DESIGN OF A REAL-TIME POLLUTION MANAGEMENT SYSTEM FOR DELHI

SUMMARY FOR POLICY MAKERS

Control of air pollution needs to be achieved through a multi-pronged strategy. High air pollution often occurs when the concentration exceeds the local ventilation capacity. As against economically or societally disruptive measures, management of traffic based on real-time, co-located data on pollution, weather variables and traffic parameters provides a viable alternative to reduce air pollution. Based on high-frequency, multi-site observations from mobile platforms CSIR-NISTADS has developed an evidence-based analysis for pollution control through dynamic traffic management. Such a system provides an effective solution for pollution control and for avoiding Extreme Pollution Events.

SMART POLLUTION MANAGEMENT

Pollution management can be viewed as a dynamic process and requires a continuous system for:

- Real-time Traffic Management
- Real time Traffic Advisory
- Alerts for Extreme Pollution Events

Telemetric data acquisition integrated to traffic control can provide a solution.

THE CSIR-NISTADS PROJECT: MISSION CLEAN DELHI

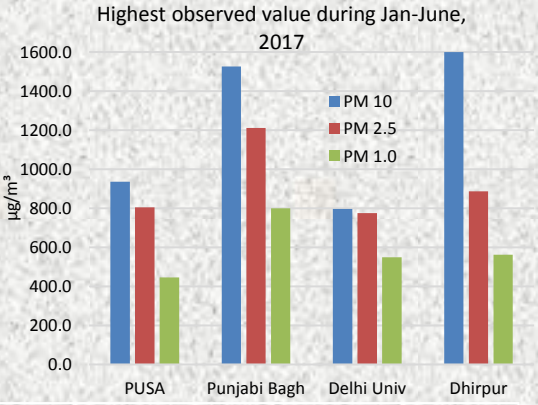
Data-Based Design of Real-time Air Pollution Management System over Delhi

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 and low pollution.

Mobile data collection platform

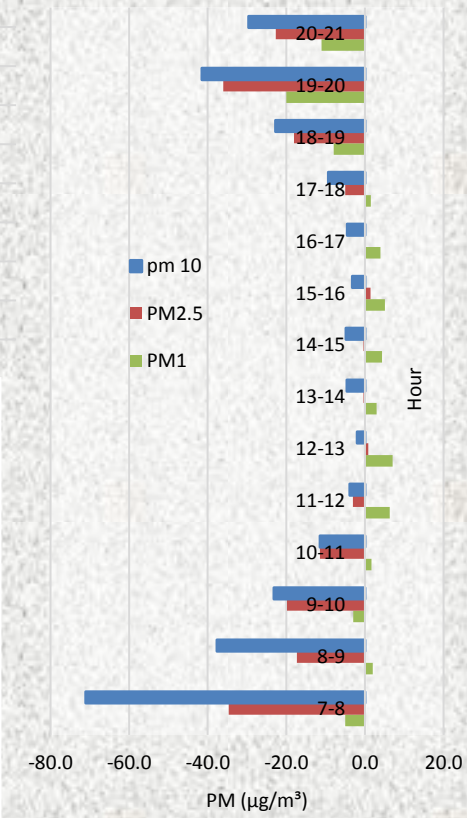


THE PARADIGM OF NON-DISRUPTIVE POLLUTION MANAGEMENT

While the harmful effects of pollution are well-known, there is no easy way yet to avoid it. In a sense, air pollution is the price we pay for our right to emit, a driver of economic activities. Thus, until carbon-friendly technologies are available, we have to live with the menace of air pollution.

Attempts at curbing air pollution through socially/economically disruptive measures like Odd-Even hadn't been very effective in Delhi or elsewhere in the world; the best option appears to be non-disruptive measures.

Rapid advances in data acquisition and data analytics with real time high resolution and high-frequency data provides an implementable, non-disruptive method for smart pollution management. Such management aims at bringing down high concentrations at any given point and time through redistribution of traffic, thus allowing the atmospheric ventilation system to be more effective.

