DEVELOPMENT OF A GRID-BASED EMISSION INVENTORY AND A SOURCE-RECEPTOR MODEL FOR DHAKA CITY

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OUTLINE OF THE PRESENTATION

- Background
- Objective
- Development of emission inventory
- Determination of PM concentration using S-R matrix
- Results
- Summery of the study
- Future works

BACKGROUND

- Dhaka is the capital city of Bangladesh,
- Around twelve million people and has a population density of about 20,000 people per km2
- One of the most polluted cities of the world
  - Air pollution
  - River pollution
  - Soil pollution
  - Noise pollution
- Air pollution is the most threatening problem now-a-days.

BACKGROUND (CONT'D)

- Economic cost associated with air pollution related environmental degradation is about 1.1% of GDP
- 15,000 premature deaths, as well as several million cases of pulmonary, respiratory and neurological illness
- Both PM10 and PM2.5 concentrations exceed the WHO guidelines
- Also exceed the national standards of annual PM10 and PM2.5 by a factor of over two

BACKGROUND (CONT'D)

- Recently, the Government introduced a number of initiatives
  - ad-hoc basis
  - some improvements
- But there is a lack of benefit modeling to support these decisions
- For addressing the air quality problem,
  - Development of an emission inventory and
  - Subsequent prediction of ambient concentration is essential.

