# CONTROL OF POLLUTION OVER DELHI THROUGH SMART TRAFFIC MANAGEMENT


## SUMMARY FOR POLICY MAKERS

*Control of air pollution over Delhi needs a multi-pronged approach; smart management can aid the overall effort. In a first-of-its-kind observation campaign by NISTADS, based on high-frequency mobile observation platform and analysis, it was found that Extreme Pollution Events (EPEs) in particulate matter, during which air quality is extremely degraded for short durations, were major contributors (up to 80%) to build-up of pollution; reduction of EPEs can thus improve the air quality significantly. It was also found that certain locations, like Delhi University, are hotspots of EPEs. As a measure to reduce the impact of such EPEs, an Air Quality-linked Traffic Advisory System (AQTAS) has been developed to issue real-time alerts and advisory to avoid EPEs; this system is currently in an open-environment demonstration at NISTADS campus. A Policy Pdvocacy is presented for deployment of AQTAS as well as other measures so as to reduce EPEs..*

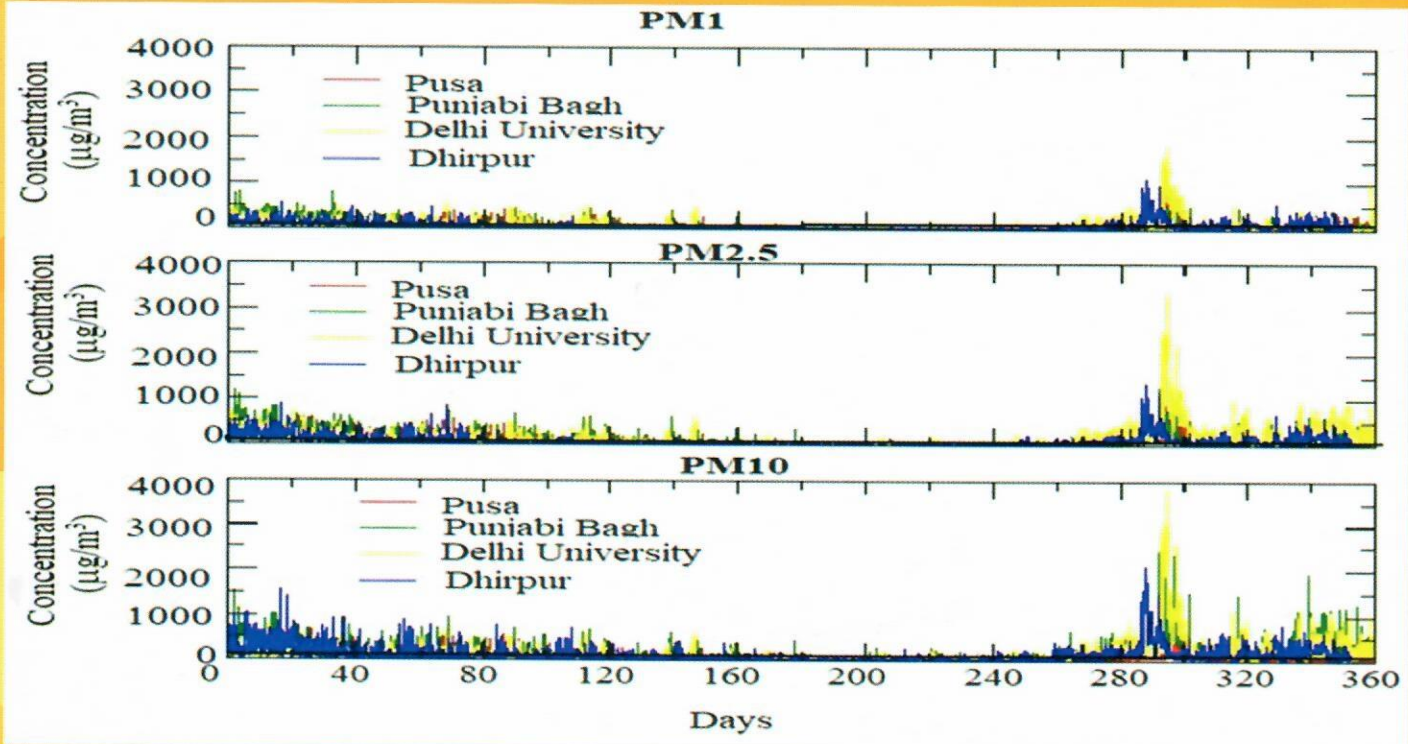

## THE CSIR-NISTADS PROJECT

### Data-Based Policy Advocacy for Real-time Air Pollution Management over Delhi

The CSIR-NISTADS project is aimed at creation of an implementable, effective and non-disruptive traffic management system based on high-frequency co-located observations of pollution concentrations, traffic parameters and weather variables for maintaining pollution below safe limit.

