Restoring Air Quality through Source Apportionment Analysis

Orientation Conclave Air Quality Management:
Building Strategies for Clean Air , Bhubaneshwar
Jun 4,2019

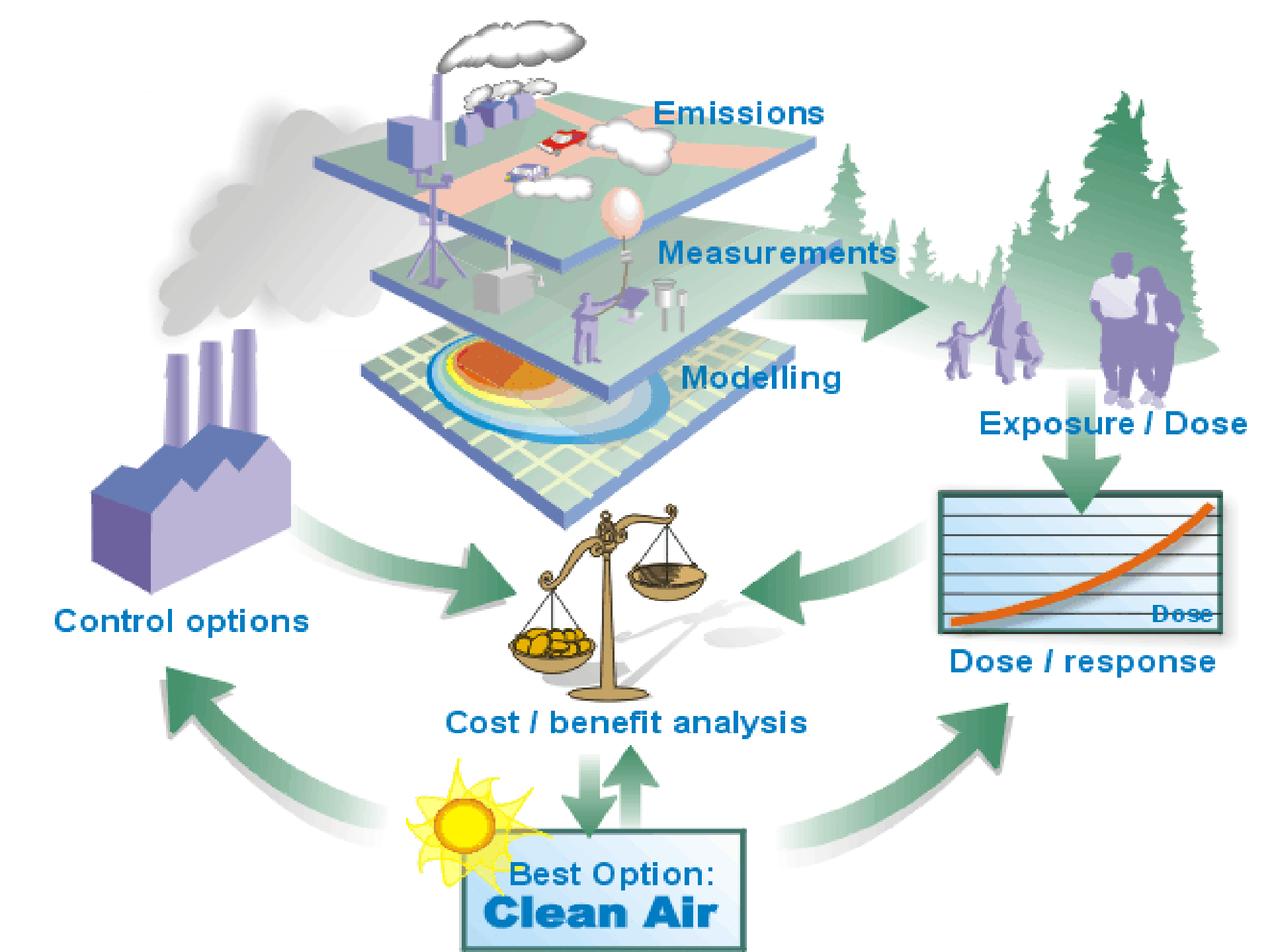
Mukesh Sharma, PhD, FNAE
Department of Civil Engineering
Indian Institute of Technology Kanpur

Why Control Air Pollution?

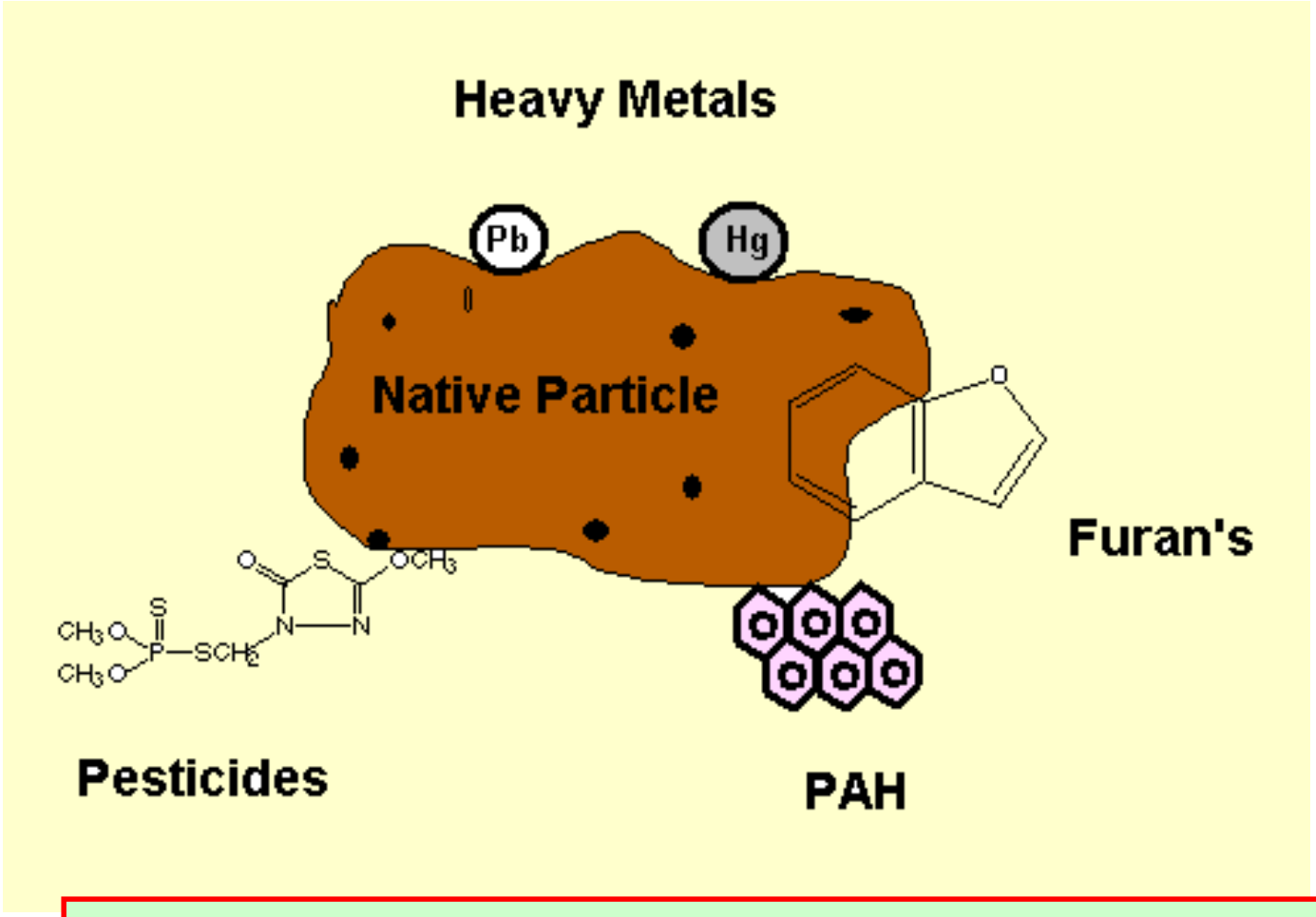
- Morbidity – Acute and Chronic
- Mortality – Premature Death and DALY
- Risk and communication – Organics and metals

Smart way

- Know all your sources well spatially and temporally (EI)
- Do not ignore small sources
- Combine meteorology to asses GL impact
- Quantified contribution of each source at breathing level
- Think of best options for controls
- Assess efficacy and cost of control options
- Develop time-sensitive action plan with targets
- Monitor targets and improvements in AQ
- Revise options, if necessary
- Translate better AQ into health benefits
- Responsibilities and fiscal allocations


Emissions
Measurements
Modelling
Exposure / Dose
Control options
Dose
Dose / response
Cost / benefit analysis
Best Option:
Clean Air

Hazardous Air Pollutants in Particulate Matter (PM2.5)



- Surface area (Smaller the Size more the HAPS)
- Elemental Carbon (more adsorption of HAPS)

रजिस्ट्री सं० डी० एल०-33004/99 REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण
EXTRAORDINARY
भाग III—खण्ड 4
PART III—Section 4
प्राधिकार से प्रकाशित
PUBLISHED BY AUTHORITY

सं. 217] नई दिल्ली, बुधवार, नवम्बर 18, 2009/कार्तिक 27, 1931
No. 217] NEW DELHI, WEDNESDAY, NOVEMBER 18, 2009/KARTIKA 27, 1931

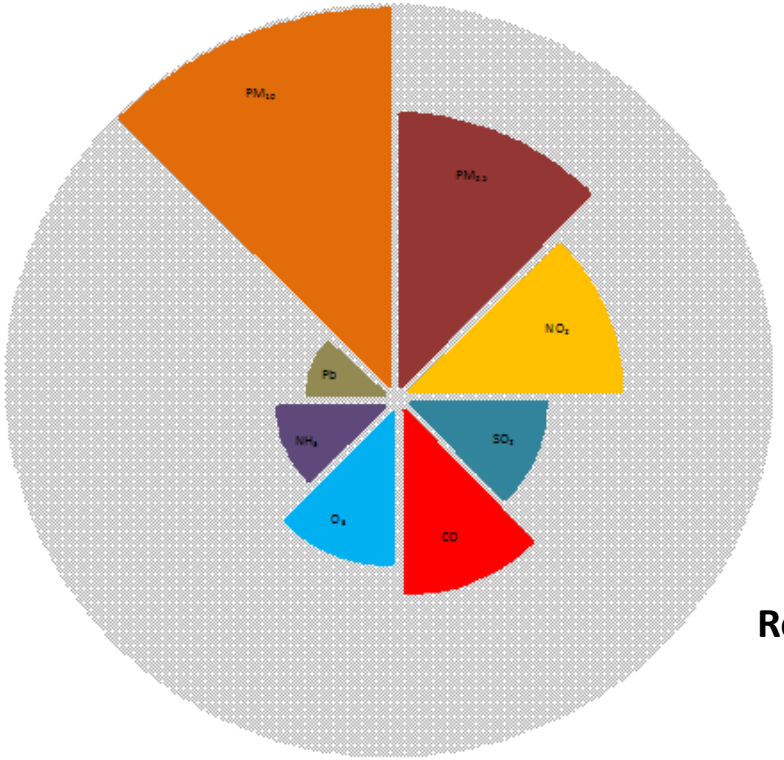
राष्ट्रीय परिवेशी वायु गुणवत्ता मानक
केन्द्रीय प्रदूषण नियंत्रण बोर्ड
अधिसूचना

NATIONAL AMBIENT AIR QUALITY STANDARDS

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur Dioxide (SO_2), $\mu g/m^3$	Annual*	50	20	- Improved West and Gaeke
		24 hours**	80	80	-Ultraviolet fluorescence
2	Nitrogen Dioxide (NO_2), $\mu g/m^3$	Annual*	40	30	- Modified Jacob & Hochheiser (Na-Arsenite)
		24 hours**	80	80	- Chemiluminescence
3	Particulate Matter (size less than 10µm) or PM_{10} $\mu g/m^3$	Annual*	60	60	- Gravimetric - TOEM
		24 hours**	100	100	- Beta attenuation
4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ $\mu g/m^3$	Annual*	40	40	- Gravimetric - TOEM
		24 hours**	60	60	- Beta attenuation
5	Ozone (O_3) $\mu g/m^3$	8 hours**	100	100	- UV photometric - Chemilminescence
		1 hour**	180	180	- Chemical Method
6	Lead (Pb) $\mu g/m^3$	Annual*	0.50	0.50	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
		24 hours**	1.0	1.0	
7	Carbon Monoxide (CO) mg/m^3	8 hours**	02	02	- Non Dispersive Infra Red (NDIR) spectroscopy
		1 hour**	04	04	
8	Ammonia (NH_3) $\mu g/m^3$	Annual*	100	100	-Chemiluminescence
		24 hours**	400	400	-Indophenol blue method
9	Benzene (C_6H_6) $\mu g/m^3$	Annual*	05	05	- Gas chromatography based continuous analyzer - Adsorption and Desorption followed by GC analysis
10	Benzo(a)Pyrene (BaP) - particulate phase only, ng/m^3	Annual*	01	01	- Solvent extraction followed by HPLC/GC analysis
11	Arsenic (As), ng/m^3	Annual*	06	06	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), ng/m^3	Annual*	20	20	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper

National Air Quality Index

(How healthy is the air we breathe?)



AQI = 230; Poor
Responsible Pollutant: PM_{10}

Indian Institute of Technology Kanpur, Kanpur

Sponsored by
Central Pollution Control Board, Delhi

Air pollution: NGT orders study of 102 cities

Background

How to attain National Air Quality Standards in Delhi?

