Trends in Ambient Concentrations of Fine Particles in Dhaka City

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Air Quality in Dhaka

Scenario

- *Rapid urbanization*
- *Increased economic activity*
- *High population density*
- *Increasing number of motor vehicles and brick kilns*
- *Traffic congestion*

Perception

- *Bad air quality especially in dry seasons*
- *Occurrence of haze in winter and reduced visibility*
- *Particulate matter is the responsible pollutant*
- *Increased incident of respiratory diseases (asthma, bronchitis, lower respiratory track infection, etc.)*

ABATEMENT/CONTROL

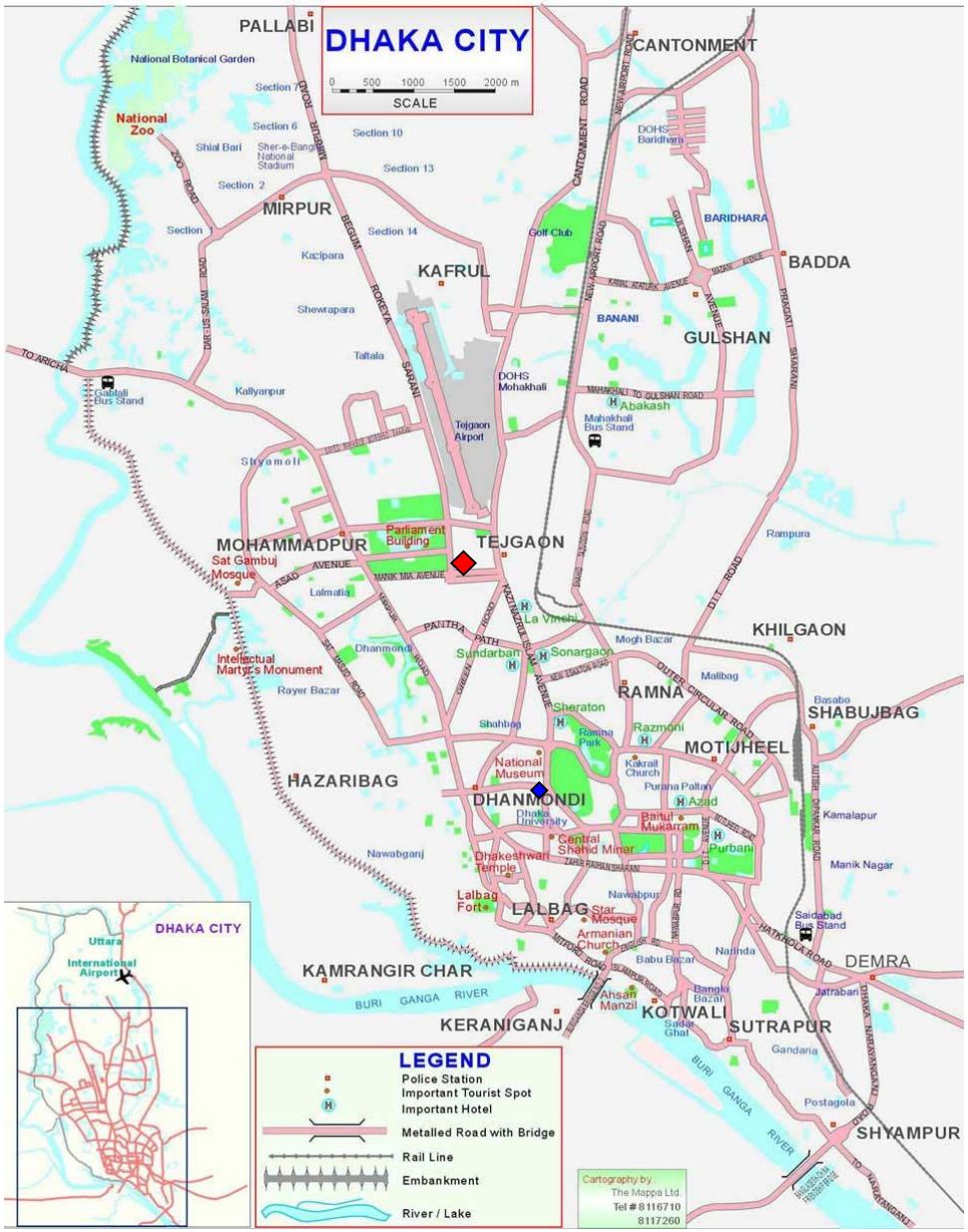
- MONITORING
- SOURCE IDENTIFICATION
- STANDARDS: Laws & Regulations
- PRIORITIZATION : Effects & Costs
- MEASURES: Policy interventions
- ENFORCEMENTS: Legal & Technical
- PUBLIC AWARENESS

