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Qualité de l’air intérieur

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Vallecillos, L., Riu, J., Marce, R. M., Borrull, F.
Air monitoring with passive samplers for volatile organic compounds in atmospheres close to petrochemical industrial areas. The case study of Tarragona (2019-2021).
Atmospheric Pollution Research, Vol. **15** n°(2), (2024)

This study reports a three-year monitoring campaign of 62 volatile organic compounds (VOCs) of increasing concern in urban atmospheres near petrochemical industrial areas. A total of 770 air samples were taken during the sampling campaigns conducted monthly between January 2019 and December 2021. The analytical method applied involved a 14-day passive sampling in Carbopack X tubes followed by thermal desorption-gas chromatography-mass spectrometry (TD-GC-MS). To gain insight into the correlations between VOCs, multivariate data analysis was used to assess the similarities and differences between datasets. Special attention was paid to benzene, 1,3-butadiene and 1,2-dichloroethane, because they are carcinogenic and are produced, handled and stored in the petrochemical industrial areas studied. The compounds found in the highest concentrations were alkanes, which were 21-66% of the total. Aromatic hydrocarbons and solvents were also detected at all the sampling sites, with BTEX and ethanol as the most prevalent compounds. Various concentration peaks of up to 4.8 mu g m(-3) for benzene and up to 4.0 mu g m(-3) for 1,3-butadiene were detected during the monitoring campaigns performed. Nevertheless, the average concentrations of these two compounds were always below the values set in the current air quality regulations, with maximum values of 1.3 mu g m(-3) for benzene and 1.5 mu g m(-3) for 1,3-butadiene near the North industrial park of Tarragona. Multivariate analysis results revealed four different patterns at the reference sites and discriminated between the sampling sites close to the petrochemical areas evaluated. The autumn-winter months, with thermal inversion phenomena and prevailing north and north-westerly winds, were the ones with the highest concentration levels of VOCs.

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Ferreira, T., Homem, V., Cereceda-Balic, F., Fadic, X., Alves, A., Ratola, N.
Are volatile methylsiloxanes in downcycled tire microplastics? Levels and human exposure estimation in synthetic turf football fields.
Environmental Science and Pollution Research, (2024)

Downcycled rubber, derived from end-of-life tires (ELTs), is frequently applied as crumb rubber (CR) as infill of synthetic turf in sports facilities. This practice has been questioned in recent years as numerous studies have reported the presence of potentially hazardous chemicals in this material. CR particles fall into the category of microplastics (MPs), making them possible vectors for emerging micropollutants. A preliminary study where volatile methylsiloxanes (VMSs) were found in CR originated the hypothesis that VMSs are present in this material worldwide. Consequently, the present work evaluates for the first time the levels and trends of seven VMSs in CR from synthetic turf football fields, while attempting to identify the main sources and impacts of these chemicals. A total of 135 CR samples and 12 other of alternative materials were analyzed, employing an ultrasound-assisted dispersive solid-phase extraction followed by gas chromatography–mass spectrometry (GC–MS), and the presence of VMSs was confirmed in all samples, in total concentrations ranging from 1.60 to 5089 ng.g−1. The levels were higher in commercial CR (before field application), a reflection of the use of VMS-containing additives in tire production and/or the degradation of silicone polymers employed in vehicles. The VMSs generally decreased over time on the turf, as expected given their volatile nature and the wearing of the material. Finally, the human exposure doses to VMSs in CR (by dermal absorption and ingestion) for people in contact with synthetic turf in football fields were negligible (maximum total exposure of 20.5 ng.kgBW−1.year−1) in comparison with the European Chemicals Agency (ECHA) reference doses: 1.35 × 109 ng.kgBW−1.year−1 for D4 and 1.83 × 109 ng.kgBW−1.year−1 for D5. Nevertheless, more knowledge on exposure through inhalation and the combined effects of all substances is necessary to provide further corroboration. This work proved the presence of VMSs in CR from ELTs, another family of chemical of concern to take into account when studying MPs as vectors of other contaminants.

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Ebrahimi, V., Yarahmadi, R., Salehi, M., Ashtarinezhad, A.
Assessing occupational exposure of airborne PMs and TVOCs in the nail salons in Tehran city, Iran.
Heliyon, Vol. **9** n°(12), (2023)

There are concerns about the health of nail salon technicians due to the inherently harmful agents such as volatile organic compounds (VOCs) and released particles in the salons. For this reason, this study was conducted to investigate the occupational exposure of nail salon technicians to VOCs and particulate matters (PMs) in the nail salons in Tehran, Iran. In this cross-sectional study, indoor air quality and measurement continually Total VOCs and PMs in the various size of PM1-PM10 using PhoCheck Tiger and particle counter device investigated, respectively. site observation, and an interview with the manager in 49 salons in Tehran. Data was analyzed using SPSS software (version 22). Mean concentrations of PM1 with 2.56 mu g/m3 was the lowest amount and PM10 with 346.86 mu g/m3 had the highest concentration. Also, the mean concentration of TVOCs was equal 2.61 ppm. The results of the regression model showed that there is a statistically significant between the number of services with airborne PMs (PM2.5), (p-Value <= 0.050). In salons only with nail activities, the concentration of PM4 was less than the others, although this correlation was statistically significant just for PM1 (p-Value = 0.010). By implementing effective local exhaust ventilation systems equipped with dust collectors and utilizing safe products, the emission of particles and chemical compounds within salons can be significantly reduced.

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Takaguchi, K., Nakaoka, H., Tsumura, K., Eguchi, A., Shimatani, K., Nakayama, Y., *et al.*
The association between clustering based on composition of volatile organic compound in indoor air and building-related symptoms.
Science of The Total Environment, Vol. **917**, (2024)

Volatile organic compounds (VOCs) have been suspected to cause building-related symptoms (BRSs). Although some studies investigated the association between BRSs and VOCs in indoor air, those results were inconsistent. This study investigated the contamination status of VOCs in the indoor air of 154 houses in Japan. Additionally, these samples were grouped by hierarchical clustering analysis based on the VOC composition, and the relationship between a VOC cluster and the BRSs was investigated. The median concentration of the sum of VOCs (ΣVOCs) was 140 μg m−3 (range: 18–3500 μg m−3). The levels of acetaldehyde in four samples and p-dichlorobenzene in one sample exceeded the guideline value. As a result of the hierarchical clustering analysis, the samples in this study were divided into six characteristic clusters based on the VOC composition. The ΣVOCs in cluster 1 were significantly lower than those in other clusters. In cluster 2, acyclic and aromatic hydrocarbons were dominant. Cluster 3 had a relatively high proportion of limonene. In cluster 4, the concentrations and composition ratios of α-pinene were higher than those of other clusters. In cluster 5, p-dichlorobenzene accounted for 42 %–72 % of the total VOCs. Cluster 6 had a relatively high proportion of decamethyl cyclopentasiloxane. This clustering likely depended on the construction of houses and lifestyles. As a result of logistic regression analysis, cluster 5 was associated with the cough symptoms of the BRSs. The results of the present study suggest that investigating the association between VOCs and BRSs is necessary to consider not only total concentrations such as TVOC and ΣVOCs but also VOC composition.

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Lee, S., Ryu, S.-H., Sul, W. J., Kim, S., Kim, D., Seo, S.
Association of exposure to indoor molds and dampness with allergic diseases at water-damaged dwellings in Korea.
Scientific Reports, Vol. **14** n°(1), (2024), 135 p.

This study aims to characterize levels of molds, bacteria, and environmental pollutants, identify the associations between indoor mold and dampness exposures and childhood allergic diseases, including asthma, allergic rhinitis, atopic dermatitis, using three different exposure assessment tools. A total of 50 children with their parents who registered in Seoul and Gyeonggi-do in Korea participated in this study. We collated the information on demographic and housing characteristics, environmental conditions, and lifestyle factors using the Korean version of the International Study of Asthma and Allergies in Childhood questionnaire. We also collected environmental monitoring samples of airborne molds and bacteria, total volatile organic compounds, formaldehyde, and particulate matter less than 10 μm. We evaluated and determined water damage, hidden dampness, and mold growth in dwellings using an infrared (IR) thermal camera and field inspection. Univariate and multivariate regression analyses were performed to evaluate the associations between prevalent allergic diseases and exposure to indoor mold and dampness. Indoor mold and bacterial

levels were related to the presence of water damage in dwellings, and the mean levels of indoor molds (93.4 ± 73.5 CFU/m3) and bacteria (221.5 ± 124.2 CFU/m3) in water-damaged homes were significantly higher than those for molds (82.0 ± 58.7 CFU/m3) and for bacteria (152.7 ± 82.1 CFU/m3) in non-damaged dwellings ($p < 0.05$). The crude odds ratios (ORs) of atopic dermatitis were associated with < 6th floor (OR = 3.80), and higher indoor mold (OR = 6.42) and bacterial levels (OR = 6.00). The crude ORs of allergic diseases, defined as a group of cases who ever suffered from two out of three allergic diseases, e.g., asthma and allergic rhinitis, and allergic rhinitis were also increased by 3.8 and 9.3 times as large, respectively, with water damage (+) determined by IR camera ($p < 0.05$). The adjusted OR of allergic rhinitis was significantly elevated by 10.4 times in the water-damaged dwellings after adjusting age, sex, and secondhand smoke. Therefore, a longitudinal study is needed to characterize dominant mold species using DNA/RNA-based sequencing techniques and identify a causal relationship between mold exposure and allergic diseases in the future.

