little is known about their exposure to chemicals, including volatile organic compounds (VOCs). This study evaluates VOC exposures of housekeepers, sources and factors affecting VOC levels, and provides preliminary estimates of VOC-related health risks. We utilized indoor and personal sampling at two hotels, assessed ventilation, and characterized the VOC composition of cleaning agents. Personal sampling of hotel staff showed a total target VOC concentration of 57 ± 36 µg/m3 (mean ± SD), about twice that of indoor samples. VOCs of greatest health significance included chloroform and formaldehyde. Several workers had exposure to alkanes that could cause non-cancer effects. VOC levels were negatively correlated with estimated air change rates. The composition and concentrations of the tested products and air samples helped identify possible emission sources, which included building sources (for formaldehyde), disinfection by-products in the laundry room, and cleaning products. VOC levels and the derived health risks in this study were at the lower range found in the US buildings. The excess lifetime cancer risk (average of 4.1x10-5) still

indicates a need to lower exposure by reducing or removing toxic constituents, especially formaldehyde, or by increasing ventilation rates.

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Mcneil, S.
The Removal of Indoor Air Contaminants by Wool Textiles.
Technical Bulletin AgResearch, (2015)

Indoor air pollution is the primary cause of Sick Building Syndrome and the associated discomfort, ill health and reduced productivity. Indoor air quality is a public health concern that is receiving increasing attention, in part, because people are spending a higher proportion of their time indoors. The problem is exacerbated by the tendency for new buildings to have air conditioning, which requires a semi-sealed environment to operate efficiently. This, in effect, traps the pollutants inside.

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Li, J., Li, B., Sui, G., Du, L., Zhuang, Y., Zhang, Y., *et al.*
Removal of volatile organic compounds from air using supported ionic liquid membrane containing ultraviolet-visible light-driven Nd-TiO2 nanoparticles.
Journal of Molecular Structure, (2021)

Volatile organic compounds (VOCs) with toxicity properties discharged from industrial emissions and combustion engines threaten human health and cause environmental problems. Therefore, it is important to develop technologies to remove VOCs from air. In this study, the performance of Nd (neodymium) -TiO2 nanoparticles embedded in a supported ionic liquid membrane (SILM) for removal of VOCs from air was investigated. Aiming at functionalizing the ionic liquid membrane with photocatalytic capability, we developed a facile and effective approach for the removal of VOCs by coupling highly efficient photocatalysts with the SILM. Nd-TiO2 nanoparticles, which are ultraviolet-visible (UV-Vis) light-driven photocatalysts, were prepared by sol-gel and immersed in the SILM for use as a photocatalytic membrane-based reactor. The gaseous VOCs tested were toluene, acetone, chloroform, benzene, and xylene. We confirmed that at a loading of 50 wt% Nd-TiO2 nanoparticles (1 wt% Nd content) and 1-hexyl-3-methylimidazolium hexafluorophosphate ([HMIm]PF6) as SILM ([HMIm]PF6/Nd-TiO2 SILM), the as-prepared photocatalytic membrane-based reactor exhibited higher removal efficiency of VOCs from air (60∼80% removal after 10 h) under UV-Vis light illumination than individual SILM or photocatalytic systems. Effluent gas analysis revealed that 25–55% of VOCs was decomposed and mineralized in the photocatalytic membrane reactor, which exhibited higher VOCs removal efficiency than membrane separation. These results indicate that the photocatalytic membrane-based reactor containing Nd-TiO2 nanoparticles and SILM designed in this study is highly active and stable. This study on [HMIm]PF6/Nd-TiO2 SILM was initiated to couple membrane separation with photocatalytic degradation of gaseous VOCs and can serve as a promising way for eliminating harmful VOCs with low concentration from air.

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Benjamin, M. L., Arnold, S., Rao, M., Davis, K., Maier, A., Virkutyte, J.
Ventilation and posture effects on inhalation exposures to volatile cleaning ingredients in a simulated domestic worker cleaning environment.
Indoor Air, Vol. **31** n°(1), (2021), 128-140 p.

Abstract Associations between cleaning chemical exposures and asthma have previously been identified in professional cleaners and healthcare workers. Domestic workers, including housecleaners and caregivers, may receive similar exposures but in residential environments with lower ventilation rates. Study objectives were to compare exposures to occupational exposure limits (OELs), to determine relative contributions from individual cleaning tasks to overall exposure, and to evaluate the effects of ventilation and posture on exposure. Airborne chemical concentrations of sprayed cleaning chemicals (acetic acid or ammonia) were measured during typical cleaning tasks in a simulated residential work environment. Whole-house cleaning exposures (18 cleaning tasks) were measured using integrated personal sampling methods. Individual task exposures were measured with a sampling line attached to subjects' breathing zones, with readings recorded by a ppbRAE monitor, equipped with a photoionization detector calibrated for ammonia and acetic acid measurements. Integrated sampling results indicated no exposures above OELs occurred, but 95th percentile air concentrations would require risk management decisions. Exposure reductions were observed with

increased source distance, with lower exposures from mopping floors compared to kneeling. Exposure reductions were also observed for most but not all tasks when ventilation was used, with implications that alternative exposure reduction methods may be needed.

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Grinins, J., Biziks, V., Marais, B. N., Rizikovs, J., Militz, H.
Weathering Stability and Durability of Birch Plywood Modified with Different Molecular Weight Phenol-Formaldehyde Oligomers.
Polymers, Vol. **13** n°(2), (2021)

This study investigated the effect of phenol-formaldehyde (PF) resin treatment on the weathering stability and biological durability of birch plywood. Silver birch (Betula pendula) veneers were vacuum-pressure impregnated with four different PF resins with average molecular weights (Mw) of 292 (resin A), 528 (resin B), 703 (resin C), and 884 g/mol (resin D). The aging properties of PF resin modified birch plywood were analyzed using artificial weathering with ultraviolet (UV) light, UV and water spray, and weathering under outdoor conditions. The same combinations of PF-treated plywood specimens were then tested in soil-bed tests to determine their resistance against soft-rot wood decay. It was not possible to compare weathering processes under artificial conditions to processes under outdoor conditions. However, the weathering stability of birch plywood treated with PF resins A, B, and C, scored better than plywood treated with commercial resin D (regardless of solid content concentration [%]). Results from unsterile soil bed tests showed improvements in resistance to soft-rot wood decay compared to untreated plywood and solid wood. Mass loss [%] was lowest for birch plywood specimens treated with resin of highest solid content concentration (resin D, 20%). Provisional durability ratings delivered durability class (DC) ratings of 2–3, considerably improved over untreated solid wood and untreated birch plywood (DC 5).

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