Air Monitoring Sensor Guidance Fact Sheet

August 26, 2019

COLORADO
Department of Public Health & Environment

Historically, air monitoring has been performed using expensive equipment that needs to be operated in a weatherproof temperature-controlled environment. As a result, information that the general public can get has been limited to networks operated by government agencies. With changes in technologies, small sensors, or next-generation sensors, are becoming more available for use and increasingly affordable for the general public. However, these new technologies have limitations and are not as accurate, and thus the data need to be considered accordingly.

Monitoring by government agencies is often to meet Federal requirements, and operation of the air monitoring is largely dictated by US Environmental Protection Agency (EPA) requirements. Not only is the equipment costly, but detailed quality assurance protocols need to be followed to make sure that the data are “regulatory” quality and can be used to make decisions that will impact large populations and industries. In contrast, small sensors can be purchased and operated by anyone, without any requirements. Small sensors, being cheaper and not needing a controlled environment, can be placed in many locations to spatially monitor a large area. While not as accurate, they can be adequate for looking at general exposures to air pollution.

Monitoring is typically performed for EPA “criteria” pollutants for which there are health-based National Ambient Air Quality Standards (NAAQS). These include ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2) and particulates (coarse or PM10, and fine or PM2.5). Other monitoring is often performed for volatile organic compounds (VOC).

While “regulatory” monitoring is considered the gold-standard, small sensors are used more for general information and have significant limitations. In many cases the sensors that are used were developed for industrial applications in a known gas stream and are simply not yet well enough developed for use in the ambient air where there is a huge mix of pollutants and changing environmental conditions. Thus, there are often issues with cross-interferences from other compounds, or sensitivities to temperature and humidity. Any data should be corrected for account for these issues before reporting.

With small sensors, drift over time can be an issue. Without routine cleaning, calibration, or co-location with a reference analyzer, drift cannot be taken into account. In addition, some sensors, particularly electrochemical, have a relatively short lifespan before the sensor needs to be replaced. Also, where a sensor is located is important, such as not putting a particulate sensor near a smoke vent or grill.

Data from small sensors is often reported every minute. While these values can be interesting, especially in a pollution plume, they are usually very noisy and erratic. It is only after developing longer averages of these data, such as 1-hour, that the sensor noise is smoothed out. The NAAQS, which are health-based, are generally 1-hour, 8-hour or 24-hour average standards, so a short-term reading (such as 1-minute) cannot be directly compared. In general, small sensor measurements are not robust enough for official comparisons to NAAQS or for assessing health risks.

The EPA has developed an “Air Sensor Toolbox” website (https://www.epa.gov/air-sensor-toolbox) which provides a lot of information on small sensors. In particular, the “Air Sensor Guidebook” provides a wealth of information on types and uses of small sensors, as well as maintenance that should be performed. EPA has also conducted performance tests on a number of small sensors, with the results posted.

Another resource is the South Coast Air Quality Management District's AQ-SPEC center (http://www.aqmd.gov/aq-spec). This center was created to evaluate different sensors, both in the field (real-world conditions) and in the laboratory (controlled environment), and make the performance results available to the public.

In general, there are many manufacturers of small sensor packages, but only a few manufacturers of the actual sensing devices that are used in the packages. What typically differentiates the sensor packages are the physical boxes they are in, the algorithms that are used to convert a raw signal to a concentration reading, the algorithms that are used to adjust the readings for interferences and sensitivties (i.e. humidity and temperature), and the software to display the data. Unfortunately, many manufacturers do not truly calibrate their sensor packages before shipping to customers.

Overall, particulate sensors are currently the best developed of small sensor technologies. Some general characteristics for different sensors are:

Particulate matter (PM)
- Laser particle counter or light scattering sensors
- Typically set up to provide PM2.5 readings
- Many also calculate PM10 readings, and some calculate PM1 readings
- Sensitive to relative humidity and temperature

Ozone (O3)
- Electrochemical or metal oxide sensors
- Electrochemical sensors sensitive to NO2 and temperature
- Metal oxide sensors sensitive to humidity and VOCs

Nitrogen dioxide (NO2)
- Electrochemical or metal oxide sensors
- Electrochemical sensors sensitive to O3 and temperature

Sulfur dioxide (SO2)
- Electrochemical or metal oxide sensors
- Electrochemical sensors sensitive to temperature and cross-interferences
- Sensitivities are often not low enough for typical ambient air concentrations

Carbon monoxide (CO)
- Electrochemical or metal oxide sensors
- Electrochemical sensors sensitive to temperature and cross-interferences
- Sensitivities are often not low enough for typical ambient air concentrations

Volatile organic compounds (VOC)
- Photo ionization detectors, spectroscopic and metal oxide sensors
- Provide a total VOC reading only, not individual compounds
- Sensitive to humidity
- Sensitivities are often not low enough for typical ambient air concentrations