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Li, Y., Fan, Y., Wei, Y., Liu, M., Xu, B., Ye, W.
Can portable air cleaners reconcile conflicting needs for open-door/window autonomy and indoor air quality for occupants in densely populated offices?
Applied Energy, Vol. **358**, (2024)

Conventional wisdom advises keeping windows and doors closed in air-conditioned or mechanically-ventilated space. However, this guideline often proves challenging in high-occupancy offices, where the constant influx and egress of individuals, coupled with a strong inclination toward open windows, trigger occupant-induced ventilation (OV) that can affect indoor air quality (IAQ) and energy consumption. To address this, we explored using portable air cleaners (PACs) as a cost-effective ventilation strategy to replace mechanical ventilation (MV) while maintaining IAQ and respecting occupant freedom. We conducted a single-blind trial in a 100 m2 office in Shanghai from December 2020 to March 2021, measuring 857 h of indoor and outdoor temperatures, CO2 and PM2.5 concentrations, and occupant behaviors. We obtained 618 valid subjective responses and conducted a 14-day test to measure possible by-products, such as O3, formaldehyde, and VOCs, during the operation of PACs. The results showed that, first, although MV achieved 2–3 times higher air change rates than PACs, indoor CO2 concentrations remained below 1000 ppm, the commonly accepted threshold, using PACs in the presence of OV. Second, PACs effectively reduced PM2.5 levels during outdoor PM2.5 peaks. Third, occupants' perceived IAQ did not differ between the use of PACs and MV ($p>0.05$), although individuals with PACs in the afternoon reported slightly increased sleepiness ($p<0.05$). Fourth, in the presence of OV, PACs demonstrated significant energy-saving potential in improving IAQ. Our study showed PACs can be a cost-effective method to replace MV while maintaining IAQ and preserving occupant freedom.

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Ribeiro, B., Vázquez-López, A., Vazquez-Pufleau, M., Llamosí, M., Sempere, J., Yuste, J.*, et al.*
Control of microbial agents by functionalization of commercial air filters with metal oxide particles.
Materials Chemistry and Physics, Vol. **313**, (2024)

According to the World Health Organization, low-quality air results in 3.2 million premature annual deaths of which 21 % are attributed to respiratory infections. The recent coronavirus (COVID-19) pandemic, responsible for millions of deaths worldwide, has highlighted the issue of airborne pathogens on human health. Air filtration is an established method to ensure good indoor air quality, being effective at capturing airborne particles and dust, as well as pathogens, and preventing diseases such as asthma. Nevertheless, with usage, water from air humidity, dust, and dirt, including fungi and bacteria spores, can accumulate on filters creating ideal conditions for the propagation of microorganisms. Thus, the filter can become a secondary source for airborne pathogens. In this work, antiviral and antibacterial filters were prepared by spray coating Ag2O, CuO, and ZnO particles into commercially available air filters. The reliability of the filters was tested through particle release in air, through a scanning mobility particle sizer, and filtration performance was measured against an aerosol of iron nanoparticles in nitrogen gas produced through a spark discharge generator. Additionally, the biosafety of the filters was measured in vitro through cytotoxicity tests against L-929 mouse fibroblast cells. Antibacterial activity was measured in vitro against two clinically relevant pathogens: Streptococcus pneumoniae and Pseudomonas aeruginosa and the anti-viral performance was measured against human respiratory syncytial virus. In general, the results have shown that spray coating is a reliable solution, with no detectable cytotoxicity effects or particle release in the air. After functionalization, both Ag2O and CuO compounds have been shown to have total

antiviral activity (over 99 %), while only Ag2O presented a clear antibacterial action. In conclusion, spray coating as post-manufacturing functionalization of air filters can be an efficient and low-cost solution against airborne pathogens.

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Liu, M. M., Nejat, P., Cao, P. L., Jimenez-Bescos, C., Calautit, J. K.
A critical review of windcatcher ventilation: Micro-environment, techno-economics, and commercialisation.
Renewable & Sustainable Energy Reviews, Vol. **191**, (2024)

Windcatcher natural ventilation is a low-energy approach that can provide effective ventilation during favour-able weather conditions. When combined with different cooling, heating, and dehumidification technologies, windcatchers can provide enhanced indoor environment quality. This work provides a critical review of wind-catchers' performance. It covers aspects such as ventilation, thermal comfort, overheating risk, indoor air quality (IAQ), energy performance, economic cost, and life cycle assessment (LCA). Although many studies have investigated windcatchers' performance in terms of thermal comfort, little attention has been paid to the po-tential overheating risk. This oversight is particularly important in the context of global warming trends and the increasing likelihood of extreme weather conditions. Moreover, previous studies on windcatchers' IAQ perfor-mance have primarily focused on indoor CO2 concentrations, while the influences of pollutants such as volatile organic compounds (VOCs) have not been reported. The quantification of energy performance for windcatchers remains an underexplored area, and very few studies have conducted economic analyses or LCAs of windcatcher systems. There is a clear need for more field experiments to investigate these aspects comprehensively. This review also provides insights into the current trends and future perspectives in the commercial windcatcher market, including available options, opportunities, and threats. The findings highlight the importance of several factors that must be considered before the large-scale commercial rollout of windcatcher technology. These include the lack of awareness and regulatory incentives, cost considerations, aesthetic preferences, and mis-conceptions or concerns regarding the effectiveness of windcatchers.

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Yu, T., Wang, Y., Chen, L. F., Leng, W. J., Shi, Y., Lin, B. C*., et al.*
Determination of uptake rates of volatile organic compounds by 24-hour passive sampling and their application in enclosed ship cabin environments.
Building and Environment, Vol. **248**, (2024)

Effective and reliable uptake rates are crucial for applying passive samplers in monitoring gaseous volatile organic compounds (VOCs). However, there is currently a lack of data regarding the 24-h passive uptake rates of VOCs for workplace and environmental monitoring. This study aims to address this gap by utilizing a Tenax TAbased sampling tube to investigate the 24-h uptake rates of 25 kinds of VOCs in enclosed ship cabin environments. The results reveal that the uptake rate of VOCs ranges from 0.32 to 0.44 mL/min. A relationship between diffusive uptake rates and the boiling point of the compounds is proposed. The variation in uptake rate under different sampling durations was examined. The difference in uptake rate between 24 h and 8 h was smaller than that between 24 h and 6 days, with an average difference of 20%. In addition, the indoor uptake rate obtained in this study was compared with the outdoor uptake rates in the literature, and results showed that the outdoor uptake rate was generally higher than the indoor uptake rate, but the difference decreased when the sampling duration was longer. Field measurement was conducted by utilizing the measured uptake rates to characterize VOC pollution in both living and engine cabins in actual ships. This study contributes to facilitating the evaluation of environmental daily average concentrations in enclosed ship cabins, which will be helpful for assessing the effectiveness of air pollution control systems or epidemiological studies in ships.

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Dadras, M.
Développement d'une membrane biosourcée pour l'enveloppe du bâtiment.
Faculté de foresterie, de géographie et de géomatique - Département des sciences du bois et de la forêt. Université Laval, Québec. Thèse 2023

L’enveloppe du bâtiment comprends un enchaînement de matériaux permettant de remplir les fonctions nécessaires pour assurer la durabilité et l’efficacité énergétique des bâtiments. Dans un climat froid comme le Canada, la concentration de vapeur d’eau à l’intérieur des bâtiments est plus élevée que dans l’environnement extérieur, ce qui entraîne une migration de l’humidité à travers le mur du bâtiment. Par conséquent, une membrane devrait être

installée dans l'enveloppe du bâtiment pour contrôler la transmission de l'humidité. Les membranes conventionnelles sont principalement des matériaux fossiles qui peuvent avoir plusieurs impacts négatifs sur l'environnement. La présente thèse, divisée en trois axes, a été consacrée au développement de membranes entièrement biosourcées pour l'application de l'enveloppe du bâtiment à partir de biopolymères et de microfibres de cellulose (CMF). Pour améliorer la dispersibilité des CMF dans la matrice polymère, trois méthodes de modification ont été conduites. Le premier axe s'est concentré sur la modification hydrophile des CMF avec le compatibilisant avec du polyéthylène glycol (PEG). Dans le deuxième axe, les CMF ont été modifiées avec de l'acide lactique (LA) via une réaction d'estérification, et l'impact environnemental des membranes développées a été étudié. Enfin, au cours du troisième axe, des membranes pare-vapeur à structure sandwich ont été développées à partir de biopolymères et de CMF modifiées par sol-gel, et leurs propriétés mécaniques et barrières ont été étudiées. De plus, un test de durabilité a été réalisé pour déterminer l'effet du vieillissement artificiel sur les propriétés des composites sandwich. Les résultats ont démontré que les propriétés mécaniques et barrières des composites incorporés avec des CMF non traitées ont diminué après le vieillissement artificiel, alors que les composites renforcés avec des CMF modifiés par sol-gel ont connu le moins de changement.

