CO_2 Monitoring to Lower the Coronavirus Threat

Graham Martin, CEO and Chairman, EnOcean Alliance

There is increasing evidence that carbon dioxide levels in buildings correlate strongly with the airborne spread of infection. Consequently, CO_2 monitors could act as the "canary in the coalmine" to mitigate the coronavirus threat.

Carbon dioxide is generated by the exhaled air of people who stay indoors. Each person in a building will exhale approximately eight liters of air per minute: air that has been in close contact with the lung tissue(1). Alongside CO_2 at a concentration around 40,000 parts per million (ppm), the exhalation also contains tiny liquid droplets (aerosols) which, due to their size, can float in the air for a long time. These droplets will contain any virus particles present in the lungs. Research shows a method to mitigate infection can be implemented with CO_2 monitors on site.

There is some consensus that sinking speeds of such aerosols are typically a few meters per hour and a decrease in biological virus infection activity has a half-life of approximately three hours in laboratory conditions(2)). This means that the room air remains polluted for a long time. If a healthy person inhales these contaminated droplets, and if the number of virus particles they contain exceeds a minimum infectious dose, the disease is transmitted. Whilst it is difficult to measure the viral load directly, energy harvesting wireless sensors are the ideal way to monitor CO_2 levels and hence prevent the build-up of reused air.

Measuring COVID transmission by proxy

With evidence like this increasingly pointing towards airborne transmission being a major factor in the spread of the virus, the inference is that CO_2 levels in rooms and other enclosed spaces may be used as a proxy for COVID-19 transmission risk.

"*Since the coronavirus is spread through the air, higher* CO_2 *levels in a room likely mean there is a higher chance of transmission if an infected person is inside*", leading aerosol scientist Prof Shelly Miller writes in The Conversation. "*Simply put, the more fresh, outside air inside a building, the better. Bringing in this air dilutes any contaminant in a building, whether a virus or something else and reduces the exposure of anyone inside*."

A 2019 study on a tuberculosis outbreak at Taipei University, Taiwan, provides detailed evidence. Many of the rooms were poorly ventilated and reached CO_2 levels above 3,000 ppm. When engineers brought levels down to under 600 ppm the outbreak stopped.

What level is safe?

Elsewhere, Prof John Wenger, director of the Centre for Research into Atmospheric Chemistry in UCC suggests a target of 1,000 ppm if CO_2 is being used as a proxy for COVID-19 in classrooms, and argues that room level transmission is "*the key. It's in the air, and it can fill a room. The amount of the virus in the air can accumulate, and we get increased exposure. If you're indoors, in a poorly ventilated room for a long time, then you're at quite a high risk even if you're distanced, because the air moves around.*"

Indoor CO_2 measurements using easy and low-cost to install sensors hold promise for the mass monitoring of indoor aerosol transmission risk for Covid-19 and other respiratory diseases. Different CO_2 level targets should be set based on the environment and activity type since infection risk level has been shown to vary by a factor of 100 or more depending on the situation and activity type. Factors such as the number of infected people in a region and measures such as mask-wearing or air filtration may reduce the presence of the airborne virus without reducing CO_2 levels. Certain activities increase virus emission far more than CO_2 levels, such as talking, singing and shouting. Both CO_2 and the virus are diluted by ventilation with outdoor air. They are not, however, removed by recirculating the air, for example through heat exchangers.

The air that you breathe

If we are in a room with several people, the measurement of the CO_2 concentration provides a measure of what percentage of the air we inhale which consists of air that has already been exhaled by other people. The mass balance shows that a measured CO_2 concentration of approx. 1200 ppm means that almost 2% of the air in the room has already had lung contact at least once. At this level, every 50th breath that a person takes in this room consists of air that has already been exhaled. The resulting specific corona infection risk is more complex to quantify, as it depends on various factors that are currently still being intensively researched.[(1)] Notwithstanding these caveats, it is clear that CO_2 measurement offers a cost-effective solution for classifying the current risk from potentially infectious aerosols.