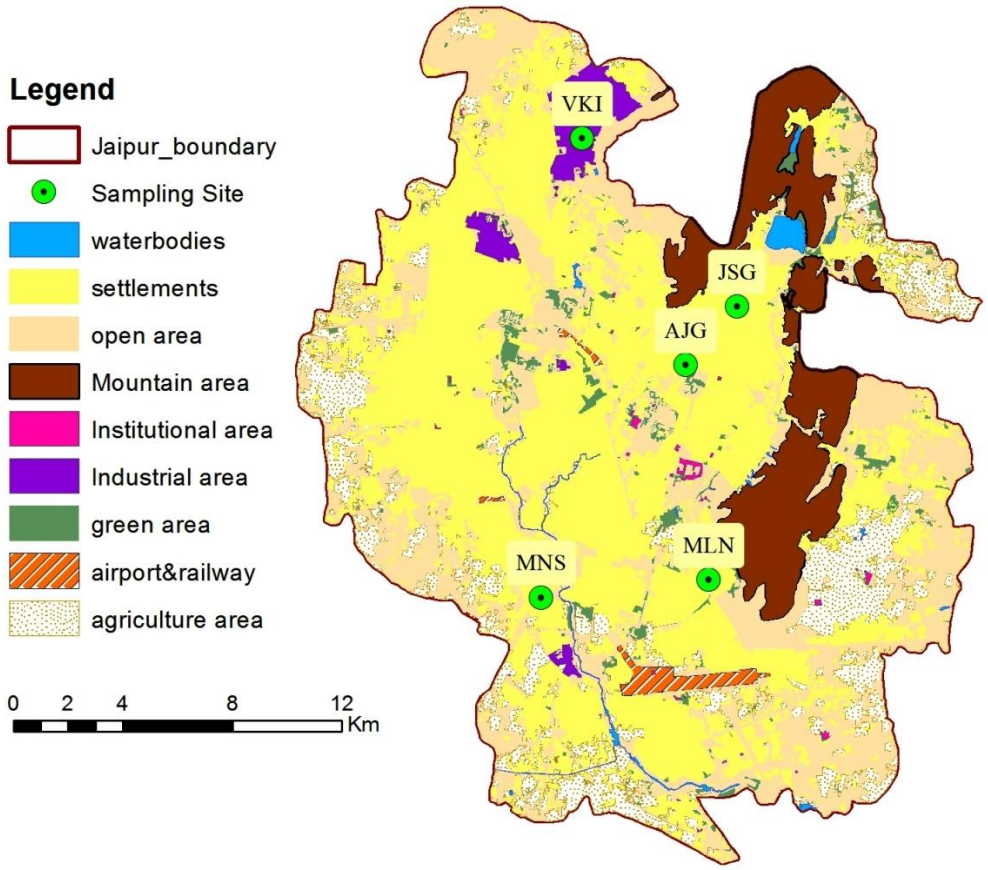
- Air Quality Measurements: Current Status
- Source Identification and Emission Quantification: Emission Inventory
- Quantification of Source Contribution to Air Pollution: Source Apportionment

→ Identification of Control Options and Their Efficacies

→ Time-bound Action Plan

- A Comprehensive Scientific Study: quantified causal source-receptor impact analysis, control options and their effectiveness, action plan - focus: $PM_{2.5}$, PM_{10} and NO_x

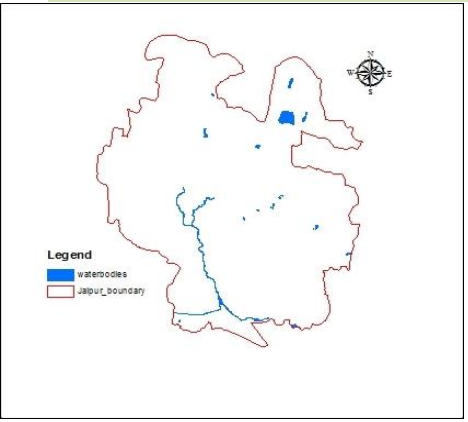
Sampling Location and Land-use Pattern Map of Jaipur



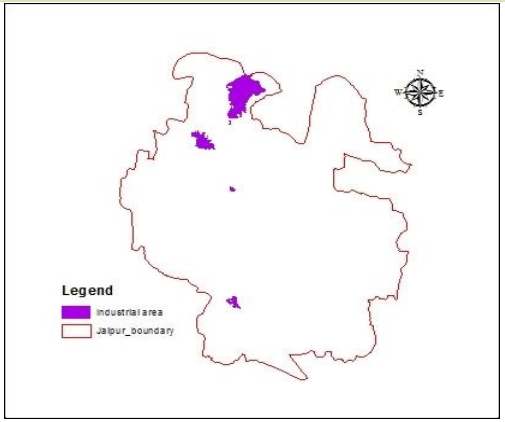
Winter	
AJG	Nov 19 – Dec 08, 2017
VKI	Dec 9 -31, 2017
JSG	Dec 14, 2017 – Jan 4, 2018
MLN	Jan 26 – Feb 14, 2018
MNS	Jan 15 – Feb 04, 2018

Summer	
AJG	May 6 - 26, 2018
VKI	May 6 - 27, 2018
JSG	May 29 – June 20, 2018
MLN	Apr 15 – May 4, 2018
MNS	Apr 15 – May 4, 2018

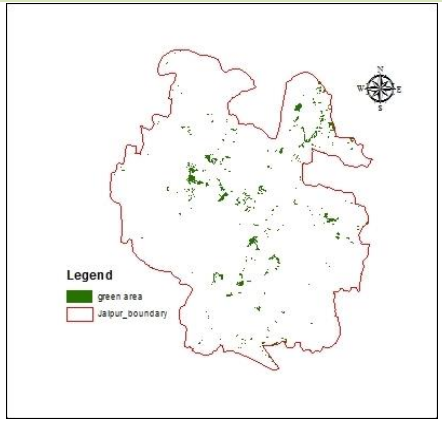
Different Layers of GIS-based land-use Map



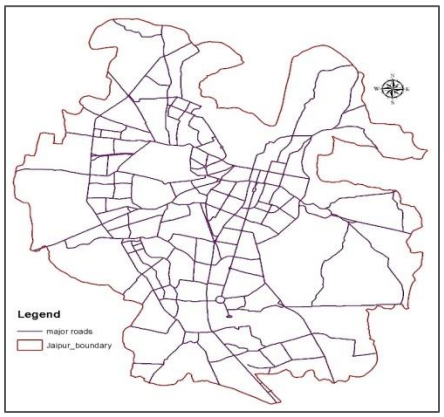
Water bodies



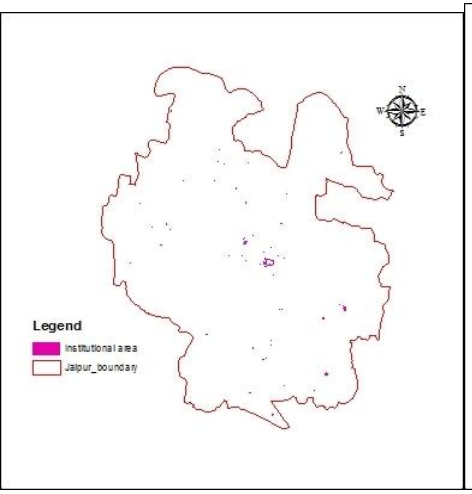
Industrial Area



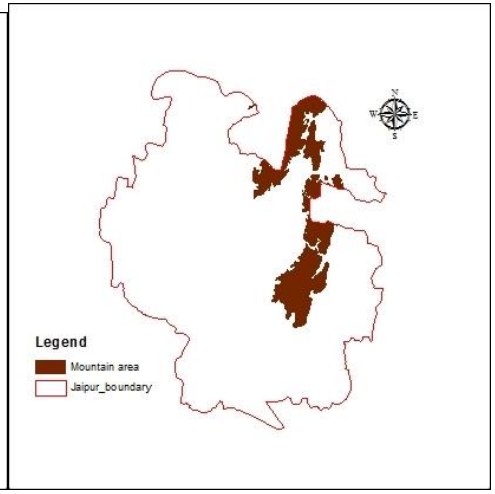
Green Area



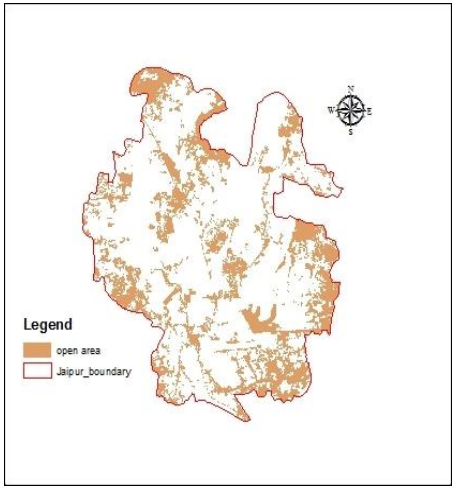
Major Roads



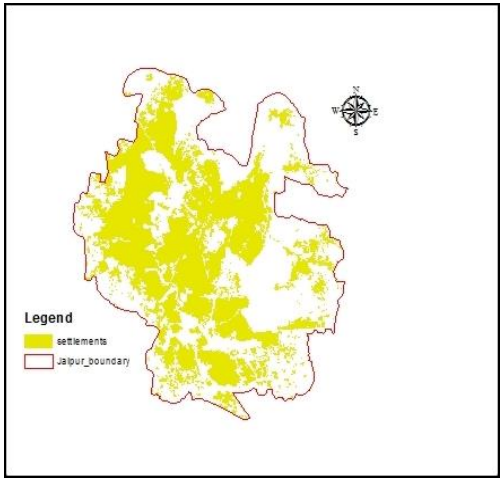
Institutional Area



Mountainous Area



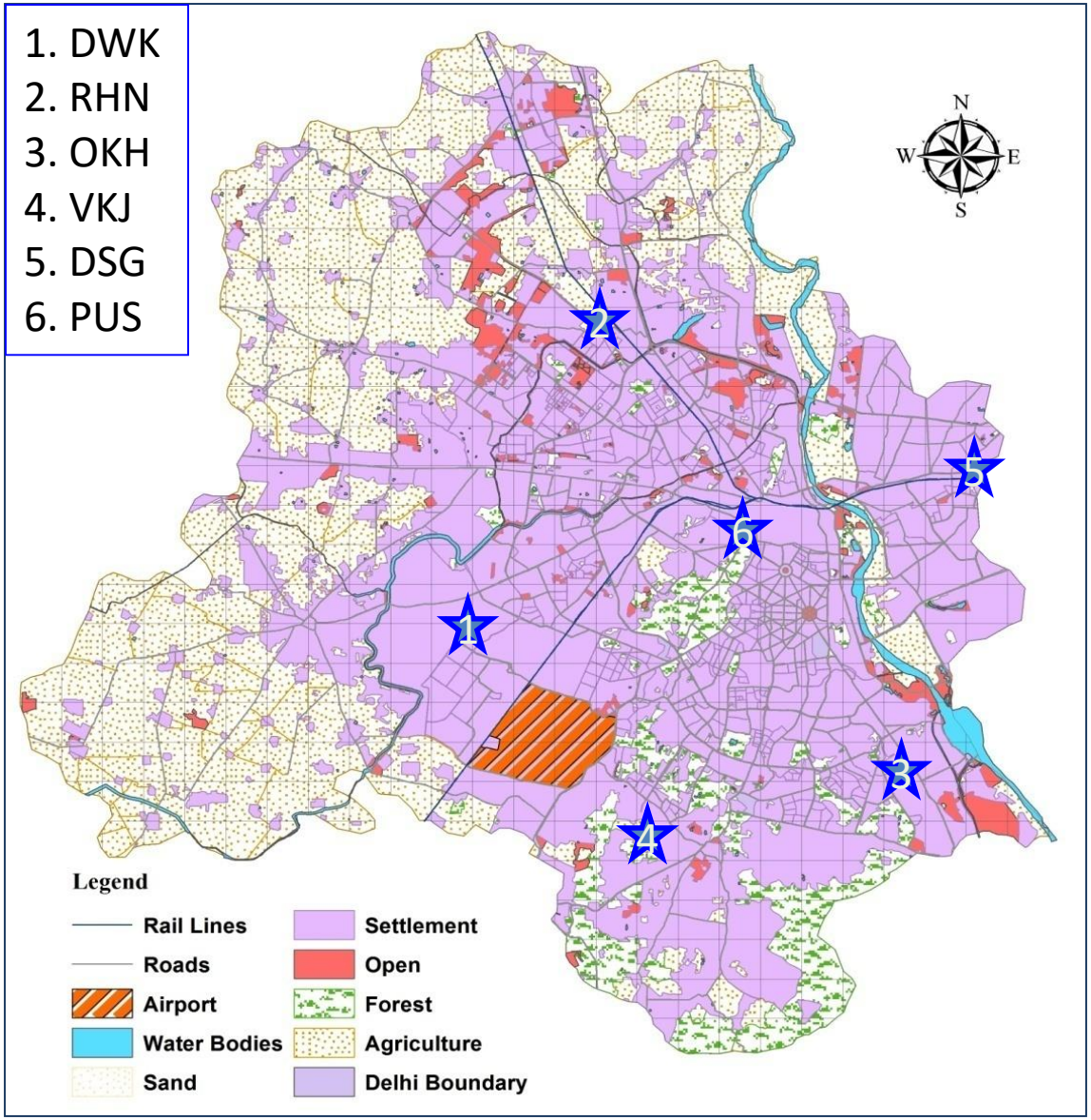
Open Fields



Settlement Area

Sampling Location and Land-use Pattern Map of Delhi

1. DWK
2. RHN
3. OKH
4. VKJ
5. DSG
6. PUS



Winter

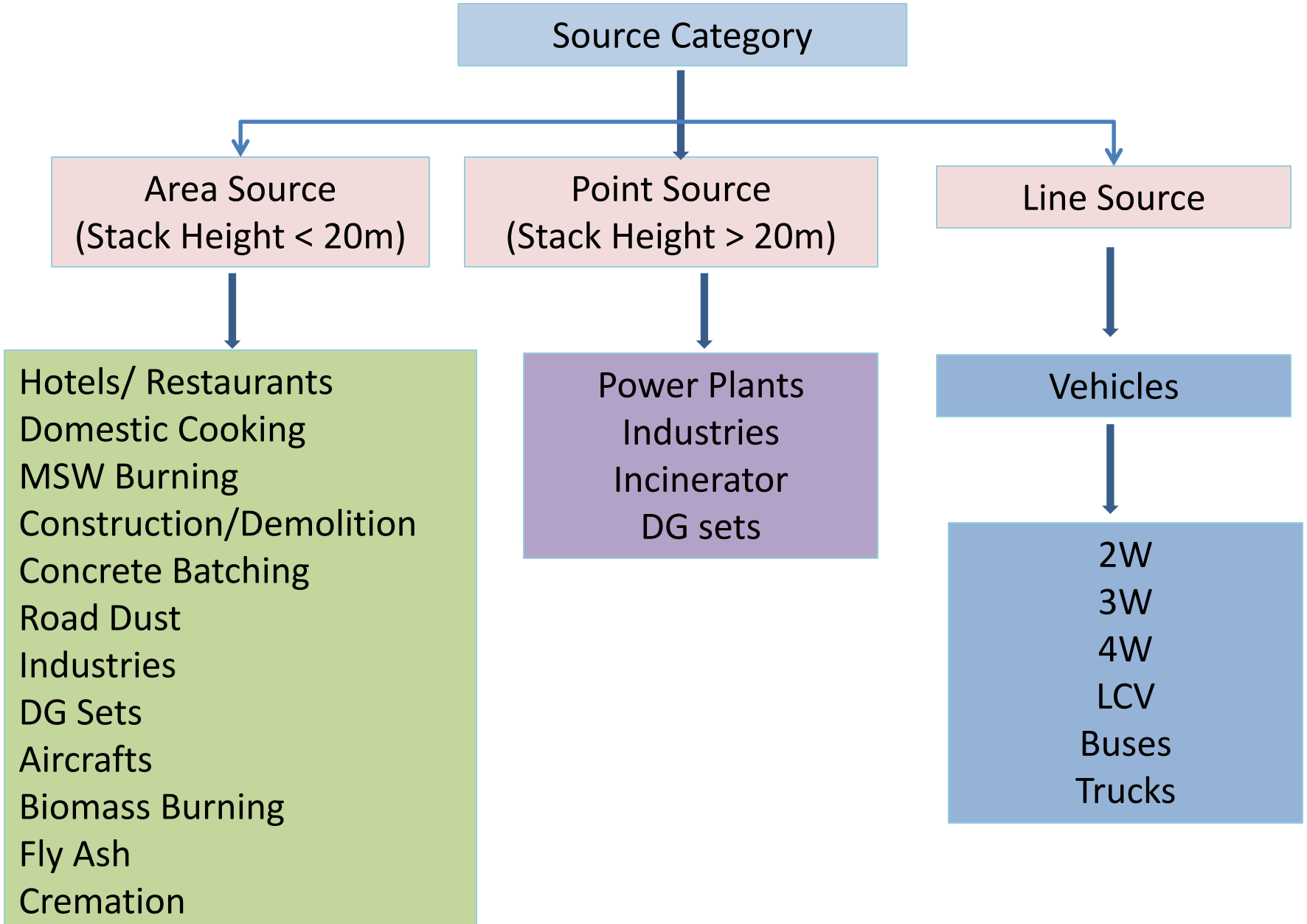
1. Nov 03 - 23, 2013
2. Nov 03 - 23, 2013
3. Dec 02 - 22, 2013
4. Dec 15, 2013 – Jan 04, 2014
5. Jan 24 - Feb 13, 2014
6. Jan 30 - Feb, 2014

