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## Crowd-Data Collection of Indoor CO<sub>2</sub>-Levels using Portable CO<sub>2</sub>-Sensors and a Mobile App

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High CO<sub>2</sub> levels in indoor spaces not only have direct adverse affects on human wellbeing but are also, in most cases, a reliable indicator of the amount of rebreathed air and thus for the risk of spread of airborne diseases. Despite its importance, large-scale datasets on indoor CO<sub>2</sub> levels across diverse, publicly accessible spaces remain scarce.

Existing research on indoor CO<sub>2</sub> levels so far focuses mostly on a narrow range of environments such as hospitals, schools, or residential homes. While these studies provide valuable insights, they are frequently constrained by limited sample sizes, narrow geographic coverage, or short observation periods. This leaves a substantial knowledge gap regarding CO<sub>2</sub> levels in a broader range of public indoor spaces, such as restaurants, shops, museums, public transport, and other high-traffic areas, which the IndoorCO<sub>2</sub>Map project attempts to close.

IndoorCO<sub>2</sub>Map.com is an open source and open data citizen data collection project that enables individuals to measure and share CO<sub>2</sub> concentration data using portable sensors. Participants can contribute data from all kinds of publicly accessible indoor locations, creating a comprehensive and diverse dataset of real-world indoor CO<sub>2</sub> levels. This crowd-sourced approach is designed to scale geographically and temporally, overcoming many resource constraints of traditional studies.

The project combines accessible technology, including low-cost CO<sub>2</sub> sensors, with an intuitive and privacy respecting mobile app where users can record and upload their measurements. Each data point is timestamped, and annotated with geodata about the location type using OpenStreetMap, facilitating detailed analysis of spatial and temporal trends in indoor air quality.

The project is currently still in beta testing and little effort has been taken to increase the user base. Nevertheless around 7000 measurements, ranging from the minimum 5 minutes to hour long recordings, have been already taken as of January 10th, making it the largest publicly available dataset. Currently around 30 to 50 measurements per day are taken in average, with around 80% of them being in Germany so far.

Preliminary results from the dataset will be discussed, highlighting patterns of CO<sub>2</sub> concentrations across various public indoor spaces. For instance, Variation of CO<sub>2</sub> levels by venue type, time of day, week of day and season.

Key challenges will also be addressed, such as ensuring data quality and reliability in a crowd-sourced dataset, addressing privacy concerns, and fostering sustained engagement from contributors. Biases resulting from differences between the general population and app users will also be discussed.

Furthermore, it will be discussed how this data can complement other studies, inform public health initiatives, urban planning, and provide guidance for policy-making. For example, insights from IndoorCO<sub>2</sub>Map.com could guide ventilation standards, identify high-risk locations and provide guidance for individual decision-making of visitors/customers. It can also be used for hypothesis generation for scientific studies.

By leveraging citizen data collection, IndoorCO<sub>2</sub>Map.com already demonstrates a scalable, community-driven approach to tackling data gaps in regards to indoor air quality. The project not only fills an important data gap, but also raises public awareness about the significance of ventilation in maintaining safe and healthy indoor environments. Because the data and code is open source, it can also be adapted by others for specific research questions, be expanded in the future to other indoor pollutants or, if necessary, a stricter approach to user verification can be implemented.

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