IoT for Environmental Applications

By
Poonam J Prasad
Senior Scientist
Analytical Instruments Division
CSIR-National Environmental Engineering Research Institute-Nagpur
Maharashtra
Email: p_prasad@neeri.res.in

Outline

- Environmental Sensors
- Worldwide Sensor Studies
- Environmental Parameter Monitoring & IoT
- Environmental Data into Wisdom
- Our case study and research findings on sensors
- Way forward towards seamless implementation

About CSIR-NEERI

- CSIR-National Environmental Engineering Research Institute (CSIR-NEERI) strives to achieve excellence and continual improvement through activities leading to scientific and technological innovations, technical solutions, sharing knowledge and expertise for enabling government, industry, and society to improve quality of environment.
- Council of Scientific & Industrial Research (CSIR) is an autonomous body under Ministry of Science & Technology, Govt. of India having 38 national laboratories working in various areas of science and technology. CSIR-NEERI is one among those laboratories.

Few Developed Technologies

- Electrolytic Defluoridation (EDF) Technique Licenses
- Hand Pump attachable Iron Removal (IR) Plant
- High Rate Transpiration System (HRTS)
- HYDROPLUME – A high Rate Secondary Clarifier for waste water treatment
- Microbial culture– for improved efficiency of existing wastewater treatment system
- NEERDHUR
- NEERI - ZAR : Portable Instant Water Filter
- Passive Air Rejuvenating System (PARS)
- Phytorid Wastewater Treatment Technology
- Automatic Mechanical Urinal-Toilet Flusher "NEERFLUSH" for Swachh Bharat Mission