Summer

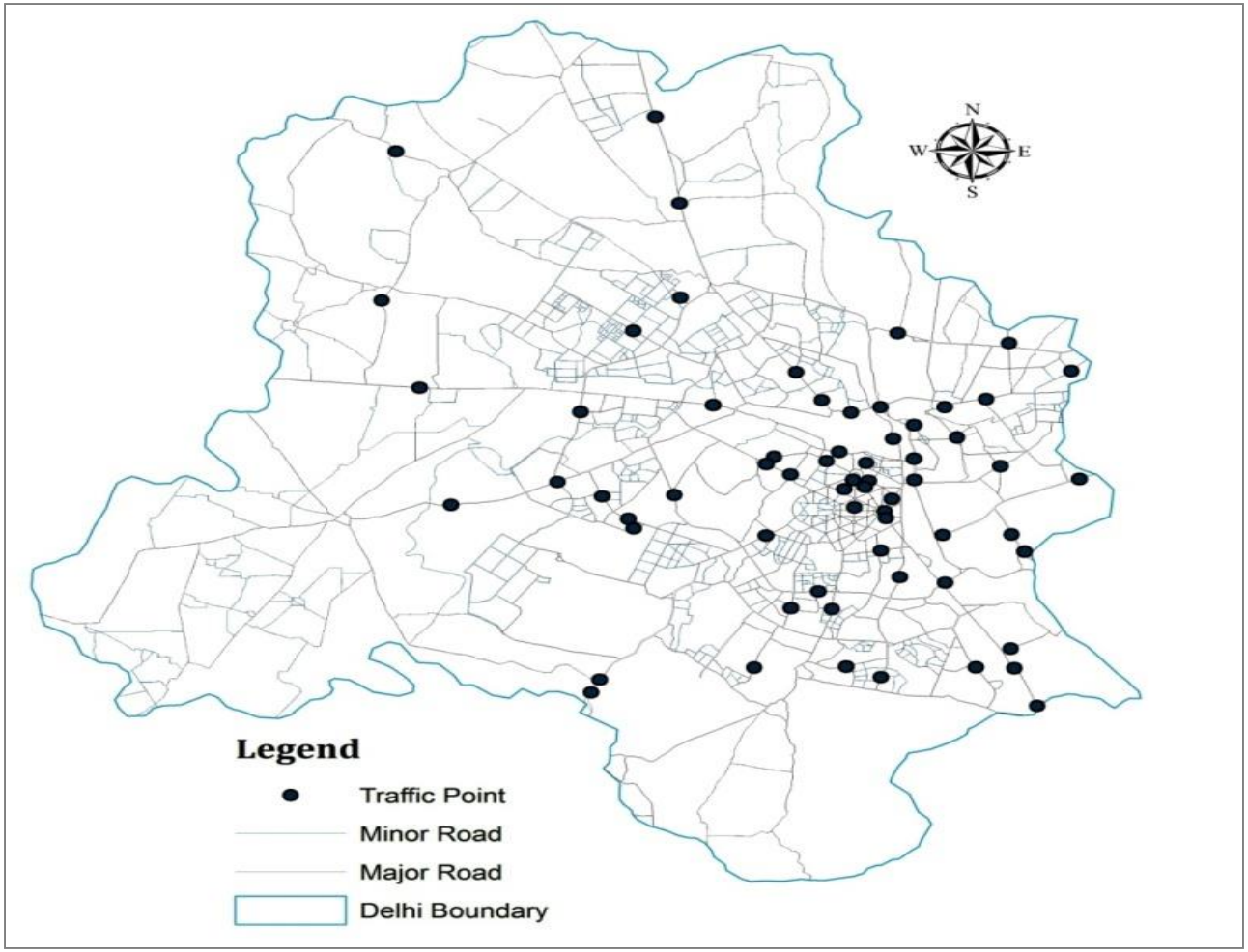
1. Apr 04 - 23, 2014
2. Apr 04 - 24, 2014
3. May 01 - 24, 2014
4. Apr 29 – May 19, 2014
5. May 26 - Jun 14, 2014
6. May 25 – Jun 16, 2014

Emission Inventory

Source Categories



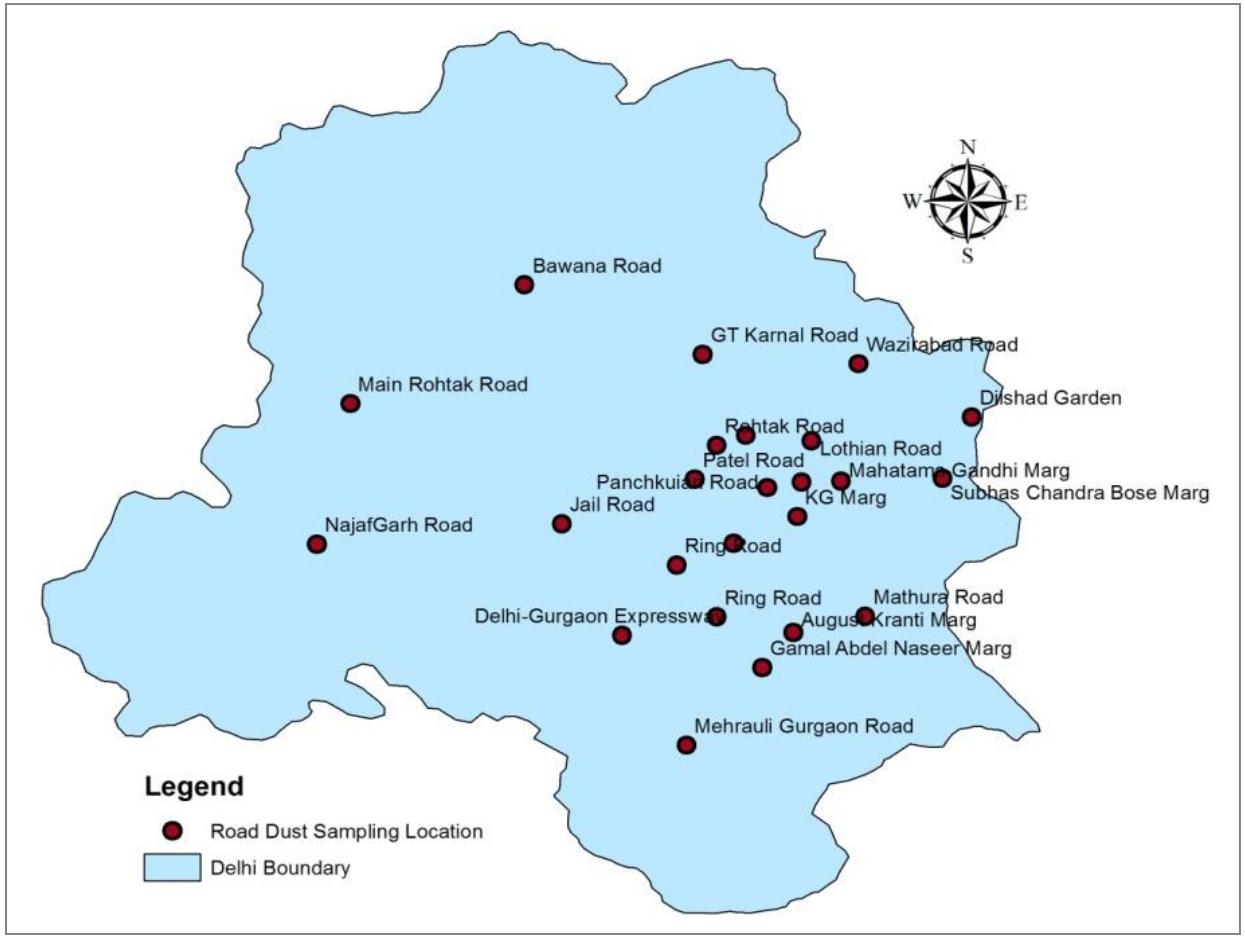
Vehicles - Line Source



- Traffic Data location for vehicle emission

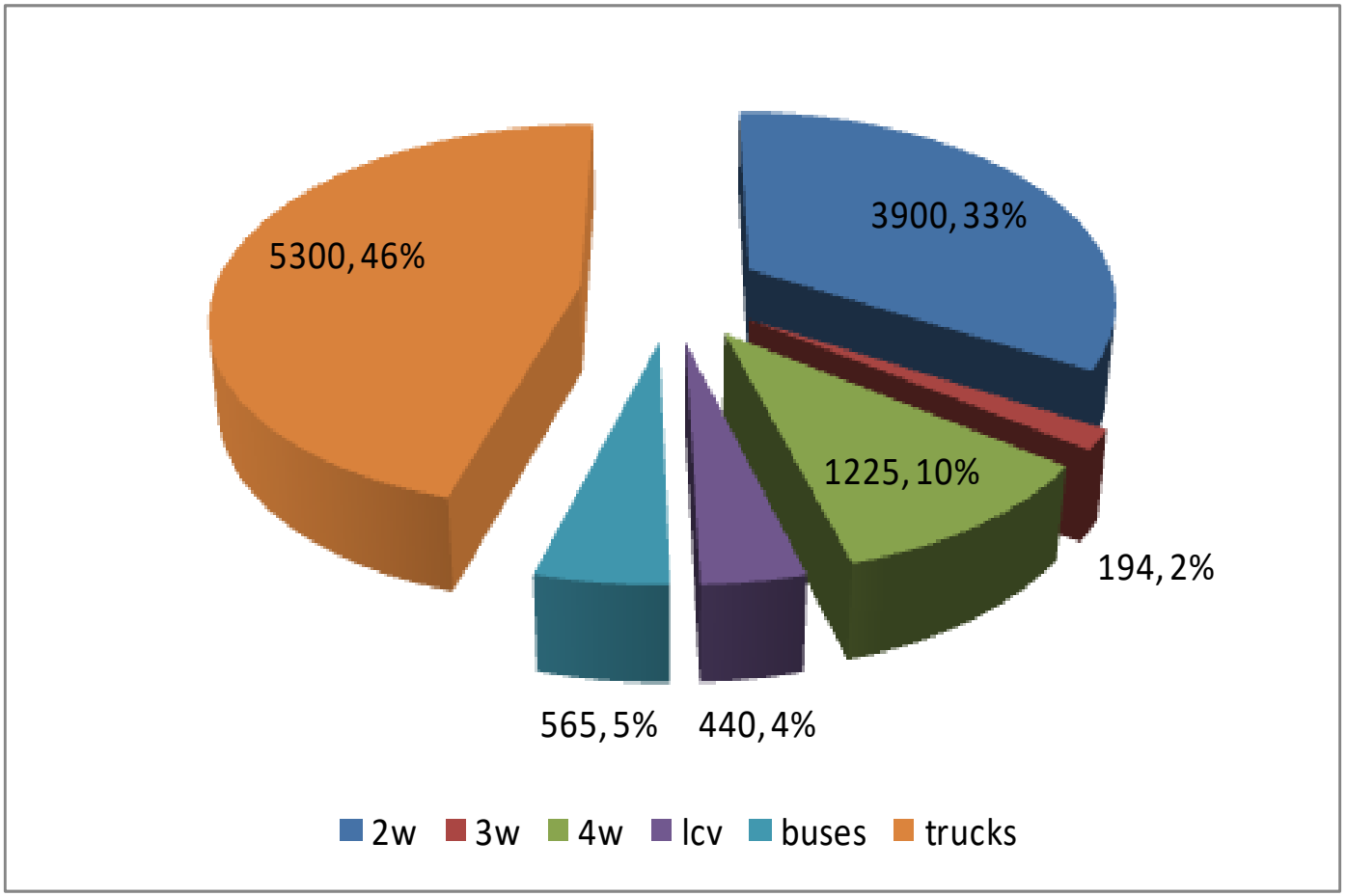
Road dust Sampling

Road Dust Sampling Locations



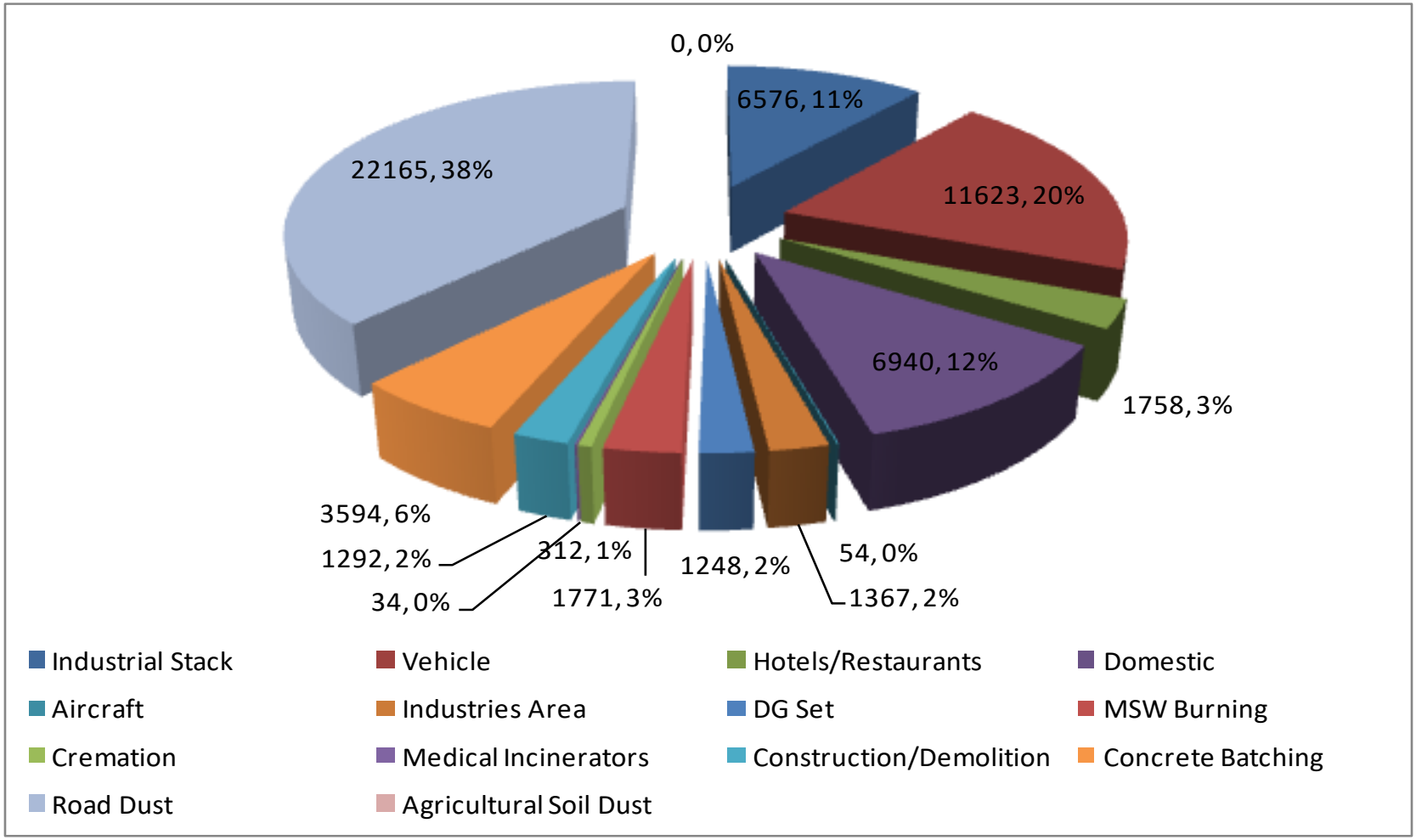
- PM_{10} emission from road dust: 79626 kg/day
- $PM_{2.5}$ emission from road dust: 22165 kg/day