Strategies to reduce infection risk

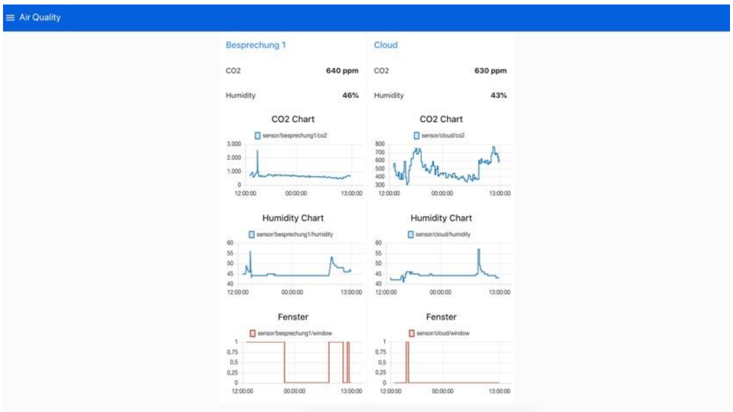
Putting the research into practice, the Federal Environment Agency has drawn up general guidelines for health assessment of carbon dioxide in indoor air, which includes advice regarding SARS-CoV-2 – advice that is also relevant to COVID-19. Accordingly, a concentration of <1000 ppm is hygienically harmless. The guideline classifies a concentration between 1000 and 2000 ppm as questionable and anything above it as unacceptable. CO_2 is also an important indicator in the DGHK (Deutsche Gesellschaft für das hochbegabte Kind - German society for gifted children) statement on prevention in schools.

Similarly, the UBA (Umweltbundesamt - German Environment Agency) ventilation working group recommends the use of CO_2 traffic lights for this purpose. The DGVU (Unfallkasse) goes even further and advocates a target value of 700 ppm in classrooms in times of epidemic. The latest findings are summarized in the UBA guide "Ventilation in schools" (15.10.20), which was created for the KMK (Kultusminister der Länder in der Bundesrepublik Deutschland).

Ventilation means not only air exchange but also heat loss in winter. A sustainable strategy should also take this effect into account. Where there is no modern air-conditioning technology with a heat exchanger, only monitoring of the CO_2 and demand-oriented or regular manual cross-ventilation helps. REHVA, the Federation of European Heating, Ventilation and Air Conditioning Associations has called for the installation in school classrooms of CO_2 monitors with traffic-light indicators, “*at least in schools where ventilation depends on opening windows and/ or grids*”.

CO_2 sensor implementation

To follow these strategies, CO_2 monitoring devices need to be dependable, and easy to place where they are needed. Ideally, they need to be connected, for example, to trigger alarms when CO_2 concentration goes above “traffic light” thresholds, even to send alarms to building management networks, or to smartphones via wireless networks. Wireless, battery-free sensors represent the ideal solution. Simple to fit and easy to maintain, such sensors utilize energy harvesting technology to draw energy from their surroundings – for example from motion, light, or temperature differences. Rapidly deployed, without the need for special installation or wiring, such solutions enable continuous monitoring of carbon dioxide concentration in the ambient air.



Dashboard for continuous monitoring of carbon dioxide concentration in the ambient air (source: EnOcean GmbH)

By sending measured values to a receiver or gateway for further processing, alarms can be triggered, and appropriate action initiated. For example, it is possible to start a room ventilation system to reduce the CO_2 concentration. What is more, a wide range of these CO_2 sensors works within the ecosystem of standards like the EnOcean Alliance. This means that they can easily combine with other devices, such as room occupancy sensors and access control, that are integral to COVID-19 measures.

www.enocean-alliance.org

Acknowledgments

(1) COVID-19 Prävention: CO2-Messung und bedarfsorientierte Lüftung - https://www.umwelt-campus.de/forschung/projekte/iot-werkstatt/ideen-zur-corona-krise

(2) Modeling aerosol transport and virus exposure with numerical simulations in relation to SARS-CoV-2 transmission by inhalation indoors - https://www.sciencedirect.com/science/article/pii/S0925753520302630#b0125