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## Indoor air quality merits closer attention

**A study covering all of French-speaking Switzerland found that energy-efficient renovation work on residential buildings tends to overlook the question of indoor air quality. The study's authors, mainly from EPFL and the School of Engineering and Architecture of Fribourg (HEIA-FR), have called for greater attention to this issue.**

Researchers from EPFL, the School of Engineering and Architecture of Fribourg (HEIA-FR) and the Center for Primary Care and Public Health (Unisanté) have conducted a broad study of residential energy use and indoor concentrations of radon, mold and numerous organic chemicals – volatile organic compounds (VOCs) and aldehydes – in both newly built and renovated energy-efficient housing in French-speaking Switzerland. The research, carried out with support from external experts, was initiated by the Western Swiss Center for Indoor Air Quality and Radon (croqAIR), based at HEIA-FR, which is leading the Mesqualair indoor air quality measurement project. Between 2013 and 2016, the researchers mailed measurement kits and comprehensive questionnaires to occupants of these dwellings, asking them about their lifestyles and characteristics of their homes. A high response rate gave the team more than enough data to draw compelling conclusions.

The highest concentrations of these airborne pollutants – which are known to cause cardiovascular and respiratory diseases, as well as lung and other cancers – were found in dwellings with good wall insulation but no mechanical ventilation or other air circulation systems. This finding has prompted the team to urge government authorities, the construction industry and the general public to pay closer attention to the issue of indoor air quality, on both sustainability and public health grounds.

### A regulatory vacuum

Although the Federal Radiological Protection Ordinance of 1994 (revised in 2017) sets limits for concentrations of radon gas, there is no equivalent regulatory framework in Switzerland for the other pollutants covered by the study. The team therefore had to look elsewhere for a comparative baseline. Their results were published in four separate papers between December 2019 and spring 2020. The most recent, which appeared in Indoor Air Journal on 14 April 2020, focuses on chemical compounds. The paper reveals that while concentrations of formaldehyde (released from building materials) were without exception below limits recommended by the World Health Organization (WHO), the French authorities and the Swiss Federal Office of Public Health (FOPH), the measurements exceeded the chronic reference exposure level set by the California Office of Environmental Health Hazard Assessment (OEHHA) in 90% of cases. Likewise,

indoor total VOC (TVOC) concentrations were above the FOPH-recommended level of 1,000 micrograms per cubic meter of air in 8% of cases.

The researchers found that levels of chemical pollutants were generally lower in buildings equipped with mechanical ventilation systems. They concluded that high VOC concentrations in dwellings built between 1950 and 1990 were, at least in part, caused by three factors: the use of certain construction materials, a lack of mechanical ventilation, and the fact that fitting energy-efficient insulation reduces natural air flow between indoors and outdoors. Increased levels were also found in buildings with an attached garage.

The team's first paper, published in the journal *Atmosphere* on 4 December 2019, reported on radon measurements in over 650 dwellings in a three-month period. The results indicate that, as a general rule, levels in new energy-efficient buildings are lower than in renovated builds because new buildings tend to be located in areas with lower underlying radon concentrations and are more likely to be equipped with mechanical ventilation systems. Looking at a sample of 60 renovated buildings, the researchers found a 20% increase in radon exposure when compared with pre-renovation levels, further underscoring the need for powerful and efficient ventilation. The team also reported higher concentrations in buildings with root cellars in radon-affected areas.

### **Opening windows isn't enough**

In a paper, which appeared in early 2020 in *Building and Environment*, the researchers revealed that people living in renovated dwellings without mechanical ventilation, ventilated their homes more often than those living in newly built dwellings with mechanical ventilation systems. However in both cases air renewal was insufficient, leading the team to conclude that adequate indoor air quality cannot be achieved by opening windows alone. The last paper, which has not yet been published, reports on mold concentrations and species in 149 dwellings. As with radon, the team found that new energy-efficient dwellings with mechanical ventilation systems provide better protection from mold than renovated buildings. They also report that suburban housing tends to have more visible mold, and a greater diversity of species, than urban and rural dwellings, and that the presence of mechanical ventilation systems affects the diversity of fungal species. They also found that such systems help prevent mold growth by reducing the build-up of moisture inside buildings.

### **Numerous solutions**

What are the future implications of this research? Dusan Licina, a tenure-track assistant professor at EPFL's Smart Living Lab in Fribourg and one of the co-authors of the papers, believes that the study paves the way for further research into smart windows and low-emission building materials, with an emphasis on the need to monitor indoor air quality continuously. Joëlle Goyette Pernot, a professor at HEIA-FR and another of the papers' co-authors, stresses that air quality warrants closer attention: "As researchers, it's our job to draw the attention of government, industry and the general public to this issue. We're currently working with the FOPH and Geneva Canton to set up an indoor air quality observatory in French-speaking Switzerland. The new facility, the first of its kind in Switzerland, will help to further our understanding and encourage collaborative research."

The researchers believe that the ultimate aim of energy-efficiency measures should be to improve occupant well-being. "It's easy to work out the energy and cost savings that flow from bringing old dwellings up to modern efficiency standards," says Licina. "But if we ignore the impact of renovation work on indoor air quality, these gains could be

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outweighed by adverse health and productivity outcomes. It's time for industry to treat these aims not as competing forces, but as two sides of the same coin.”

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