AIR QUALITY OF DHAKA

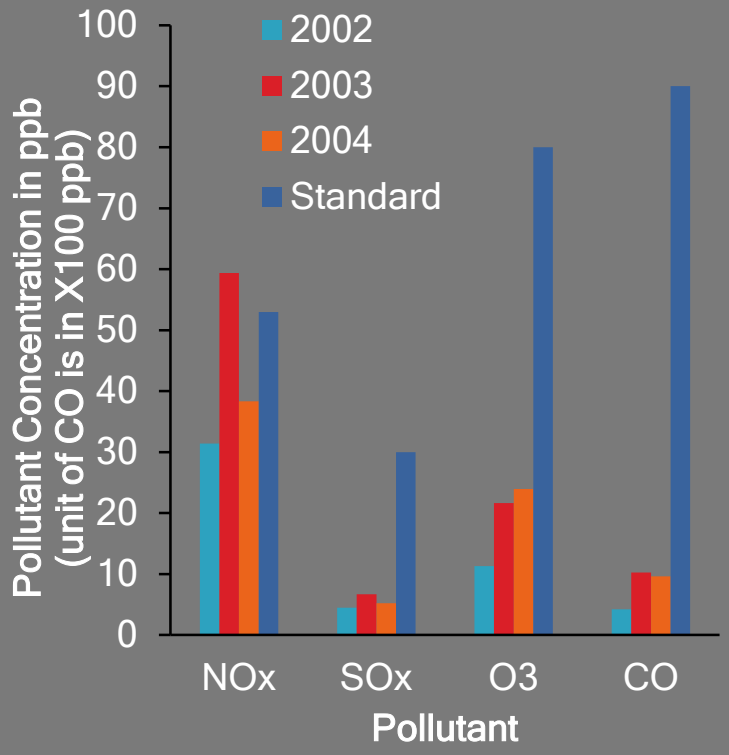


Figure : Yearly average Concentration of NO_x, SO_x, O_3 and CO

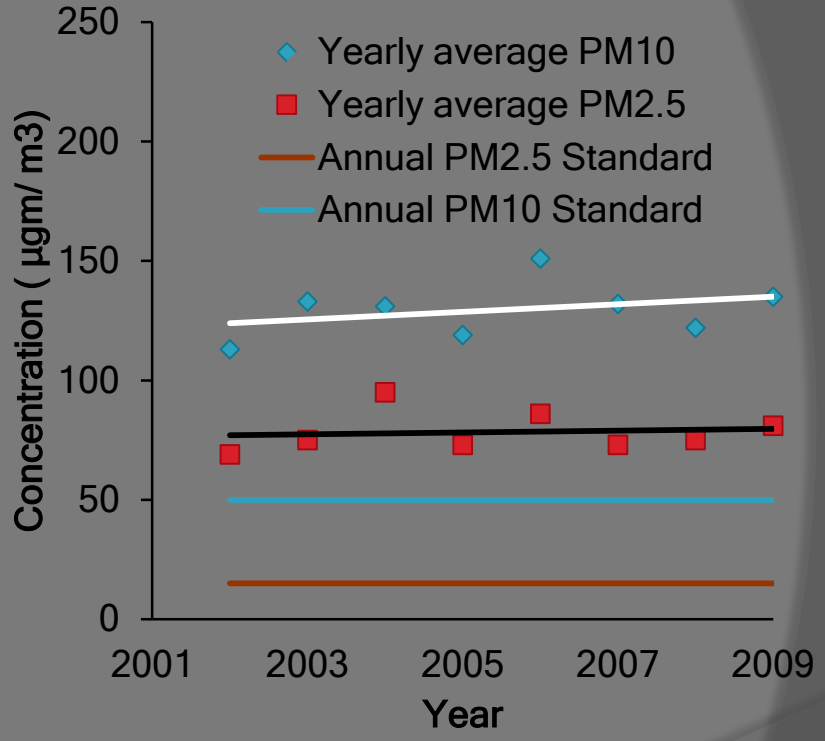


Figure: Variation of yearly average PM_{10} and $PM_{2.5}$

AIR QUALITY OF DHAKA (CONT'D)

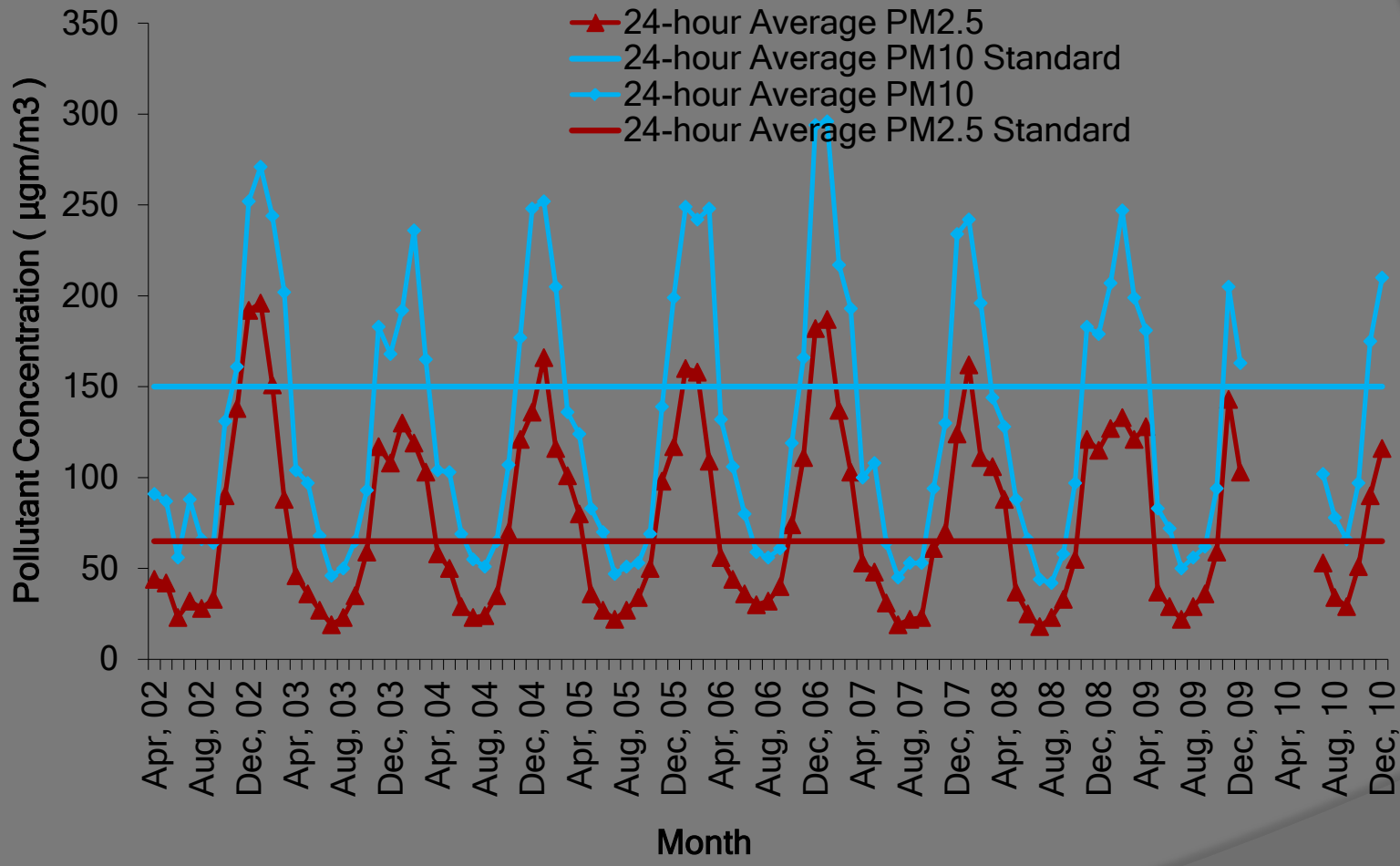


Figure: Monthly 24-hour average concentration of $PM_{2.5}$ and PM_{10}

OBJECTIVE

- To develop a grid-based emission inventory for Dhaka City.
- Development of Source-Receptor Matrix (SRM)
- To show the applicability of SRM, a case study is presented to generate ambient concentration of Particulate Matter (PM10, PM2.5) for the most critical month for air pollution i.e. March.