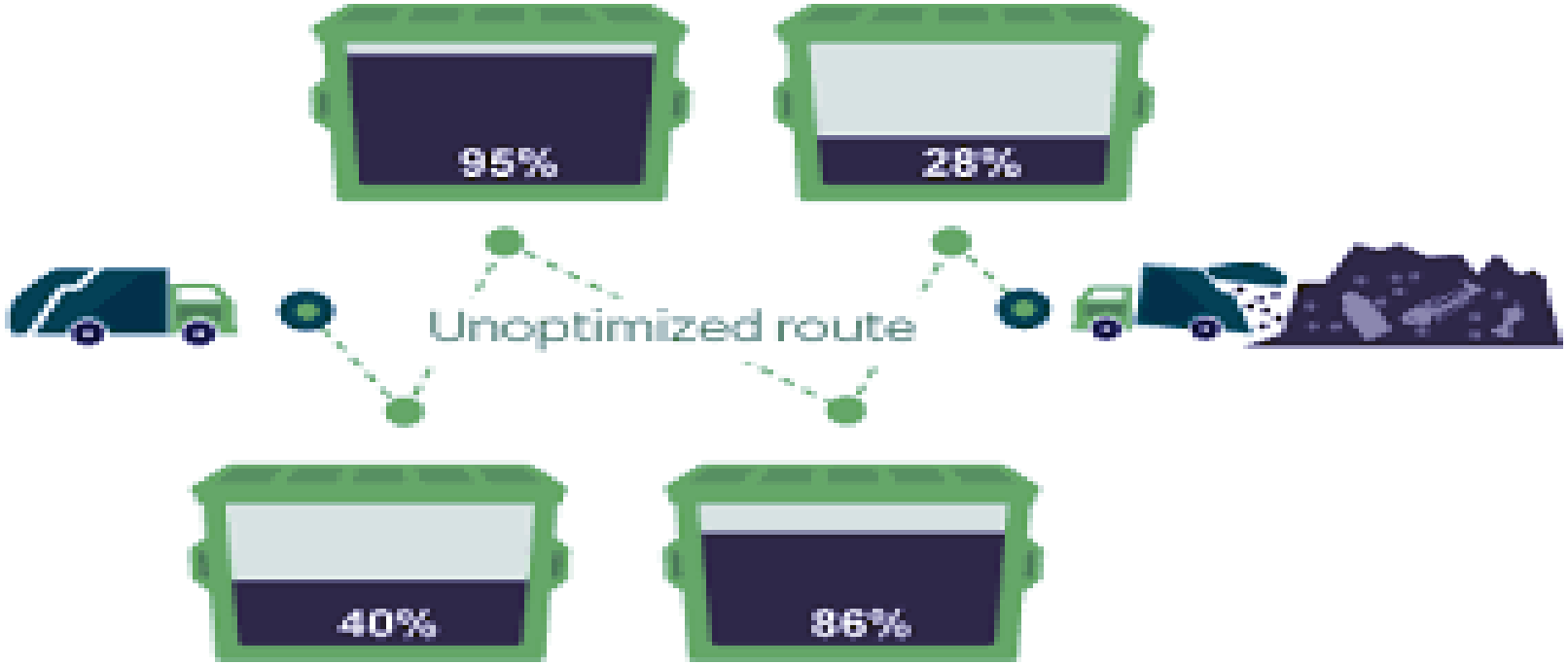
IoT for Environmental Monitoring

https://data-flair.training/blogs/iot-environmental-monitoring/

IoT Environmental Monitoring Application

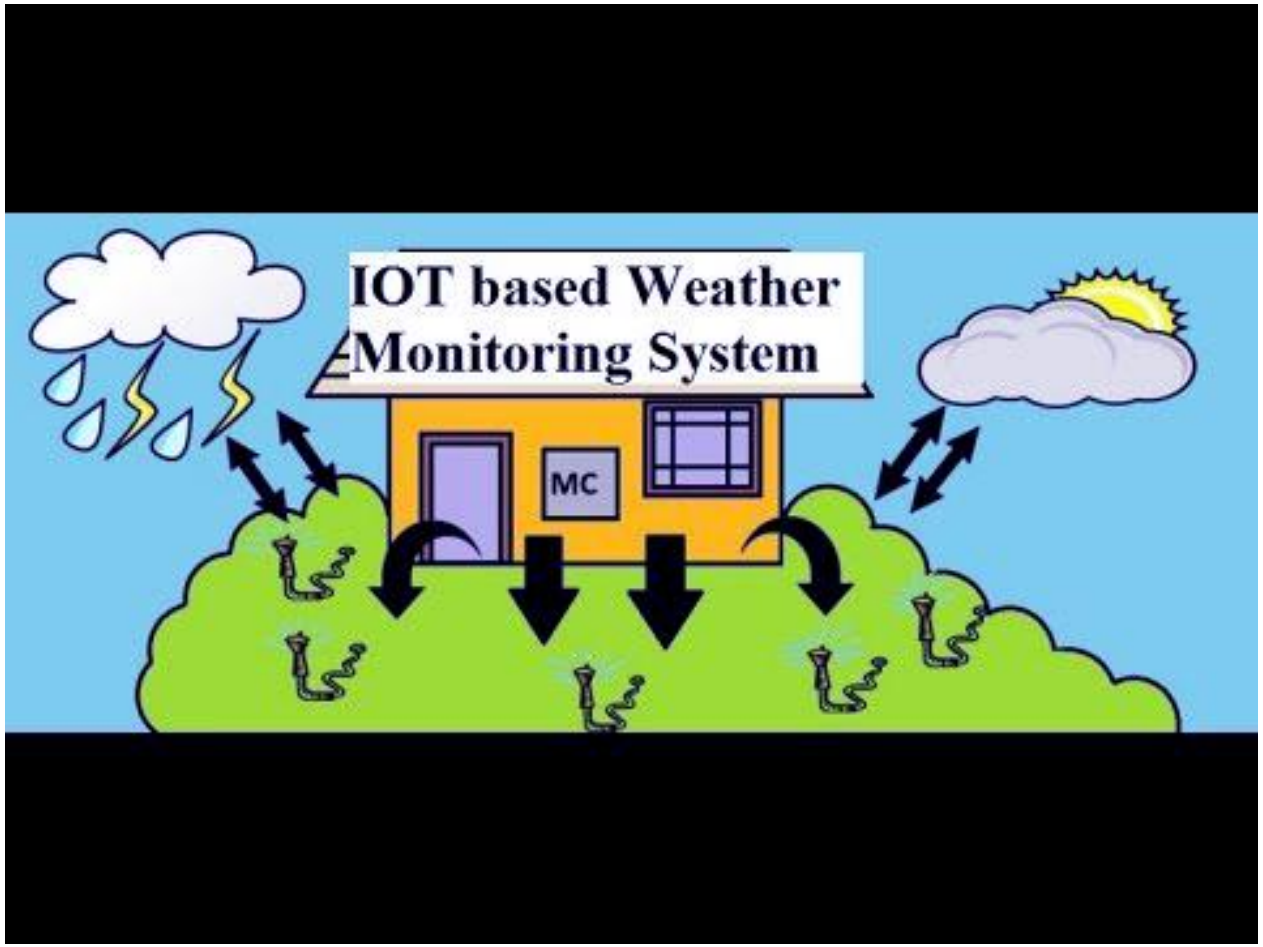
https://data-flair.training/blogs/iot-environmental-monitoring/

Waste Management



Waste Management

https://data-flair.training/blogs/iot-environmental-monitoring/



Extreme Weather

https://data-flair.training/blogs/iot-environmental-monitoring/

The Need of IoT in Environment:

•Help to conserve energy, water, and resources

•Big data via water and air monitoring systems provides information on our environments

Environmental Sensors:

•Deploying sensors to measure elements like air or water quality, radiation, or sensors to detect hazardous chemicals can help in seamless monitoring
•Inaccessible, polluted or uninhabitable spaces can be accessed without risking the health of technicians

https://iot.telefonica.com/blog/5-ways-the-iot-is-helping-the-environment

Glimpses of Review

- An outdoor air quality monitoring system based on ZigBee wireless sensor network

- An air quality monitoring system based on environmental sensors was presented to display and record the data of PM 10, CO2, temperature, and humidity of waiting rooms, platforms, tunnels, and outdoor sites at underground subway stations

- A mobile sensing system was proposed to collect PM 2.5 data in the city

- Paper described the design and development of a low-cost, portable monitoring system for indoor environment quality (IEQ). The unit can monitor temperature, humidity, PM2.5, PM10, total VOCs (×3), CO2, CO, illuminance, and sound levels

