WHITE PAPER

Hybrid air quality monitoring network

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Introduction

Rapid urbanization, industrialization, and a rise in vehicular pollution have severely affected air quality in cities. With growing concerns about air pollution and cascading effects across the population, air pollution is emerging as a significant problem. Vehicular pollution, road dust, construction, and industrial pollution are some of the major sources responsible for air pollution in Indian cities. Urban air quality is particularly difficult to measure owing to highly heterogeneous pollution distribution. Therefore, it is very crucial to create a dense air quality monitoring network in order to understand the spatio-temporal variations in pollutant concentration.

Monitoring air quality at such a scale with (first and second generation) continuous ambient air quality monitoring stations (CAAQMS) is very expensive; as a result, a dense network of them cannot be deployed. In recent times, low-cost sensor-based systems have evolved as a highly reliable and scalable solution for real-time ambient air quality monitoring. However, calibration is crucial for sensor accuracy. Hybrid air quality networks provide the best of both worlds. It is a network of air quality monitors in which traditional air quality stations are supported with the deployment of multiple sensor-based air quality monitors. The hybrid network complements the data gaps of CAAQMS by incorporating spatially dense data inputs from low-cost sensor-based air quality monitors.

	1st Generation : AAQMS Ambient Air Quality Monitoring System	2nd Generation : CAAQMS Continuous Ambient Air Quality Monitoring Station	3rd Generation : CAAQMS Sensor-based Continuous Ambient Air Quality Monitoring System
Technology	Gravimetric & Titration Analysis using HVS (High Volume Samplers)	Analyzer Instrumentation	Sensor Based
Data Monitoring Method	Manual Analysis in Laboratory	Automated Continuous Monitoring	Automated Continuous Monitoring
Data Frequency	1 data point from 8Hr sample	Continuous (every minute)	Continuous (every minute)
Man-power Required	16 Man Hours per monitoring	Not Required	Not Required
Electricity Required	600-800 Kw.Hr. / year	4-5 Mw.Hr. / year	25 Kw.Hr. / year (No power required if Solar Powered)
Cost * for PM2.5, PM10, SOx, NOx, CO, O3 Monitoring	CAPEX : $7000 - $10,000 OPEX : $500,000 / year	CAPEX : $80,000 - $120,000 OPEX : $15,000 / year	CAPEX : $5000 - $ 8000 OPEX : $1000 / year

Need Of Hybrid Air Quality Monitoring Network

Conventional continuous ambient air monitoring systems (CAAQMS) or reference stations ensure better data accuracy and quality but spatially dense monitoring network is not economically viable due to very high capital cost. Also, they occupy larger areas, almost equivalent to a kiosk lab, and incurs high operational costs. On the other hand, sensor-based air quality monitors are a very cost-effective option. However, prolonged exposure of sensors to ambient conditions introduces data drift and affects the accuracy of the measurement. Frequent correction by spot-calibration or collocation ensures high data quality.

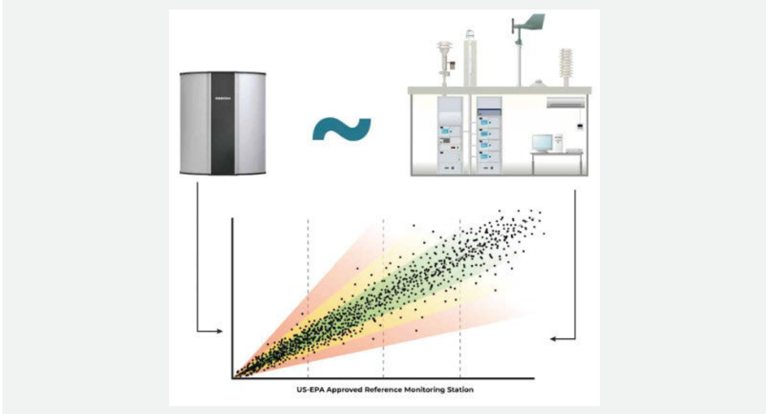
A hybrid network of air quality monitors consisting; traditional ambient air quality monitors as reference stations along with sensor-based monitors as spatially dense data generation points, is the future of urban air quality monitoring. The following benefits of hybrid air quality network makes them cost-effective, high quality air quality monitoring approach.

Scalability

Reference stations are ineffective in scalability and flexibility due to their inadequate spatio-temporal resolution. Hybrid networks are highly scalable by their design. They can be used for diverse objectives, which may range from urban background monitoring to exposure level monitoring.