MODEL DOMAIN

- Domain is between
  23 30’0” to 24 6’0” N
  90 18’0” to 90 48’0” E

- Areas outside the city also contribute. So domain is extended in both north and south direction.

- The model area is divided into 200 grids of 0.03 0.03 , which is approximately 3 km 3 km.

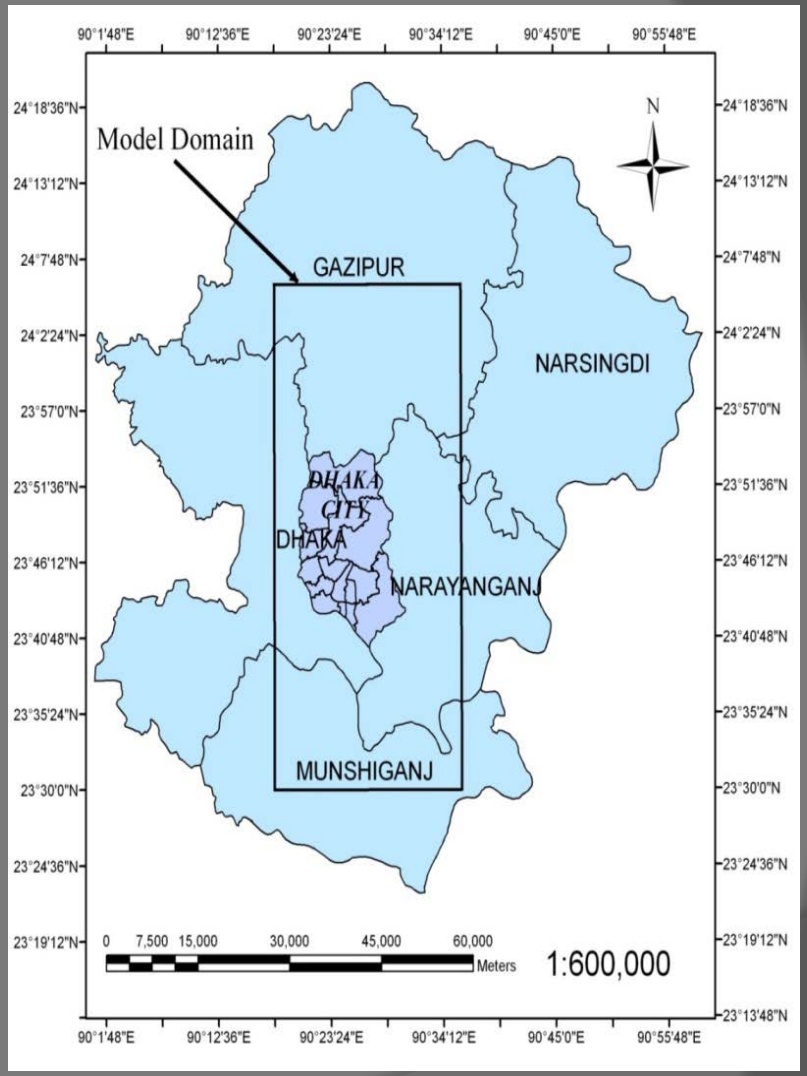


Figure: Model domain for the study

DEVELOPMENT OF EMISSION INVENTORY

Emission from each of following source groups has been estimated separately and finally they have been summed up to estimate the total emission.

- Traffic Emission
- Road Dust
- Brick Kiln Emission

DEVELOPMENT OF EMISSION INVENTORY (CONT'D)

Traffic Emission :

$$\sum \text{Emission } E_i = \sum_j \sum_k [EF_{ijk} * A_{jk}]$$

where,

i = Type of a pollutant like PM10

j = Fuel usages like CNG, Gasoline

k = Vehicle type like Car

Emission E_i = Emissions from pollutant for each grid cell

EF = Emission Factor for each pollutant sector

A =Activity level for each pollutant source.