BAEC Activities

- PM monitoring using Gent sampler ($PM_{2.2}$ and $PM_{2.2-10}$)
- Characterization of PM (Mass, Black Carbon, Elemental Concentration)
- Source apportionment
- Assessment of regional/transboundary source using Back Trajectory calculation and PSCF modelling
- Collaboration with DoE

Analysis Technique

- *Mass by gravimetric analysis*
- *Black Carbon by reflectance measurement*
- *Elemental analysis by Ion Beam Analysis (IBA) technique*
- *Source apportionment by receptor modeling*
- *Transboundary effect by Back Trajectory calculation*



- Hot Spot Monitoring Station
- Semi-residential Area Monitoring Station

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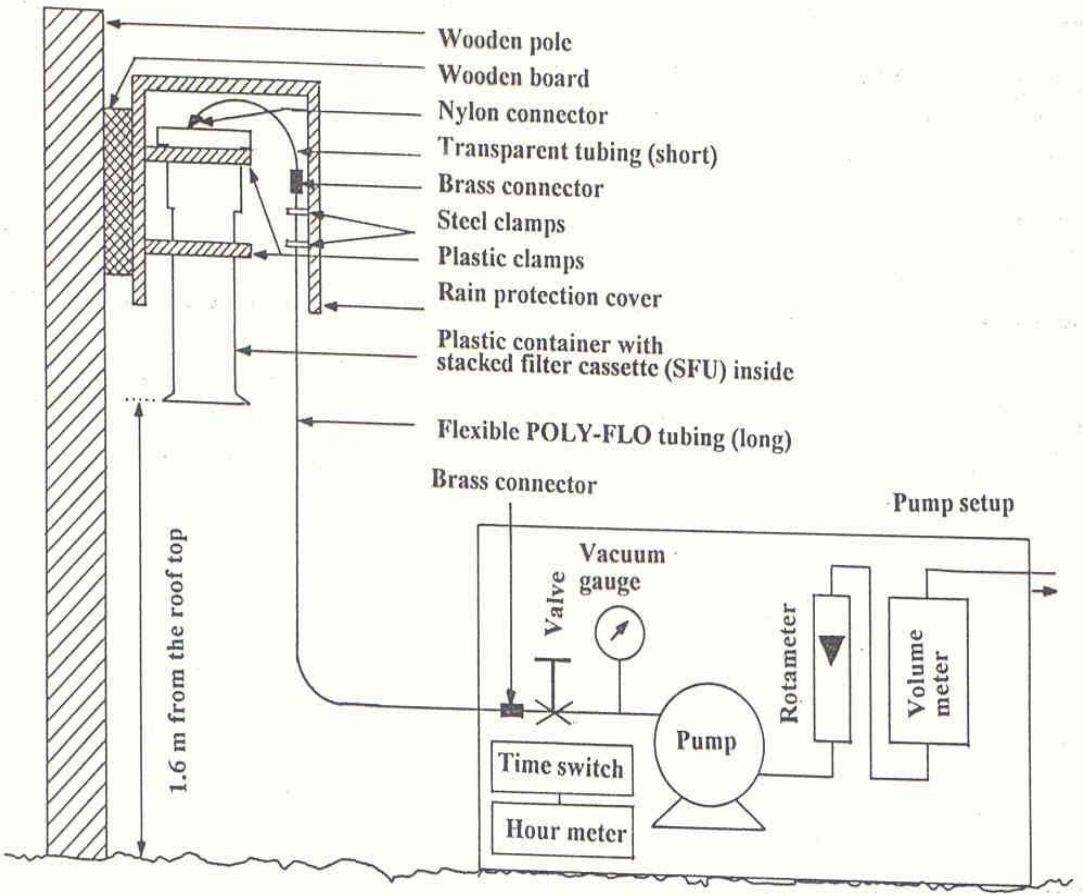

