Real time Hyperlocal Air Quality Monitoring & Assessment at Granular Level

Presented By:
Elango Kamalasekaran
Advisor, CUBE

Stakeholder Workshop on Comprehensive Action Plan for Clean Air for Non-Attainment Cities of Odisha
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Established in May 2017 as an outfit of IIT Madras and a Centre of Excellence of Govt of Tamil Nadu as per State Vision 2023.

Uniquely placed organization that amalgamates the research and technological strengths of academia, facilitation and support from the Government, and practical and innovative approach of the private sector to act as an enabler to tackle any multifaceted urban development challenges and provide holistic solutions.

Applied Research, Technology, Engineering & Consultancy Organization

CUBE extends its services under four verticals, namely, Building & Construction, Environment & Sustainability, Smart Cities and Urban Planning & Transportation
### Domains & Expertise

#### Building & Construction
- Design & Engineering
- Project Management Consultancy
- Quality Assurance
- Advanced Construction Technologies
- Research & Development
- Training & Capacity Building

#### Environment & Sustainability
- CUBE Environment Lab
- Environment & Social Impact Assessment
- Technology Assessment
- Design & Engineering for STPs & ETPs
- Environment Management Advisory
- Project Management & Implementation
- Solid Waster Management
- Air Quality Monitoring

#### Smart Cities
- Advanced Technologies
- IoT
- Data Management
- Data Analysis & Visualization
- E Governance
- Smart Platforms
- Data Driven Policy Advisory

#### Urban Planning & Transportation
- Urban Planning & Mobility
- Transportation Infrastructure - DPRs, Technical Audits, Technical Advisory
- Advanced Investigative Surveys
- Urban Design & Conservation
- Research & Development
- Training & Capacity Building

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Centre for Urbanization, Buildings & Environment, IIT Madras
Real time Hyperlocal Air Quality Monitoring & Assessment at Granular Level
Promoting & Implementing Cutting Edge Technological Solutions

Facilitating high quality human resource development – through training programs, workshops, conferences, sponsoring research in relevant domains.

Promote entrepreneurship by assisting start-up companies in relevant domains.

Create Public awareness on sustainability through outreach programs

R & D on pioneering & more pertinent problem statements

Ideate, Conceptualize, Design, Manage & Deliver Comprehensive Solutions

Evidence & Data Driven Policy Advisory

Promote & Implement Applied Research

Multidisciplinary Comprehensive Approach

Cross Fertilization of Ideas, innovation, expertise, & experience – academic excellence of IIT Madras Faculty, domain experts of CUBE & industries to provide apt solution to clients

Collaboration with leading national and international institutions and organizations

Force Multiplier, Enabling Partnerships

Centre for Urbanization, Buildings & Environment, IIT Madras

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A few key Projects in E & S...

- Multiple Projects including Detailed Project Reports, Project Management Consultancy for Waste Water Treatment.
- Certificate Course on Waste Management under Green Skill Development Program (GSDP) of the Ministry of Environment, Forest and Climate Change (MoEF&CC) with IIT Madras.
- Project Management Consultant for water conservation, rehabilitation of water bodies, waste management, drinking water supply and development of community facilities as part of a consortium with IITM.
- Treatment of Coolant Effluents Consequent to Use of Coolant Oil as Die Lubricant.

- “Real Time Hyperlocal Air Quality Assessment at Granular Level to Evaluate & Quantify the Effects of Urban Dynamics on Air Quality” – Pilot Scale study at Chennai.
- Design & Implementation of STP at Industrial Estates / Parks at Thirumudivakkam, Kancheepuram. & Chengarayi, Thiruvallur, Tamil Nadu.
- Conduct a study on "Environmental Impact of Mining of Stone Aggregates, Identification of Alternate Sites & Viable Alternatives" for Andaman & Nicobar Island.
- Currently in discussions with ISRO through IWMA on developing a solution to handle the waste generated during production of solid propellant for space launches in association with Department of Aerospace Engineering, IITM.
Working on a concept note for “Future Roads” to be implemented as a Pilot Project in Tamil Nadu. The concept includes use of solar energy, recycling plastic waste, charging for electric vehicles and other futuristic features for the roads of the future.

Submitted letter of intent to assist the Govt. of Jammu & Kashmir to prepare a strategic and detailed solid waste management plan for the urban areas of J&K, the main challenges being the terrain, economies of scale and the weather conditions.