- The development of gas sensors that are based on metal/metal-oxide nanoclusters has attracted intensive research interest in the last years

- Authors had presented a framework for micro-scale air quality monitoring and sensor management system. The developed system was validated in a preliminary test environment. The test result showed that it was feasible to adopt sensor networks for micro-scale monitoring

- Micro sensor based air quality monitoring system was developed for detecting the real time monitoring of airborne fine particulates. The hybrid particle sensing system consisted of a zinc oxide (ZnO) based solidly mounted resonator (SMR) device interfaced to a CMOS application-specific integrated circuit (ASIC) chip. PM 2.5 particles were separated in virtual impactor and then deposited onto the SMR surface

Smart Environment using IoT (2017)

- Now a days Health condition s of the society is a major concern
- The emission from the vehicle are one such factor having huge impact
- According to the IPCC,40% of the environmental pollution is due to vehicular emission
- This paper described an efficient pollution monitoring system which monitors the each emission from each vehicle on a daily bases and update it to the web server that respective action taken by the authorities
- Android GSM/GPRS , RFID , Amazon Web Server were used

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8079563

- The issue of environmental pollution and climate change has become an international concern due to their affects to the physical and biological entities of the environment.

- The main objective of this paper was to find the pollutants in nature with the help of the Internet of Things (IoT).

- The UV Sensor outputs an analog signal of the amount of UV light it detects. The 2 in one Temperature and PH sensor are used to monitor the quality of water, interns of monitoring the level of water, the temperature of the water and its surrounding, the turbidity of the water (how clean the water is) as well as the PH levels of the Water.

- Therefore, this system monitors all of these result and finally when all data are collected, it sends the information or data to the cloud

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8079563

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6158307

An IoT System for Environmental Monitoring and Protecting with Heterogeneous Communication Networks

- This paper presents the design, deployment and empirical study of an Internet of things (IOT) system, which is used to monitor and protect the living environment of the wildlife.

- The communication module of the system is composed to three different communication networks, which supports the protocol of IEEE 802.15.4/ ZigBee networks, IEEE 802.11b WLANs and 3G respectively

- Introduced a power management scheme which can reduce the energy expenditure of the system effectively.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6158307

Remote environmental monitoring using Internet of Things (IoT)

- This paper focuses on using Internet of Things (IoT) technology to build and deploy smart, connected sensors that provide continuous monitoring of air and soil quality
- Acquired data would be displayed on a graphical user interface (GUI) that provides real-time information, which may be used to define current conditions of the area being monitored, and also to establish trends or detect any abnormalities
- Parameter thresholds will be established in order to trigger email/text alerts to users, stakeholders, or monitoring personnel, when there is a deviation from normal
- This paper presented an IoT solutions for remote and continuous monitoring of air, soil, and water quality, using cost-effective, low-power processor and sensors

https://ieeexplore.ieee.org/document/8239335

A low-cost IoT based environmental monitoring system. : A citizen approach to pollution awareness

- The concept of quality of life is used as a measure of the welfare of a society, highlighting the relationship between the environment and health, mainly associated with pollution

- The importance of monitoring and communicating its results, in a timely manner, to the community. However, the last part of the process fail, there is a lack of communication between data, information and community

- Using open hardware and open source tools, and based on the Internet of Things (IoT) concept, a low-cost citizen monitoring network, costing less than US $ 150 was implemented

https://ieeexplore.ieee.org/document/822959

- This network measures Carbon Monoxide (CO), Temperature, Relative Humidity, Particulate Matter 2.5, Noise and UV radiation, with a reading frequency of every 40s and a hibernation period of 15 min.

- The framework of the monitoring system is based on combination of pervasive distributed sensing units, information system for data aggregation, reasoning and context awareness

- Results were encouraging as the reliability of sensing information transmission through the proposed integrated network architecture is 97%.

- The prototype was tested to generate real-time graphical information rather than a test bed scenario

http://pgembeddedsystems.com/securelogin/upload/project/IEEE/33/PGEMB0063/Towards%20the%20Implementation%20of%20IoT%20for%20Environmental%20Condition%20Monitoring%20in%20Homes.pdf

Top Sensors Used in Environment

Temperature sensors

- By definition, “A device, used to measure amount of heat energy that allows to detect a physical change in temperature from a particular source and converts the data for a device or user, is known as a Temperature Sensor.”

Proximity sensor

- A device that detects the presence or absence of a nearby object, or properties of that object, and converts it into signal which can be easily read by user or a simple electronic instrument without getting in contact with them.

https://www.finoit.com/blog/top-15-sensor-types-used-iot/

Water quality sensor

- Used to detect the water quality and Ion monitoring primarily in water distribution systems.

Pressure sensor

- A pressure sensor is a device that senses pressure and converts it into an electric signal. Here, the amount depends upon the level of pressure applied

https://www.finoit.com/blog/top-15-sensor-types-used-iot/

Gas sensor

- Used to monitor changes of the air quality and detect the presence of various gases.