$PM_{2.5}$ Emission Load from Vehicles (kg/day, %)



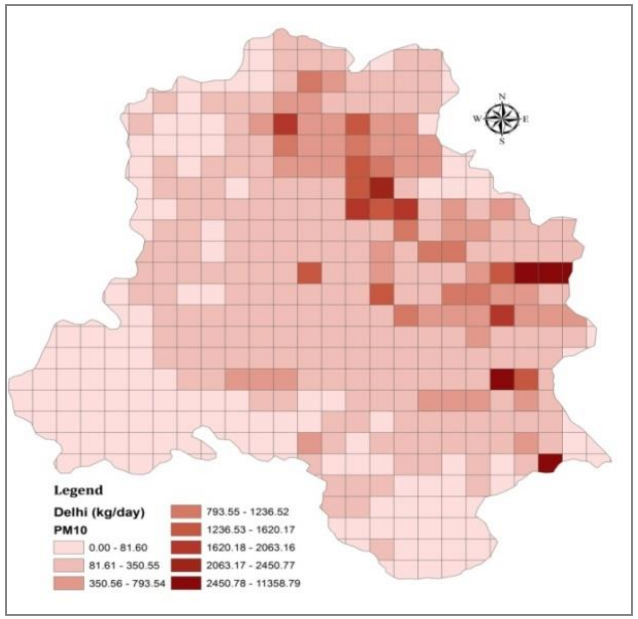
- 12000 kg/d
- Major Contributor : Trucks – 46% , 2W – 33%, 4W – 10%

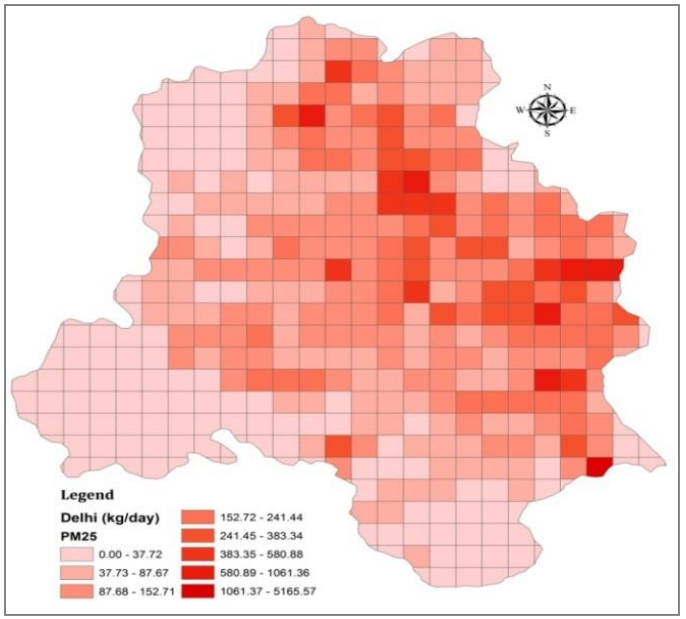
$PM_{2.5}$ Emission Load of Different Sources

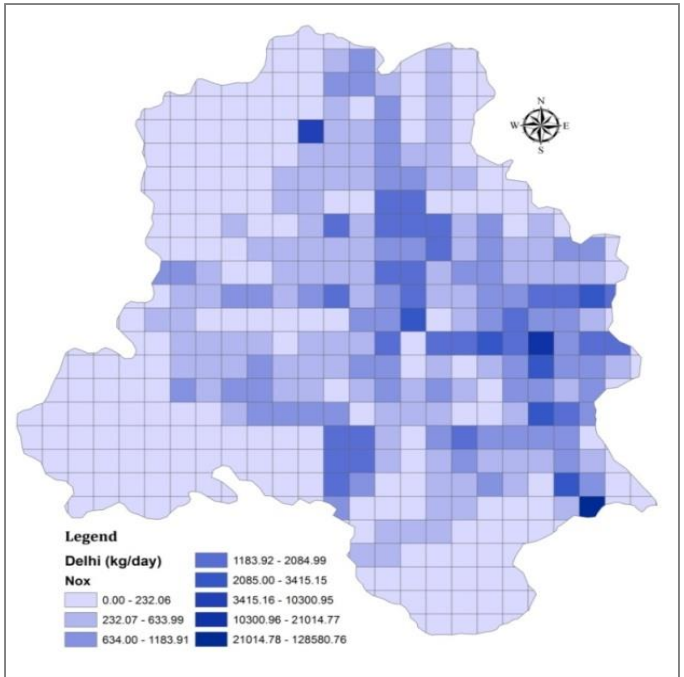


- $PM_{2.5}$ emission load: 59 t/d.
- Road dust (38 %), vehicles (20 %), domestic (12 %) and industrial point sources (11%).
- PM_{10} emission load: 143 t/d.
- Road dust (56%), concrete batching (10%), industrial point sources (10%) and vehicles (9%).

Spatial Distribution of PM_{10} , $PM_{2.5}$ and NO_X

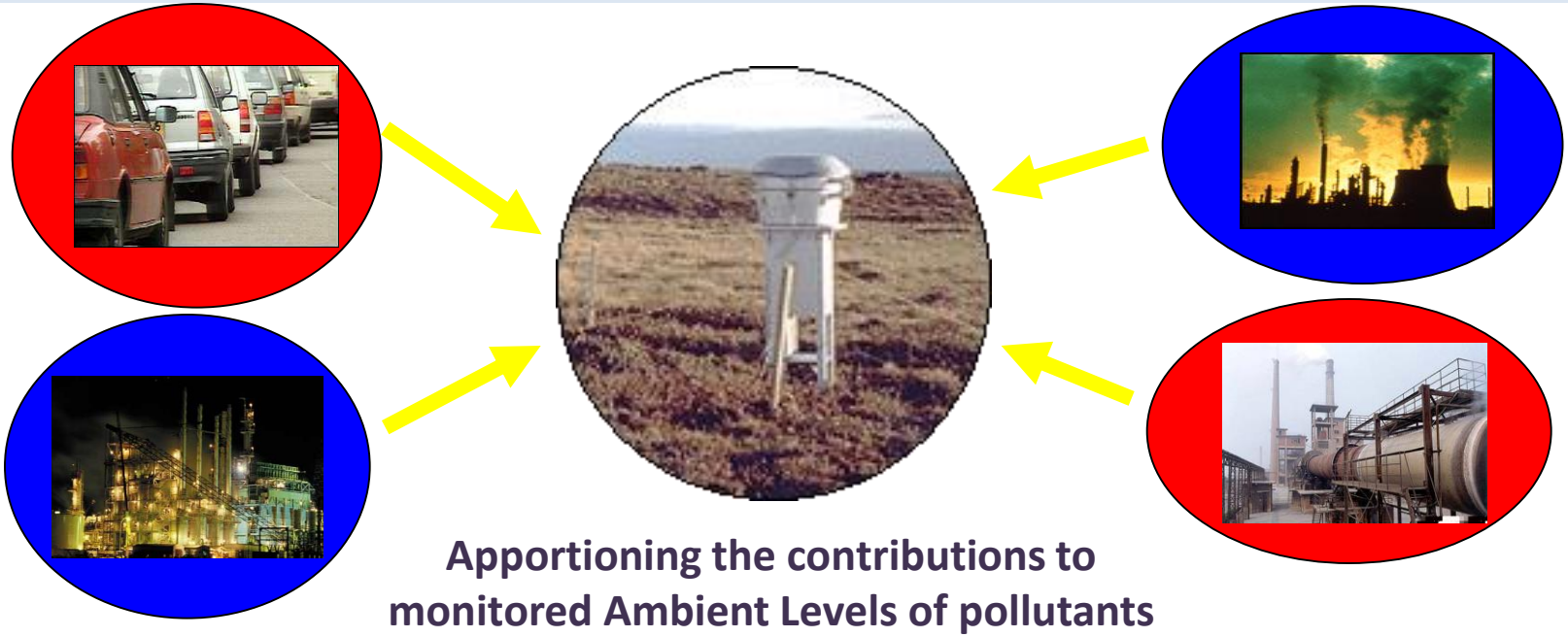






Source Apportionment: PM Composition and Receptor Modeling

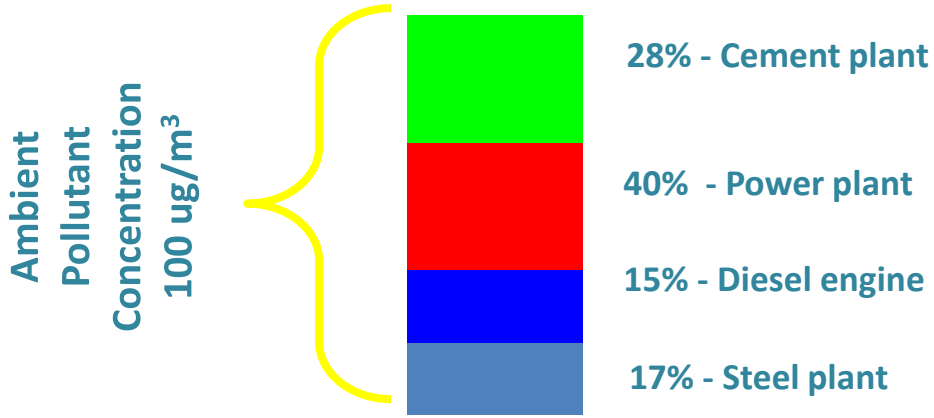
Receptor Modeling: Chemical mass balance (CMB)



Apportioning the contributions to monitored Ambient Levels of pollutants among various sources

Capabilities

Identification of pollutant contribution due to several sources (for example)



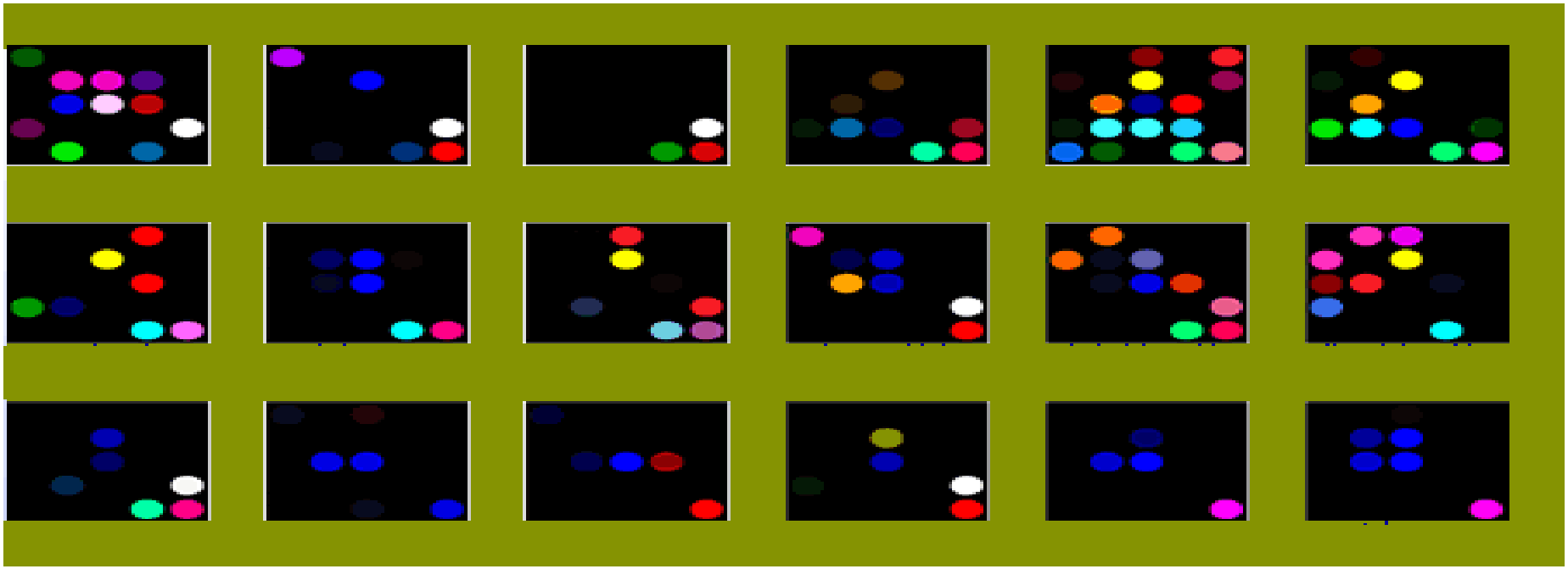
Back calculate impacts due to specific sources

Source Composition

Each source may possess unique

- **Chemical composition or**
- **Size distributed species**
- **Unique tracer compound**

Fingerprints



Basic Models

$$C_{ik} = \sum_{j=1}^{j} a_{ij} S_{jk} \quad for\ i = 1, n$$

C_{ik} = Concentration of component "i" in the "k" sample

a_{ij} = Fractional amount of component "i" in source "j"

S_{jk} = Total contribution from source "J"