Likely to carry out Geotechnical and Geophysical Investigations for Seismic Micro-zonation of Eight Cities for National Centre for Seismology as Implementation Partner of IITM.

Support Kerala State Pollution Control Board for rejuvenation of Alleppy Canal which is currently facing environmental degradation in the inland waterways systems due to unauthorized discharge of pollutants and unregulated tourism & cost effective septage treatment and treatment of effluent from fish processing industries.

Discussions are underway to conduct "Adequacy Audits" for several of the member industries of CII to gauge the effectiveness and current state of the waste treatment & disposal facilities and their adequacy for present & future operations.
Real Time Hyperlocal Air Quality Monitoring…

**Why Monitor Air Quality – Real Time & Hyper locally & at Granular Levels?**

- Air Pollution kills 4.5 Mn people a year world wide and costs the World $225 Billion a year in economic damages. In Indian cities the problem is now acutely disturbing. The polluted air just sits near the ground at breathable levels.

- Recent studies show that air pollution varies as much as eight times within one city block. Hence, increasing complexities in urban dynamics have impacts on Air Quality at hyperlocal levels which go undetected by city level stationary sensors.

- Living by the streets/roads with elevated pollution levels may increase the instances of related health conditions by up to 40% suggesting that air pollution is far more dangerous that it was perceived previously.

- Understanding the Air Quality at a hyperlocal intimate level where we breathe could bring a spot light on the problem and increase urgency for action.

- These insights can provide a springboard resulting in local, city, regional and even national level impacts. Measurement of the real time, hyperlocal Air Quality at granular levels would go a long way in improving the quality of data available for decision making.

- CUBE has initiated a pioneering study on a pilot scale that is replicable, scalable and economical and therefore implementable across all Smart Cities to deeply impact the quality of life.
Real Time Hyperlocal Air Quality Monitoring & Assessment at Granular Level

Sources of Air Pollution

- Energy Industries: PM$_2.5$, NO$_x$, SO$_2$, CO, NH$_3$, NMHC
- Manufacturing industries and construction: PM$_2.5$, NO$_x$, SO$_2$, CO, NH$_3$, NMHC
- Industrial processes: PM$_2.5$, NO$_x$, SO$_2$, CO, NH$_3$, NMHC
- Residential and small-scale commercial combustion: PM$_2.5$, NO$_x$, SO$_2$, CO, NH$_3$, NMHC
- Fugitive emissions: PM$_2.5$, NO$_x$, SO$_2$, CO, NH$_3$, NMHC
- Non-road transport: PM$_2.5$, NO$_x$, SO$_2$, CO, NH$_3$, NMHC
- Road transport: PM$_2.5$, NO$_x$, SO$_2$, CO, NH$_3$, NMHC
- Agriculture: PM$_2.5$, NO$_x$, SO$_2$, CO, NH$_3$, NMHC

Pollution substances:
- SO$_2$ - Sulphur oxide
- NO$_x$ - Nitrogen oxides
- NH$_3$ - Ammonia
- PM$_{2.5}$ - Primary particulate matter

Cumulative Health Impacts

- Headaches & anxiety (SO$_2$)
- Irritation of eyes, nose and throat
- Breathing problems (BaP, NO$_2$, PM, SO$_2$, O$_3$)

- Cardiovascular diseases (PM, SO$_2$, O$_3$)
- Impacts on the respiratory system: irritation, inflammation, infections, asthma, reduced lung function, chronic obstructive pulmonary disease (PM), Lung cancer (BaP)

- PM = Particulate Matter
- SO$_2$ = Sulphur (USA: Sulfur) Dioxide
- BaP = Benzo(a)pyrene
- O$_3$ = Ozone
- NO$_2$ = Nitrogen Dioxide

- Impacts on spleen, liver and blood

- Impacts on the reproductive system (PM)
Real Time Hyperlocal Air Quality Monitoring…

The Pilot – Aims & Objectives

- Determine Air Quality at Breathable levels
- Monitor & Visualise Air Quality where it matters
- Understand and Monitor the impact of urban and local dynamics on Air Quality
- Transform the understanding of pollution sources and impacts
- Identify recurring hot spots in real time and establish trends
- Organised, Methodical and Sharable information assisting in early and better detection of issues at local levels
- Assist in data driven decision making
- Identifying opportunities to achieve greater air quality improvements
- Scalable pilot that can be easily replicated at city level
- Possibility of Citizen Engagement at an intimate level inspiring behavioral changes
Real Time Hyperlocal Air Quality Monitoring...