*Goal: A smart, dynamic traffic management system for reduced air pollution over Delhi*

The effectiveness of the solution lies in creating a real-time traffic decision support for smooth traffic movement




**Extreme Pollution Events:** Concentration of PM1 (top panel), PM2.5 (middle panel) and PM10 (bottom panel) is recorded during the period from 10 January, 2017 to 15 January, 2018, at 20-minute interval at the four locations

**A significant finding is that the prevalence and the intensity of EPEs are much higher over certain locations like Delhi University and Dhirpur; this offers possible avenues for control of EPEs**

# CSIR-NISTADS MOBILE OBSERVATION AND DATA ACQUISITION PLATFORM


**NISTADS Mobile Data Acquisition Platform**

### NISTADS DATA ACQUISITION PLATFORM

- Mobile platform; sensors mounted on the roof of the vehicles
  Pollution sensors (PM10, PM2.5, PM1)
- Meteorology sensors (relative humidity, wind speed, rainfall and temperature)
- Vehicular sensor (2, 3, 4-wheelers, etc)
- Sociological indicator (exposure hours)

### Improved Air Quality through Smart Management

A non-disruptive solution for smart pollution management can significantly aid efforts to improve Delhi's air quality. The prototype is devised to monitor and provide information on real-time pollution concentration by means pollution alert. The information can be used in real time to reduce traffic congestion and thus to avoid build-up of pollution.

## Validation

Validation of the observations is a critical requirement but a major challenge, since such high-frequency observations over prolonged period had not been carried out before; thus reference data sets for making comparisons is not available. However, the average annual cycle of monthly average concentrations (Figure-1) match well with other observations.

## Highlights

Co-located data on traffic, pollution and meteorological variables at vehicle top level (≈6-8 feet)

**Duration of Observation Campaign:** 12 months (2016-17); 7 AM to 9 PM

**Sampling time:** 15 minutes

**Locations:** Four (04) traffic zones: Delhi University, each with 3 nodes at a node along roadside/highways.

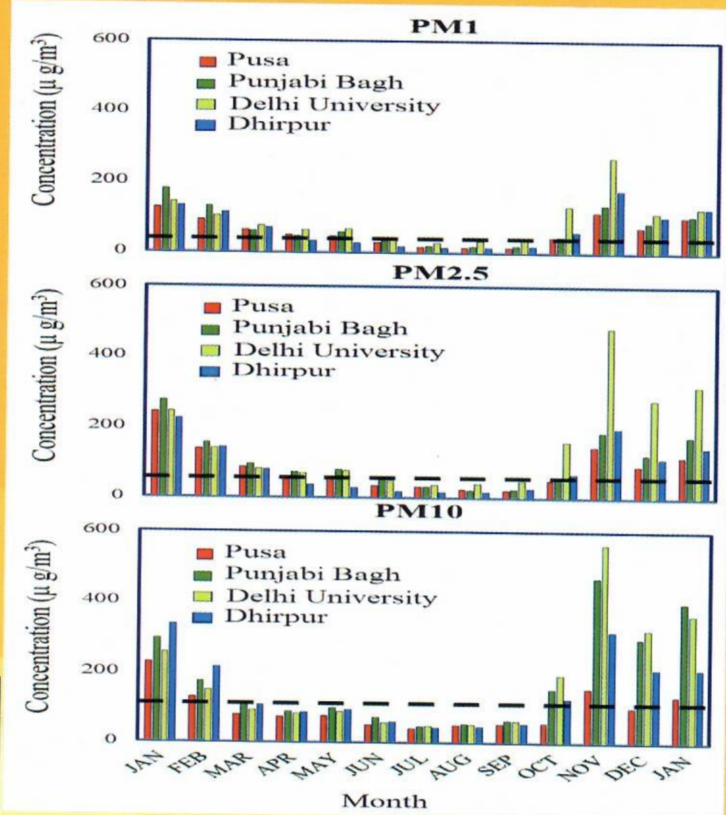
**Sampling Interval at one Node:** One hour