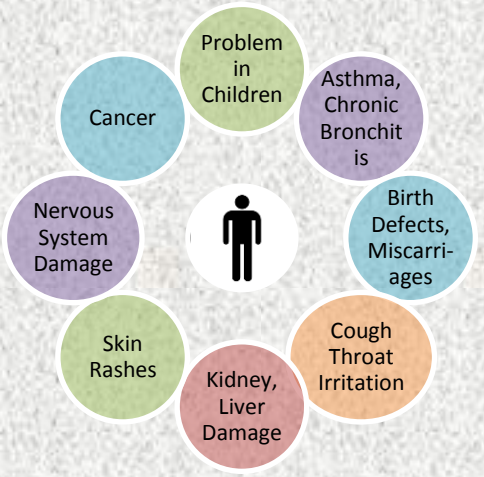


Hourly difference of PMs; Delhi Uni V/s Punjabi Bagh (Jan-Jun 2017)

Analysis shows high (significant at 99% confidence) correlations among hourly concentrations of three particulate matters (PM1, PM2.5 and PM10) over Delhi indicating common sources for the three pollutants.

IMPACT OF POLLUTION

Particulate matter (PM) has multiple effects on health, environment and economic activities. PM causes eye, nose and throat irritations, shortness of breath, exacerbation of respiratory conditions, chronic obstructive pulmonary disease, asthma and exacerbation of allergies, increased risk of cardiovascular disease and premature death. The young, the elderly and those with acute illnesses are at greater risk. PM can also reduce plant growth and productivity and can cause physical damage to plant surfaces via abrasion. Permissible limits of PM10 and PM2.5 are is 100 µg/m^3 and 60 µg/m^3, respectively; PM1, which can penetrate the cardiovascular stream even further, is more harmful than PM 2.5 or PM 10; however, there is no standard data yet on permissible levels of PM1.



OBSERVATION SYSTEM DESIGN

Data-driven traffic management demands stringent conditions on the observation system design. The following are the highlights of the NISTADS observation platform.

High Sampling Frequency: Traffic decision support requires data at short intervals; the NISTADS observations were sampled at 15-minute intervals.

Multi-Site Sampling: An important requirement is to create concurrent distribution of pollutants to understand the locational dependencies. The NISTADS observations were designed to sample data over 12 locations.

Collocated Observations: In order to determine relative roles of various drivers and their inter-dependence, measurements were collocated for air quality, meteorological variables, vehicular data and socio-economic parameters (like exposure-hours).

Mobile Platform: The data was collected using a mobile platform with sensors mounted at breathing level (~ 2m). The use of the mobile platform ensured much wider spatial sampling than that through a point observation.

OBSERVATION SCHEDULE

- Data Collection zones; Pusa, Delhi university, Punjabi Bagh & Dhirpur
- 15-minutes average data at three nodes in each zone
- Measurement at vehicular top using mountable sensors on a mobile van
- Measurement Duration: 7 AM to 9 PM