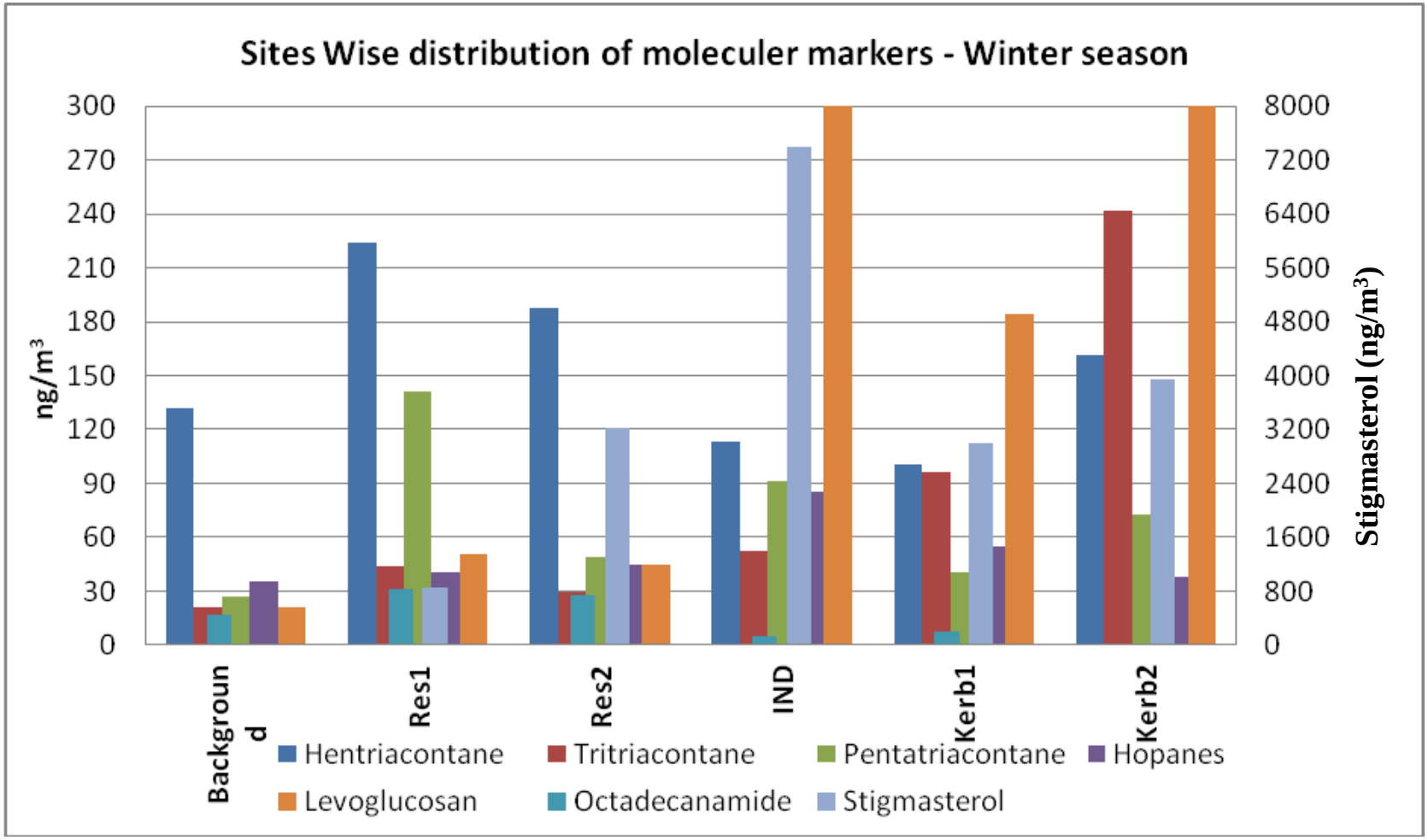
n = Total number of components measured

Solve simultaneous equation for S_{jk}

Assumptions:

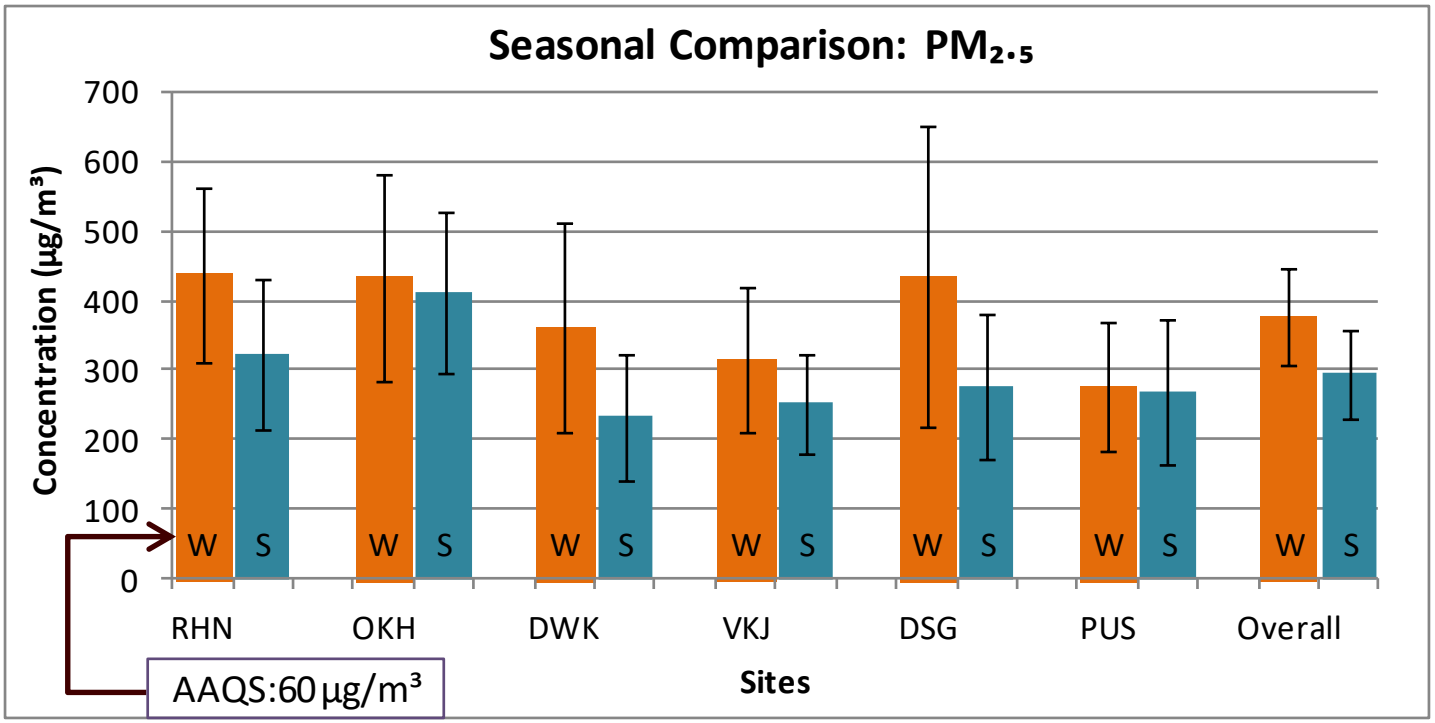
- **Number of sources "j" is less than or equal to number of components "I"**
- **The composition of all sources is linearly independent of each other**

Molecular Markers: Emission Source Indicator in Kanpur **(Sharma 2008)**



- **Stigmasterol – huge quantity, signifies biomass burning, major source of POC and thus SOA**

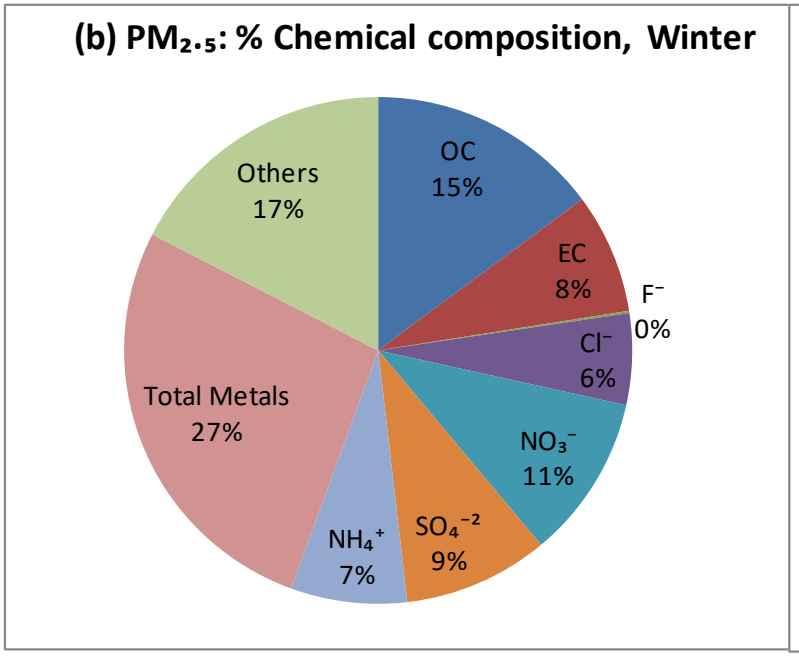
Variation in $PM_{2.5}$

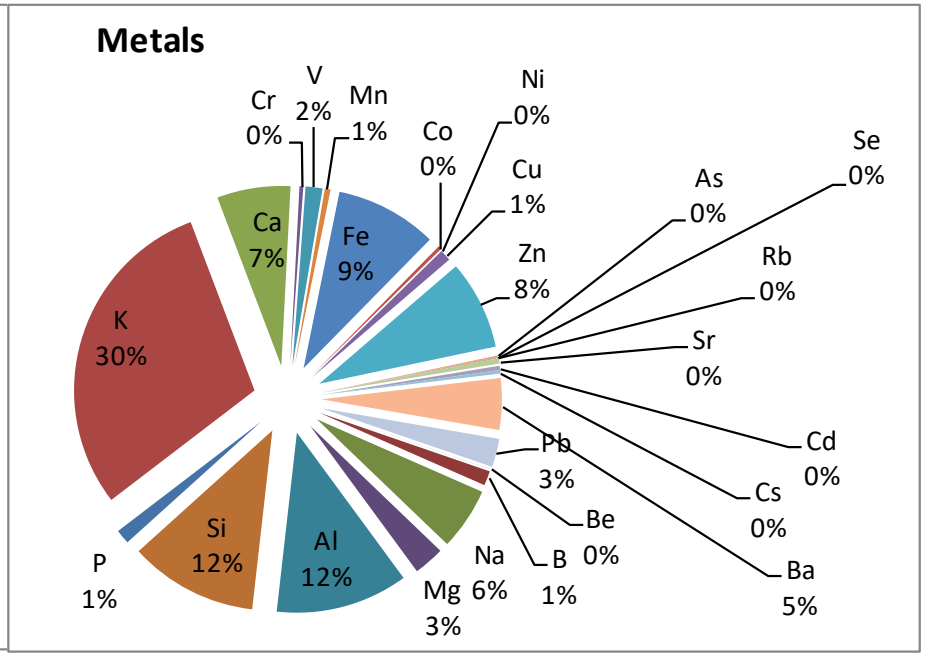


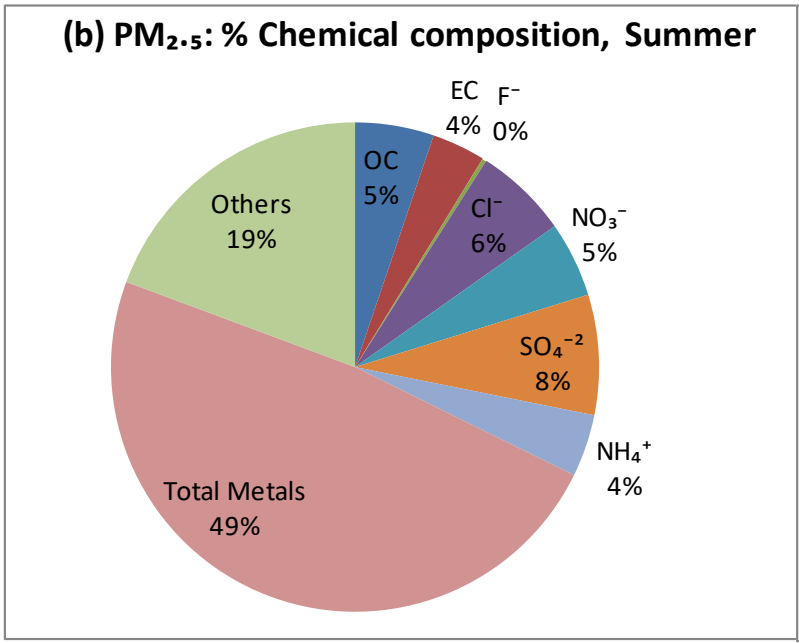
- $PM_{2.5}$ levels are 4-7 times higher than the national air quality standards in summer and winter months.
- The overall average concentration of $PM_{2.5}$ in summer season is around 300 µg/m³ against the acceptable level of 60 µg/m³.
- The overall average concentration of $PM_{2.5}$ in winter is 375 µg/m³ against the acceptable level of 60 µg/m³.

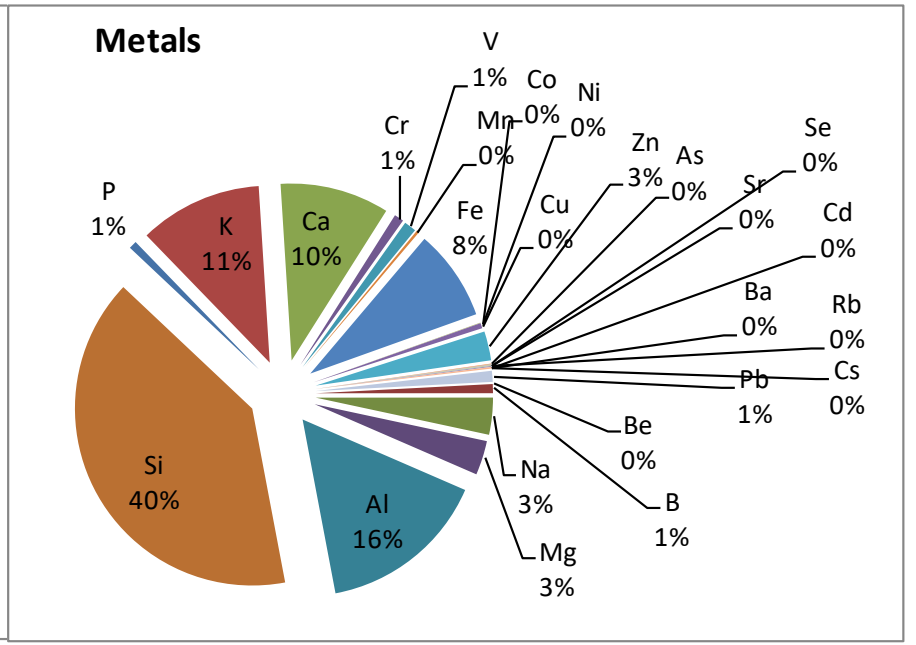
Ratio $PM_{2.5}/PM_{10}$: Winter - 0.63, Summer - 0.57