**Vehicular data on**

(i) number & types of vehicles passing per hour
(ii) average idling/waiting time at traffic junction/hour
(iii) average on-road congestion (>1 minute)

**Socio-economic data on:**

(i) Number of people exposed to on-road traffic (hourly)
(ii) Open food vendors exposed to on-road traffic (hourly)
(iii) Number and types (open/doors) and shops in the area




**Monthly average concentrations of particulate matters; PM1, PM2.5 and PM10 at four locations over Delhi**
**The horizontal line represents permissible limit for the respective pollutant**

## PATTERN OF EPE IN DELHI NCR

### EPE AND THEIR MEASUREMENT

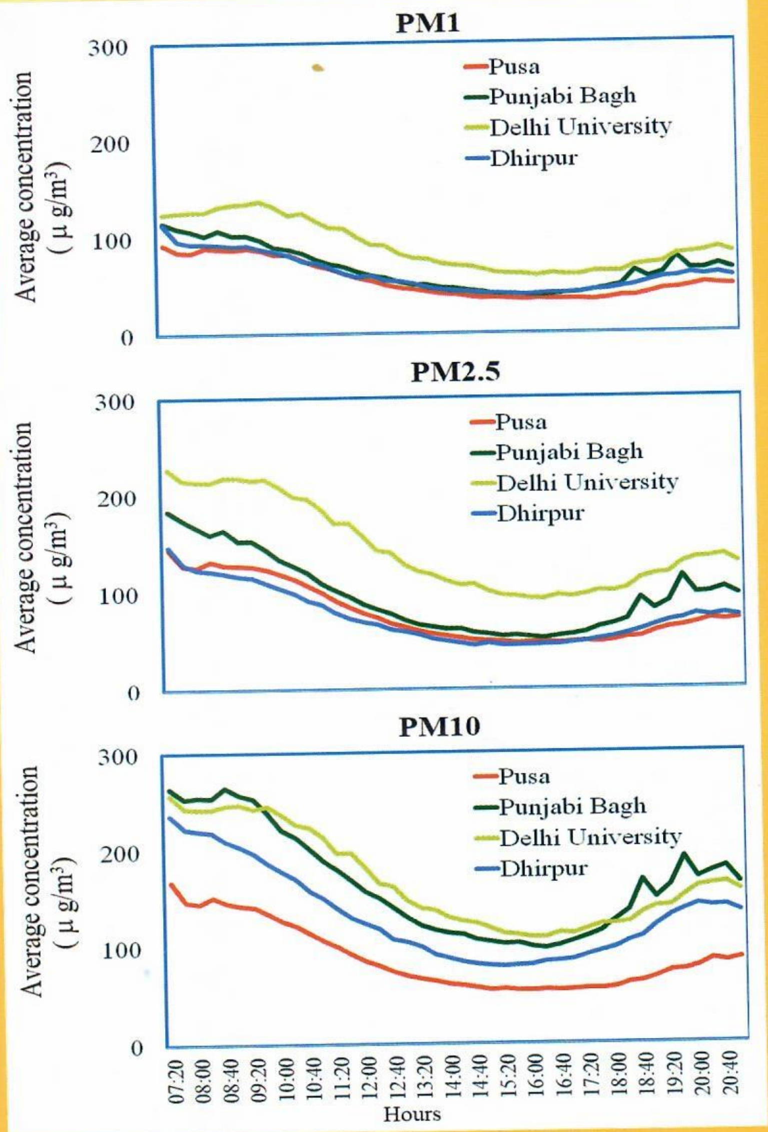
Ambient air pollution has been found to play a major role in development of several health problems. Several studies have estimated the influence of ambient air pollution on cardio-vascular diseases, establishing a causal relationship between exposure and disease, including factors like location, duration and timing of the exposures.

Many factors, from industrial to vehicular traffic to off-location activities like stubble burning, contribute to air pollution; meteorological factors like wind speed, rainfall and the structure of the boundary layer also play major roles.

A major unknown factor in the study of pollution over Delhi, or any megacity, is the spatio-temporal distribution of the high-concentration events, or Extreme Pollution Events (EPEs). This knowledge requires real-time, high-resolution and high-frequency data. The average diurnal cycles of PM1, PM2.5 and PM10 show (Figure-2) significant hourly variations over the four locations.