Smoke sensor

- A smoke sensor is a device that senses smoke (airborne particulates & gases) and it’s level.

https://www.finoit.com/blog/top-15-sensor-types-used-iot/

Specification of different PM sensors

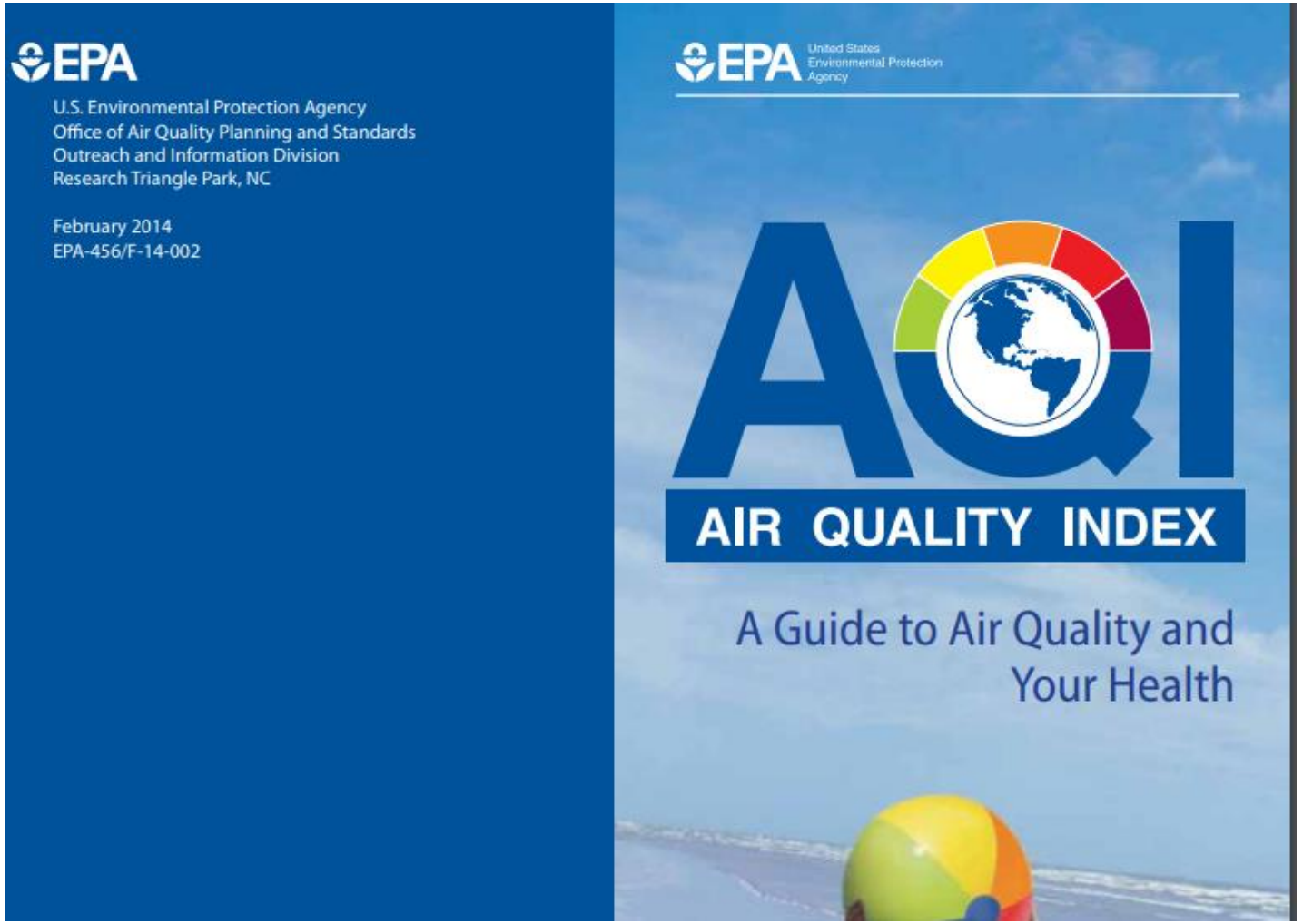
Model	Size(mm)	Weight(g)	Power Supply	Maximum Current Consumption(mA)	Cost (US$)	Detectable particle size	Concentration range of measurement	Performance tested in scientific literature	Country
Alphasense OPC-N2	75x64x60	105	5V DC	175	~500	0.38-17 µm in 16 size bins	0.1-1,500,000 µg/m³	Yes	
Dylos DC 1100 Pro	178x114x76	544	110V AC	NA	~300	0.5-2.5 µm and 0.5-10 µm in two size bins	0-106 particles/c m³	Yes	
Dylos DC 1700	178x114x76	544	110V AC or battery	NA	~400	0.5-2.5 µm and 0.5-10 µm in two size bins	0-106 particles/cm³	Yes	
Novafitness SDL301	204x100x36	580	5 V DC	NA	~250	0.3-2.5 µm and 0.3-10 µm in two size bins	0-1000 µg/m³	No	
Novafitness SDL607	73x73x20	120	5 V DC	NA	~120	0.3-2.5 µm and 0.3-10 µm in two bins	0-1000 µg/m³	No	
Novafitness SDS011	71x70x23	NA	5 V DC	80	~35	0.3-2.5 µm and 0.3-10 µm in two size bins	0-1000 µg/m³	No	
Novafitness SDS018	59x45x20	NA	5 V DC	70	~40	0.3-2.5 µm and 0.3-10 µm in two size bins	0-1000 µg/m³	No	
Novafitness SDS021	42x32x24	NA	5 V DC	70	~35	0.3-2.5 µm and 0.3-10 µm in two size bins	0-1000 µg/m³	No	
Novafitness SDS198	71x70x23	NA	5 V DC	80	~80	1-100 µm	0-20000 µg/m³	No	
Plantower PMS 1003	65x42x23	NA	5 V DC	120	~20	0.3-1.0 µm, 1.0-2.5 µm, and 2.5-10 µm in three size bins	0-500 µg/m³	Yes	
Plantower PMS 3003	65x42x23	NA	5 V DC	120	~20	0.3-1.0 µm, 1.0-2.5 µm, and 2.5-10 µm in three size bins	NA	Yes	
Samyoung DSM501A	59x45x20	25	5 V DC	90	~15	Greater than 1.0 µm	0-1400 µg/m³	Yes	
Sharp DN7C3CA006	50x44x20	52	5 V DC	180	~20	0.5-2.5µm	25-500 µg/m³	Yes	
Sharp GP2Y1010AU0F	46x30x18	15	5 V DC	20	~10	Greater than 0.5 µm	0-600 µg/m³	Yes	
Shinyei PPD42NS	59x45x22	24	5 V DC	90	~15	Greater than 1.0 µm	0-28 particles/cm³	Yes	
Shinyei PPD60PV	88x60x20	36	5 V DC	NA	~250	Greater than 0.5 µm	0-70 particles/cm³	Yes	