DEVELOPMENT OF EMISSION INVENTORY (CONT'D)

Road Dust :

$$E= (k*(sL/2)0.65*(W/3)1.5)-C)*(1-P/4N)$$

where,

E=PM10 emission factor units matching units of k

k=particle size multiplier = 4.6 gram/vehicle km traveled/day

sL=silt loading = 30 grams per square meter for Dhaka City

C= EF for brake and tire wear = 0.1317 gram/vehicle km traveled/day for PM_{10}

W=average weight (tons) of each type of vehicles on the road

P= number of wet days with precipitation > 0.01 in or 0.254mm=5 for March

N=number of days in averaging period = 30 for this analysis

DEVELOPMENT OF EMISSION INVENTORY (CONT'D)

Brick Kiln Emission :

$$\text{Emission } E_i = EF_i * AL * N$$

where,

i = Type of a pollutant, e.g., PM10

N=Number of brick kilns in every grid

EF = Emission Factor for each pollutant

AL =Duration of brick manufacture

SOURCE RECEPTOR (S-R) MODEL

- Indication of the relationship between the source the receptor
- Defined as change in concentrations in a receptor grid per unit change in emissions in the source grid
- S-R matrix, also known as transfer coefficient/matrix
- Helps in calculation of ambient concentration if emission is known and vice-versa

ELEMENTS OF SOURCE RECEPTOR MATRIX (SRM)

- For a series of sources in the domain $C_j = \sum_i m_{ij} Q$

Where, Cj = Ambient concentrations in area j,

mij = Transfer matrix that determines the proportion of net emissions from area i transported to area j, and

Qi = emissions from area i

- Matrix form: $C = MQ$

Where, C = Concentration vector

M = Source-Receptor Matrix (SRM)

Q = Emission vector

ELEMENTS OF SOURCE RECEPTOR MATRIX (SRM) (CONTD. .)

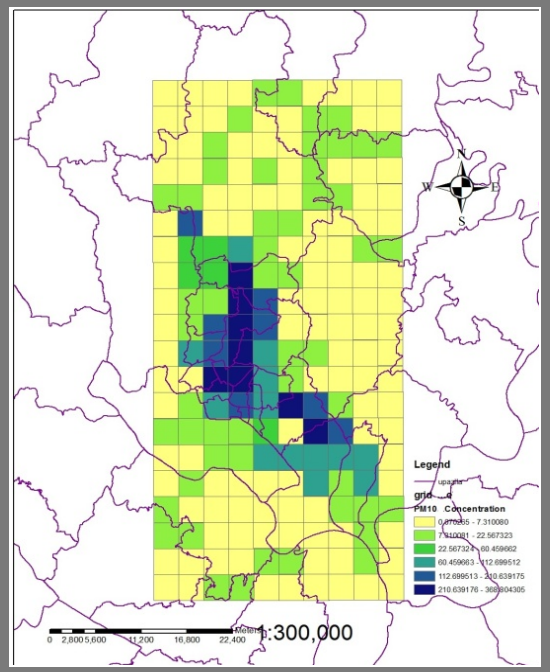
- SRM, *M* is generated with elements m_{ij}

