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Editorial: Indoor environmental air quality in urban areas

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Editorial on the Research Topic
Indoor environmental air quality in urban areas

Indoor air quality plays an increasingly important role in the modern world, especially in urban areas (Leung, 2015). This is due to usually limited access to green areas in towns and a growing number of activities that take place mainly indoors (Kumar et al., 2019). It forces people to spend most of their time in various types of indoor environments (i.e., residential houses, apartments, offices, schools, kindergartens, hospitals, churches, museums, libraries, shopping centers, gyms, fitness centers, swimming pools, cafes, restaurants, etc.) (Śmiełowska et al., 2017; Kozielska et al., 2020). Therefore, human exposure to indoor contaminants has become a more and more important factor influencing people's health, especially in the case of children and older people, who can often spend entire days in their homes. Additionally, in extraordinary situations such as the COVID-19 pandemic, governments widely implemented stay-at-home orders to minimize the risk of disease transmission and, by the same, protect public health (Peixoto et al., 2024).

Dense urban development (high share of multi-family buildings, blocks of flats, and skyscrapers in comparison to traditional outskirts with single-family buildings) and high occupational density, which manifests with reduced distance between people, rises the risk of unwanted exposure to pollution generated by others (bacteria, viruses, fungi, cigarette smoke, etc.) (McMillen et al., 2004; Gilbert and Stephens, 2018). High center street traffic due to a lack of ring roads, industrial objects located close to dwelling areas, and combustion of wrong quality fuels cause, in addition to the residential sector, increased outdoor air pollution–especially respirable particles, carcinogenic substances, and nitrogen oxide. All these substances infiltrate in part into buildings, raising concentration of contaminants indoors. The vital problem that arises in modern cities is increased street noise, which reduces people's wellbeing or even influences their mental health when opening windows to ventilate rooms. In big cities with little greenery, urban heat islands tend to appear in hot months, increasing overall air temperatures by a few degrees. It leads to an increase indoor temperature, powering emissions of pollutants from building materials due to more intensive evaporation (for example, formaldehyde and other volatile organic compounds) and worsening human thermal comfort.

On the other hand, all activities towards health and environmental protection, as well as minimizing energy consumption, force the search for new technical solutions and modern zero-emission materials used for interior furnishing. The pursuit of reducing the energy demand of buildings cannot be at the expense of the thermal comfort of residents and indoor air quality (Grygierek and Ferdyn-Grygierek, 2022). New concepts of environmentally friendly energy production support the design of advanced technical systems that shape the desired indoor air quality. Different air cleaners or air purifiers (Brągoszewska and Biedroń, 2021) and air-conditioning systems, de-odoring and anti-bacterial modules, and energy recovery features are now commonly used in residential buildings. Research on environmental and energy assessment of such systems should be further developed, along with optimizing of control systems. Artificial intelligence and machine learning have emerged as promising solutions to address these challenges, supported by commonly available individual measuring devices that provide data on indoor air quality, helping to maintain the desired indoor air quality. Creating a healthy indoor environment is impossible without well-operating heating, ventilation, and air-conditioning systems. The vast improvement of the air quality in buildings can be achieved using mechanical ventilation systems. They do entail investment outlays and increased operating costs, but despite this, their attributes make them worthy to maintain further development. The control system is crucial in this case because it ensures the right amount of fresh air in the room while minimizing energy consumption in the building.

In this context, five different articles contributed to this Research Topic. They addressed a variety of issues, which are summarized below.

Combining intelligent predictive models with indoor air quality control devices makes it possible to accurately predict pollutant concentrations and translate them into control signals. Accurate and reliable prediction of pollutant concentration can effectively alleviate the delay problem in the indoor air quality control system. This problem was noticed by Guo et al., who developed a predictive model based on machine learning algorithms that accurately predicts PM2.5 concentration levels in closed rooms. The authors used the CatBoost algorithm based on rank lifting training into the classification and predicted indoor PM2.5 concentration. The accuracy and effectiveness of the model were determined and checked on the basis of real monitoring data for office buildings. The previous indoor particulate concentration, indoor temperature, relative humidity, CO_2 concentration, and lighting were taken into account as input variables, and the result indicates whether the indoor PM2.5 concentration exceeds 25 $\mu g/m^3$. Compared to other algorithms commonly used, the CatBoost model showed tangible benefits in predicting PM2.5 concentrations. Furthermore, this study indicated that the previous concentration of PM2.5 and relative humidity are the two factors that have the most significant influence on prediction.