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Harding-Smith, E., Shaw, D. R., Shaw, M., Dillon, T. J., Carslaw, N.
Does green mean clean? Volatile organic emissions from regular versus green cleaning products.
Environmental Science: Processes & Impacts, (2024)

Cleaning products emit a range of volatile organic compounds (VOCs), including some which are hazardous or can undergo chemical transformations to generate harmful secondary pollutants. In recent years, "green" cleaners have become increasingly popular, with an implicit assumption that these are better for our health and/or the environment. However, there is no strong evidence to suggest that they are better for indoor air quality compared to regular products. In this study, the VOC composition of 10 regular and 13 green cleaners was examined by headspace analysis. Monoterpenes were the most prevalent VOCs, with average total monoterpene concentrations of 8.6 and 25.0 mg L−1 for regular and green cleaners, respectively. Speciated monoterpene emissions were applied to a detailed chemical model to investigate the indoor air chemistry following a typical cleaning event. Green cleaners generally emitted more monoterpenes than regular cleaners, resulting in larger increases in harmful secondary pollutant concentrations following use, such as formaldehyde (up to 7%) and PAN species (up to 6%). However, emissions of the most reactive monoterpenes (α-terpinene, terpinolene and α-phellandrene), were observed more frequently from regular cleaners, resulting in a disproportionately large impact on the concentrations of radical species and secondary pollutants that were formed after cleaning occurred.

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Schumacher, S., Caspari, A., Schneiderwind, U., Staack, K., Sager, U., Asbach, C.
The Drawback of Optimizing Air Cleaner Filters for the Adsorption of Formaldehyde.
Atmosphere, Vol. **15** n°(1), (2024)

Air cleaners with activated carbon (AC) filters for the adsorption of gaseous pollutants are often used to improve indoor air quality. As formaldehyde is a common and health-relevant indoor air pollutant, many testing standards for air cleaners, such as GB/T 18801:2015, require the cleaning efficacy to be tested with this substance. This often persuades manufacturers to optimize the employed filters specifically for formaldehyde. However, in regions where indoor formaldehyde levels are far below the guideline values, other gaseous pollutants might be more relevant. Thus, the question arises of whether the optimization for formaldehyde can have a negative impact on the adsorption of other gases. To address this question, the clean air delivery rate (CADR) of an air cleaner was determined for different test gases with either a standard AC filter or an AC filter modified for improved formaldehyde adsorption. Although the modified AC filter performed substantially better for formaldehyde, a strong reduction in the CADR was observed for toluene and nitrogen dioxide. This is a drawback for situations in which these gases are more problematic than formaldehyde. The findings suggest using either specialized filters for different applications or blends of different adsorbants to find the best compromise for the most relevant pollutants.

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Norvihoho, L. K., Yin, J., Liu, Y., Yu, H.-T., Jiang, Y., Zhou, Z.-F., Chen, B.
The effects of desk-partition layout on cough droplet dynamics relating to seasonal influenza.
Physics of Fluids, Vol. **36** n°(1), (2024)

The use of physical dividers as control measures for short-range viral transmission in indoor settings has gained increasing attention. However, the understanding regarding their correct usage under different seating arrangements is incomplete. In this study, we focused on assessing the effectiveness of physical dividers in impeding the transient transmission of cough droplets in three representative layouts using the large-eddy simulation technique with the Eulerian–Lagrangian model. We computationally also investigated the effects of ventilation on viral droplet transmission under three representative desk-divider layouts. The ventilation approach was tested using two different ventilation rates (1.0 and 1.8 m/s). A comparative analysis of the ventilation flow fields, topologies, and particle directions has been studied. The findings indicate that the sitting arrangements, ventilation rates, and partition layouts play a significant role in designing effective control measures for indoor infection under the office setup considered. The protected occupied zone ventilation (POV) worked best in situations of low ventilation (1.0 m/s) for cross-partition in protecting the three healthy persons. In addition, the POV performed well for low (1.0 m/s) and high (1.8 m/s) ventilation rates for face-to-face layout. The side-by-side configuration performed poorly for the POV considered in protecting the healthy person seated directly opposite the infected person. The numerical predictions may be used to validate other experimental studies and educate office workers and engineers on indoor airborne infection control.

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Pandey, S., Mishra, S. O.
Electronic sensors for detecting polluton due to organic gases using parafac technology.
International Journal of Scientific Research in Engineering and Management, (2023)

Due to health-related environmental regulations, the detection of volatile organic compounds (VOCs) is becoming increasingly important. Normal VOCs are benzene, naphthalene, formaldehyde, and tetra chloroethylene; however, there are a lot more in the climate and in application. They can cause skin irritation and respiratory infections if you are exposed to them. Interest is filling in as of late in guideline of scent builds having a direct/circuitous impact. The odor monitoring of volatile organic compounds (VOCs) with MOS sensors is the primary focus of this article. The goal is to create and improve a VOCs detector model that can be used for indoor and outdoor environmental monitoring, both at the source and on the impact side, for a variety of industries.

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Jung, C. L., Mahmoud, N. S. A., Alqassimi, N.
Enhancing indoor air quality and sustainable living in newly constructed apartments: insights from Dubai.
Frontiers in Built Environment, Vol. **9**, (2023)

This research paper examines Indoor Air Quality (IAQ) conditions in newly constructed apartments in Dubai to be more sustainable for residents to have healthier lifestyles. Enhanced airtightness and chemical-laden materials contribute to IAQ pollution in these buildings. The study aims to assess pollutant concentrations and variations based on building height. Measurements were conducted in 12 apartment units using the WHO's IAQ assessment methodology. Most pollutants were within limits, but TVOC exceeded the Dubai Municipality's standard, measuring at 2634.4 mu g/m(3), approximately nine times higher than the standard. HCHO (163.4 mu g/m(3)) and toluene (551.4 mu g/m(3)) were identified as significant pollutants with potential health effects. Analysis of pollutant concentrations based on building height revealed higher TVOC levels in upper areas, with 2,828 mu g/m(3) in the upper area compared to 2,443 mu g/m(3) in the lower area, indicating more severe indoor air pollution in Ethylbenzene and styrene also highest in upper areas, with ethylbenzene at 122 mu g/m(3) and styrene at 82 mu g/m(3) in the upper area, potentially due to elevated sources. Toluene and xylene concentrations were elevated in the middle area, with toluene at 574 mu g/m(3) and xylene at 321 mu g/m(3), likely influenced by materials and occupant activities. Benzene concentrations were consistent across all heights at 2.94 mu g/m(3), suggesting a common source. HCHO concentrations were relatively consistent but slightly higher in the middle and upper areas, with 171 mu g/m(3) in both, likely influenced by ventilation and emissions. While average pollutant concentrations met WHO standards, many units exceeded recommended limits, requiring targeted interventions. The study highlights the importance of addressing IAQ concerns and implementing strategies to reduce indoor air pollutants and improve ventilation. These findings contribute to IAQ knowledge in Dubai's residential buildings, guiding policymakers, architects, and developers in effective policies and guidelines. Further research on seasonal variations and other IAQ factors is recommended for better understanding and long-term monitoring. Prioritizing IAQ in newly constructed apartments is crucial for healthier living in Dubai. The residential building sector can protect residents' health by implementing appropriate measures while delivering upscale living experiences.

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Van Den Brekel, L., Lenters, V., Mackenbach, J. D., Hoek, G., Wagtendonk, A., Lakerveld, J.*, et al.*
Ethnic and socioeconomic inequalities in air pollution exposure: a cross-sectional analysis of nationwide individual-level data from the Netherlands.
The Lancet Planetary Health, Vol. **8** n°(1), (2024), e18-e29 p.

Background
Air pollution contributes to a large disease burden and some populations are disproportionately exposed. We aimed to evaluate ethnic and socioeconomic differences in exposure to air pollution in the Netherlands.
Methods
We did a nationwide, cross-sectional analysis of all residents of the Netherlands on Jan 1, 2019. Sociodemographic information was centralised by Statistics Netherlands and mainly originated from the National Population Register, the tax register, and education registers. Concentrations of NO2, PM2·5, PM10, and elemental carbon, modelled by the National Institute for Public Health and the Environment, were linked to the individual-level demographic data. We assessed differences in air pollution exposures across the 40 largest minority ethnic groups. Evaluation of how ethnicity intersected with socioeconomic position in relation to exposures was done for the ten largest ethnic groups, plus Chinese and Indian groups, in both urban and rural areas using multivariable linear regression analyses.
Findings
The total study population consisted of 17 251 511 individuals. Minority ethnic groups were consistently exposed to higher levels of air pollution than the ethnic Dutch population. The magnitude of inequalities varied between the minority ethnic groups, with 3–44% higher exposures to NO2 and 1–9% higher exposures to PM2·5 compared with the ethnic Dutch group. Average exposures were highest for the lowest socioeconomic group. Ethnic inequalities in exposure remained after adjustment for socioeconomic position and were of similar magnitude in urban and rural areas.
Interpretation
The variability in air pollution exposure across ethnic and socioeconomic subgroups in the Netherlands indicates environmental injustice at the intersection of social characteristics. The health consequences of the observed inequalities and the underlying processes driving them warrant further investigation.