Concept - Data Acquisition & Analytics – At a Glance

Specialized Vehicles / STC Buses - Sensors, GPS, WiFi

Continuous Data Collection

Data Storage

Data Analytics – Algorithms / Correlations

Google Traffic + Surveys to identify traffic trends

Area Mapping – Google Earth / Ground Truthing / Hyperlocal Parameters

Overlays of:
- **Air Quality Map** – Parameter Wise, Real Time / Trend
- **Weather Map** – Parameter Wise, Real Time / Trend
- **Area Map** – Urban & Hyperlocal Urban Parameters, Point of Interest – Fixed
- **Traffic Map** – Real Time / Trend
Real Time Hyperlocal Air Quality Monitoring...

**Concept:** Mobile & Web Based Dashboard – At a Glance

- Spatio Temporal
- Real Time
- Correlations
- Trends
- Queries
- Reports
The Pilot – Design & Features

- An area in Chennai was selected to represent the local urban dynamics having representations of all major land uses like, Industrial, Institutional, Commercial, Residential, Mixed Land Use, Open Spaces and Water Bodies.

- The Route of the Air Quality Monitoring Vehicle was designed to cross each point thrice in a day at different times.

- The study vehicle goes on the predetermined route at a predetermined schedule for 24 days continuously for 24 Hours to monitor Air Quality Parameters.

- The Air Quality parameters chosen to be studied are: PM 2.5, PM 10, SOX, NOX, CO2, CO, that are impacted due to Hyperlocal conditions.

- The traffic intensity is collated using Google Traffic Maps.

- Satellite Imagery & Google Earth along with ground truthing & reconnaissance surveys to prepare the base maps.
Data Acquisition:

Air Quality - GPS and WiFi enabled Mobile Sensors mounted on vehicle(s) to understand Air Quality at Granular Levels. Primarily capturing six parameters – PM 2.5, PM 10, SOX, NOX, CO, CO2 (expandable). Field Data Validation through Correlation Studies.

Weather - Mobile Weather Station, measuring Temperature, Humidity, Pressure, Wind Speed, Wind Direction, Noise, Rainfall simultaneously along with AQ Parameters.
Data Acquisition:-

- Traffic – Trend Analysis (Survey) / Real Time (Google)

- Area Level Urban Parameters – Satellite Imagery / Google Earth and Ground Truthing for Land Use, Land Cover, Open Spaces, Road Types, Water Bodies etc.

- Hyperlocal Urban Parameters – Satellite Imagery / Google Maps & Reconnaissance Surveys (Industrial Categories, Road Widths, Hospitals, Schools, Places of Worship, Bus Stops, Parking, Tree Cover, Building Heights, Water Bodies, Open Spaces and more...)
Data Analysis & Representation:

- Algorithms and Correlations to arrive at trends and interesting qualitative and quantitative information regarding AQ and its geo spatial relationships with traffic, urban land use and other hyperlocal parameters.

- Identification of Points of Interest (PoI) – Based on point attributes & characteristics significant spots are identified to establish trends & correlations.

All Values are representative only
Data Analysis & Representation:

- Trends & their Spatio-Temporal Visualization – Point of Interest / Hyperlocal Urban Parameters / Land Use Zones / Traffic Intensity and so on...
- Real Time Data Representation using Base GIS Map with Hyperlocal Parameters, Google Traffic & Sensor Data
- Identification of Emission Hot Spots
- Deductions & Implications
Product:

Spatio Temporal Real Time Dynamic Dash Board, Customizable to suit Client requirements. Main features

- Spatio Temporal – Understand Air Quality as a factor of Time and Space along with other parameters
- PoI Attributes and correlations with AQ parameters - Trends & Real Time Information
- Emission Hot Spots – At a Glance & Spatio – Temporal Trends
- Trends
- Correlations
- Queries
- Reports
- Monitoring impacts of policy decisions over a period of time
Real Time Hyperlocal Air Quality Monitoring...

Further Scope:-

- Predictive Analysis
- Air Quality Modelling
- Policy Advisory
- Identification of Short Term & Long-Term Focus Areas & Solutions

Thank You