Environmental Parameter Monitoring & IoT

Environmental Data into Wisdom

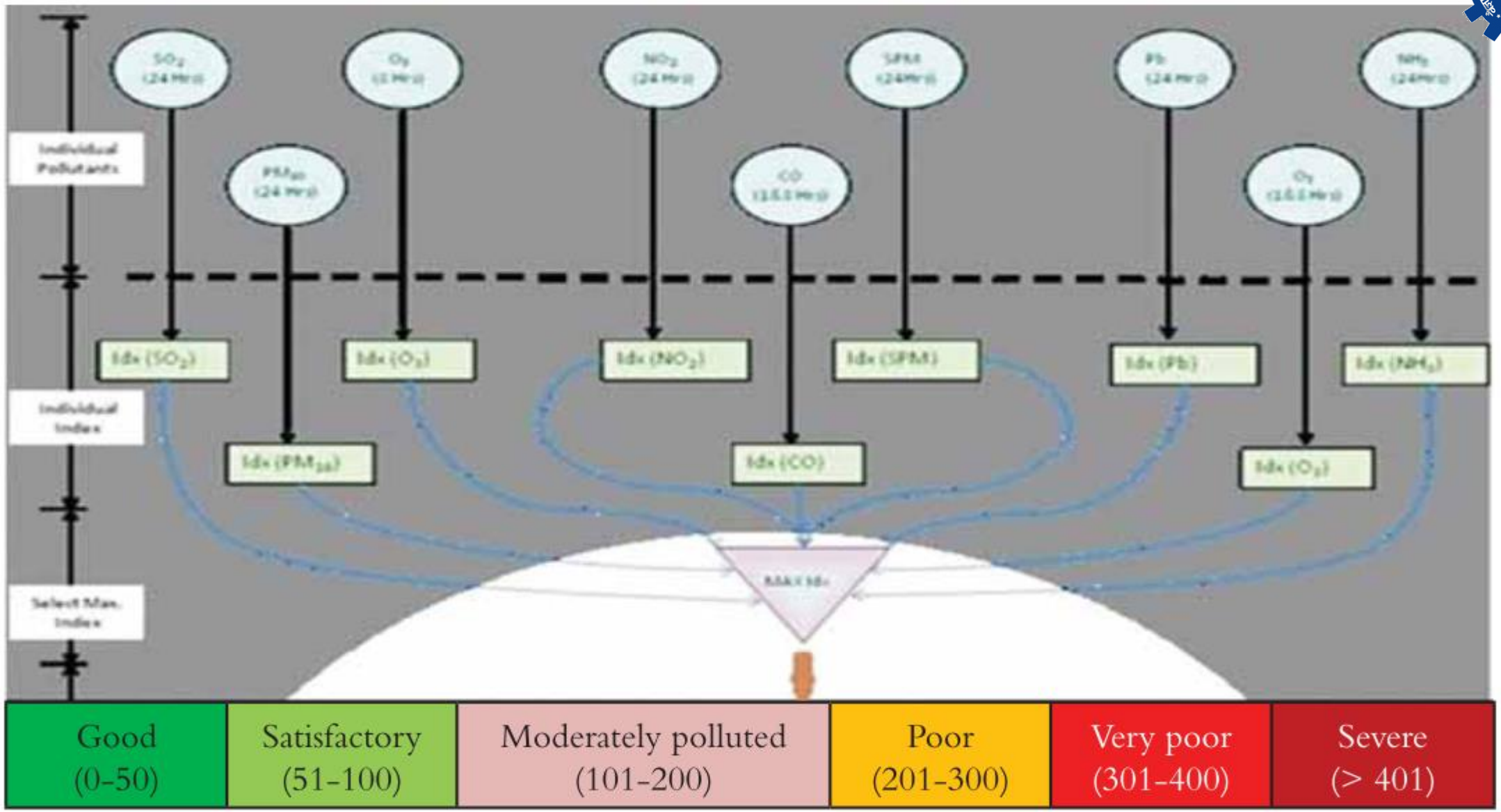
How Air Quality Index (AQI) is being developed

