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# Monitoring Indoor Air Quality in Austrian Homes

Pilot 5 of the K-HEALTHinAIR project investigates indoor air quality (IAQ) in residential and educational settings across Poland and Austria. Using low-cost sensor technology, the study aims to validate sensor performance, identify pollutant sources, and explore links between air quality fluctuations and health outcomes.

## The pilot structure

Two main scenarios are monitored:

- Homes, including those of individuals with chronic respiratory conditions
- Schools, with occupants such as children, teachers, and staff

## Home monitoring methodology

Several complementary methods are employed in residential settings:

- Continuous IAQ monitoring: Low-cost sensors track temperature, humidity, $CO_2$, particulate matter (PM), and total VOCs (tVOCs).
- Outdoor air quality assessment: Local air quality and meteorological data are estimated through model-based interpolation, land-use regression, and dispersion modelling.
- Spot VOC measurements: Single-time-point calibrations complement continuous monitoring.
- Housing questionnaires: Participants report structural and lifestyle characteristics.
- Monthly health surveys: Residents detail perceived health, well-being, and activities that might affect indoor environments (e.g., renovations).
- Detailed activity diaries: In a subset of homes, participants log minute-level activities (e.g., cooking, smoking, ventilation) over several weeks.
- Air filter intervention: Selected households test filtration devices intermittently during the diary period to assess their efficacy.

## Key Findings

### Sensor performance in general

Continuous IAQ monitoring is feasible. After some start-up problems regarding the connection of the sensors to the WLAN in the homes, the sensors work nearly continuously in most of the homes and participants do not report any problems.

Sensor modules must be replaced regularly according to the producer. Especially regarding the tVOC module, a change became necessary in most homes after 1.5 years. Refraining from the exchange in selected homes where 2 sensors were operated in parallel, demonstrated that module life is a few months longer than indicated by the producer. But then the signal strength starts to decline steadily over about one year, although not reaching zero. About half of the new replacement modules did not work properly and reported implausibly high tVOC values, often following a steep increasing trend. Automatic reset and re-calibration did not solve this problem and the modules had to be replaced again.

### Quality of sensor results

The sensors reported plausible values for temperature, humidity, and $CO_2$.

Regarding PM it seems the sensor signals are triggered by single particles touching the reactive module surface. Thus, the signal would be expected to be correlated with the particle number concentration. The particle number itself is relevant for health and wellbeing. Unfortunately, the sensors do not report number concentrations, but particle mass concentrations for particles smaller than 10µm (PM10) and 2.5µm (PM2.5). These reported concentrations are calculated based on an internal formula assuming a constant size distribution and average density of the particles. Clearly, in indoor settings, there are very different sources with very different geometric and chemical properties of the particles. Because count data are computationally translated into PM10 and PM2.5 values, the two mass variables are strongly correlated with each other ($R > 0.99$), which is implausible and renders the reporting of the two variables separately unnecessary. Nevertheless, in comparison with outdoor PM concentration, especially PM10, the figures obtained from the sensors are mostly plausible. Indoor activities supposed to affect the indoor PM concentration, and the operation of the filter device, lead to the expected changes in concentration.

Similar to PM, also tVOC is a measure of a multitude of different (in this case, volatile organic) substances. It is not to be expected that each volatile organic compound (VOC) would give the same signal per unit of mass. According to the producer, the sensor module has been calibrated by the traditional "Molhave" mixture of VOCs. Since this mixture has been described many decades ago (Molhave et al., 1986, 1991, 1992), a different VOC spectrum is to be expected nowadays and the reported numbers are bound to be incorrect. This was clearly demonstrated by comparing results of spot measurements (samples analysed by GC-MS) with sensor data obtained at the time of sampling. Besides that, the modules also tend to report too high concentration values.

As with PM, it might well be that the signal caused by VOCs is relevant for health, even if the concentration values estimated from the signal are incorrect. It is not reported which chemical reaction is used to produce the monitoring signal. But many chemical reactions of VOCs are directly relevant for health, be it a solvent effect on lipids, be it an oxidation reaction or the formation of ions and radicals. Clearly, the temporal variation of tVOC values is affected by various indoor activities in a plausible way. Correlation analysis with $CO_2$ indicates that tVOC mostly comes from indoor sources.

## Effects on health and wellbeing

In spite of the shortcomings regarding the interpretability of sensor data, a first analysis of panel data indicates that IAQ as reported by sensor data does have a subtle effect on health and wellbeing. In order to better control for seasonal variation and to increase the power of the data set, we want to continue data collection until the end of the year 2025 before the final analysis of the panel data can be performed.

## Contribution to Knowledge

Already now, the pilot study established continuous contact with the participants of the study and therefore helped raise awareness about IAQ and how it is shaped also by everyday activities. These practical facts will be shared with the broader community as more data are collected and analysed.

## References

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