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Ayeni, O., Ibrahim, E. C., Stanley, A. M., Abdulsalam, D., Isah, I., Lawal, F. M., Agada, V. O.
Evaluation of air pollutants concentration in the indoor spaces of printing presses in Zaria metropolis.
Journal of Contemporary Research in the Built Environment, (2022)

Purpose: Indoor Air Quality (IAQ) is becoming an increasingly important building design consideration due to the growth in occupants' health and comfort problems attributed to indoor air pollution (IAP). This study evaluated the concentration of indoor air pollutants in the built spaces of printing presses within the Zaria metropolis with the view to improving the IAQ of this built environment. Design/methodology/approach: The study adopted the quantitative research method. Twentytwo (22) printing presses were studied during active periods of printing to identify air pollutants. Concentration levels were measured and compared against the National Environmental Standard and Regulatory Enforcement Agency (NESREA) standard for excellent IAQ. A handheld Air quality meter, Carbon monoxide meter, and Ozone concentration meter were used to measure the mean levels of nine (9) IAQ indicators; Temperature, Relative humidity, Carbon monoxide (CO), Carbon dioxide (CO2), Total volatile organic compound (TVOC),

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Caron, F., Guichard, R., Robert, L., Verriele, M., Thevenet, F.
Experimental assessment of modelling VOC emissions from particleboard into a ventilated chamber.
Atmospheric Environment, Vol. **320**, (2024)

The interactions between the emission of Volatile Organic Compounds (VOCs) and airflow play a key role in determining indoor pollutant concentrations. In the framework of Indoor Air Quality (IAQ) prediction, numerical models based on fluid dynamics are useful tools to address typical cases and then make decisions to improve both public and occupational health. This requires an accurate description of VOC emission processes from building materials, products and furniture, taking into account the diffusion of VOCs into these materials instead of using constant surface emission

rates. A predictive model combining Computational Fluid Dynamics (CFD) for airflow and kinetics modelling for VOC emissions is described. The validation of airflow and VOC transfer models is carried out by comparing experimental and simulation results into a 128 L ventilated experimental chamber. Our results show that the Reynolds-Averaged Navier Stokes (RANS) approach, together with a standard k-ω turbulence model, provide good agreement between numerical and experimental airflows regarding both air velocity and age of air profiles. The overall VOC dynamics is also reproduced by numerical simulation for the eight VOCs monitored. The predicted absolute VOC concentrations are in agreement with experimental data for acetone, formaldehyde, hexanal and terpenes. However, numerical simulations underestimate the concentration of pentanal, propanal, butanal, acetaldehyde, which is discussed in terms of representativeness of emission parameters. Our results highlight that CFD simulations combined with VOC emission kinetics modelling is a promising tool for IAQ prediction, but it requires further investigation to fully understand the observed behaviour for some VOCs. This finally demonstrates the crucial need of tracking various VOCs simultaneously in the framework of assessing an IAQ prediction model.

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Kleinbeck, S., Wolkoff, P.
Exposure limits for indoor volatile substances concerning the general population: The role of population-based differences in sensory irritation of the eyes and airways for assessment factors.
Archives of Toxicology, (2024)

Assessment factors (AFs) are essential in the derivation of occupational exposure limits (OELs) and indoor air quality guidelines. The factors shall accommodate differences in sensitivity between subgroups, i.e., workers, healthy and sick people, and occupational exposure versus life-long exposure for the general population. Derivation of AFs itself is based on empirical knowledge from human and animal exposure studies with immanent uncertainty in the empirical evidence due to knowledge gaps and experimental reliability. Sensory irritation in the eyes and airways constitute about 30–40% of OELs and is an abundant symptom in non-industrial buildings characterizing the indoor air quality and general health. Intraspecies differences between subgroups of the general population should be quantified for the proposal of more ‘empirical’ based AFs. In this review, we focus on sensitivity differences in sensory irritation about gender, age, health status, and vulnerability in people, based solely on human exposure studies. Females are more sensitive to sensory irritation than males for few volatile substances. Older people appear less sensitive than younger ones. However, impaired defense mechanisms may increase vulnerability in the long term. Empirical evidence of sensory irritation in children is rare and limited to children down to the age of six years. Studies of the nervous system in children compared to adults suggest a higher sensitivity in children; however, some defense mechanisms are more efficient in children than in adults. Usually, exposure studies are performed with healthy subjects. Exposure studies with sick people are not representative due to the deselection of subjects with moderate or severe eye or airway diseases, which likely underestimates the sensitivity of the group of people with diseases. Psychological characterization like personality factors shows that concentrations of volatile substances far below their sensory irritation thresholds may influence the sensitivity, in part biased by odor perception. Thus, the protection of people with extreme personality traits is not feasible by an AF and other mitigation strategies are required. The available empirical evidence comprising age, lifestyle, and health supports an AF of not greater than up to 2 for sensory irritation. Further, general AFs are discouraged for derivation, rather substance-specific derivation of AFs is recommended based on the risk assessment of empirical data, deposition in the airways depending on the substance’s water solubility and compensating for knowledge and experimental gaps. Modeling of sensory irritation would be a better ‘empirical’ starting point for derivation of AFs for children, older, and sick people, as human exposure studies are not possible (due to ethical reasons) or not generalizable (due to self-selection). Dedicated AFs may be derived for environments where dry air, high room temperature, and visually demanding tasks aggravate the eyes or airways than for places in which the workload is balanced, while indoor playgrounds might need other AFs due to physical workload and affected groups of the general population.

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Li, D., Gao, Y.
Gas Supplies of Incubators, Air Quality, and Volatile Organic Compounds Management of the Laboratory Environment.
In: Quality Management in the Assisted Reproduction Laboratory. Springer Nature Singapore; 2024. 49-68 p.

A safe and stable environment for gamete and embryo culture is essential for assisted reproductive treatment, but this environment is influenced by multiple factors, one of which is gas. Regardless of ambient air or medical grade gas in an incubator, the cleanliness, purity, concentration, and the level of volatile organic compounds (VOCs) will directly affect gamete function, embryo development, and pregnancy outcomes [1, 2].

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Dey, S., Sarker, P., Khan, M. a. R., Songeeta, N. T., Al, M. K.
A greener solution for the mitigation of indoor air pollution: where technology synergizes with nature.
Icmiee2022. Khulna University of Engineering & Technology. Bangladesh, December 22-24,2022

Indoor air pollution is now a major concern, particularly in developing countries where people are the worst affected. It silently paves the way to numerous chronic diseases and adverse health conditions. Efforts are being made by the scientific community for the abatement of such an alarming problem. Several technologies can be named which have been working on the control of indoor air pollution such as catalytic conversion technology, adsorption technology and so on. This endeavor, however, devises an energy-efficient air filtration technique combined with indoor tree plantation. The energy for running this filtration method will be supplied by a solar system. This developed technology is environmentally friendly, economically affordable, and has no negative impact on people; rather, it protects the environment and promotes equality. This development will eventually be available for the living room, institutional classroom, kitchen, office, and meeting room.

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Morantes, G., Jones, B., Molina, C., Sherman, M. H.
Harm from Residential Indoor Air Contaminants.
Environmental Science & Technology, Vol. **58** n°(1), (2024), 242-257 p.

This study presents a health-centered approach to quantify and compare the chronic harm caused by indoor air contaminants using disability-adjusted life-year (DALY). The aim is to understand the chronic harm caused by airborne contaminants in dwellings and identify the most harmful. Epidemiological and toxicological evidence of population morbidity and mortality is used to determine harm intensities, a metric of chronic harm per unit of contaminant concentration. Uncertainty is evaluated in the concentrations of 45 indoor air contaminants commonly found in dwellings. Chronic harm is estimated from the harm intensities and the concentrations. The most harmful contaminants in dwellings are PM2.5, PM10–2.5, NO2, formaldehyde, radon, and O3, accounting for over 99% of total median harm of 2200 DALYs/105 person/year. The chronic harm caused by all airborne contaminants in dwellings accounts for 7% of the total global burden from all diseases.

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Iqbal, M. M., Shafiq, M.
Indoor air quality monitoring in metropolitan city Lahore, using handheld devices.
Journal of Air Pollution and Health, (2023)

Introduction: Outdoor air pollution has been considered the primary issue by scientists and environmentalists for decades. With the advancement of technology, the activities of human are shifting from outdoor to indoor, urging researchers to investigate the indoor environment. Theerefore, the focus of this study is to examine indoor air quality in the metropolitan of Lahore.
Materials and methods: The Temtop M2000C and Temtop H3 Laser monitors were used to collect data on Particulate Matter (PM), Carbon dioxide (CO2) concentration, Total Volatile Organic Compounds (TVOC), and formaldehyde (HCHO). The concentration of air pollutants in nine indoor areas was measured for a specified time interval. The values of particulate matter are measured to find the impact of the outdoor environment on the indoor environment.
Results: The maximum average values of the particulate matter PM2.5 and PM10 were 488.6 µg/m3 and 737.2 6 µg/m3, respectively, which reduced drastically after the rain to 219 µg/m3 and 340 µg/m3, respectively. The maximum values of PM2.5 and PM1 0 during coal burning outside the room were 997.6 µg/m3 and 999.9 µg/m3, respectively, far higher than the values during normal conditions. TVOC and HCHO were found within the prescribed limits.
Conclusion: The outcomes of this study established a deep impact of the outdoor environment on the indoor environment and recommend air purifiers to reduce the level of pollutants in the indoor environment.

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Kuncoro, C., Asyikin, M. B. Z., Sakanti, M. M., Efendi, A.

Indoor Photovoltaic Energy Harvester-Based Autonomous Total Volatile Organic Compounds Sensor Node for Indoor Air Quality Monitoring Application in Smart Building System.

