The dilemma with low-cost sensors

By Merlin Francis, CSTEP

Low-cost air quality sensors are the talk of the town. By addressing cost issues and bringing in portability, these sensors are quickly becoming the game-changers in efforts toward better air quality. Low-cost sensors (LCS) enable dense monitoring of air pollution, allowing policymakers to target interventions at highly polluted areas, thereby improving air quality. But their large-scale use needs careful consideration, given the concerns around the accuracy and reliability of LCS data.

A study by Adroit Market Research found that the global air quality sensor market is expected to grow at a compounded annual growth rate (CAGR) of 8.36% during the study period (2021–2028). The Asia-Pacific region, with China and India in the lead, is seen leading the market for air quality monitoring systems. Incidentally, the report found that in 2020, government agencies and academic institutions had the largest share of the global air quality monitoring systems market, owing to policies targeted at air pollution control and more research collaborations.

This is reflected in India, where the national policy for clean air, the National Clean Air Programme, encourages the use of alternative methods of monitoring and measurement, including low-cost sensors, to develop robust datasets and enable real-time monitoring of air pollution.

With growing awareness about the health impact of air pollution, the need for tracking and monitoring air quality, and the increasing number of citizen-science initiatives in this space, low-cost sensors are becoming popular in residential and commercial establishments as well.

That low-cost sensors can augment data obtained through traditional technology—large, expensive, reference-grade instruments—is a no-brainer. India has approximately 800 air-monitoring stations set up in various cities, woefully short of the estimated 4000 stations that are actually required. Using low-cost sensors along with reference-grade instruments (as well as other alternative methods of pollution monitoring), India can set up an air pollution monitoring network in any region to provide robust, real-time, local data on air quality.

However, for meaningful use, these data need to be accurate and reliable. This is where the problem arises.

Earlier this year, on March 25, the Central Pollution Control Board (CPCB) released a circular stating that it would not be using measurements from low-cost sensors for regulatory purposes as ‘its accuracy, linearity, reliability, and long-term performance are not yet fully established’.

Likewise, the European Union does not accept LCS data for official air quality reporting, given its ‘questionable data quality compared to official gravimetric measurements’.

A recent study by the Center for Study of Science, Technology, and Policy (CSTEP) that compares the performance of nine low-cost sensors against a beta attenuation monitor (a reference-grade instrument) found discrepancies in the air pollution data provided by low-cost sensors. This is not surprising, considering that most low-cost sensors quantify PM2.5 on the basis of ‘light-scattering technique’, which is sensitive to environmental factors (e.g. humidity in the atmosphere) as well as the optical and micro-physical properties of particulate matter, in addition to particle concentration.

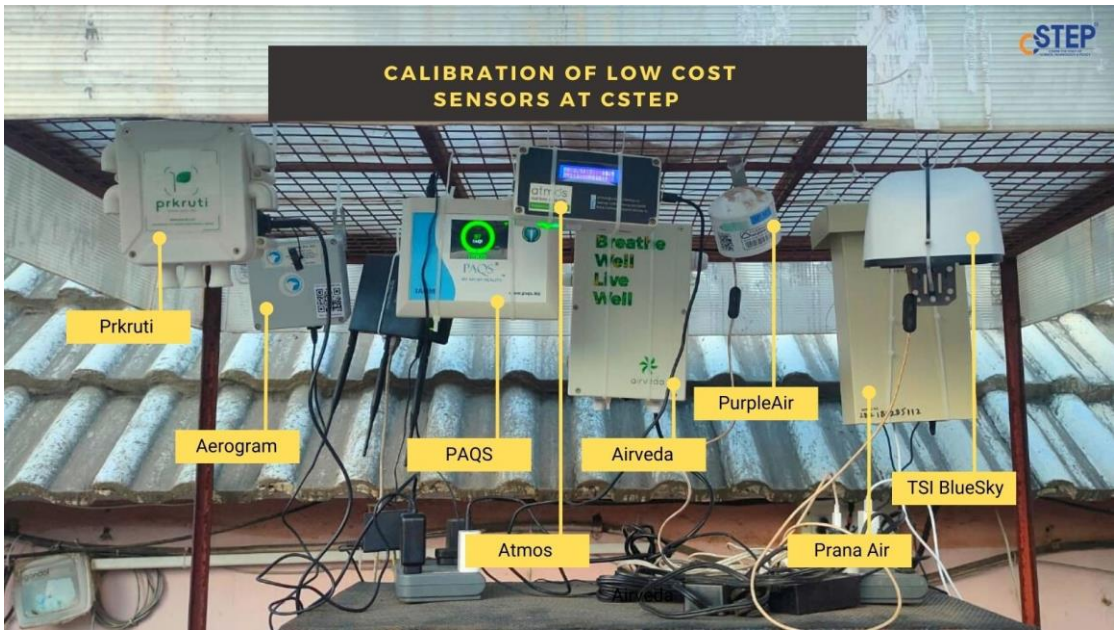
Does this mean that low-cost sensors are unreliable?

Not exactly.

The CPCB—which is considering a pilot study to evaluate the efficacy of LCS—as well as CSTEP's study, notes that the raw data from low-cost sensors can be utilised for qualitative assessment; for instance, to identify specific days or locations that are more polluted than others.

In areas where there is little to no monitoring, low-cost sensors can provide quality information on pollution trends. Moreover, the higher temporal resolution of low-cost sensors (compared to reference-grade instruments) is useful in capturing short pollution events.

To assess its accuracy, many users are conducting 'collocation' experiments. By collocating low-cost sensors with reference-grade instruments at the local level, researchers are able to develop models for aligning the data with the reference-grade instruments. Once the data is collected by these LCS, the calibration models or coefficients are used to correct the data.



CSTEP's study noted that there are differences in the data of low-cost sensors of different make and models, and therefore, calibration models need to be make-specific.

According to Sreekanth Vakacherla, Principal Investigator for the study 'data democratisation' and greater awareness are key to effective air pollution management using low-cost sensors in India.

"We need to increase the awareness on how to use low-cost sensor data. Direct LCS data are biased. We need to interpret the calibration models in a layman language such that general public can understand the degree of bias in the sensor data," he says.

By putting the models needed for calibration in the public domain, those using the sensors can understand how to calibrate them. As calibration ensures greater accuracy in the sensor data, this will be very useful for citizen groups as well as for researchers who are using low-cost sensors to monitor air quality. India faces a challenge in that it has very few reference-grade instruments which are mostly owned by pollution control boards, research institutions, or industries. Facilitating and enabling access to reference-grade instruments for conducting collocation experiments will help improve the quality of data from low-cost sensors', he explains.

As the industry evolves, we will also see an increasing demand for skilled workers capable of interpreting data from low-cost sensors. Building expertise will be an important step if we intend to use low-cost sensors for air quality monitoring reliably, he adds.

There’s no denying the science behind low-cost sensors or the value they can bring to the air quality monitoring ecosystem. Observing, learning, and tracking this development can ensure that we leverage the full potential of low-cost sensors.

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Join us at the India Clean Air Summit 2022, CSTEP’s flagship event on air pollution, which will bring together experts working in the air pollution ecosystem. This year, ICAS2022 will be held along with the Air Sensors International Conference (ASIC) organised by UC Davis. Stay tuned for updates on the event by following us on Twitter @CSTEP_India.