Overall Distribution of Species in $PM_{2.5}$

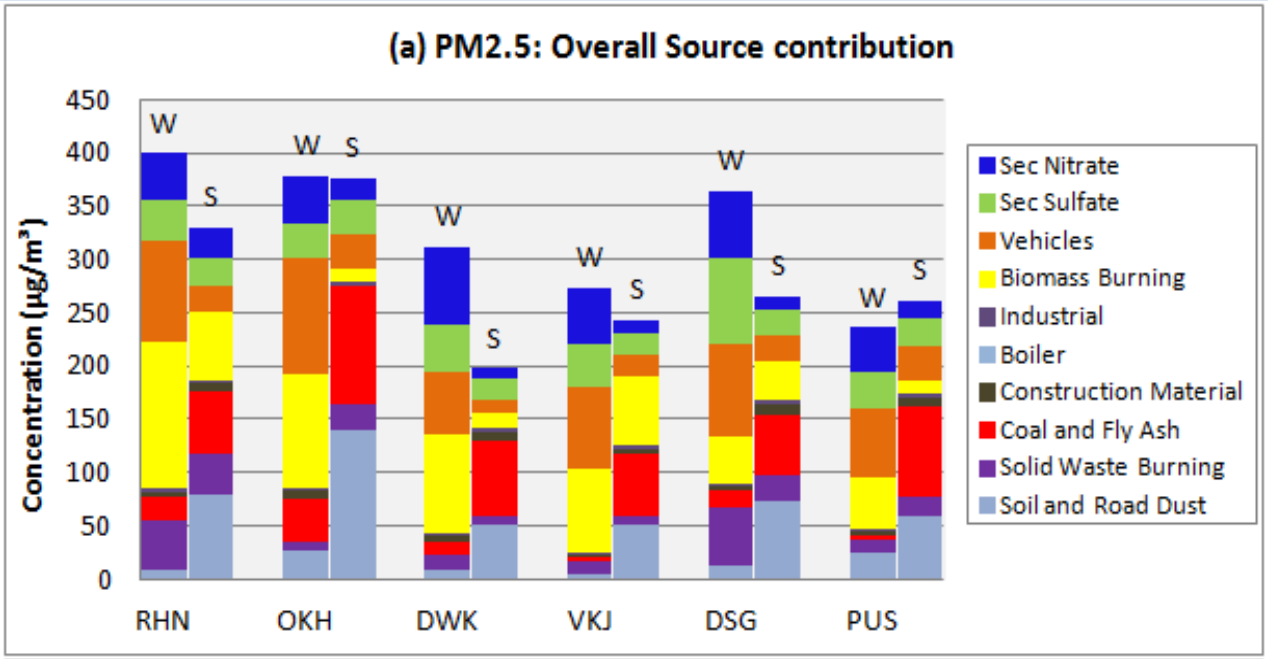


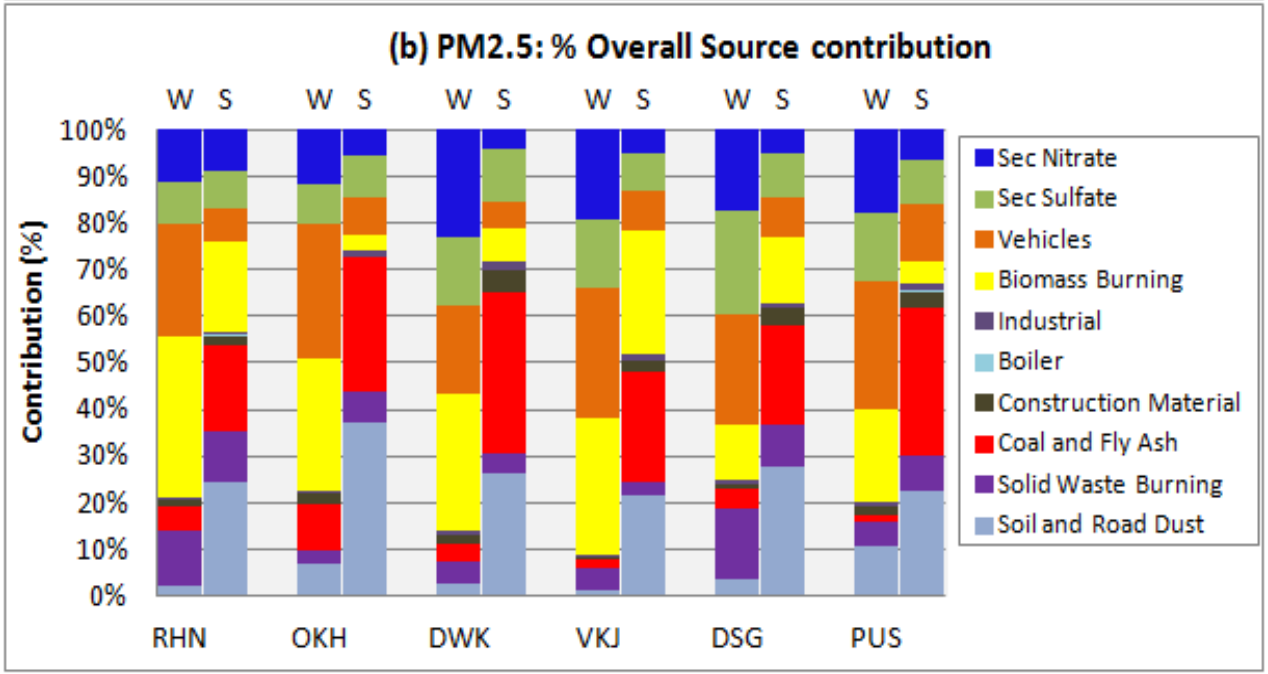




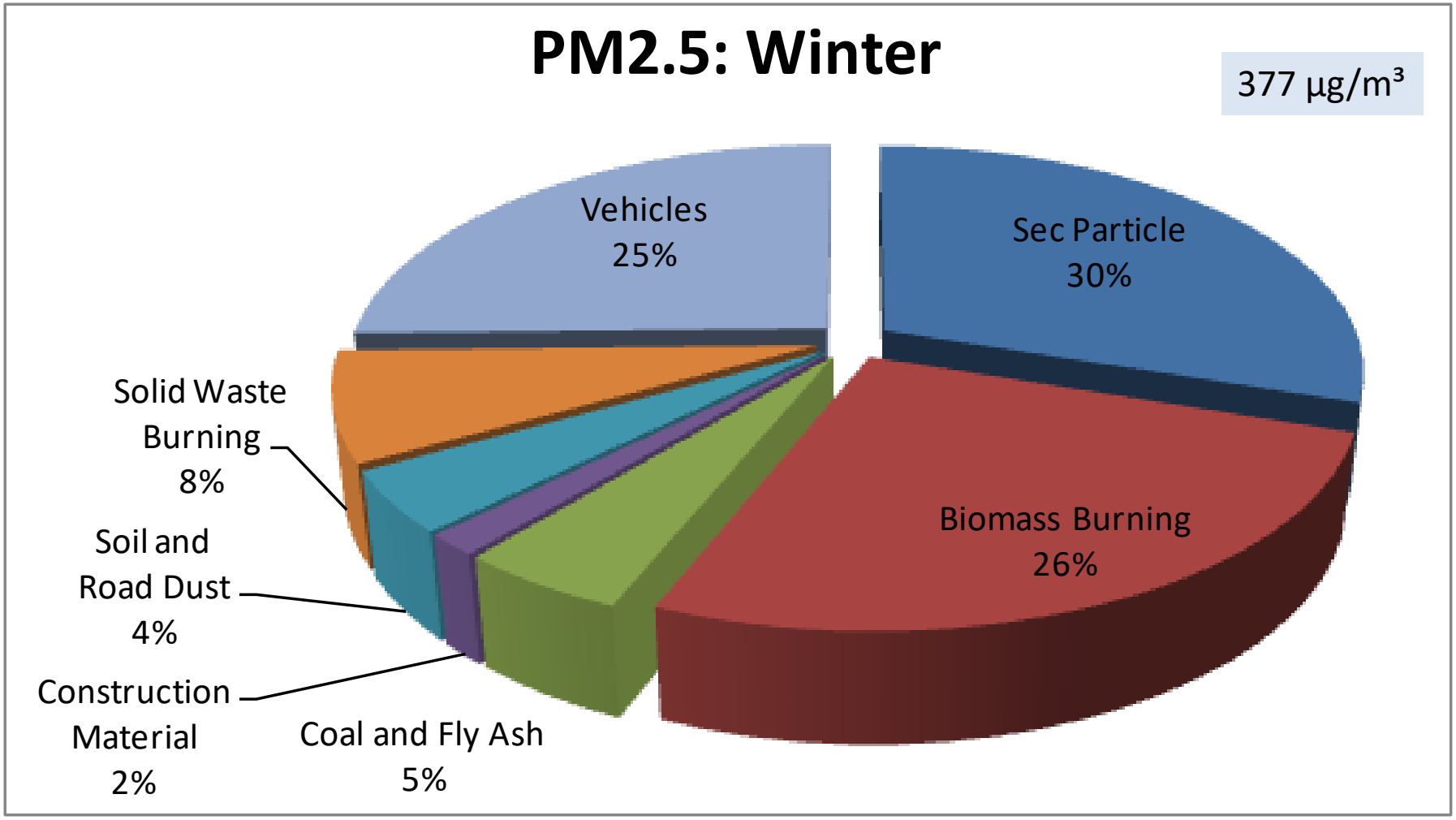


Overall CMB Modeling Results for $PM_{2.5}$





CMB: Overall Summary of Source contribution in Delhi



- **Winter sources % contribution**: **Secondary particles** (30%), **vehicles** (25%), **biomass burning** (26%), **MSW burning** (8%)
- **Secondary nitrate particles of vehicles origin** contribute to **3%** of total $PM_{2.5}$
- **Total Average vehicle contribution** to $PM_{2.5}$ at about **28%**

Analytical Instruments

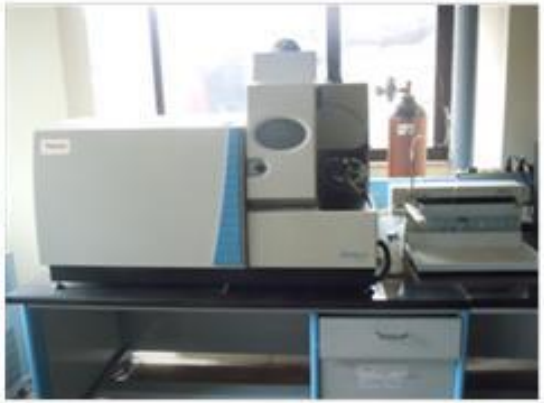
(a) 4-Channel Speciation Sampler

(b) Microbalance

(c) OC/EC Analyzer

(d) GC-MS with ATD

(e) Ion Chromatography



(f) ICP-MS

Control Options and Action Plan

Recommended Control Options

A. Immediate Actions

Source	Option No.	Description Option
Hotels/ Restaurants	1	Stop use of Coal
Domestic Cooking	2	LPG to all
MSW Burning	3	Stop MSW burning: Improve collection and disposal (landfill and waste to energy plants)
Construction and Demolition	4	Vertically cover the construction area with fine screens
		Handling and Storage of Raw Material: completely cover the material
		Water spray and wind breaker
		Store the waste inside premises with proper cover
		Movement of Vehicles : paved paths/roads
Concrete Batching	5	Water Spray
		Wind Breaker
		Bag Filter at Silos
		Enclosures, Hoods, Curtains, Telescopic Chutes, Cover Transfer Points and Conveyer Belts
Road Dust and Soil dust	6.1	Vacuum Sweeping of major roads (Four Times a Month)
		Carpeting of shoulders, maintenance of road ,dividers and kerbs
		Mechanical sweeping with water wash
	6.2	plant small shrubs, perennial forages, grass covers in open areas

Recommended Control Options

B. Time-bound Actions

Source	Option No.	Description Option
Vehicles	7.1	Electric/Hybrid Vehicles: 2% of 2-Ws, 10% of 3-Ws and 2% 4Ws wef July 2017: New residential and commercial buildings to have charging facilities
	7.2	Retrofitment of Diesel Particulate Filter: wef July 2018
	7.3	Implementation of BS – VI for all diesel vehicles including heavy duty vehicles (non-CNG buses and trucks) and LCVs (non-CNG): wef January 2019
	7.4	Inspection/ Maintenance of Vehicles
	7.5	Ultra Low Sulphur Fuel (<10 PPM); BS-VI compliant: wef January 2018
	7.6	2-Ws with Multi Point Fuel Injection (MPFI) system or equivalent: wef January 2019
Industry and DG Sets	8.1	Reduce sulphur content in Industrial Fuel (LDO, HSD) to less than 500 PPM
	8.2	Minimize uses, uninterrupted power supply, Banning 2-KVA or smaller DG sets
Secondary Particles	9.1	De-SOx-ing at Power Plants within 300 km of Delhi
	9.2	De-NOx-ing at Power Plants within 300 km of Delhi
Secondary Organic Aerosols	10	Controlling Evaporative emissions: Vapour Recovery System at petrol pumps (Fuel unloading and dispensing)
Biomass Burning	11	Managing crop residue burning in Haryana, Punjab and other local biomass burning, Potential alternatives: energy production, biogas generation, commercial feedstock for cattle, composting, conversion in biochar, Raw material for industry: wef July 2016

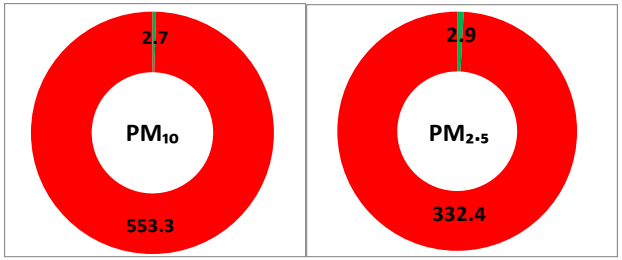
Similar action plan should be implemented in NCR

1. Hotels and Restaurants

- Stop use of Coal

Parameter	Existing (kg/day)	Controlled (kg/day)	Mean Modeled Concentration ($\mu g/m^3$)		
			Existing	Controlled	% Reduction in AP Level
PM_{10}	3493	1350	4	1.3	67.5
$PM_{2.5}$	1758	675	3.6	0.7	80.56

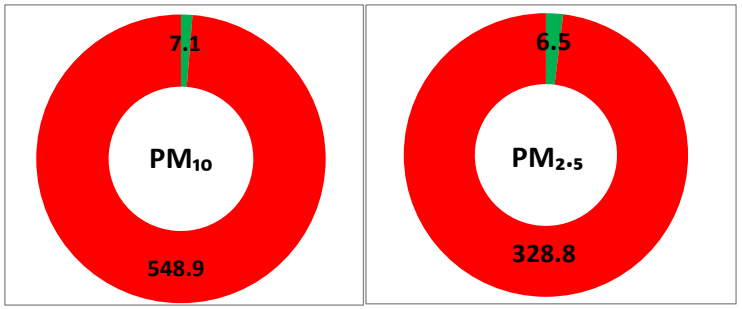
- 9000 Hotels/Restaurants uses coal (mostly in tandoors)
- Restaurants of sitting capacity more than 10 should not use coal and shift to electric or gas-based appliances



2. Domestic Sector

- LPG should be made available to remaining 10% households to make the city 100% LPG-fueled.