Hyperlocal Pollution Mapping

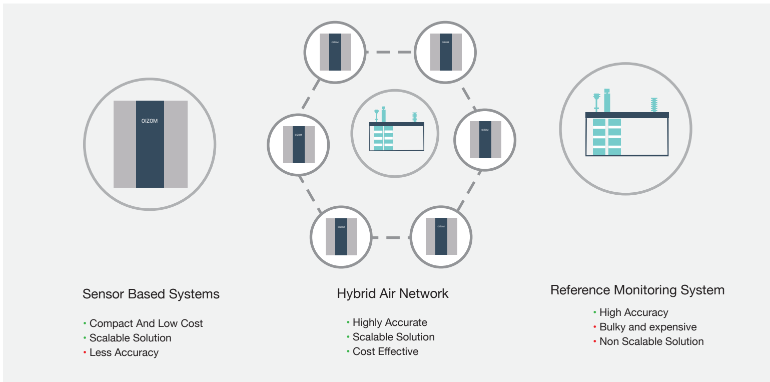
Pollution heat maps and odour impact maps generated by dispersion models provide hyper-local pollution concentration. With real-time air quality monitoring, these maps can also be generated and updated in real-time. However, the number of datapoints which is required for such exercise is very high for traditional monitoring stations to achieve. Sensor-based real-time monitors bridges this gap and traditional monitoring acts as a reference station. The sensor-based device is constantly collocated and corrected against the reference station, ensuring the highest level of data quality. Such a hybrid network of air quality monitors provides very high-quality hyperlocal pollution measurement at significantly low cost



In a hybrid network, sensors are located in the same locality having similar topographical and meteorological conditions. If one of the sensor nodes is not measuring correct pollutant concentration, it can be cross-validated and corrected by reference stations or recently calibrated sensor-based devices deployed in the same area. This ensures constant QA / QC for sensor-based systems and provides the highest level air quality data. With such a hybrid network, the limitations and gaps of traditional monitoring stations are complemented and hyper-local air quality data can be generated.

Calibration And Collocation

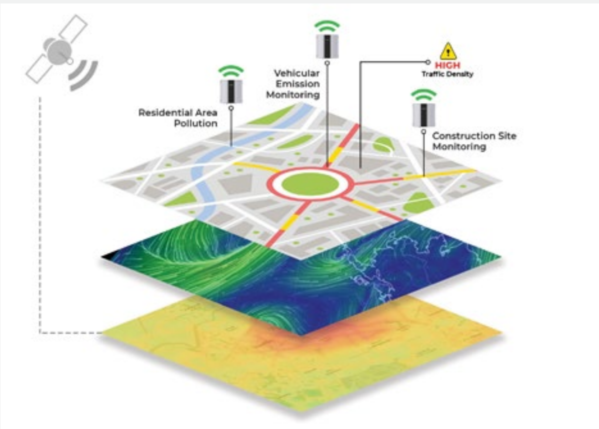
Frequent calibration of sensor-based systems is crucial to ensure data accuracy and precision. USEPA recommends collocating sensor-based systems with reference systems to correct data drift and measurement bias. The sensor-based system can be placed in similar ambient conditions in which it was collocated.



Setting Up A Hybrid Network

Sensor-based air monitoring systems are installed around reference monitoring systems to form a hybrid air monitoring cluster. A reference station and Oizom sensor-based systems are to be set up in 1:12 proportion to form a hybrid air monitoring cluster. For a city, such clusters are required for an average area of 25 sq. km.

A cluster-based approach to establish a hybrid air monitoring network at a city scale ensures accurate environmental data collection with higher density. Using secondary data sources like satellite data, traffic, meteorological data along with data from the sensor, city-scale pollution mapping is done to derive a high resolution (100m x 100 m) pollution map of the city.



Benefits Of Hybrid Network

Hybrid networks integrate the key features of reference stations and low-cost sensor-based devices providing a robust network for a region. It yields better data quality and Spatio-temporal resolution as compared to the network of its individual monitoring systems. Carefully designed hybrid monitoring networks can provide valuable data that helps in the identification of hyperlocal pollution hotspots and accurate pollution heat maps. The network also aids in defining and designing more efficient regulatory monitoring networks. User-specific benefits are as follows:

Stakeholders

The control of air pollution may not be restricted only to the government and policies. Involvement of Individuals, Corporates as well as Industries will benefit the clean air plans with the help of such novel methods of air quality monitoring.

