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Online particulate matter monitoring to track and control air quality in public transport

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Objective: As an indoor environment, public transport is subject to special conditions with many passengers in a comparatively small space. Therefore, both an efficient control of the climatic parameters and a good air exchange are necessary to avoid transmission and spread of respiratory diseases. However, in such a dynamic system it is practically impossible to determine pathogenic substances with high temporal and spatial resolution, but easy-to-measure parameters like airborne particulate matter and carbon dioxide allow the air quality to be assessed in a passenger compartment online, which is useful for controlling the ventilation system.
Methods: Hand-held devices were used to measure temperature, relative humidity RH and carbon dioxide. An optical particle sizer was used to measure the particle concentration. The conversion to mass-related concentrations was based on the assumption of spherical particles and a density of 1 g/cm³. A portable monitoring system was also used for the recording of environmental parameters. The system consisted of a carbon dioxide sensor, an optical particle sensor and a temperature/humidity/pressure sensor. The measurement program focused on regional bus, tram and train traffic in Braunschweig and Hannover, or between the two cities. The occupancy of the passenger area was recorded for all route sections. In addition, measurements were carried out on the tram platform of the underground station at Hannover Central.
Results: In the case of the particles, the concentration peaks did not correspond to the occupancy density of the passengers, but often to their dynamics when the doors were regularly opened, combined with getting on and off. Some of the particles were brought in through the ambient air, some through clothing and the movement of passengers. As a result, the particle concentration in the cabin increased significantly at the bus stops. It was also noticeable that in various measurements the highest particle concentrations were recorded when several passengers boarded at the same time at the starting point. It is known that moving people are relevant particle sources or resuspend particles, but it is certain that the passengers' breathing is not the source of the particles. The maxima occurred only for a short time and reached the base level again within a few seconds. For each measurement run, ambient air measurements were carried out on PM_{10}, but only at the respective start and final stations. These concentrations were mostly in the range of 10 µg/m³. However, there were bus and train platforms with significantly higher ambient air concentrations of PM_{10}. For example, the values in the metro station at Hannover central station were consistently around 50 µg/m³. At other stations in Braunschweig and Hannover, smoking areas on the platforms, traffic or construction sites influenced the PM_{10} concentration in the passenger cabins when the doors were open. Therefore, the PM_{10} peaks did not always coincide with entry and exit of many people. As expected, the carbon dioxide concentration in the transport cabin was directly linked to the density of passengers.
The parameters PM_1 and $\mathrm{PM}_{2.5}$, which were also measured with the sensors, did not provide any additional information for the issue of efficient ventilation, which is relevant here. There were also some deviations from the OPC data, which is due to the different measurement technologies.
Conclusion: The investigations carried out and the results presented do not claim to assess the risk of persons for an infection by pathogenic bioaerosols in passenger cabins in public transport. It is also explicitly warned against using this methodology for such purposes. However, it was demonstrated that the online measurement of simple parameters like PM_{10} and carbon dioxide is a valuable tool for assessing air quality as a function of time, location, number and dynamics of people and for controlling the ventilation in public transport.

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