Abdel-Salam concentrated on controlling air quality in urban residences during the COVID-19 pandemic. His research focused specifically on children's exposure aged 5–10 to indoor selected pollutants (PM2.5, PM10, TVOCs, CO and CO_2). He showed that children spent on average 98% of their time at home during the pandemic, mainly in living rooms and bedrooms. While staying in living rooms, they were particularly exposed to high concentrations of particulate matter and in bedrooms to CO_2. Research showed that Abdel-Salam concentrated on controlling air quality in urban residences during the COVID-19 pandemic. His research focused specifically on children's exposure aged 5–10 to indoor selected pollutants (PM2.5, PM10, TVOCs, CO and CO_2). He showed that children spent on average 98% of their time at home during the pandemic, mainly in living rooms and bedrooms. While staying in living rooms, they were particularly exposed to high concentrations of particulate matter and in bedrooms to CO_2. Research showed that PM came mainly from outdoor sources, but also from smoking, extensive cleaning activities, and the large number of occupants in the living rooms, and thus more indoor activities conducted while TVOC and CO_2 come mainly from human activities routinely undertaken in households. Small volume of bedroom and kitchen, inadequate ventilation, no kitchen exhaust systems resulted in an increased concentrations of the pollutants examined. PM came mainly from outdoor sources, but also from smoking, extensive cleaning activities, and the large number of occupants in the living rooms, and thus more indoor activities conducted, while TVOC and CO_2 come mainly from human activities routinely undertaken in households. Small volume of bedroom and kitchen, inadequate ventilation, no kitchen exhaust systems resulted in an increased concentrations of the pollutants examined.

Yang et al. presented a paper on the emission of air pollutants while heating liquids used in electronic cigarettes. Six nicotine salts most commonly used by electronic cigarette manufacturers were tested against VOC emissions during the heating of liquids up to 350°C. Analysis showed that the pyrolysis of nicotine salts is a process of non-spontaneous heat absorption, and there are differences in the characteristic thermogravimetric parameters between different nicotine salts. In the case of three nicotine salts (nicotine citrate, nicotine tartrate, and nicotine malate), more than 90% of the nicotine contained in them was released into the air. The study contributes to the still insufficient knowledge base on the harmfulness of e-cigarettes. The results can set new indicators for monitoring air pollutants from this source.

The studies by Jung et al. and Jung and Abdelaziz Mahmoud provided valuable information on the air quality conditions in Dubai residential buildings. The aim of the first study was to assess the concentrations of pollutants including Total Volatile Organic Compounds (TVOC), HCHO, and VOCs depending on the height of the building. Measurements were carried out in twelve apartments using the WHO IAQ assessment methodology. Most pollutants were within permissible concentration limits, but TVOC exceeded the limit in Dubai by nine times. The aim of the second study was to measure and analyze particulate matter (PM) concentrations inside and outside buildings during spring dust storm periods. The authors analyzed the relationship between the diameter of PM particles, air exchange in the building and the concentration of PM in the outdoor air. The study found that smaller particles, especially ultrafine PM2.5, had a greater impact on indoor PM concentrations than larger particles. Buildings with greater air exchange, especially those with natural ventilation, were observed to be more susceptible to PM infiltration from the outside. Furthermore, the study highlighted the significant contribution of household chores, such as cooking and cleaning, to the generation of

indoor PM. This identification of problems in the residential building sector highlighted the importance of the challenges associated with ensuring good indoor air quality.

There is still a wide area for further original research, especially in the field of monitoring and numerical analyzes of the indoor environment quality.

Author contributions

BK: Conceptualization, Writing–original draft. JF-G: Writing–original draft, Writing–review and editing. KS: Writing–review and editing. JS: Writing–original draft. SH: Writing–review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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