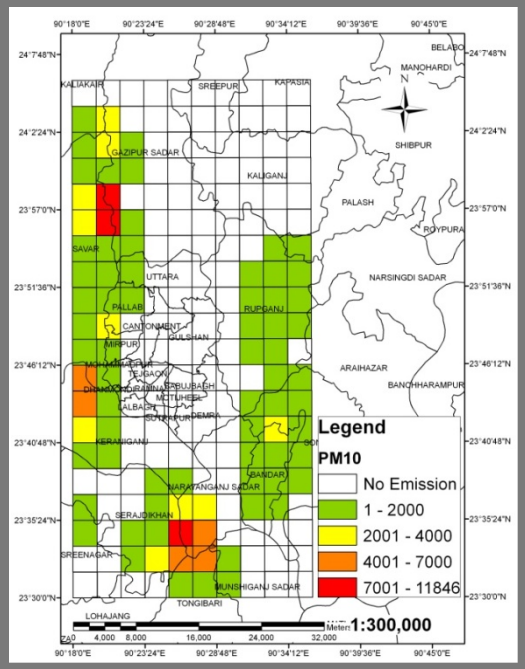
$$m_{ij} = \frac{c_j}{q_i}$$

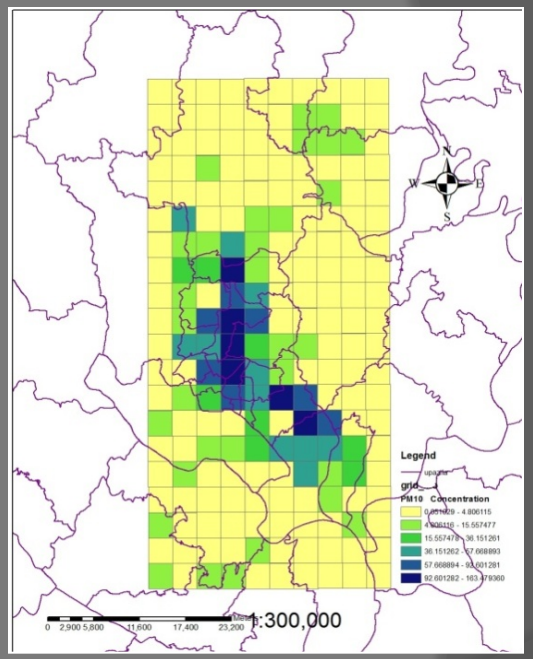
Where, c_j = Ambient concentrations in area j due to q_i emission in area i

- To generate the SRM an air quality model is required
- ATMoS-4.0
  - ✓ Modified version of The Atmospheric Transport Modeling System (ATMoS)

SPATIAL VARIATION OF PARTICULATE MATTER (PM10)



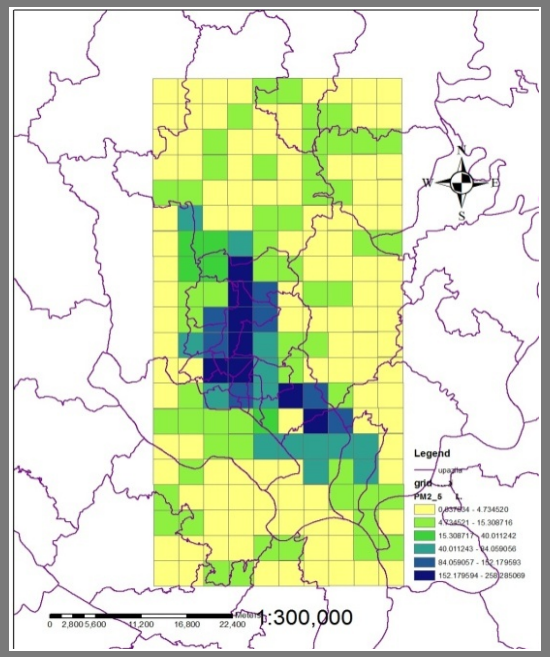


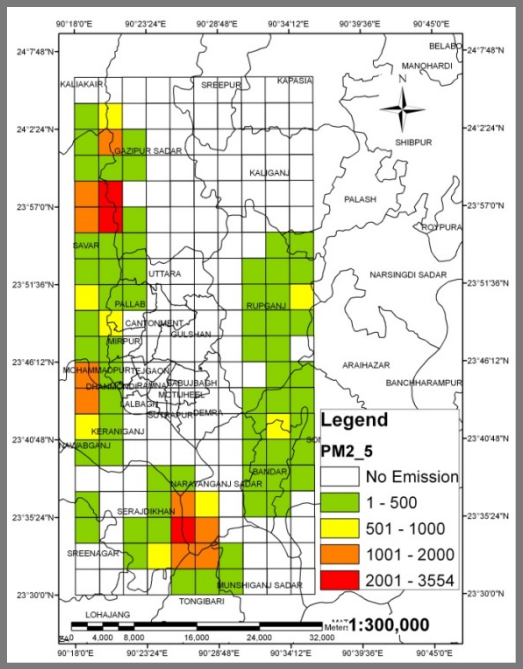


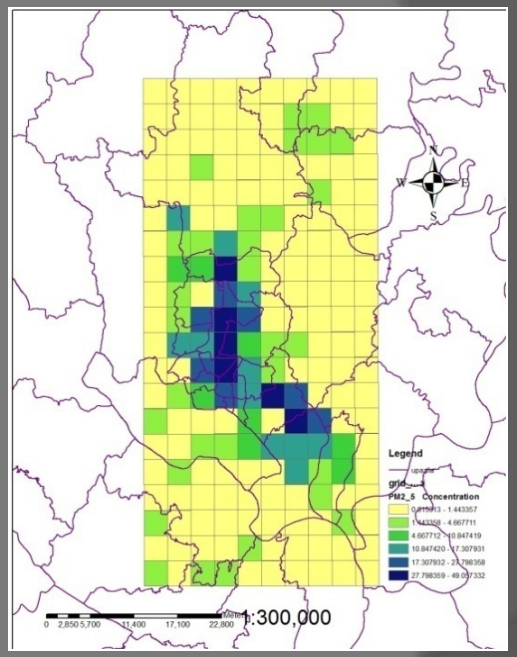
Traffic Emission Brick kiln Road dust Emission