Parameter	Existing (kg/day)	Controlled (kg/day)	Mean Modeled Concentration (µg/m^3)		
			Existing	Controlled	% Reduction in AP Level
PM_{10}	7381	4111	8.0	3.6	55.0
$PM_{2.5}$	6940	4111	7.2	3.6	50.0

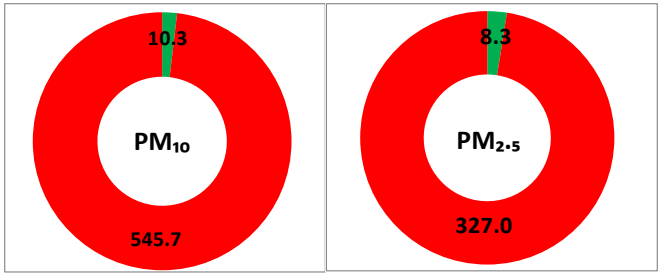


3. Municipal Solid Waste (MSW) Burning

- Stop MSW burning

Parameter	Existing (kg/day)	Controlled (kg/day)	Mean Modeled Concentration (µg/m^3)		
			Existing	Controlled	% Reduction in AP Level
PM_{10}	1968	0	3.2	0.0	100.0
$PM_{2.5}$	1771	0	1.8	0.0	100.0

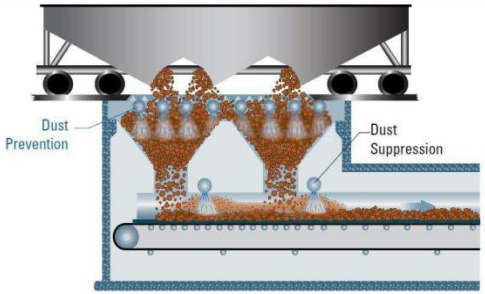
MSW burning of 190-246 tons/day (~2–3% of MSW generated; 8390 tons/day) (Nagpure et al., 2015)



4. Construction and Demolition

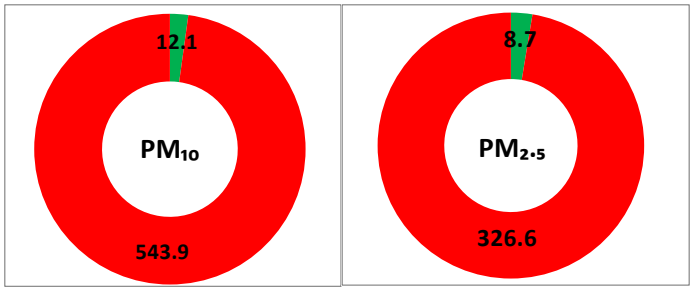
- Wet suppression
- wind speed reduction
- Actual construction area is covered by fine screen
- Proper handling and storage of raw material
- No storage (no matter how small) of construction material near road side (up to 10 m from the edge of road)
- Regulations must be brought in for construction/demolition

Parameter	Existing (kg/day)	Controlled (kg/day)	Mean Modeled Concentration (µg/m^3)		
			Existing	Controlled	% Reduction in AP Level
PM_{10}	5167	2584	3.4	1.6	52.0
$PM_{2.5}$	1292	646	0.8	0.4	50.0



Suppression System

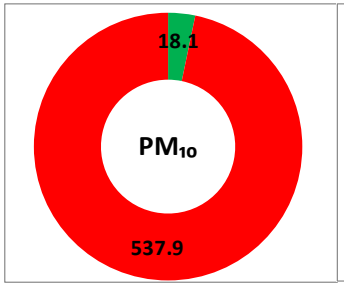
Windscreen for dust control

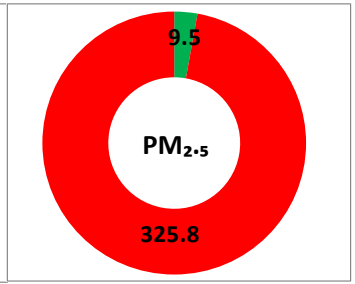


5. Ready Mix Concrete Batching

- Wet suppression
- wind speed reduction
- The transfer of cement and pozzalan material to silos is one of the major emission sources in the plant, and installation of fabric filter should be compulsory
- Proper handling and storage of raw material
- No storage (no matter how small) of construction material near road side (up to 10m from the edge of road)
- Regulations must be brought in for concrete batching

Parameter	Existing (kg/day)	Controlled (kg/day)	Mean Modeled Concentration (µg/m^3)		
			Existing	Controlled	% Reduction in AP Level
PM_{10}	14370	516	8.0	2.0	75.0
$PM_{2.5}$	1292	646	0.8	0.4	40.0

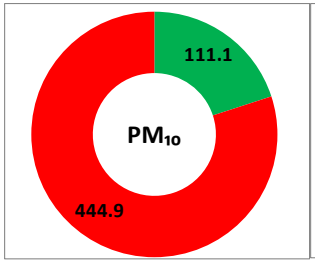


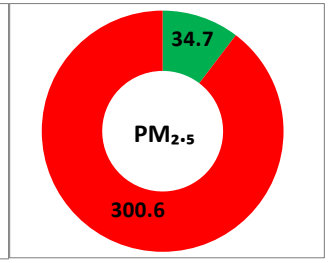


6. Road Dust

- **Vacuum Sweeping of major roads (Four Times a Month)**
- Roads are maintained properly
- Watering of roads
- paved wall to wall
- open fields should be kept slightly wet and small shrubs are planted to prevent drift of dust in summer
- No storage and disposal of material (construction, ash, etc) near road side (up to 10 m from the edge of road).

Parameter	Existing (kg/day)	Controlled (kg/day)	Mean Modeled Concentration (µg/m^3)		
			Existing	Controlled	% Reduction in AP Level
PM_{10}	79626	23887	131.0	38.0	71.0
$PM_{2.5}$	22165	6649	36.0	10.8	70.0

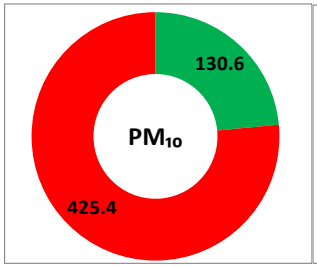


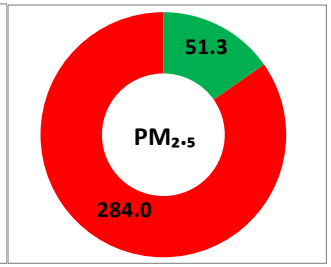


7. Vehicles

- Electric/Hybrid Vehicles: 2% of 2-Ws, 10% of 3-Ws And 2% 4Ws wef January 2017
- Retro Fitment of Diesel Particulate Filter: wef July 2016
- Implementation of BS – VI : wef January 2019*
- Inspection/ Maintenance of Vehicles
- Ultra Low Sulphur Fuel (<10 PPM): wef January 2018

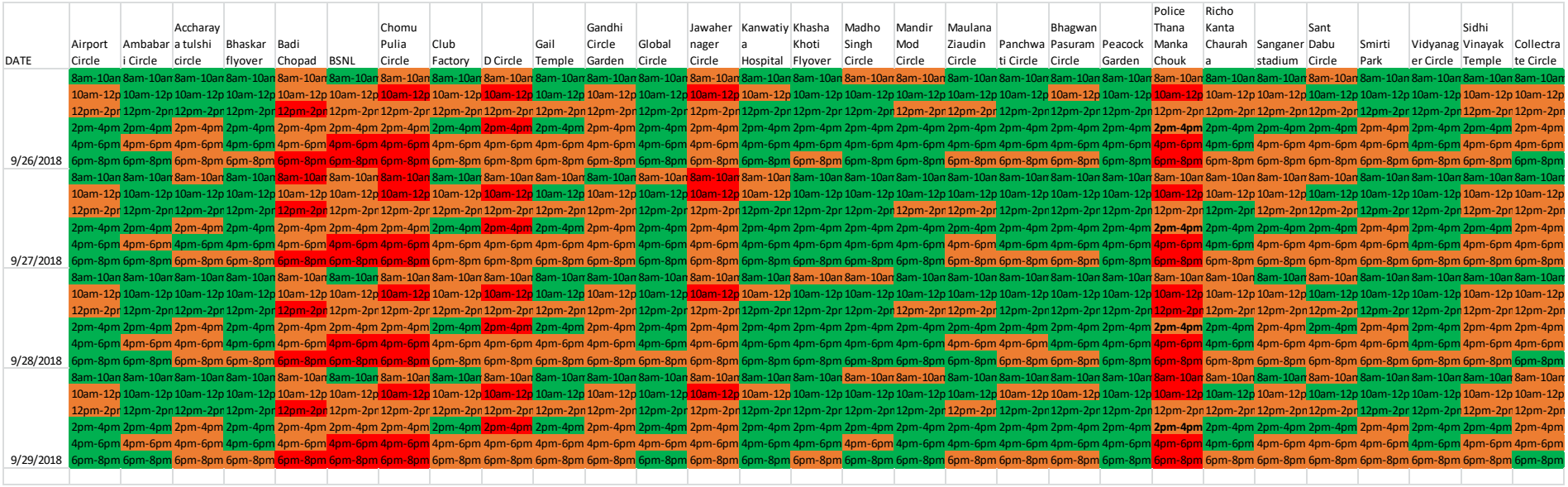
Parameter	Existing (kg/day)	Controlled (kg/day)	Mean Modeled Concentration ($\mu g/m^3$)		
			Existing	Controlled	% Reduction in AP Level
PM_{10}	12914	6453	38.0	18.5	51.3
$PM_{2.5}$	11623	5807	33.2	16.6	50.0





- **Introduction of Electric/Hybrid Vehicles**:
  - Introduction of electrical and hybrid vehicles by January 2017, 2% of 2-Ws, 10% of 3-Ws and 2% 4Ws will be electric/hybrid vehicles. There will be reduction of 2.3% in PM10 and PM2.5 emissions
  - If we assume additional multiplier of 1.5 to electrical and hybrid vehicles by January 2017, there will be reduction of 4-5% of PM10 and PM2.5 emissions. Net improvement in air quality concentration by about 1-2 µg/m3.
- **Retro-fitment of Diesel Particulate Filter (DPF):**
  - Diesel Vehicles (entering and running on Delhi roads) should be equipped with DPF .
  - Reduction of 40% emission in PM may be achieved. This reduction in emission will reduce the ambient air concentration by 10 µg/m3.

Traffic congestion



Total Location examined: 29

Highly congested locations

- Badi Chopad and Manak Chowk
- BSNL Circle
- Chomu Pulia
- D Circle/sindhi camp/ stn road
- Jawahar Nagar Circle

congested locations

- Collectorate Circle
- Sant Dabu circle
- Sanganer stadium circle
- RICCO Kanta chauraha, Mansarover
- Gandhi Circle

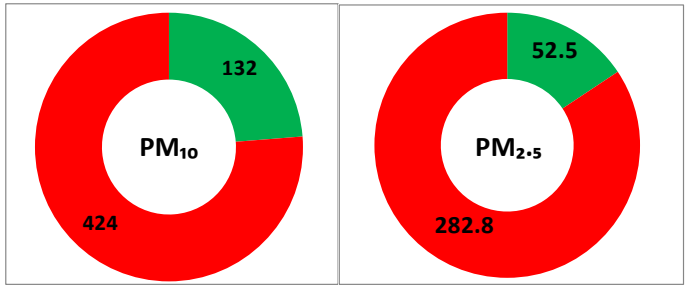
- **Implementation of BS – VI : wef January 2019**
  - Both PM and NOx emissions are expected to reduce
  - Expected reduction in ambient air concentration is 2.4 µg/m3 for the introduction year (2019)
  - The reduction in NOx emission will help in reducing secondary nitrates and will also prevent formation of ozone
- **Inspection/ Maintenance of Vehicles**
  - Ensure that vehicles are properly maintained as per the recommendation of the manufacturer
  - The automobiles manufacturing company owned service centers (AMCOSC) should be fully equipped for complete inspection and maintenance of vehicles ensuring vehicles conforming to emission norms and fuel economy after servicing
- **Ultra Low Sulphur Fuel (<10 PPM): wef January 2018**
  - Sulphur content in diesel should be brought down to 10 ppm or less by end of 2017
  - Reduce PM emissions from vehicles by about 6 percent

8. Industries and Diesel Generator Sets

- Reduce sulphur content in Industrial Fuel (LDO, HSD) to less than 500 PPM

Parameter	Existing (kg/day)	Controlled (kg/day)	Mean Modeled Concentration ($\mu g/m^3$)		
			Existing	Controlled	% Reduction in AP Level
PM_{10}	1937	1355	4.7	3.3	30
$PM_{2.5}$	1743	1220	3.9	2.8	30

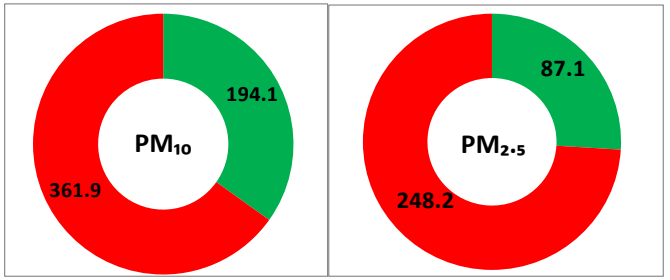
- Sulphur Content (Present Day)
  - LDO = 18000 ppm ; HSD = 10000 ppm
- Expected PM control would be about 15 to 30 %.
- DG sets of size 2 KVA or less should not be allowed to operate



9. Secondary Particles: Control of SO_2 and NO_x from Large sources

- De-SOx-ing at Power Plants Within 300 Km of Delhi
- De-NOx-ing at Power Plants Within 300 Km of Delhi

Parameter	Controlled (kg/day)	Mean Modeled Concentration (µg/m^3)		
		Existing	Controlled	% Reduction in AP Level
PM_{10}	132437 (SO2 emissions)	69.0	6.9	90
$PM_{2.5}$		38.5	3.9	90
PM_{10}	153349 (NOx emissions)	41.0	4.1	90
$PM_{2.5}$		25.2	2.5	90

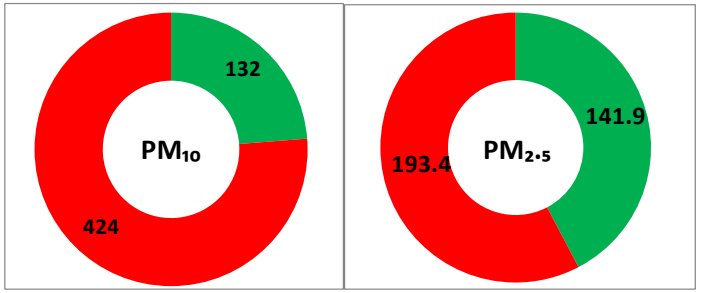


10. Secondary Organic Aerosols

- Controlling Evaporative Loss during fuel unloading and Re-Fueling through Vapour Recovery System at petrol pumps

Parameter	Mean Modeled Concentration ($\mu g/m^3$)		
	Existing	Controlled	% Reduction in AP Level
PM_{10}	48.9	9.7	80.2
$PM_{2.5}$	40.1	8.0	90.0

- The evaporative losses from solvent industries should also be minimized.