Such information can be used to bring down high concentrations at any given point and time through redistribution of traffic, thus allowing the atmospheric ventilation system to be more effective.

NISTADS effort is the first observational campaign to measure EPEs over Delhi for a prolonged (13 months) period over multiple locations and at high frequency.




Average diurnal cycle (7:30-20:30 hours) of PM1 (top panel), PM2.5 (middle panel) and PM10 (bottom panel) during January 2017 to January 2018 at four locations in Delhi.

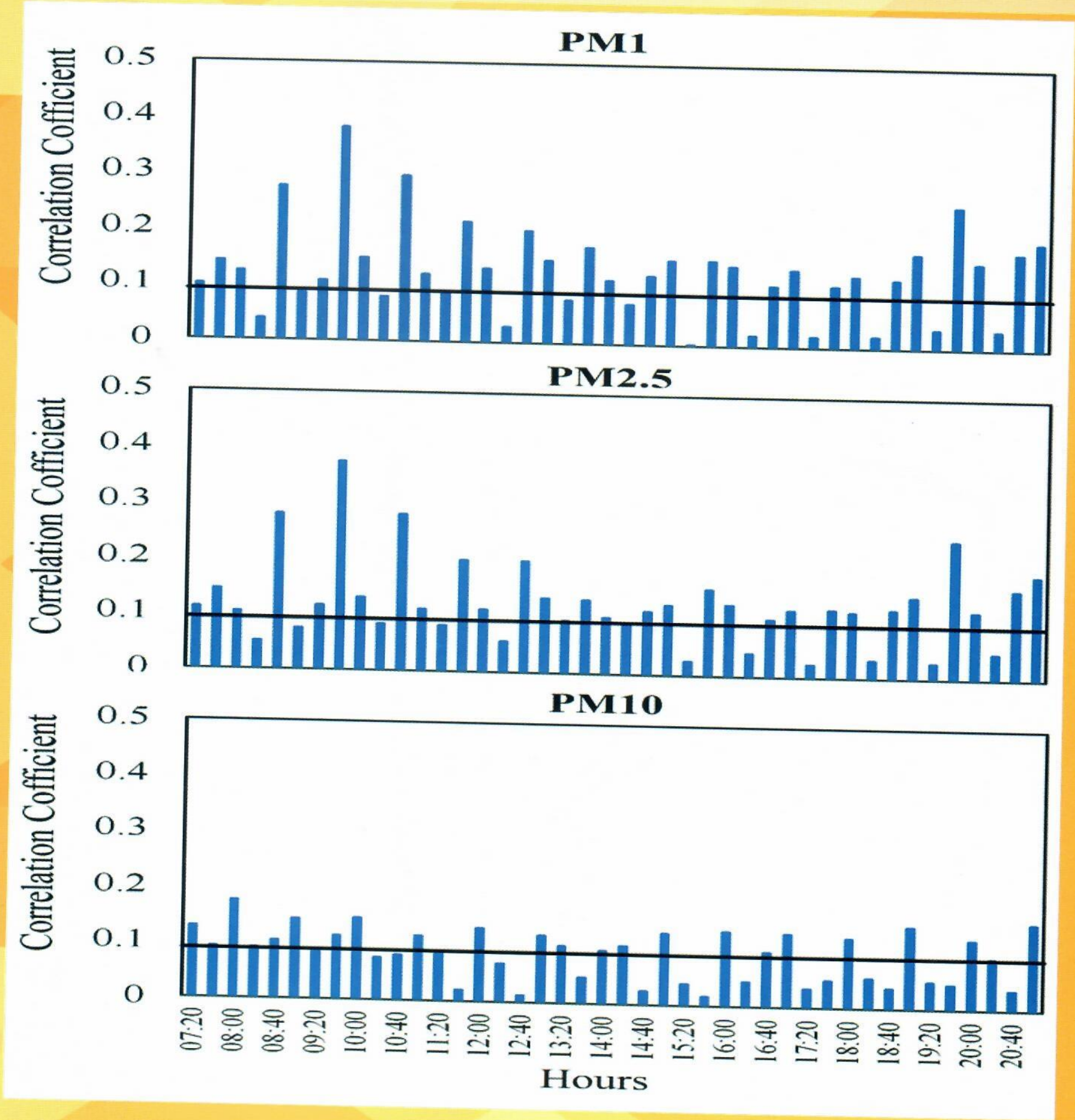
A scrutiny of extreme pollution events over the four location during the observation campaign shows (Table below) close to 40% of the total observations to be EPE, with Delhi University recording the highest percentaage of EPE. The EPE are also more prominent in PM1, followed by PM2.5 an PM10.