NISTADS DATA ACQUISITION PLATFORM

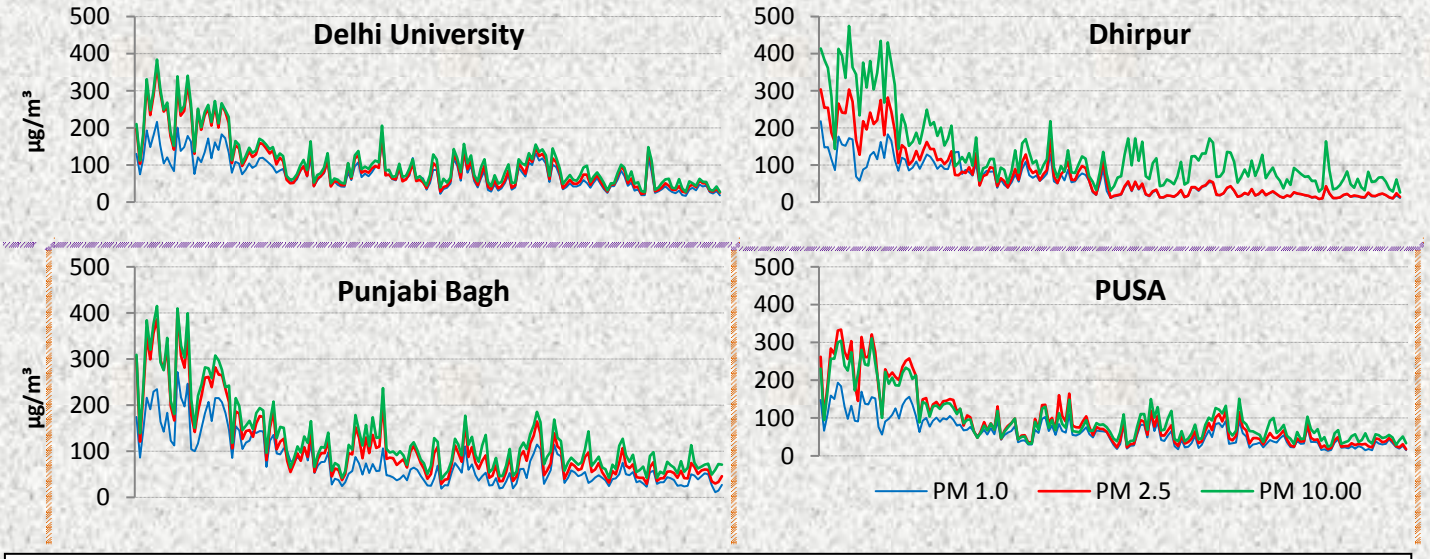
- Pollution sensors (PM10, PM2.5, PM1)
- Meteorology sensors (relative humidity, wind speed, rain fall & temp.)
- Vehicular sensor (2, 3, 4-wheelers, etc)
- Sociological indicator (exposure hours)

DATA POLICY

Calibration: All sensors are calibrated at the time of supply; they are also periodically calibrated by the vendor according to manufacturer's specification. However, calibration in field conditions is a challenge. Thus actual values may be contaminated by bias introduced by calibrations. Unlike conclusions based on absolute values, analysis based on differences, gradients and statistical quantities like correlation are less affected by bias due to calibration.

Quality Control: Pollution or weather data at the frequency and resolution adopted are generally not available over Delhi; thus quality control based on reference data is not feasible. Instead, a dynamic quality control was adopted by passing data through an Adaptive Quality Control Gateway.

Archival: Data is archived in NISTADS Data Centre in structured files with metadata for easy retrieval and analysis.



Results from NISTADS measurements on variation of daily-averaged values of pollutants (Jan-Jun 2017)

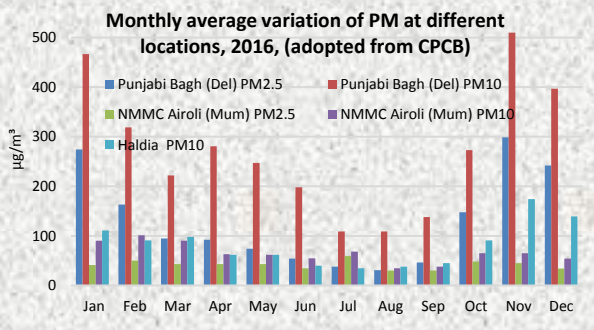
MAJOR UNKNOWN:

ACHIEVABLE MINIMUM POLLUTION (REFERENCE) STATE

A practical pollution management effort for Delhi must be based on a quantitative knowledge of minimum pollution attainable over Delhi; attempts to reach lower pollution levels may not be practical. However, this remains a major unknown and a major challenge to determine. In a sense, the Achievable Minimum Pollution State (AMPS) can be only determined hypothetically.

An urban habitat is embedded in a geo-climatic environment that makes it a part of the local circulation system. Thus AMPS is a characteristic of the location; AMPS will be different for different locations (coastal, mountainous, forested etc); result from one location cannot be applied to another.