Figure : PM_{10} emissions in tons/year

SPATIAL VARIATION OF PARTICULATE MATTER (PM 2.5)







Traffic Emission Brick kiln Road dust Emission

Figure : $PM_{2.5}$ emissions in tons/year

PARTICULATE MATTER (PM) CONCENTRATION

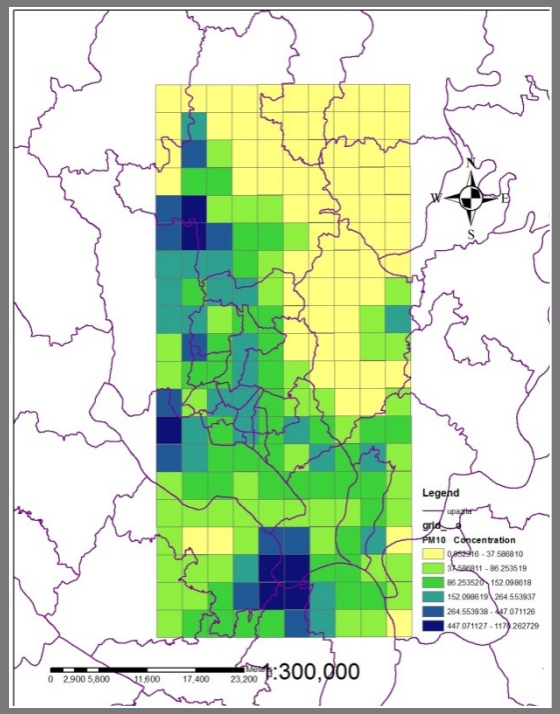


Figure: PM_{10} concentration in $\mu g/m^3$ in March

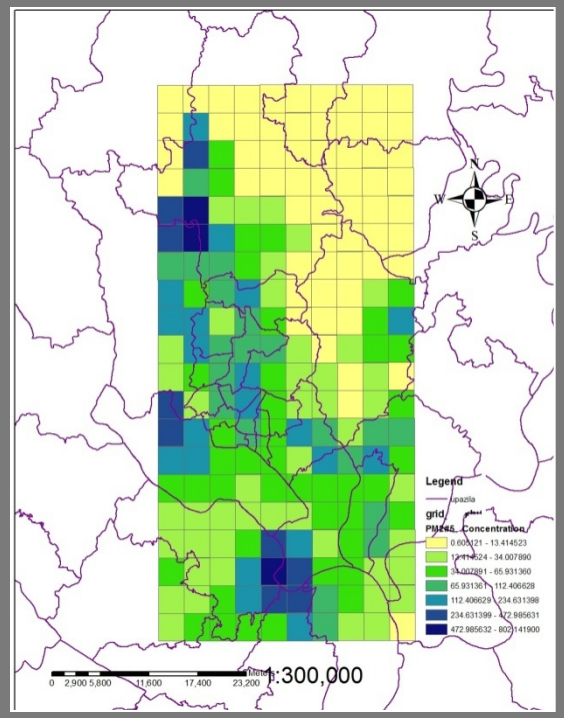


Figure: $PM_{2.5}$ concentration in $\mu g/m^3$ in March

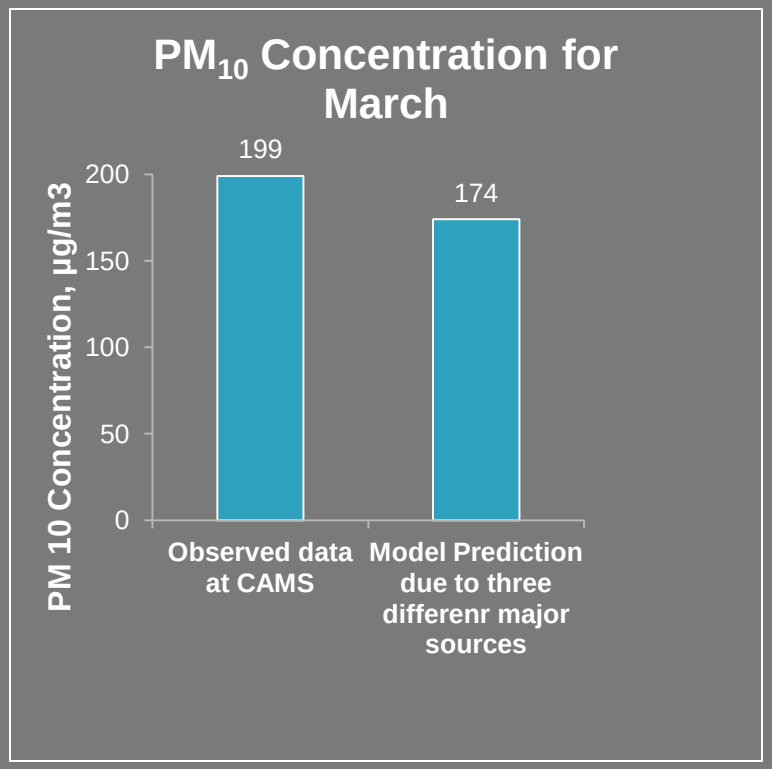
SPATIAL VARIATION OF PARTICULATE MATTER (PM10 &PM 2.5)