- https://www3.epa.gov/airnow/aqi_brochure_02_14.pdf



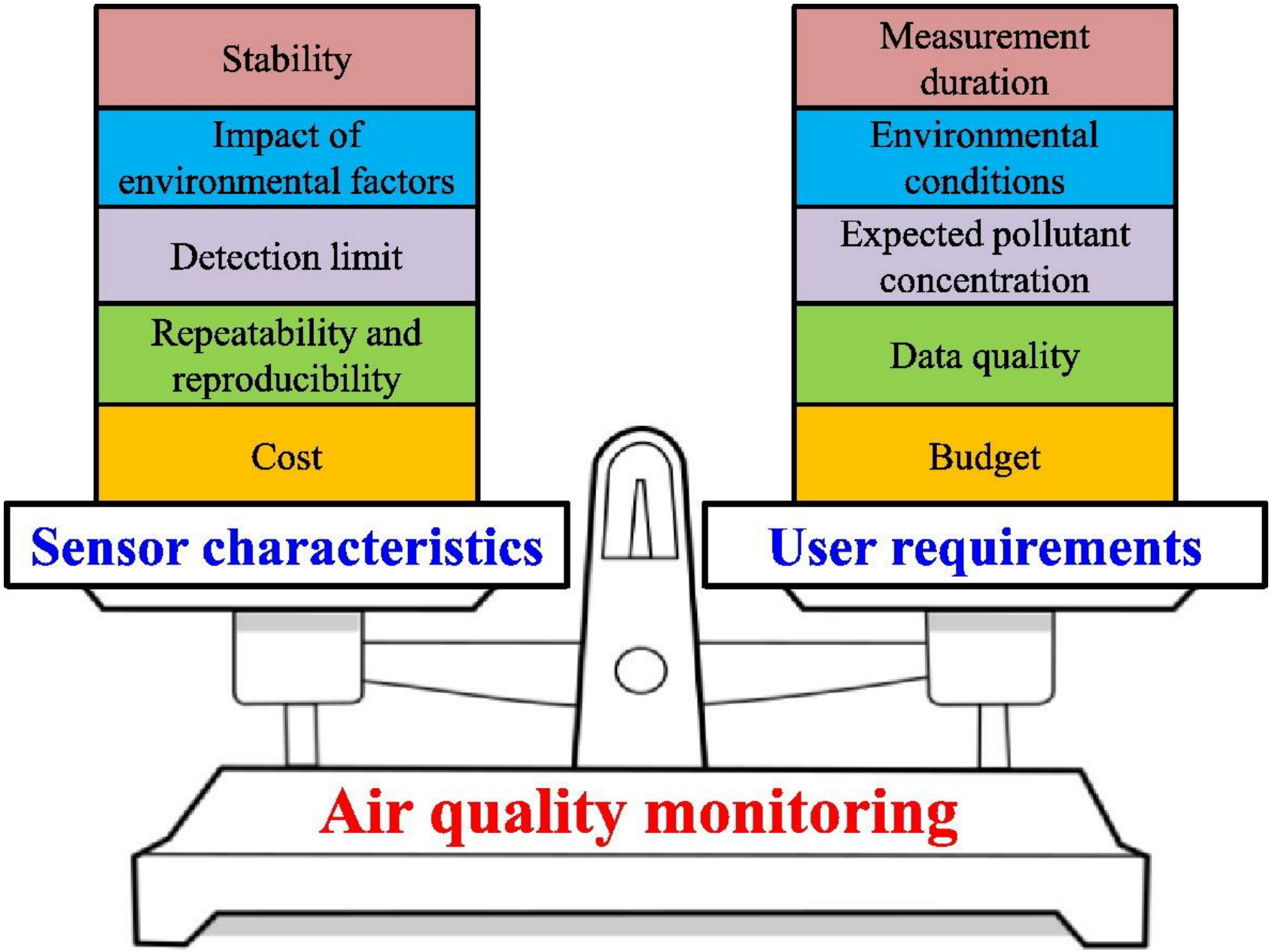
AQI to act as 'One Number- One Color-One Description' to judge the Air Quality for Common Man: Shri Prakash Javadekar (17-October-2014)