A major objective of the project is identification of an AMPS for Delhi.



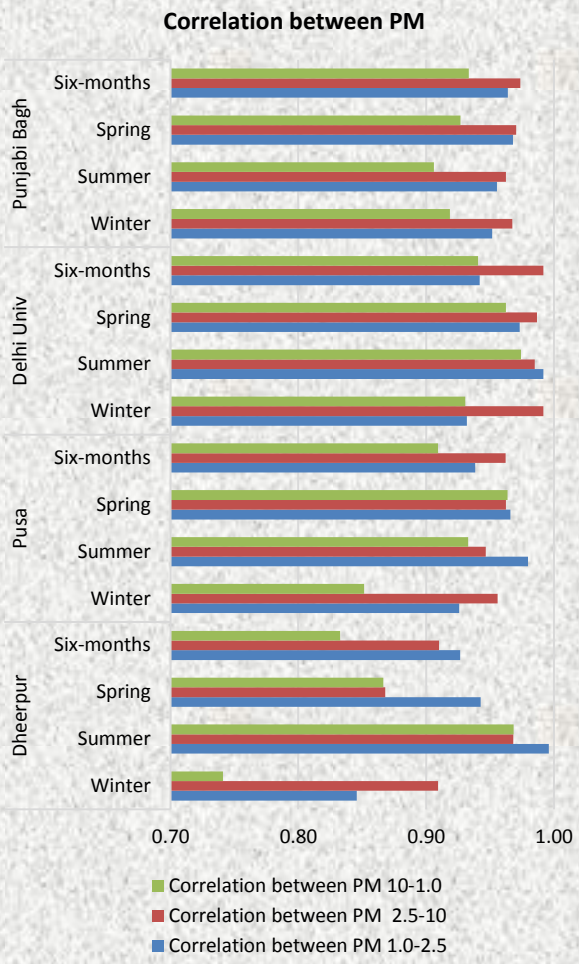
Even within the same city, different locations show diverse annual cycles of pollution concentrations.

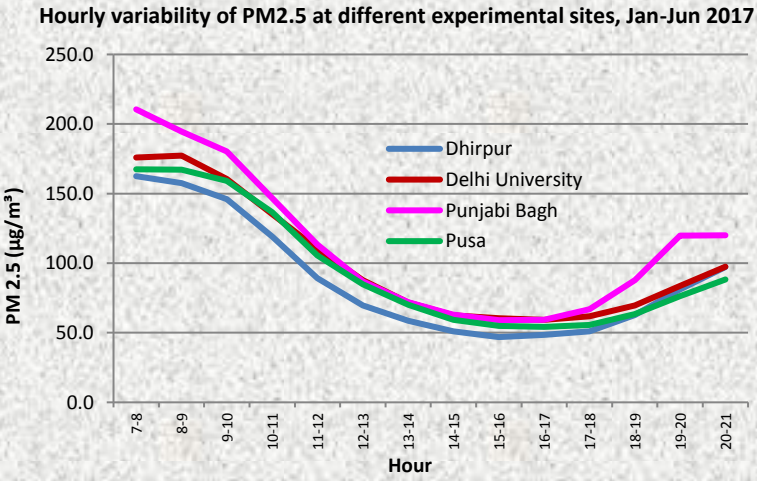
MAJOR UNKNOWN: SOURCE DELINEATION

Several studies have reported statistically significant associations between air pollution, characterized by particulate matter (PM) and/or gaseous pollutant levels.

Studies show that there is strong statistical association between different pollutants such as particulate matters and oxides of nitrogen and sulphur.

Sample concentrations of PM indicate strong correlations at all 04 experimental sites, indicating similar sources.