- Both PM_{10} and $PM_{2.5}$concentration varies widely
- The brick kiln emissions take place outside the main city.
- The traffic emissions are higher in the Dhaka city area.
- Emissions from re-suspended road dust are relatively higher than that of vehicular emission.
- Emission load of brick kiln is very high in comparison to the traffic emissions

SPATIAL VARIATION OF PARTICULATE MATTER (PM10 &PM 2.5) (CONT'D)

- Average concentration of PM10 and PM2.5 have been found 118 $\mu g/m^3$ and 67 $\mu g/m^3$ respectively.
- Both average concentrations exceed the 24- hour average concentration of Bangladesh standards.
- The concentration also exceeds the Bangladesh standard for annual average concentration.

COMPARISON WITH DATA AT CAMS



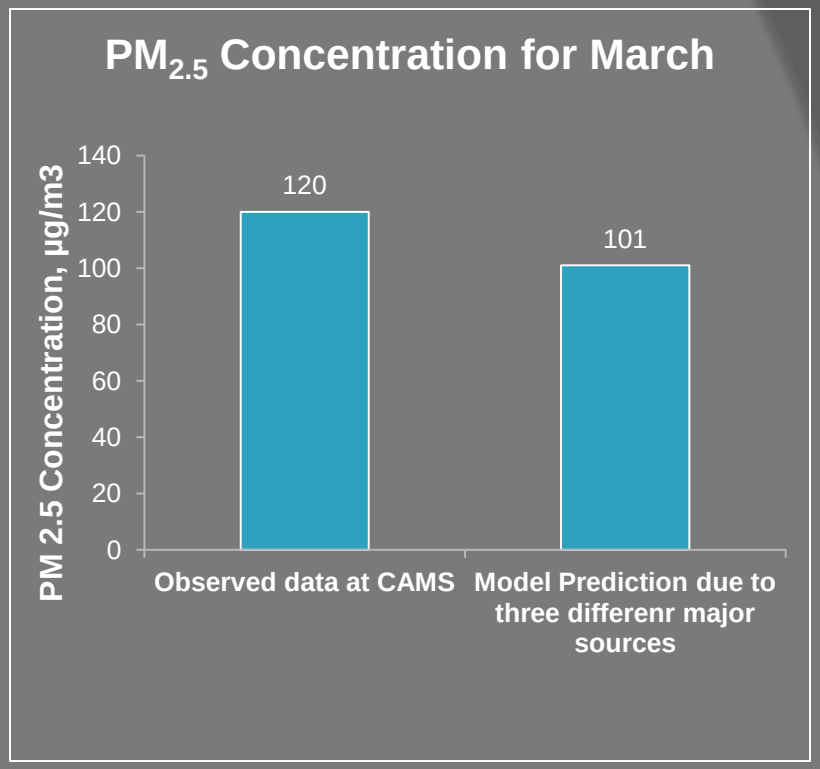


Figure : Comparison of PM_{10} concentration at the CAMS point

Figure : Comparison of $PM_{2.5}$ concentration at the CAMS point

COMPARISON OF CONTRIBUTIONS FROM DIFFERENT SOURCES

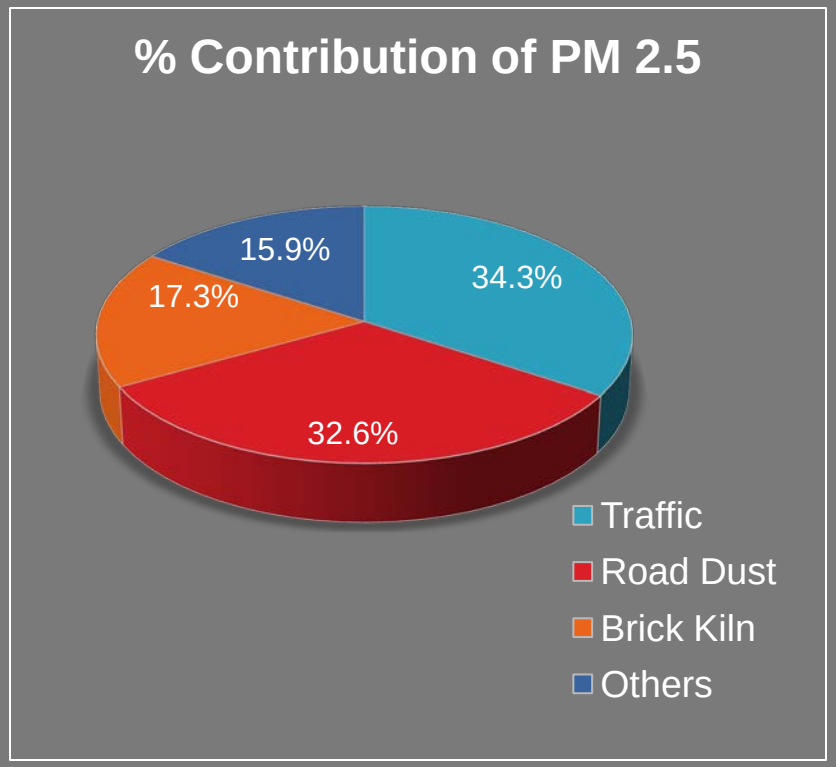


Figure : Source contribution for $PM_{2.5}$ at Sangshad Bhaban CAMS in March

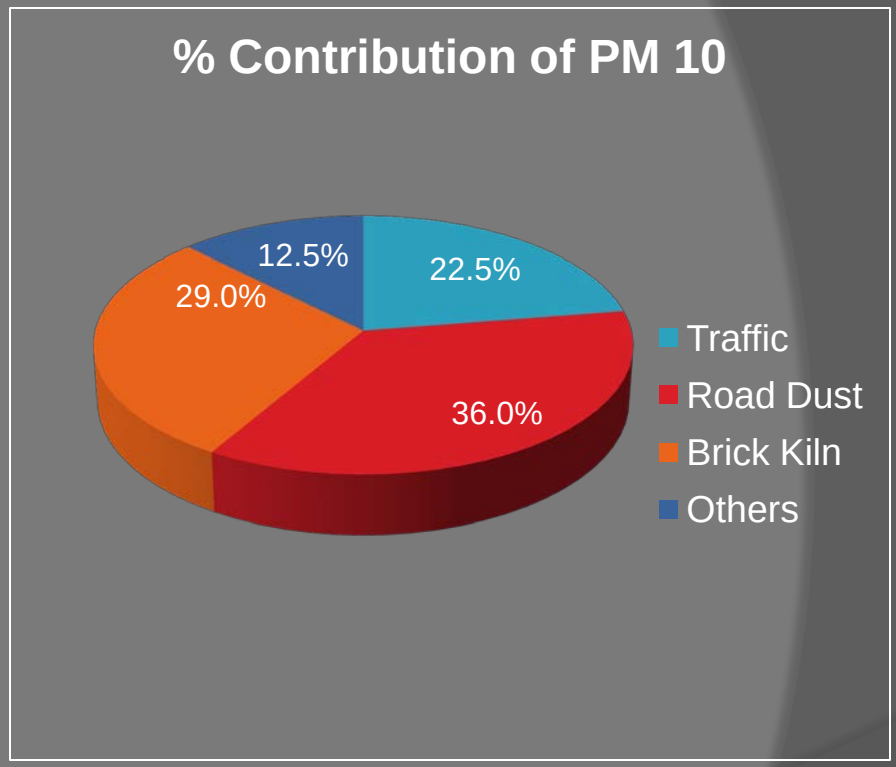


Figure : Source contribution for PM_{10} at Sangshad Bhaban CAMS in March

SUMMERY OF THE STUDY

- An emission inventory has been developed for Dhaka city and its surrounding areas, incorporating three major sources: traffic emission, road dust and brick kiln emission.
- Concentrations for both PM10 and PM2.5 have been estimated using an S-R model.
- At March, both concentrations exceed the national standards for 24-hours and annual average.
- Road dust is found to be dominant source for particulate pollution in Dhaka city, followed by brick kiln and traffic emissions.

FUTURE WORKS

- Other potential sources of emission should be incorporated in future.
- Works are currently underway on
  - Predictions of ambient concentrations throughout the year and comparison with available data.
  - Analysis of uncertainty of different parameters used in the simulations.

THANK YOU

QUESTIONS??????

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