http://www.indiaenvironmentportal.org.in/files/file/Air%20Quality%20Index.pdf



Air Pollution Index

Overall AQI System



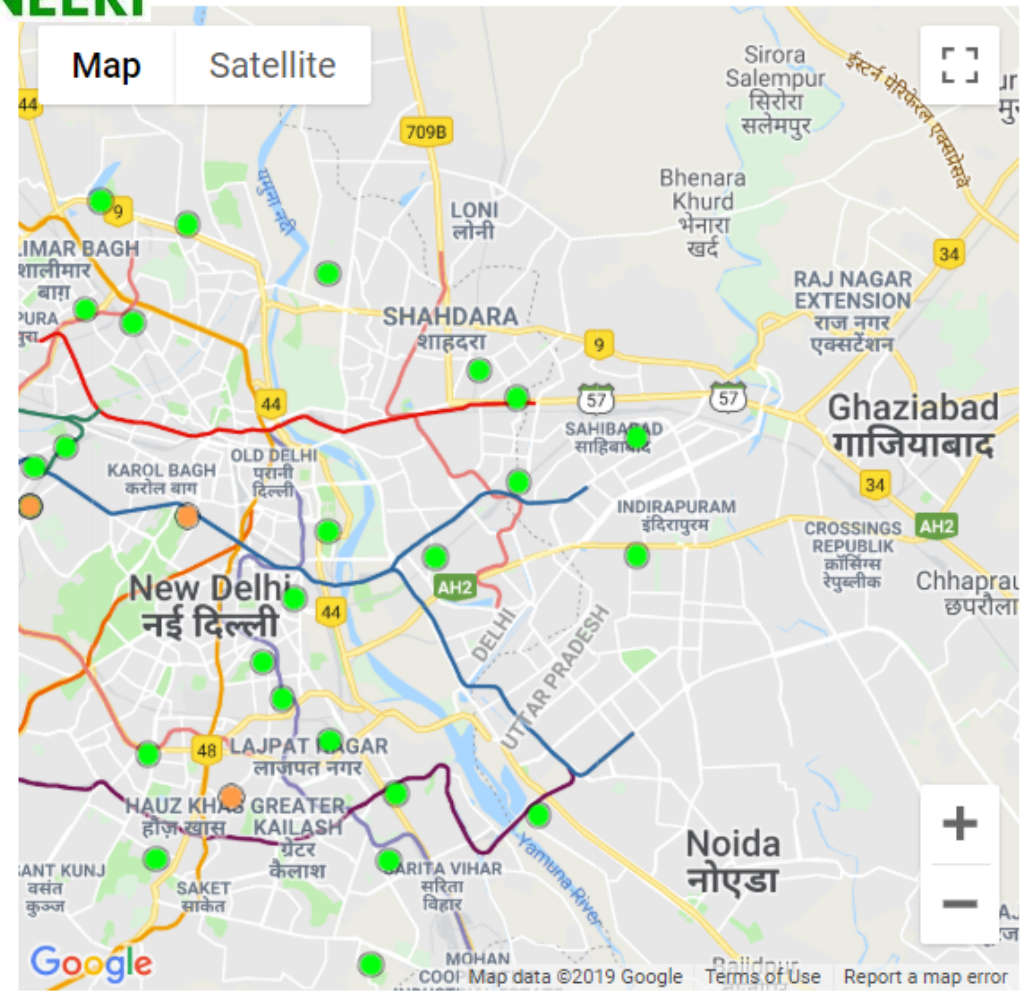
https://www.sciencedirect.com/science/article/pii/S0048969717316935

al Air Quality Index

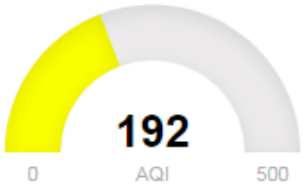
Central Pollution Control Board,
Ministry of Environment, Forests & Climate Change

NEERI

Delhi ▾ | City: Delhi ▾ | Station: Anand Vihar, Delhi - DPC(▾ | 08/02/2019 | 16:00



Moderate

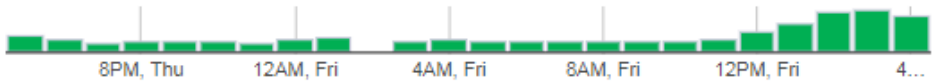


Anand Vihar, Delhi - DPCC

Prominent Pollutant is **PM2.5**

On **Friday, 08 Feb 2019 04:00 PM**

Pollutant	Timeline	Avg	Min	Max
PM2.5		192	83	391
NO2		120	90	197
NH3		9	6	14
SO2		14	8	24
CO		74	30	109
OZONE		27	10	47



AQI	Remark	Color Code	Possible Health Impacts

List of AQI Stations with Data

Our case study and research findings on sensors

- 10 Sensors are installed in Delhi
- IoT based

The rise of low-cost sensing for managing air pollution in cities

Challenges:

- Reliability of measured air pollution data, since most gaseous and particulate matter sensors require independent evaluation under a range of ambient environmental conditions
- Sensors short working time
- Economic challenges : include reducing maintenance (including calibration, battery replacement) and data management/analysis/visualisation costs, which in many cases exceed the cost of the actual sensor system itself.