**Table: Extreme Pollution Events**

| Location | No. of observed EPEs out of total observations (≈15000) | | | Percentage of observed EPEs out of total observations | | |
|---|---|---|---|---|---|---|
| | PM1 | PM2.5 | PM10 | PM1 | PM2.5 | PM10 |
| Pusa | 6684 | 5749 | 3838 | 43 | 37 | 25 |
| Punjabi Bagh | 7198 | 6700 | 6659 | 47 | 44 | 43 |
| Delhi University | 9644 | 8169 | 6555 | 63 | 53 | 43 |
| Dhirpur | 6532 | 5339 | 5875 | 44 | 36 | 39 |

## VEHICULAR TRAFFIC AND POLLUTION

The NISTADS observation campaign also included recording of vehicular traffic in terms of number of vehicles crossing the observation point in four categories: Two Wheeler, Three-Wheeler, Cars and heavy Motor Vehicles (HMV). This vehicular data was used to gain insight into the dynamics of pollution.




Diurnal variations in correlation coefficients between PM concentration and the total number of vehicles for Punjabi Bagh, Delhi. The horizontal line represents the significant level at 95%

The correlation between the vehicular numbers and particulate matter is generally significant and highest in the morning hours; the correlation is also most significant for PM1. This information has been used to design our policy advocacy

**CSIR NISTADS**

## Air-Quality linked Traffic Alert System (AQTAS)

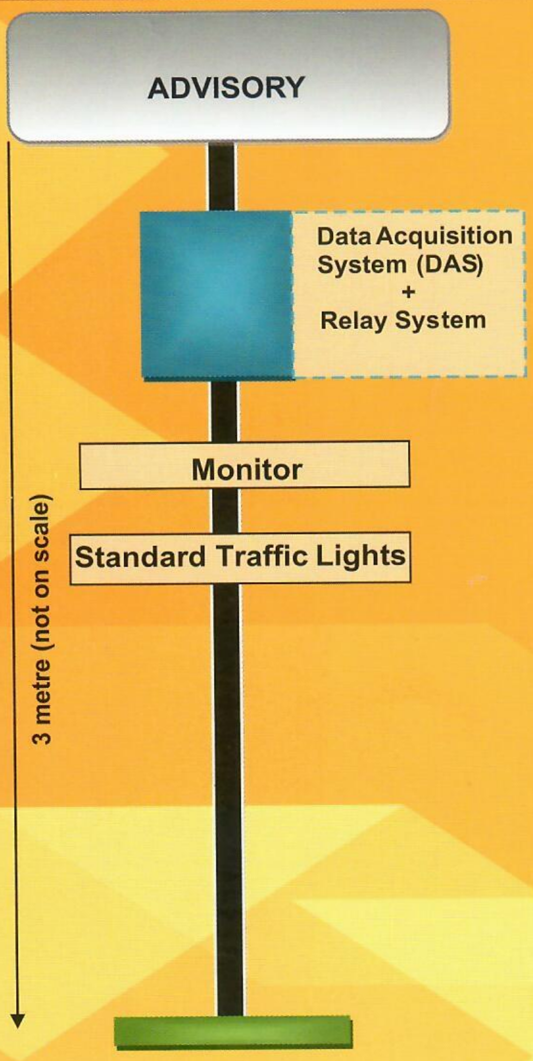
**A Smart City Solution under NISTADS Technology Innovation Programme (NTIP)**

**Why Real-time pollution alert?**

As a part of its policy advocacy based on the observations and findings, CSIR-NISTADS has developed a prototype Air Quality Linked Traffic Advisory System (AQTAS) for providing a Smart Solution. Based on the findings from its observation programme and technology prototype,

For making the commuters aware of the information on real-time traffic emission and ambient air pollution, an effective real-time air quality alert system is required. This is possible if real-time data is collected on air quality for monitoring campaigns using on ground systems. The system will generate real-time alert of pollution concentration by giving advice to the on-road commuters to avoid extreme pollution concentration.