SSRN, (2024)

Abstract-Indoor pollution is primarily caused by volatile organic compounds, which have chronic health effects on humans. Therefore, indoor air quality monitoring is a crucial aspect of reducing the health impact because of prolonged exposure to volatile organic compounds. This study proposes the development of a smart sensor node with an emphasis on a low-power approach to facilitate autonomous functioning in system for indoor volatile organic compounds monitoring. A low-power volatile organic compounds sensor coupled with a tiny microcontroller was utilized to perform an indoor air quality monitoring system over Internet of Things platform. A low-power algorithm was applied to achieve low power consumption. The measurement results show that the proposed sensor node consumes a total power consumption of 924mW per operational cycle (initialization, sensor reading, data transmission, and sleep) with a total duration of 63s. The data transmission donates the most significant power consumption, approximately 419mW. The study also investigates the feasibility of micro-energy harvesting from the indoor environment as a means to prolong the lifespan of the smart sensor. By utilizing indoor photovoltaics, the operating time of proposed sensor node can be increased from 16hr and 30min to 19hr under artificial light intensity of 500lx, or even further to 21hr and 30min under artificial light intensity of 750lx. The developed smart sensor demonstrates reliable performance in measuring pollutant levels of total volatile organic compounds in field tests (in laboratory and dormitory environments).

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Dwivedi, S., Zehra, F., Masih, J., Gupta, T., Lawrence, A.

Investigating the temporal dynamics of sub-micron particles and particle-bound transition metals in indoor air of a metropolitan city.

Environmental Geochemistry and Health, Vol. **46** n°(2), (2024), 49 p.

The present study portrays an association between particle-bound transition metals and children's health. The indoor air quality of the urban metropolitan city households was monitored for four PM sizes, namely PM1.0–2.5, PM0.50–1.0, PM0.25–0.50 and PM<0.25, in major seasons observed in the city; summer and winter. Further transition/heavy metals, viz. Cr, Cu, Fe, Mn, Ni, Pb and Zn, were analysed in PM1-2.5 samples. In order to evaluate the effect, health risk assessment was performed using mathematical and computational model for assessing dermal exposure and dose estimation (multiple path particle dosimetry model version3.0). The study principally targeted the children aged 2–15 years for the health risk assessment. According to the results, for the largest particle size i.e. PM1.0–2.5 the highest deposition was in the head region (49.1%) followed by pulmonary (43.6%) and tracheobronchial region (7.2%), whereas, for the smallest particle size i.e. PM<0.25 the highest deposition was obtained in the pulmonary region (73.0%) followed by the head (13.6%) and TB region (13.2%). Also, the most imperilled group of children with highest dose accumulation was found to be children aged 8–9 years for all particle sizes. Moreover, the dermal exposure dose as evaluated was found to be preeminent for Ni, Zn and Pb. Besides, seasonal variation gesticulated towards elevated concentrations in winter relative to the summer season. Altogether, the study will provide a conception to the researchers in the fields mounting season-specific guidelines and mitigation approaches. Conclusively, the study commends future work focussing on defining the effects of other chemical components on particles and associated transition metal composition along with proper extenuation of the same.

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Pourang, S.

Les défis et les avantages du télétravail.

Université du Québec à Rimouski. Thèse 2023

Les êtres humains passent plus d'un tiers de leurs heures éveillées à s'engager dans des activités liées au travail. Il est donc primordial de prendre en considération l'importance de maintenir un environnement de travail optimal, surtout lorsqu'il s'agit de télétravail au sein d'un contexte familial et résidentiel. Dans de telles circonstances, il est essentiel de veiller à créer une atmosphère propice, tout en mettant l'accent sur l'importance de facteurs physiques, psychologiques et ergonomiques de qualité. En donnant la priorité à ces aspects, les individus peuvent améliorer leur performance professionnelle globale, ce qui entraîne une productivité accrue et un bien-être dans leur vie professionnelle. Le but de

notre recherche est de comprendre les tendances et les schémas plus larges associés au télétravail. Pour cela, nous avons choisi l'autopraxéographie, une méthode narrative à la première personne centrée sur l'expérience du chercheur et une approche multidisciplinaire. L'autopraxéographie a été choisie afin de pouvoir non seulement se référer à la littérature, mais aussi fournir des exemples pratiques de situations que la chercheuse a rencontrées lors de son expérience personnelle en tant que travailleuse à distance, ce qui a conduit à une meilleure compréhension de son vécu. J'ai approfondi le sujet en comparant ces expériences des participants à la littérature existante sur le télétravail. Cette analyse comparative a, non seulement fourni un contexte plus large, mais m'a également permis d'identifier des similitudes entre les expériences rapportées par les participants et les résultats de la littérature.

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Trad, P.
Procédé de séparation membranaire et procédé d'oxydation : une association pertinente pour le traitement des COV dans l'atmosphère de travail.
Université Paris-Saclay. Thèse 2023

L'objectif de cette thèse est d'évaluer la pertinence de l'association d'un procédé d'oxydation avancé par plasma non thermique et d'une technique séparative telle que la perméation gazeuse pour le traitement d'effluents contenant des COV. Ce sujet est adossé à un contrat de collaboration de recherche entre trois laboratoires : le Laboratoire de Physique des Gaz et des Plasmas (LPGP), UMR 8578 du CNRS - Université Paris-Saclay, le Laboratoire de Réactions et Génie des Procédés (LRGP) UMR 7274 du CNRS – Université de Lorraine et le Laboratoire PROCédés et Epuration des Polluants (PROCEP) de l'INRS. Dans un premier temps, une étude est effectuée sur le traitement par plasma de plusieurs COV avant de passer à la phase d'étude du procédé de couplage dans son ensemble. L'étude se décline sous la forme d'une approche expérimentale conséquente. Les molécules étudiées sont le n-hexane, le formaldéhyde, et le dichlorométhane. L'étude de la décomposition de COV par plasma froid est réalisée au LPGP alors que l'étude du procédé de séparation des COV est conduite au PROCEP avec le soutien du LRGP. Les capacités d'un plasma froid à dégrader ces molécules est examinée pour des valeurs de paramètres (débit de gaz, concentration de polluants) rencontrées dans des réacteurs d'extraction de COV par membranes. Une attention particulière est portée sur les points suivants : stabilité de fonctionnement d'une décharge à barrière diélectrique pour un faible flux, effet d'une forte concentration sur la stabilité et le dépôt d'énergie dans le plasma, rôle de la forme temporelle de l'impulsion de tension appliquée à la structure de décharge, géométrie de cette structure (réacteur packed-bed ou décharge à barrière diélectrique). Les sous-produits de dégradation de ces molécules sont caractérisés et quantifiés le plus finement possible à l'aide de différents diagnostiques, en particulier un spectromètre de masse haute résolution de type PTR FT-ICR (Proton Transfer Reaction associated with Fourier Transform Ion Cyclotron Resonance). Cette technologie permet de réaliser la détection à haute résolution et la quantification de traces. D'autres diagnostiques chimiques comme la chromatographie avec un détecteur TCD ou MS et des détecteurs spécifiques pour l'ozone et le CO_2 sont utilisés. Dans une dernière étape, le couplage séparation membranaire - procédé plasma est effectué dans le cas du n-hexane pour évaluer la capacité d'un ensemble composé d'un module de séparation et d'un module plasma à traiter un effluent gazeux représentatif de l'application en termes de composition et de concentration en COV.

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E, V., Ghadei, S. K., Ruidas, S., Bhakta, V., Sakthivel, R., Sankaran, K. J.*, et al.*
A Metal-Free Triazacoronene-Based Bimodal VOC Sensor.
ACS Sensors, Vol. **9** n°(1), (2024), 251-261 p.

Developing suitable sensors for selective and sensitive detection of volatile organic compounds (VOCs) is crucial for monitoring indoor and outdoor air quality. VOCs are very harmful to our health upon inhalation or contact. Bimodal sensor materials with more than one transduction capability (optical and electrical) offer the ability to extract complementary information from the individual analyte, thus improving detection accuracy and performance. The privilege of manipulating the optoelectronic properties of the polycyclic aromatic hydrocarbon-based semiconducting materials offers rapid signal transduction in multimodal sensing applications. A thiophene-functionalized triazacoronene (TTAC) donor–acceptor–donor (D–A–D) type sensor is reported here for VOC sensing. The single-crystal X-ray structure analysis of the TTAC revealed that a distinctive supramolecular polymer architecture was formed because of cooperative π–π and intermolecular D–A interactions and exhibited rapid signal transduction upon exposure to specific VOCs. The TTAC-embedded green luminescent paper-based test strip exhibited an on–off fluorescence response upon nitrobenzene vapor exposure for 120 s. The selective and rapid response is due to the fast photoinduced electron

transfer, as is evident from the time-resolved excited-state dynamics and density functional theory studies. The thick-film-based prototype chemiresistive sensor detects harmful VOCs in a custom-made gas sensing system including benzene, toluene, and nitrobenzene. The TTAC sensor rapidly responds (200 s) at relatively low temperatures (180 oC) compared to other reported metal-oxide-based sensors.

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Jebaseeli, T. J., Kim, D., Lee, D.
Modeling a Smart IoT Device for Monitoring Indoor and Outdoor Atmospheric Pollution.
Scalable Computing: Practice and Experience, Vol. **25** n°(1), (2024), 547-556 p.

