Measuring Air Quality Indoors and Outdoors with Low-Cost Sensors

According to guidelines set by the World Health Organisation, 9 out of 10 people are exposed to polluted air. One type of pollutant which has been linked to poor visibility, changes in the climate, and serious health issues is something called particulate matter. Also known as aerosol particles, particulate matter refers to particles of liquid or solid matter with varying size and chemical composition that are suspended in the air. Particles with a diameter less than 10 μm (PM_{10}) and less than 2.5 μm ($PM_{2.5}$) are regulated air pollutants in ambient air due to their negative impacts on both human health and the environment.

However, regulations and guidelines for indoor air quality are almost non-existent. Apart from outdoor air infiltrating our indoor spaces through windows, doors, and ventilation, there are many activities inside which can generate particulate matter themselves. Cooking, vacuuming, cosmetic aerosols, and burning candles are just some sources of different indoor aerosol particles. Considering the average person spends 85-90% of their time indoors, it is definitely important to properly understand and monitor the quality of the air they are breathing.

The standard reference method for measuring particulate matter uses instruments that collect the particles on special filters and weigh them with very sensitive scales. While this may be the most reliable method, these instruments are typically very expensive and require special know-how and many man-hours to obtain results, normally with only 24-hour resolution. An emerging field within aerosol science is that of low-cost sensors. These are smaller, more portable devices which can continuously measure air pollutants such as particulate matter at a fraction of the cost of laboratory-grade sensors. These features provide an opportunity to, among other things, provide new insights into the particulate matter found in our homes.

This study uses a low-cost optical particle sensor to explore how common indoor and outdoor activities affect the levels and trends of PM_{10}, $PM_{2.5}$, and additionally PM_1 (less than 1 μm). The sensor determines the size of the particles by measuring how they cause light from a laser to scatter. This information is then used to calculate the total mass concentration of particles in the air flowing through the sensor. Since low-cost sensor technology is still evolving, there is often a trade-off between the price and useability and the quality of the data. For this reason, data from four co-located sensors is compared to assess their precision, and the average PM_{10} measurements from two sensors placed outdoors are compared with official data from the air quality monitoring station in Lund.

Results indicate that these low-cost sensors are indeed able to identify trends in particle mass concentration associated with residential activities both indoors and outdoors. While the outdoor concentration was generally more than 3 times more than indoors, there were significant peaks in indoor concentration matching periods of cooking and burning candles. Outdoors, the concentration spiked in accordance with vaping episodes. In comparison to the Lund measurements, the low-cost sensors actually performed relatively well, except for a period when the outdoor sensors unexplainably registered much higher values.

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