Taxpayers- Citizens

The people of the city are the most affected when it comes to urban air pollution. It is said the worst victims of air pollution are the ones who have contributed the least to it. Children are the most prone to poor air quality resulting in several deaths. Citizens need to be aware of the air they breathe and the data must be reliable, accurate, and should not be prone to any errors. A hybrid network helps in achieving the above with public health being the key area of concern. Actionable insights for better healthcare can be taken by the public if they're aware of their environmental conditions.

Taxpayers- Industries And Businesses

With a better understanding of the air quality, businesses and industries can attract better employability. Necessary steps and measures can be taken based on the data insights to ensure the health and safety of the people concerned. By engaging experts and key researchers to interact with the data we can identify the correlations between environmental depletion and its impact on quality of life and disease prediction probability.

City Planners

High density accurate environmental data can be used to create high-resolution air quality models considering the effect of pollution sources and meteorological conditions. This enables strategic developments by placing high sensitive infrastructure.

Regulators

The Central and the State Pollution control boards are the key enforcers of environmental laws. A denser network of air quality monitoring stations will help in providing hyper-local data and help in the identification of hot spots & source apportionment studies. Such analyses will be helpful in taking source-based actions and chalk out mitigation measures aimed at reducing emissions from key emission sources like industries, transportations, combustion, biomass & solid waste burning, construction, and demolition.

Policymakers

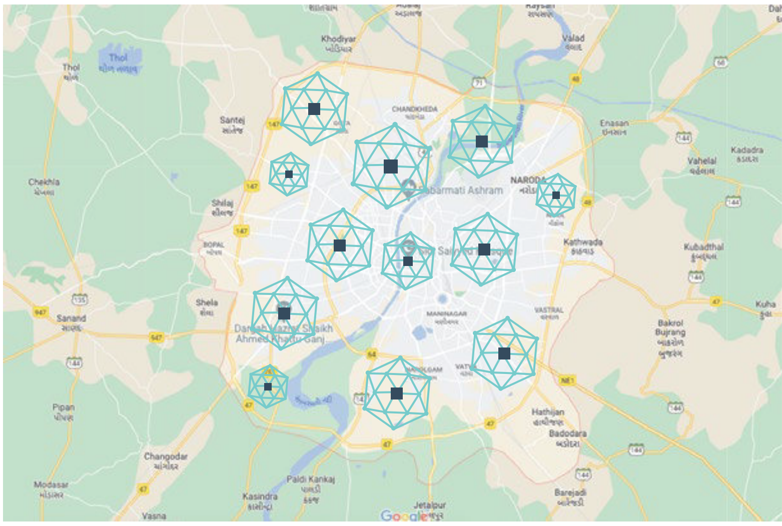
Useful data helps to fill knowledge gaps and provides a robust platform for policy advocacy. Insightful data & corresponding analyses contribute to the selection of policies, programs & interventions. In addition to this, once the policy is implemented, a denser network of air quality data would be necessary for monitoring the expected results. While forecasting using advanced data algorithms and models would set a trend for possible impacts on the current trends, it also assesses policy goals and targets which are likely to be met.

Urban Local Bodies

Real-time monitoring of the city's air quality will contribute to the city level Clean Air Plans. Data-empowered ULBs can plan their policies and infrastructure backed by data rather than depending on experience and assumptions.

Oizom's Offering

Oizom's devices viz. Polludrone™, Odosense™, Dustroid™, Weathercom™ can be easily integrated with both existing and new reference stations. The devices are compact, easily retrofitted to the poles, and transferable in case of location change. With the E-breathing technology and active sensor-based systems, sensors are safeguarded against external environmental factors. They can be easily collocated remotely and at the site (reference station) and the machine learning algorithms ensure better data quality and calibration. A visual representation of a typical hybrid network for the city of Ahmedabad(India) is shown here:



Reference Station   Sensor Based CAAQMS

Area	464 sq. km
Number Of Clusters Required	18
Number Of Reference Stations	18
Number Of Low Cost Stations	216

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About the Authors

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With an experience of Business Development and entrepreneurship for more than 11 years, Ankit Vyas heads the overall business operations at Oizom. His expertise in engineering and design thinking builds a better roadmap for the organization.

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With an experience of more than 10 years promoting various Environmental Technologies, Ayyan Karmakar currently leads marketing at Oizom. He is an industry professional with core Environmental Engineering skills with a spirit of continuous learning.

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