**Air Quality Alert Display Board**




Schematic of Air Quality inked Traffic Alert System (AQTAS) (Standalone Model TRL-5)

**Schematic Diagram of Air Quality Linked Traffic Advisory System (AQTAS)**

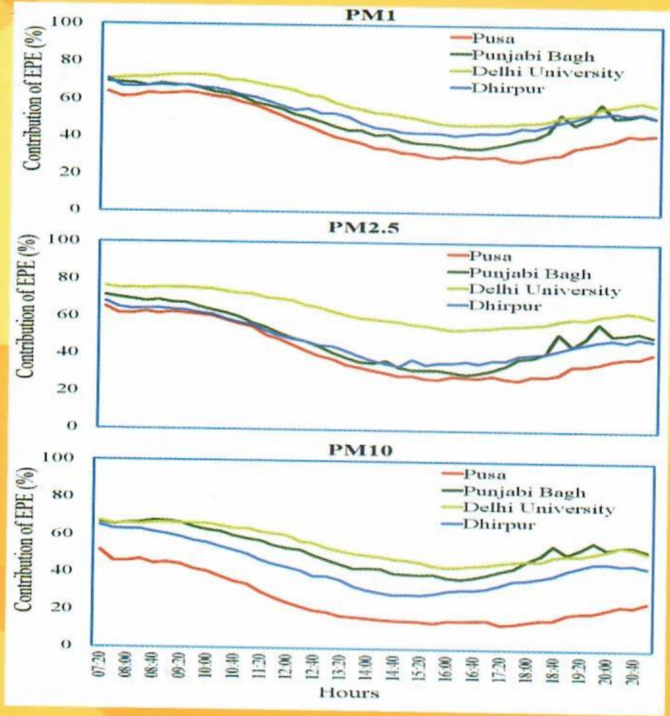
**Main objective:** To develop an Air Quality Linked Traffic Alert System (AQTAS), which will display real-time pollution level to the commuters to enable them to take an appropriate alternative traffic route to avoid exposure to Extreme Pollution Event (EPEs).

### Salient Features of AQTAS

- Real-time air quality alert through algorithm-based display
- Multi-site high-frequency real-time air quality monitoring
- Easily deployable
- Retrofitting – can be fitted to existing traffic light
- Modularity – can be built up gradually
- Customizable – according to the admissible limit of pollutants
- Can be integrated with the traffic light system
- Non-disruptive with the existing traffic light system
- Generation of real-time pollution alert based on high-frequency real-time data
- Display of pollution in three different colours according to the pollution concentration

**Energy Source**

The prototype is environmental-friendly and does not require conventional energy to operate. The system is battery-operated by renewable (solar) energy.




**Diurnal contribution of EPEs as percentage of total concentration of pollutants**

## MAJOR FINDINGS

- Up to 80% of the pollution comes from the EPEs, especially in the morning hours\
- The occurrence of EPEs shows strong spatial variations; Delhi University has more EPEs than Pusa, Punjabi Bagh and Dhirpur
- Traffic management can play a significant role in pollution control through avoidance of EPE.
- The number EPE follows the same annual variation as that of pollution (highest in winter and lowest in the monsoon season)
- The contribution of extreme events is 60% to 75% in the winter while it is 25-60% in the monsoon season

## RECOMMENDATIONS

Based on the role and the distribution of Extreme Pollution Events, the following measures are recommended in order of their implementability and resource requirements:

1. The entry timings of heavy motor vehicles (HMV) in Delhi NCR may be restricted to an earlier hour to allow HMV vehicular emission sufficient time to settle down before dawn.
2. For reducing particulate matter concentration over EPE hotspots like Delhi University, alternate routes may be devised and opted for
3. Congestion hours may be reduced by keeping the traffic flow away from obstacles
4. The Air Quality Linked Traffic Advisory System (AQTAS) developed by NISTADS can be integrated with the traffic system to avoid build-up of EPEs
5. Electric Rail (Conveyor) transfer of HMVs for the last 20 to 30 km to Delhi can be considered in order to avoid exhaust emission from the vehicles entering/exiting Delhi.

## For further information

Director, CSIR-NISTADS
Dr. K.S. Krishnan Marg, PUSA, New Delhi-110012
Phone No: +91 11-25843227; Fax: +91 11-25846064, Email: director@nistads.res.in;

Visit us: www.nistads.res.in