Air pollution is caused by chemical, physical, or biological components alters the fundamental properties of the atmosphere, and contaminates the interior or outdoor settings. With the rapid industrialization activity in recent years, there is an urgent need to monitor air quality. The proposed research provides a mechanism for monitoring air pollution in indoor and outdoor environments. The system consists of an IoT-based Arduino device. The Arduino IDE connects the Temperature and Humidity sensor, Grove light sensor, and air quality sensor to measure the air pollutants such as Carbon dioxide CO2, Nitrogen oxide (NOx), and Particulate Matter PM2.5. The sensors work efficiently and provide qualitative findings from the environment when they are exposed to CO2, gasoline, solvents, thinner, formaldehyde, and other harmful chemicals. The Wi-Fi module of the Blues Wireless Notehub is used for secure data routing to the IoT cloud. The Air Quality Index (AQI) measures provide information on whether there is something unsafe in indoor and outdoor environments. For collecting and analyzing the device data, the Notecard is intended to be used with a cloud storage service. Also, the indoor fire detector identifies the incident of fire intimates the users through the alarm, and measures the indoor pollutant at that time. The proposed smart IoT product model would be an excellent device for air quality monitoring because of its long-term consistency and low electricity consumption.

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Kvasnicka, J., Hubal, E. a. C., Diamond, M. L.
Modeling clothing as a secondary source of exposure to SVOCs across indoor microenvironments.
Journal of Exposure Science and Environmental Epidemiology, (2023)

BackgroundEvidence suggests that clothing can influence human exposure to semi-volatile organic compounds (SVOCs) through transdermal uptake and inhalation.ObjectivesThe objectives of this study were [1] to investigate the potential for clothing to function as a transport vector and secondary source of gas-phase SVOCs across indoor microenvironments, [2] to elucidate how clothing storage, wear, and laundering can influence the dynamics of transdermal uptake, and [3] to assess the potential for multiple human occupants to influence the multimedia dynamics of SVOCs indoors.MethodsA computational modeling framework (ABICAM) was expanded, applied, and evaluated by simulating and augmenting two "real-world" chamber experiments. A primary strength of this framework was its representation of occupants and their clothing as unique entities with the potential for location changes.ResultsEstimates of transdermal uptake of diethyl phthalate (DEP) and di(n-butyl) phthalate (DnBP) were generally consistent with those extrapolated from measured concentrations of urinary metabolites, and those predicted by two other mechanistic models. ABICAM predicted that clean clothing (long sleeves, long pants, and socks, 100% cotton, 1 mm thick) readily accumulated DEP (6900-9700 mu g) and DnBP (4500-4800 mu g) from the surrounding chamber air over 6 h of exposure to average concentrations of 233 (DEP) and 114 (DnBP) mu g center dot m-3. Because of their high capacity, clean clothing also effectively minimized transdermal uptake. In addition, ABICAM predicted that contaminated clothing functioned as a vector for transporting DEP and DnBP across indoor microenvironments and reemitted 13-80% (DEP) and 3-27% (DnBP) of the accumulated masses over 48 h.SignificanceThough the estimated secondary inhalation exposures from contaminated clothing were low compared to the corresponding primary exposures, these secondary exposures could be accentuated in other contexts, for example, involving longer timeframes of clothing storage, multiple occupants wearing contaminated clothing, and/or repeated instances of clothing-mediated transport of contaminants (e.g., from an occupational setting).ImpactThis modeling study reaffirms the effectiveness of clean clothing in reducing transdermal uptake of airborne SVOCs and conversely, that contaminated clothing could be a source of SVOC exposure via transdermal uptake and by acting as a vector for transporting those contaminants to other locations.

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Li, X. R., Yan, Y. H., Fang, X., Tu, J. Y.

Numerical studies of indoor particulate and gaseous micropollutant transport and its impact on human health in densely-occupied spaces.
Environmental Pollution, Vol. **342**, (2024)

Micropollutants (MPs) have increasingly become a matter of concern owing to potential health risks associated with human inhalation exposure, particularly in densely-occupied indoor environments. This study employed numerical simulations in a traditional built indoor workspace and a public transport cabin to elucidate the transport dynamics and health impacts of particulate and gaseous type of indoor MPs on varying groups of occupants. The risk of infection from pathogen-bearing MPs was evaluated in the workspace using the integrated Eulerian-Lagrangian and modified Wells-Riley model. In the cabin environment, the health impact of inhaled TVOC within the human nasal system was assessed via the integrated nasal-involved manikin model and cancer/ non-cancer risk model. The results demonstrated that when ventilation layout was in favour of restricting particulate MPs spread, considerably high health risks (up to 17.22% infection possibility) were generally found in near-fields of emission source (< 2.25 m). Conversely, if the ventilated flow interacts robustly with emission source, every occupant has a minimum 5% infection risk. Incorporating the nasal cavity in the human model offers a nuanced understanding of gaseous MP distributions post-inhalation. Notably, the olfactory and sinus regions displayed heightened vulnerability to TVOC exposure, with a 62.5%-108% concentration increase compared to other nasal areas. Cancer risk assessment plausibly explained the rising occurrence of brain and central nervous system cancer for aircrew members. Non-cancer risk was found acceptable. This study was expected to advance the understanding of environmental pollution and the health risks tied to indoor MPs in densely-populated environments.

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Cecinato, A., Romagnoli, P., Cerasa, M., Perilli, M., Balducci, C.
Organic toxicants and emerging contaminants in hospital interiors before and during the SARS-CoV2 pandemic: alkanes and PAHs.
Environmental Science and Pollution Research, Vol. **31** n°(6), (2024), 9713-9731 p.

Indoor pollution and deposition dust (DD), in particular, are acquiring concern, due to long exposure time and importance of intake by humans through contact and ingestion. Hospitals look a special category of sites, owing to peculiar contaminants affecting them and to presence of people prone to adverse effects induced by toxicants. Four in-field campaigns aimed at understanding the chemical composition of DD were performed in five Italian hospitals. Measurements were performed before (autumn 2019), during (spring 2021), and after (winter 2022) the peak of SARS-CoV2 and when restrictions caused by pandemic were revoked (winter 2023). Parallel measurements were made outdoors (2022), as well as in a university and a dwelling. Targeted contaminants were n-alkanes and polycyclic aromatic hydrocarbons (PAHs), while iso- and anteiso-alkanes were analyzed to assess the impact of tobacco smoking. Total n-alkanes ranged from 3.9 ± 2.3 to 20.5 ± 4.2 mg/g, with higher percentages of short chain homologs in 2019. PAHs ranged from 0.24 ± 0.22 to 0.83 ± 0.50 mg/g, with light congeners (≤ 228 a.m.u.) always exceeding the heavy ones (≥ 252 a.m.u.). According to carbon preference indexes, alkanes originated overall from anthropogenic sources. Microorganisms resulted to affect a hospital, and tobacco smoke accounted for ~ 4–20‰ of DD mass. As for PAH sources, the diagnostic concentration ratios suggested the concourse of biological matter burning and vehicle emission. Benzo[a]pyrene equivalent carcinogenic and mutagenic potencies of depositions at hospitals ranged ~ 9–39 μg/g and ~ 15–76 μg/g, respectively, which seems of concern for health. DD composition in hospitals was different from that outside the premises, as well as that found at university and at dwelling.

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Zhang, C., Ji, J., Tang, Y., Ke, W.
Overall performance investigation of a CdTe double-skin ventilated facade integrated with a thermal catalytic air-type PV/T in heating and cooling seasons.
Energy, Vol. **292**, (2024)

To reduce building energy consumption and improve indoor air quality, this paper proposes a CdTe PV double-skin ventilated facade integrated with a thermal-catalytic air type PV/T (PV-DSF-TCPV/T). The mathematical model of the proposed system was developed and validated against the experimental data. The daily and seasonal overall performances of the proposed system, including the electrical, thermal, and formaldehyde degradation performances, were studied and compared with that of a conventional PV-DSF. Moreover, parametric analysis was conducted. The

main results are: (1) The annual electricity outputs of the proposed system and the conventional system were 414.88 kWh and 105.88 kWh, respectively. (2) Compared with the conventional PV-DSF, the heating and cooling loads of the proposed system decreased by 10.85 % and 34.86 %, respectively, due to the reduction of indoor heat gain in summers and the increase of it in winters. (3) The daily formaldehyde conversion ratio and CADR were 30.84 % and 67.86 m3/h (4) The volumetric flow rate and the cell coverage of the PV-DSF both exerted obvious impacts on the proposed system.

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De Serres, A., Duchesne, E.
Penser l'immobilier autrement : nouvelles perspectives en recherche.
Collection Chaire Ivanhoé Cambridge d'immobilier, ESG UQAM. Québec, Canada. 2023

Les grands bouleversements sociétaux engendrés par la crise sanitaire, l'impératif climatique et la transformation numérique, mais aussi l'évolution des besoins et des attentes des usagers, entraînent un véritable changement de paradigme dans la façon de penser l'immobilier. Les recherches menées par la Chaire soulignent notamment l'importance :
• d'adopter une vision globale, écosystémique et multidimensionnelle de l'immobilier;
• de mieux comprendre les interactions et les interdépendances entre les différents acteurs évoluant au sein de l'écosystème de l'immobilier;
• de miser sur les innovations ouvertes, le transfert et le partage des connaissances pour accélérer leur application auprès de tous les intervenants en immobilier;
• de proposer de nouvelles formes de partenariat et de collaboration entre ces différents acteurs essentiels au développement social et économique.