On road average exposure & vehicles/hour (Jan-June, 2017)				
Number	**PUSA**	**Punjabi Bagh**	**Delhi Univ**	**Dhirpur**
People	22	35	24	18
Food vendor/days	6	34	28	32
Shops/day	1	14	14	3
2-Wheelers	391	799	609	655
Auto -Rickshaws	81	243	159	145
4- Wheelers	399	1253	626	399
HMV's	19	84	16	30

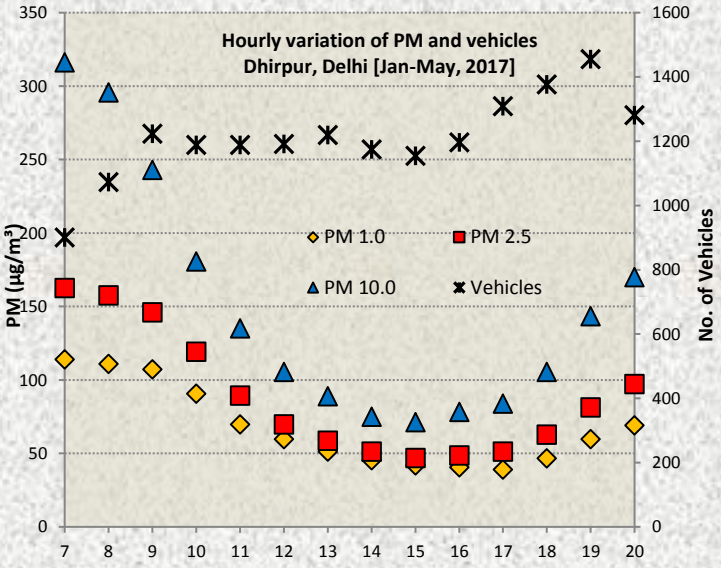
MAJOR UNKNOWN: EXTREME POLLUTION EVENTS (EPE)

Even short durations of exposure to high levels of pollution can have much higher damaging effects than longer duration low pollution. Such high levels of pollution can occur for short durations; however, averages over several hours can mask such Extreme Pollution Events (EPE). Since most conventional observations consider time averages, incidents of EPE are not reported. CSIR-NISTADS observations are aimed at identifying EPE for creating advisories in a location-specific manner.

Dynamic data-based traffic management can be used to avoid EPE.

NON-DISRUPTIVE POLLUTION MANAGEMENT: VIRTUAL ATTENDANCE AT WORK AND SCHOOL (VAWS)

CSIR-NISTADS in 2015 proposed a 2+1+2 working week in which the third day (Wednesday) will be a day of Virtual Attendance at Work and School (VAWS). Unlike other measures, VAWS allows to avoid plying of all kinds of vehicles such as bikes and buses, whose contributions to pollution are higher than cars. Through a day's break, VAWS allows effective ventilation of accumulated pollution. VAWS is a non-disruptive measure and can be implemented easily, with no adverse effects but with significant socio-economic benefits. The day of Virtual Attendance also allows parents and the children to have quality time together without any compromise of work, as travel time is saved. VAWS is an adaptive system that can be customized for schools and organizations.



Hours: 7:00 AM-9:00 PM

DATA-BASED AIR POLLUTION MANAGEMENT OVER DELHI: MAJOR RECOMMENDATIONS

Intelligent Traffic Information System: Sustained precision observations of all the necessary variables at required frequency and resolution should be ensured for effective traffic management solution.

Enabling Traffic Infrastructure: For efficient management of pollution grid infrastructure should be developed to reduce vehicle idling time.

EPE Alert System: Data-based Alerts for Extreme Pollution Events may be included in the display systems.

Utility for VAWS: Virtual presence at work e.g. virtual classes, offices etc. through digital utility may be enabled to avoid incidents of high pollution observed during the mid of the week.

A SCHEMATIC FOR A DATA BASED SMART TRAFFIC MANAGEMENT SYSTEM

High-Frequency Data

- Pollutants
- Weather Conditions
- Traffic Density

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Traffic Control

- Alternate Roads (GPS)
- Road Capacity (GPS)
- Decision Parameters

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Traffic Decision Support

- Route Advisory
- Signal Scheduling
- Traffic Density Scheduling

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Towards a Low-Pollution Delhi: A Vision

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