- Scientific community and decision makers are not prepared to embrace such technology. Awareness, education and technology will have to mature together, in order to bring a paradigm shift in air pollution monitoring

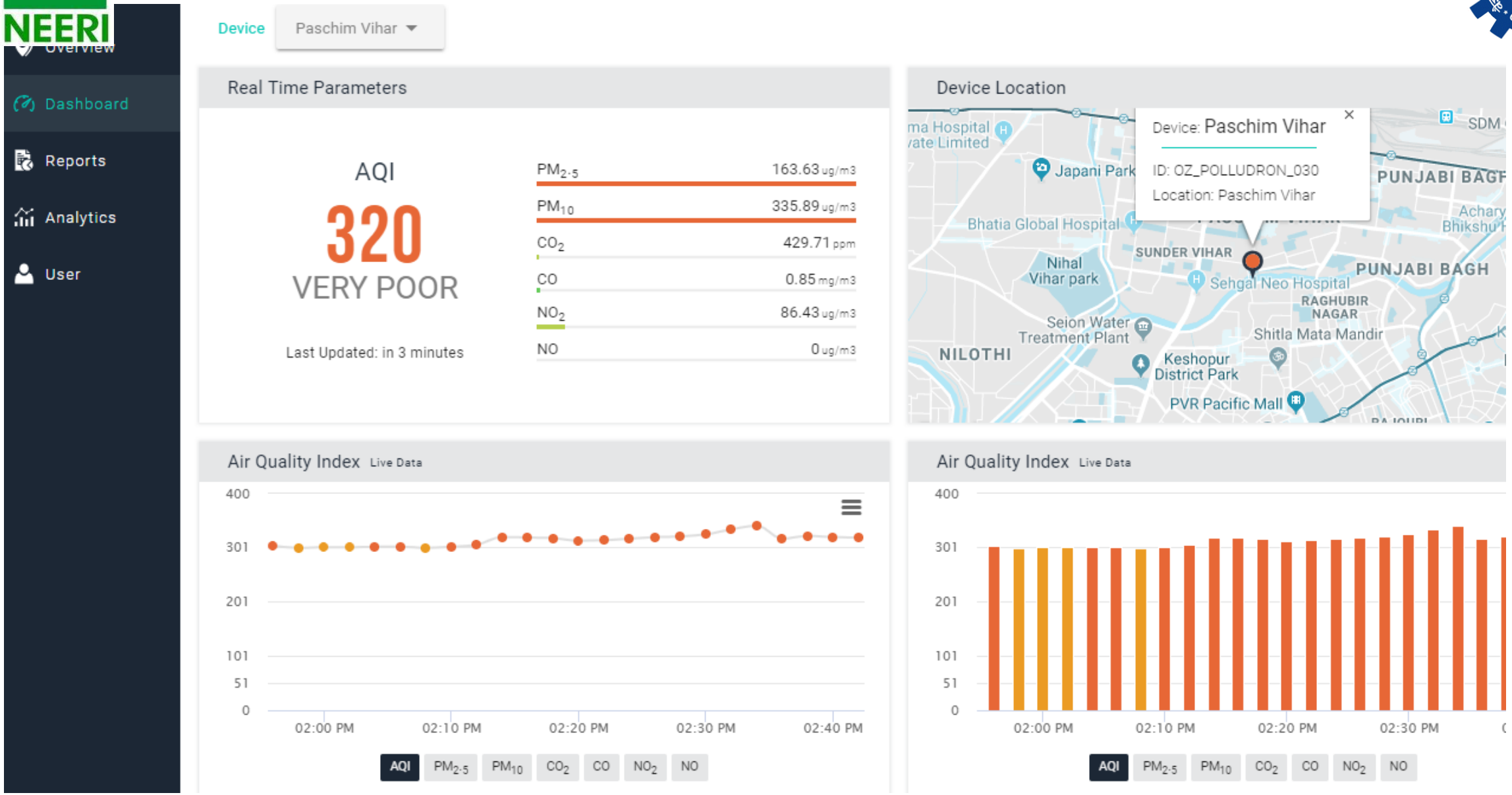
- **Improve sensors sensitivity, stability and longevity of operation before replacement**

Monitoring of essential Air-Quality Parameters

- **PM 2.5, PM 10, CO, NO, NO2**
- **Ambient Noise**
- **Temperature and Humidity**

Parameter	Range	Accuracy	Working Principal
PM2.5	Upto 500 µg/m3	Upto +/- 5%	Laser Scattering
PM 10	Upto 500 µg/m3	Upto +/- 5%	Laser Scattering
CO	0 to 500 ppm for High concentration	Upto +/- 2%	Electrochemical Sensing
NO	0 to 250 ppm for high concentration	Upto +/- 2%	Electrochemical Sensing
NO2 -	0 to 20 ppm	Upto +/- 2%	Electrochemical Sensing

One going case study: Delhi sensors



Future Directions

- Effort from scientists and instrument manufacturers, as well as improvements in wireless automated systems, have made it possible to reduce the cost of air pollution sensors from thousands to hundreds of pounds or less (Envirowatch, 2014; Air Monitors, 2014).
- Costs involved in their installation, maintenance and data analysis need to be reduced

Way forward towards seamless implementation

- Assurance towards the data quality
- Reliability