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Matthaios, V. N., Knibbs, L. D., Kramer, L. J., Crilley, L. R., Bloss, W. J.
Predicting real-time within-vehicle air pollution exposure with mass-balance and machine learning approaches using on-road and air quality data.
Atmospheric Environment, Vol. **318**, (2024)

Modelling the air pollutant concentrations within-vehicles is an essential step to estimate our daily exposure to air pollution. This is a challenging issue however, since the processes that affect the exposures within-vehicles change with different driving patterns and ventilation settings. This study introduces an innovative approach that combines mass-balance principles and machine learning techniques, leveraging ambient air quality, on-road and within-vehicle measurements of particulate matter (PM10, PM2.5, PM1), nitrogen dioxide (NO2), nitrogen oxides (NOx), aerosol lung surface deposited area (LSDA) and ultrafine particles (UFP) under different ventilation settings to estimate air pollution exposure levels within vehicles. The first model (MB) includes basic physical and chemical processes and follows a mass-balance approach to estimate the within-vehicle concentrations. The second model (ML) applies data driven machine learning algorithms to a training set of observations to predict unseen within-vehicle concentrations. By using a number generator, the whole observational dataset was divided to 80:20 and 80% was used to build and train the ML model, while 20% was used for validation. Both models demonstrated good predictions of observations apart from an underestimation in UFP and LSDA. The ML model showed better predictive power than the MB model and had skill in predicting the unseen within-vehicle exposures. The ML model predictions were as good as the MB model for most of the species and improved for NO2. The ML model demonstrated good index of agreement (IOA >0.69) and Pearson correlation coefficient ($r > 0.80$) for all the species. The inclusion of air quality data from nearby monitoring stations instead of on-road (sampled while driving), in the ML model showed promising and new capabilities to within-vehicle exposure predictions. In an era where air pollution is a growing concern, understanding and predicting within-vehicle air pollution exposure is of great importance for public health and environmental research. This research not only advances the field of exposure assessment but (at no extra cost) also demonstrates practical implications for real-time exposure mapping and health impact assessment of vehicle occupants with existing infrastructure.

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Yang, Y., Hao, Y., Huang, L., Luo, Y., Chen, S., Xu, M., Chen, W.
Recent Advances in Electrochemical Sensors for Formaldehyde.
Molecules, Vol. **29** n°(2), (2024)

Formaldehyde, a ubiquitous indoor air pollutant, plays a significant role in various biological processes, posing both environmental and health challenges. This comprehensive review delves into the latest advancements in electrochemical methods for detecting formaldehyde, a compound of growing concern due to its widespread use and potential health hazards. This review underscores the inherent advantages of electrochemical techniques, such as high sensitivity, selectivity, and capability for real-time analysis, making them highly effective for formaldehyde monitoring. We explore the fundamental principles, mechanisms, and diverse methodologies employed in electrochemical formaldehyde detection, highlighting the role of innovative sensing materials and electrodes. Special attention is given to recent developments in nanotechnology and sensor design, which significantly enhance the sensitivity and selectivity of these detection systems. Moreover, this review identifies current challenges and discusses future research directions. Our aim is to encourage ongoing research and innovation in this field, ultimately leading to the development of advanced, practical solutions for formaldehyde detection in various environmental and biological contexts.

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Wang, L., Gao, K., Li, W., Lu, L.
Research progress on the characteristics, sources, and environmental and potential health effects of water-soluble organic compounds in atmospheric particulate matter.
Environmental Science and Pollution Research, (2024)

Water-soluble organic compounds (WSOCs) have received extensive attention due to their indistinct chemical components, complex sources, negative environmental impact, and potential health effects. To the best of our knowledge, until now, there has been no comprehensive review focused on the research progress of WSOCs. This paper reviewed the studies on chemical constituent and characterization, distribution condition, sources, environmental impact, as well as the potential health effects of WSOCs in the past 13 years. Moreover, the main existing challenges and directions for the future research on WSOCs were discussed from several aspects. Because of the complex composition of WSOCs and many unknown individual components that have not been detected, there is still a need for the identification and quantification of WSOCs. As modern people spend more time in indoor environments, it is meaningful to fill the gaps in the component characteristics and sources of indoor WSOCs. In addition, although in vitro cell experiments have shown that WSOCs could induce cellular oxidative stress and trigger the inflammatory response, the corresponding mechanisms of action need to be further explored. The current population epidemiology research of WSOCs is missing. Prospectively, we propose to conduct a comprehensive and simultaneous analysis strategy for concentration screening, source apportionment, potential health effects, and action mechanisms of WSOCs based on high throughput omics coupled with machine learning simulation and prediction.

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Crawford, K. A., Hartmann, N.
Respiratory Exposure to Highly Fluorinated Chemicals via Application of Ski Wax and Related Health Effects.
Current Environmental Health Reports, (2024)

Waxes containing per- and polyfluoroalkyl substances (PFAS) are applied to the base of skis and snowboards (“skis”) to reduce friction with the snow surface and improve glide. PFAS exposure can adversely impact cardiometabolic, thyroid, liver, kidney, reproductive, and immune health and are associated with increased risk of certain cancers. In the present review, we summarize the state of the science on PFAS exposure from fluorinated ski wax use, including acute respiratory health effects and PFAS concentrations in biological and environmental media collected from ski waxing settings.

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Cao, X., Li, N., Li, Y., Che, L., Yu, B., Liu, H.
A review of photovoltaic/thermal (PV/T) technology applied in building environment control.
Energy and Built Environment, (2023)

Solar energy is widely used to replace traditional energy because of its clean and efficient characteristics. Solar energy has great application potential and prospects in building energy conservation. Combining solar energy with buildings can achieve higher efficiency while reducing costs, and the life of the system is longer. PV/T technology combines solar photovoltaic and photothermal technology and obtains sustainable electrical energy and thermal energy at the same

time. PV/T systems can be easily integrated to buildings and the electricity and heat generated by PV/T can drive a variety of physical and chemical processes such as heat collection process, solid/liquid dehumidification process and photo/thermal catalytic purification process. Therefore, building-integrated PV/T system has good application potential in building environment control such as indoor air temperature, air humidity and gaseous pollutants control. In the review of the past decade at home and abroad, most of the research on PV/T focuses on the development process, equipment and materials, accounting for 28 %, 21 % and 19 %, respectively, while only 15 % is related to the building-integrated PV/T system. The present work mainly investigates the application of PV/T in building environment in the past ten years, and reports a variety of application cases of PV/T technology combined with building systems to regulate indoor comfort and improve indoor environment. In addition, this paper reviews the simulation and experimental works of different building solar integrated PV/T systems and puts forward the prospect and suggestion for future research.

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Rojas, G., Fletcher, M., Johnston, D., Siddall, M.
A review of the indoor air quality in residential Passive House dwellings.
Energy and Buildings, Vol. **306**, (2024)

The Passive House (PH) Standard is a voluntary building energy performance standard focused upon reducing space heating demand to a very low level and therefore considered a viable climate change mitigation technology. Besides comfort and energy requirements, the PH standard also defines criteria with respect to ventilation. However, the question remains, how well do PH dwellings perform when they are occupied? Does the PH approach provide good indoor air quality (IAQ) for its occupants and how does IAQ compare to non-PH homes, in particular, naturally ventilated homes? Additionally, can PH certification improve the quality of installed ventilation systems? This paper summarizes indoor air quality relevant aspects of the PH standard and presents results from measurements examining in-use IAQ in more than 600 PH or PH-like, newly built or retrofitted dwellings. The results reveal that pollutant and carbon dioxide concentration are generally lower compared to naturally ventilated homes, presumably due to the requirement to install a balanced Mechanical Ventilation with Heat Recovery (MVHR) system. Results also suggest that the quality assurance measures of PH certification are capable of improving ventilation and IAQ performance. However, the lack of cooking fume capture requirements in the PH standard, in combination with efforts to avoid energy losses associated with a possible extraction kitchen hood, may lead to elevated particulate matter concentration in PHs. Future research on cooking induced IAQ impairment is encouraged to assess the effectiveness of recently published PH-specific recommendations. Future efforts in empirical IAQ research should also address the lack of high quality IAQ measurement data and the standardisation of IAQ assessment methods and protocols.

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Serpente, V., Girolami, M., Mastellone, M., Sabbatella, G., Vitulano, A., Staccioli, M. P.*, et al.*
Selective flexible sensor for monitoring volatile organic compounds in museum display cases.
Journal of Cultural Heritage, Vol. **66**, (2024), 1-9 p.

Aim of this work is the development of a new kind of corrosion sensors, based on low-cost flexible sub-strates, specifically designed to detect Volatile Organic Compounds (VOCs) producing significant degrada-tion of artifacts in museum display cases. Sensors have been fabricated and tested in relevant environ-ment with three of the most relevant VOCs (acetic acid, formic acid and formaldehyde) to the artifacts preservation. Sensitivity has been measured to be lower than 1 ppm, which is several times better than what reported in the literature on corrosion sensors for the same VOCs. In addition, different sensors, arranged with different active materials, have been implemented for the first time into a so-called multi -sensor architecture, aimed at demonstrating VOC specificity: in particular, we report here on a prelimi-nary test in which the multi-sensor has been able to be selective between acetic acid and formaldehyde.(c) 2023 Consiglio Nazionale delle Ricerche (CNR). Published by Elsevier Masson SAS. All rights reserved.