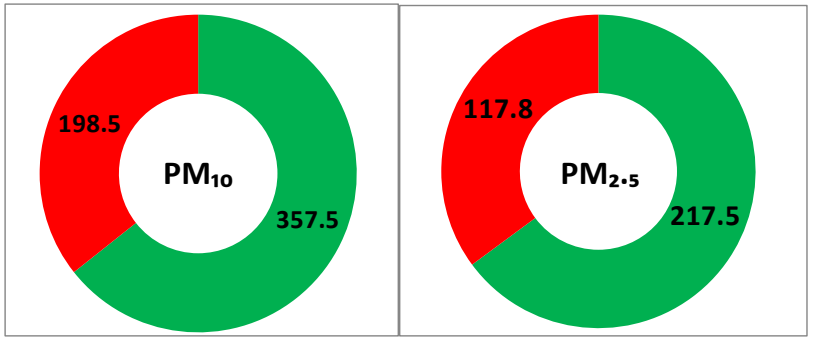


11. Biomass Burning

- Managing crop residue burning in Haryana, Punjab and other local biomass burning.

Parameter	Mean Modeled Concentration ($\mu g/m^3$)		
	Existing	Controlled	% Reduction in AP Level
PM_{10}	97.0	9.7	90
$PM_{2.5}$	84.0	8.4	90

- Biomass contribution in PM_{10} in the month of November could be as high as 140 $\mu g/m^3$ and about 120 $\mu g/m^3$ for $PM_{2.5}$ (mean of contribution in entire winter season: 97 $\mu g/m^3$ and 86 $\mu g/m^3$) respectively.
- In all likelihood, the PM from biomass burning is contributed from CRB prevalent in Punjab and Haryana in winter.

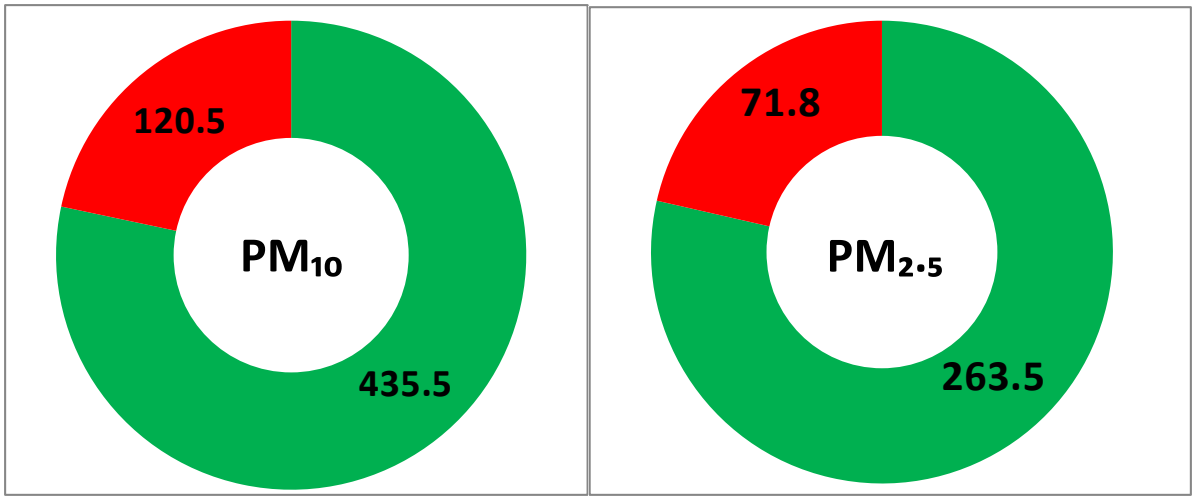


12. Fly Ash

- Control at other sources (hotels/restaurants and rapid mix plants, fly ash ponds etc)
- Install Wind Breaker at construction and fly ash pond sites.
- Keep fly ash pond moist and possibly maintained about 1mm of water layer over the entire fly ash pond

13. Control outside Delhi in NCR

- Control option should be implemented in NCR in similar manner as in Delhi



Control Options, Emission Load and Reductions in NOx

Source	Option No.	Description Option	Existing NO_2 (kg/day)	Controlled NO_2 (kg/day)	% Reduction in AP Level
Hotels/Restaurants	1	Prohibit use of Coal	1103.0	502.5	54.4
Domestic Cooking	2	LPG to all	7682.0	7047.5	8.3
MSW Burning	3	Prohibit MSW burning	738.0	0.0	100.0
Vehicles	4.1	Electric/Hybrid Vehicles: 2% of 2-Ws, 10% of 3-Ws And 2% 4Ws Wef January 2017	113443.0	111264.0	1.9
	4.2	Implementation of BS – VI : Wef January 2019	119607.0	116558.3	2.5
	4.3	Inspection/ Maintenance of Vehicles	-	-	-
	4.4	Ultra Low Sulphur Fuel (<10 PPM): January 2018	-	-	-
Power Plants	5.1	De-NOx-ing at Power Plants Within Delhi	161612.0	32322.4	80.0
Total			**--**	**--**	**34**

Action Plan for NCT of Delhi

A. Immediate Actions

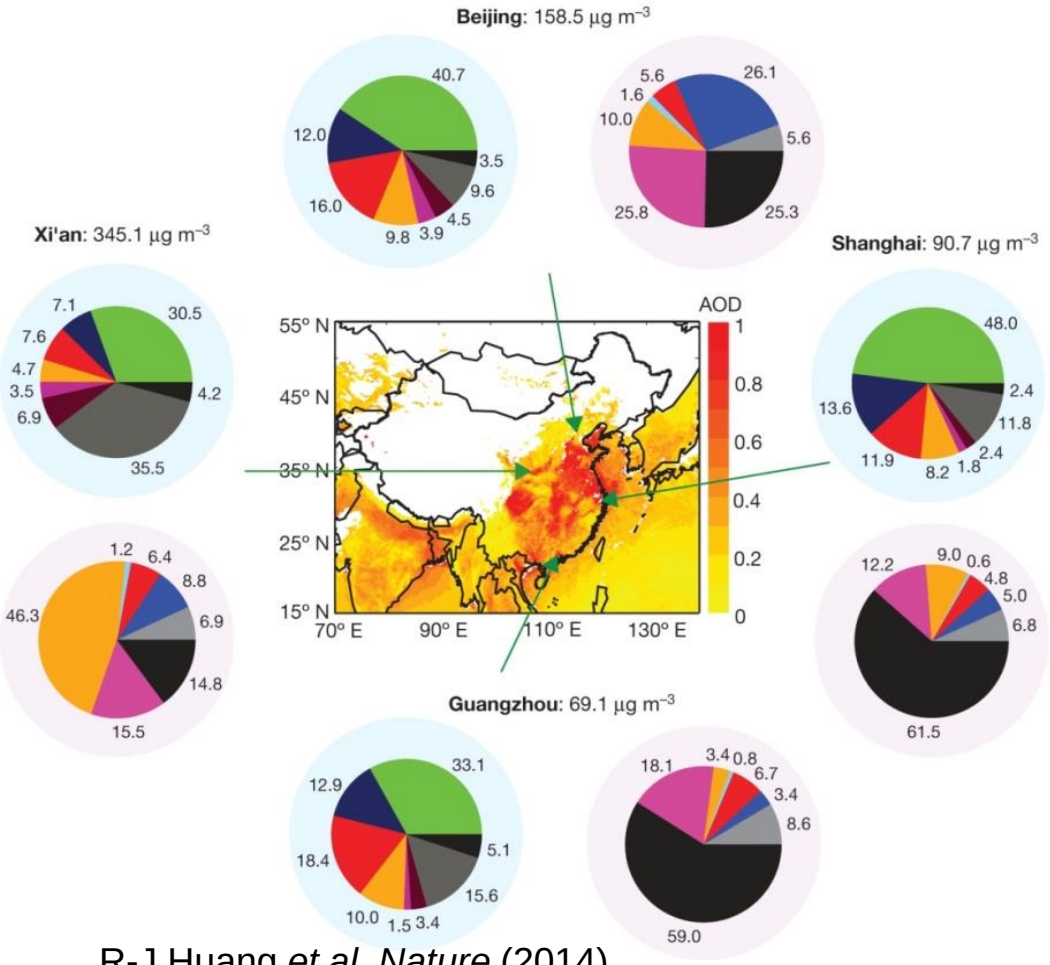
Source	Option No.	Description Option	2016	2017	2018	2019	2020-2023	Percent improvement in AQ
Hotels/ Restaurants	1	Stop use of Coal						80.56
Domestic Cooking	2	LPG to all						50.00
MSW Burning	3	Stop MSW burning: Improve collection and disposal (landfill and waste to energy plants)						100.00
Construction and Demolition	4	Vertically cover the construction area with fine screens						50.00
		Handling and Storage of Raw Material: completely cover the material						
		Water spray and wind breaker						
		Store the waste inside premises with proper cover						
Concrete Batching	5	Water Spray						40.00
		Wind Breaker						
		Bag Filter at Silos						
		Enclosures, Hoods, Curtains, Telescopic Chutes, Cover Transfer Points and Conveyer Belts						
Road Dust and Soil dust	6.1	Vacuum Sweeping of major roads (Four Times a Month)						70.00
		Carpeting of shoulders						
		Mechanical sweeping with water wash						
	6.2	plant small shrubs, perennial forages, grass covers in open areas						--
Note: for implementation year 2016 may begin from July 2016								

Action Plan for NCT of Delhi

B. Time-bound Actions

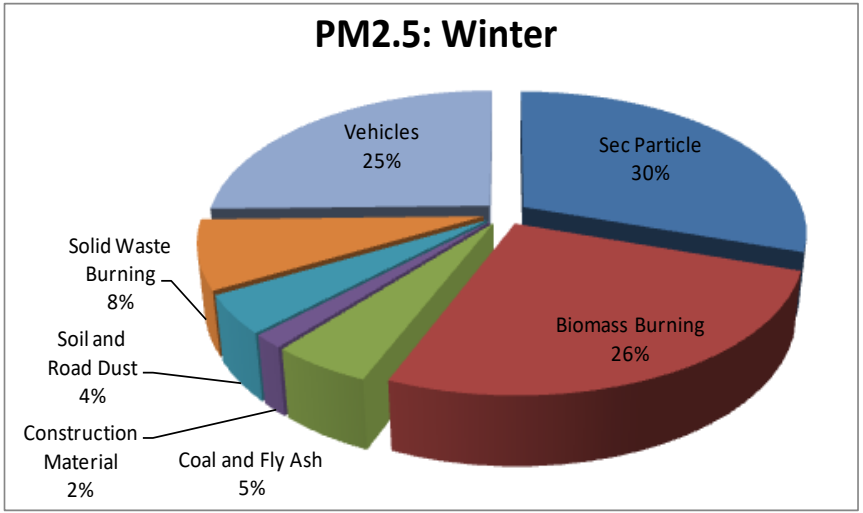
Source	Option No.	Description Option	2016	2017	2018	2019	2020-2023	Percent improvement in AQ
Vehicles	7.1	Electric/Hybrid Vehicles: 2% of 2-Ws, 10% of 3-Ws and 2% 4Ws wef July 2017: New residential and commercial buildings to have charging facilities						50.0
	7.2	Retrofitment of Diesel Particulate Filter: wef July 2018						
	7.3	Implementation of BS – VI for all diesel vehicles including heavy duty vehicles (non-CNG buses and trucks) and LCVs (non-CNG): wef January 2019						
	7.4	Inspection/ Maintenance of Vehicles						
	7.5	Ultra Low Sulphur Fuel (<10 PPM); BS-VI compliant: wef January 2018						
	7.6	2-Ws with Multi Point Fuel Injection (MPFI) system or equivalent: wef January 2019						
Industry and DG Sets	8.1	Reduce sulphur content in Industrial Fuel (LDO, HSD) to less than 500 PPM						30.00
	8.2	Minimize uses, uninterrupted power supply, Banning 2-KVA or smaller DG sets						--
Secondary Particles	9.1	De-SOx-ing at Power Plants within 300 km of Delhi						90.0
	9.2	De-NOx-ing at Power Plants within 300 km of Delhi						90.1
Secondary Organic Aerosols	10	Controlling Evaporative emissions: Vapour Recovery System at petrol pumps (Fuel unloading and dispensing)						80.0
Biomass Burning	11	Managing crop residue burning in Haryana, Punjab and other local biomass burning, Potential alternatives: energy production, biogas generation, commercial feedstock for cattle, composting, conversion in biochar, Raw material for industry: wef July 2016						90.0
Fly Ash	12	Wind Breaker, Water Spraying, plantation, reclamation						--
Note: for implementation year 2016 may begin from July 2016								

Comparison: Delhi Vs Beijing, Shanghai, Xi'am, Guangzhou



R-J Huang *et al. Nature* (2014)

"In response to the severe haze events of 2013, the Chinese State Council quickly released the 'Atmospheric Pollution Prevention and Control Action Plan' on 10 September 2013 which aims to reduce PM2.5 by up to 25% by 2017 relative to 2012 levels, and is backed by US $277 billion in investments from the central Government."



Comprehensive Study on Air Pollution and Green House Gases (GHGs) in Delhi

(Final Report: Air Pollution component)

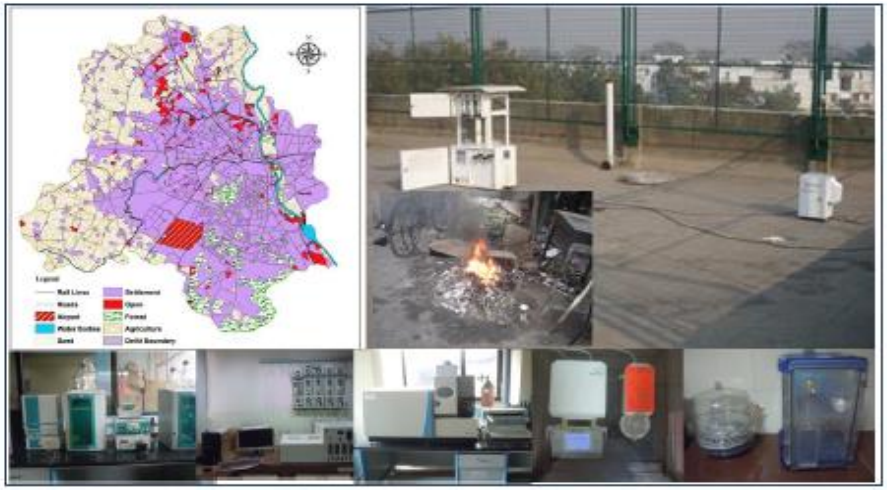
Submitted to

Department of Environment

Government of National Capital Territory of Delhi

and

Delhi Pollution Control Committee, Delhi



Mukesh Sharma; PhD and Onkar Dikshit; PhD

Professors, Department of Civil Engineering

Indian Institute of Technology Kanpur, Kanpur- 208016

January 2016

- Its worth it only if….
  - Quality control and quality assurance
  - Data collection, quality instruments, trained manpower, experience, committed team
  - Right TOR and Scoping
  - Right model selection
  - Deal with sources from outside
  - Ground truthing