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Cech, P., Paschova, Z., Gaff, M., Li, H. T., Kacik, F.
Synthetic leathers as a possible source of chemicals and odorous substances in indoor environment.
Reviews on Advanced Materials Science, Vol. **62** n°(1), (2023)

This article deals with volatile organic substances (VOCs) and odours that can be released into the indoor environment from synthetic leathers that are part of upholstered furniture. The primary task of this study was to provide a detailed

analysis of selected synthetic leathers and assess their emission characteristics, including odour substances. VOC emissions were determined using the test chamber method (& Ccaron;SN EN ISO 16000-9) at a temperature of 23 degrees C and a relative humidity of 50%. The emitted compounds were adsorbed by standard stainless steel tubes with Tenax TA sorbent. VOCs were analysed by thermal desorption and gas chromatography with mass spectrometry The properties of odours were tested using a Sniffer 9000 device, which was directly connected to a gas chromatograph with a flame ionization detector. The dominant substances (with the highest concentration) that were emitted by samples of tested synthetic leathers include toluene (118.2 mu g<middle dot>m(-3)), 1,2-propanediol (46.2 mu g<middle dot>m(-3)), and limonene (153.0 mu g<middle dot>m(-3)). Ohio synthetic leather produced the most unpleasantness hedonic tone (-4) from all evaluated materials.

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Ebrahimifakhar, A., Poursadegh, M., Hu, Y. F., Yuill, D. P., Luo, Y.
A systematic review and meta-analysis of field studies of portable air cleaners: Performance, user behavior, and by-product emissions.
Science of the Total Environment, Vol. **912**, (2024)

Indoor air quality is important for the health of building occupants, and public interest in controlling indoor airborne pathogens increased dramatically with the COVID-19 pandemic. Pollutant concentrations can be controlled locally using portable air cleaners (sometimes called air purifiers), which allow occupants to apply air cleaning technology to meet their needs in the location and times that they find appropriate. This paper provides a systematic review of scientific literature that describes field studies of the effectiveness of portable air cleaners. Over 500 papers were considered, and 148 were reviewed in detail, to extract 35 specific research results (e.g., particulate removal performance) or characteristics (e.g., type of building). These were aggregated to provide an overview of results and approaches to this type of research, and to provide meta-analyses of the results. The review includes: descriptions of the geographical location of the research; rate of publications over time; types of buildings and occupants in the field study; types of air cleaner technology being tested; pollutants being measured; resulting pollutant removal effectiveness; patterns of usage and potential barriers to usage by occupants; and the potential for by-product emissions in some air cleaner technologies. An example result is that 83 of the 148 papers measured reductions in fine particulates (PM2.5) and found a mean reduction of 49 % with standard deviation of 20 %. The aggregated results were approximately normally distributed, ranging from finding no significant reduction up to a maximum above 90 % reduction. Sixteen of the 148 papers considered gaseous pollutants, such as volatile organic compounds, nitrogen dioxide, and ozone; 36 papers considered biological pollutants, such as bacteria, viruses, pollen, fungi, etc. An important challenge, common to several studies, is that occupants run the air cleaners for shorter periods and on low airflow rate settings, because of concerns about noise, drafts, and electricity cost, which significantly reduces air cleaning effectiveness.

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Ikeda, E., Hamilton, J., Wood, C., Chatzidiakou, L., Warburton, T., Ruangkanit, A.*, et al.*
Understanding the patterns and health impact of indoor air pollutant exposures in Bradford, UK: a study protocol.
Bmj Open, Vol. **13** n°(12), (2023)

IntroductionRelative to outdoor air pollution, there is little evidence examining the composition and concentrations of indoor air pollution and its associated health impacts. The INGENIOUS project aims to provide the comprehensive understanding of indoor air pollution in UK homes.Methods and analysis'Real Home Assessment' is a cross-sectional, multimethod study within INGENIOUS. This study monitors indoor air pollutants over 2 weeks using low-cost sensors placed in three rooms in 300 Born in Bradford (BiB) households. Building audits are completed by researchers, and participants are asked to complete a home survey and a health and behaviour questionnaire, in addition to recording household activities and health symptoms on at least 1 weekday and 1 weekend day. A subsample of 150 households will receive more intensive measurements of volatile organic compound and particulate matter for 3 days. Qualitative interviews conducted with 30 participants will identify key barriers and enablers of effective ventilation practices. Outdoor air pollution is measured in 14 locations across Bradford to explore relationships between indoor and outdoor air quality. Data will be analysed to explore total concentrations of indoor air pollutants, how these vary with building characteristics, and whether they are related to health symptoms. Interviews will be analysed through content and thematic analysis.Ethics and disseminationEthical approval has been obtained from the NHS Health Research Authority Yorkshire and the Humber (Bradford Leeds) Research Ethics Committee (22/YH/0288). We will disseminate findings

using our websites, social media, publications and conferences. Data will be open access through the BiB, the Open Science Framework and the UK Data Service.

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Fukuzaki, S.
Uses of gaseous hypochlorous acid for controlling microorganisms in indoor spaces.
Journal of Microorganism Control, Vol. **28** n°(4), (2023), 165-175 p.

Hypochlorous acid (HOCl) is an active species in the chlorination process. Hypochlorite salts that release hypochlorite ion (OCl–) have been used for more than 200 years as disinfecting, cleaning, deodorizing, and decolorizing agents in various technological fields. In the food industry, sodium hypochlorite is the most widely used among chlorine compounds. The antimicrobial activity of a dilute hypochlorite solution is attributed largely to HOCl because of its cell membrane permeability. OCl– exhibits an excellent cleaning action for organic soils on solid surfaces. HOCl has been used as an aqueous solution, and its objects to be treated are things. In hypochlorite solution, HOCl is volatile and easily volatilized by stirring, bubbling, atomizing, or forced-air vaporization. On the other hand, OCl– is non-volatile and stays in the solution. Recently, the scope of objects to be treated with hypochlorite solution has been expanded to indoor spaces, and the use of gaseous hypochlorous acid (HOCl（g)) has been studied intensively. This review describes the mechanisms of actions of hypochlorous acid as liquid-based and gaseous disinfectants and provides the evidence for the safety and effectiveness of HOCl（g) for controlling microorganisms in indoor spaces.

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Ramírez, D. M., Gutenkunst, S., Lothrop, N., Quijada, C., Chaires, M., Cortez, I.*, et al.*
What a mix! Volatile organic compounds and worker exposure in small business beauty salons in Tucson, Arizona.
Frontiers in Public Health, Vol. **11**, (2023)

IntroductionSmall business beauty salons have volatile organic compounds (VOCs) in their workplace air. VOCs are present as ingredients in beauty or hair products. They may also form because of chemical reactions, where thermal-styling elements accelerate the volatilization of these compounds. Uncertainties remain about the relationship between air pollutant concentrations and the variety of beauty salon activities in a work shift. Investigating these associations can help determine high-risk services, associated products, and at-risk workers.MethodsIn this exploratory study, female community health workers recruited beauty salons from target zip codes in predominately Latino neighborhoods, including primarily Spanish-speaking small businesses. We collected salon chemical inventories, business characteristics, and participant activity logs to understand how chemicals and activities influence the total and specific VOC concentrations. We sampled personal total VOCs and specific VOCs from the same shop during the participant work shift. We also measured personal total VOCs for four work shifts per shop.ResultsA linear mixed effects model of log VOCs on the fixed effect of activity and the random effects of salon and shift within the salon showed that the variance between salons explains over half (55%) of the total variance and is 4.1 times bigger than for shifts within salons. Summa canisters detected 31 specific VOCs, and hazard scores ranged between 0 and 4.3. 2-Propanol (isopropyl alcohol) was the only VOC detected in all shifts of all salons.DiscussionIn this study, differences in VOC measurements were primarily between salons. These differences may result from differences in ventilation, services rendered, and product lines applied.

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Lesego, M., Ndinteh, D. T., Ndungu, P., Mamo, M. A.
Zeolitic imidazolate framework as humidity-resistant solid state-chemiresistive gas sensors: A review.
Heliyon, Vol. **9** n°(11), (2023)

With significant technological advances, solid-state gas sensors have been extensively applied to detect toxic gases and volatile organic compounds (VOCs) in confined areas such as indoor environments and industries and to identify gas leakage. Semiconductor metal oxides are the primary sensing materials, although their major drawbacks include a lack of sensitivity, poor performance at high humidity, and operating at high temperatures ranging between 140 and 400 degrees C. Recently, the use of zeolitic imidazolate frameworks (ZIFs) in gas sensors has received considerable attention as a promising material to overcome the drawbacks possessed by semiconductor metal oxide-based gas sensors. Because of their unique properties, including size tunability, high surface area, and stability in humidity, ZIF becomes a preferred candidate for sensing materials. The use of ZIF materials in gas sensors is limited because of their high-

temperature operation and low gas responses. This review outlines the strategies and developments in the utilization of ZIF-based materials in gas sensing. The significant influence of the addition of carbon additives in ZIF materials for temperature operation sensors is discussed. Finally, ZIF-carbon additives and SMO@ZIFs/carbon additives are the proposed materials to be studied for future prospects for the detection of VOCs at low temperatures and exhibiting good selectivity towards the gas of interest.

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