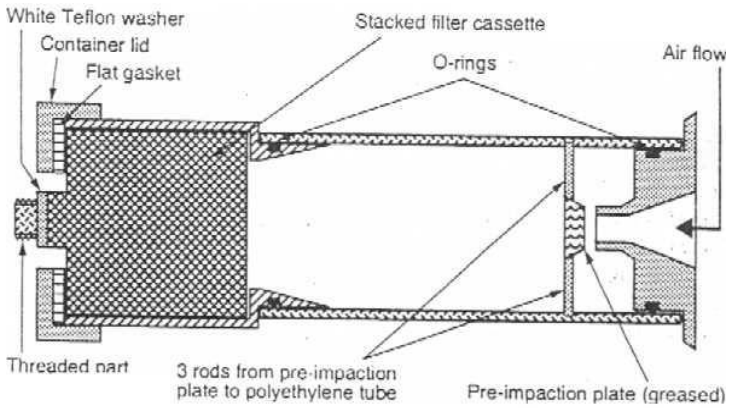

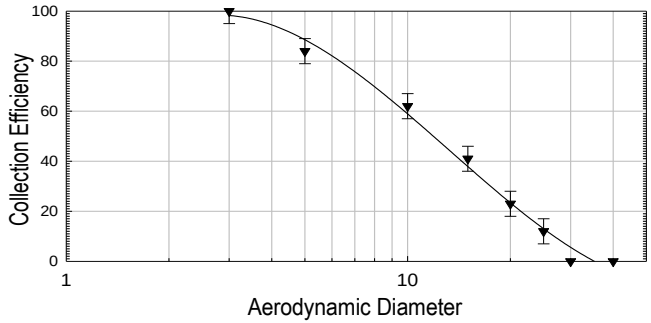

Stacked Filter Unit

Diagram of the Sampling line of GENT Sampler

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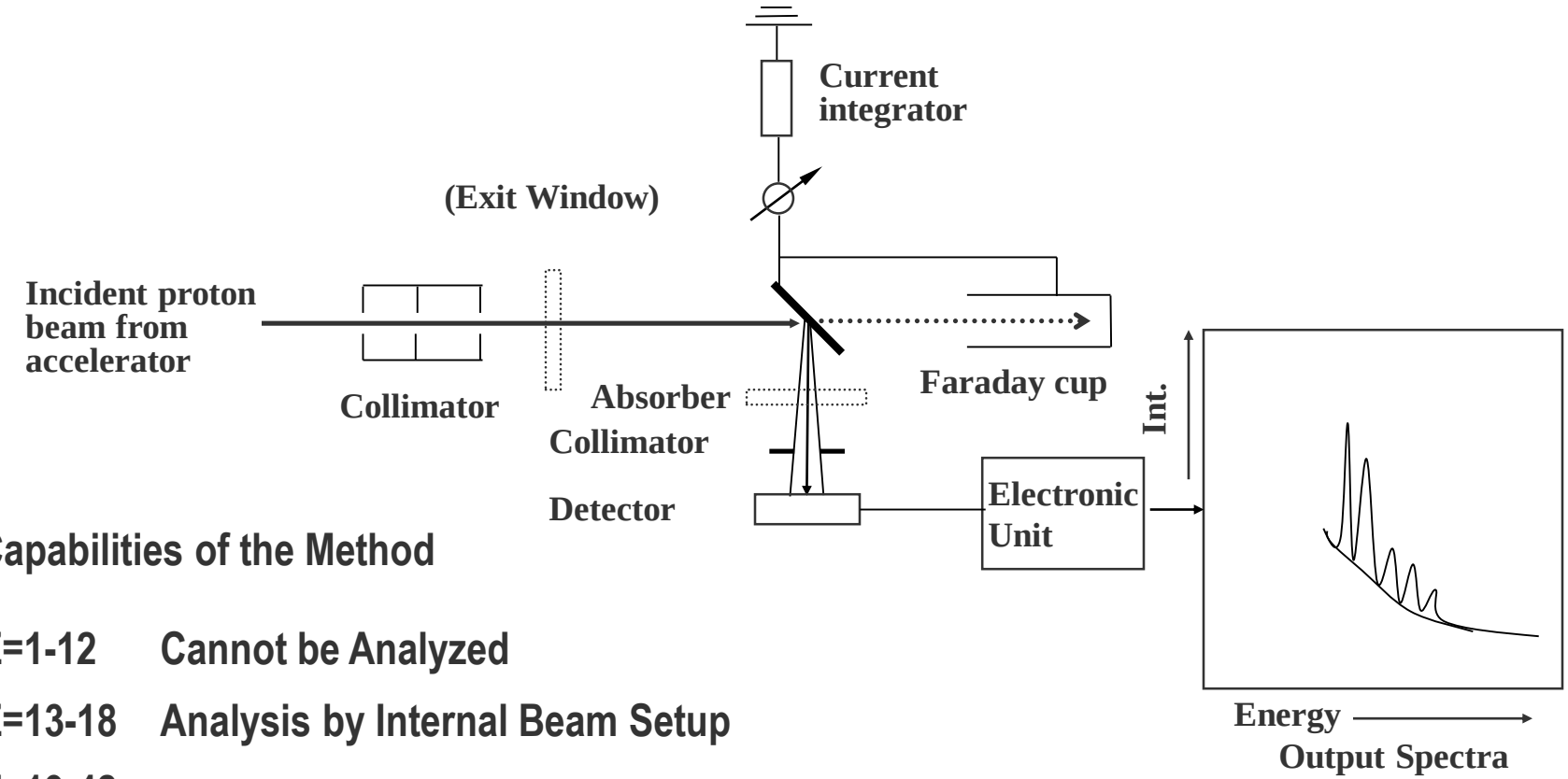
PIXE Analytical System



Capabilities of the Method

Z=1-12	Cannot be Analyzed
Z=13-18	Analysis by Internal Beam Setup
Z=19-42 Z=49-92	Analysis by Internal or External Beam Setup
Z=43-48	Analysis with reduced MDL

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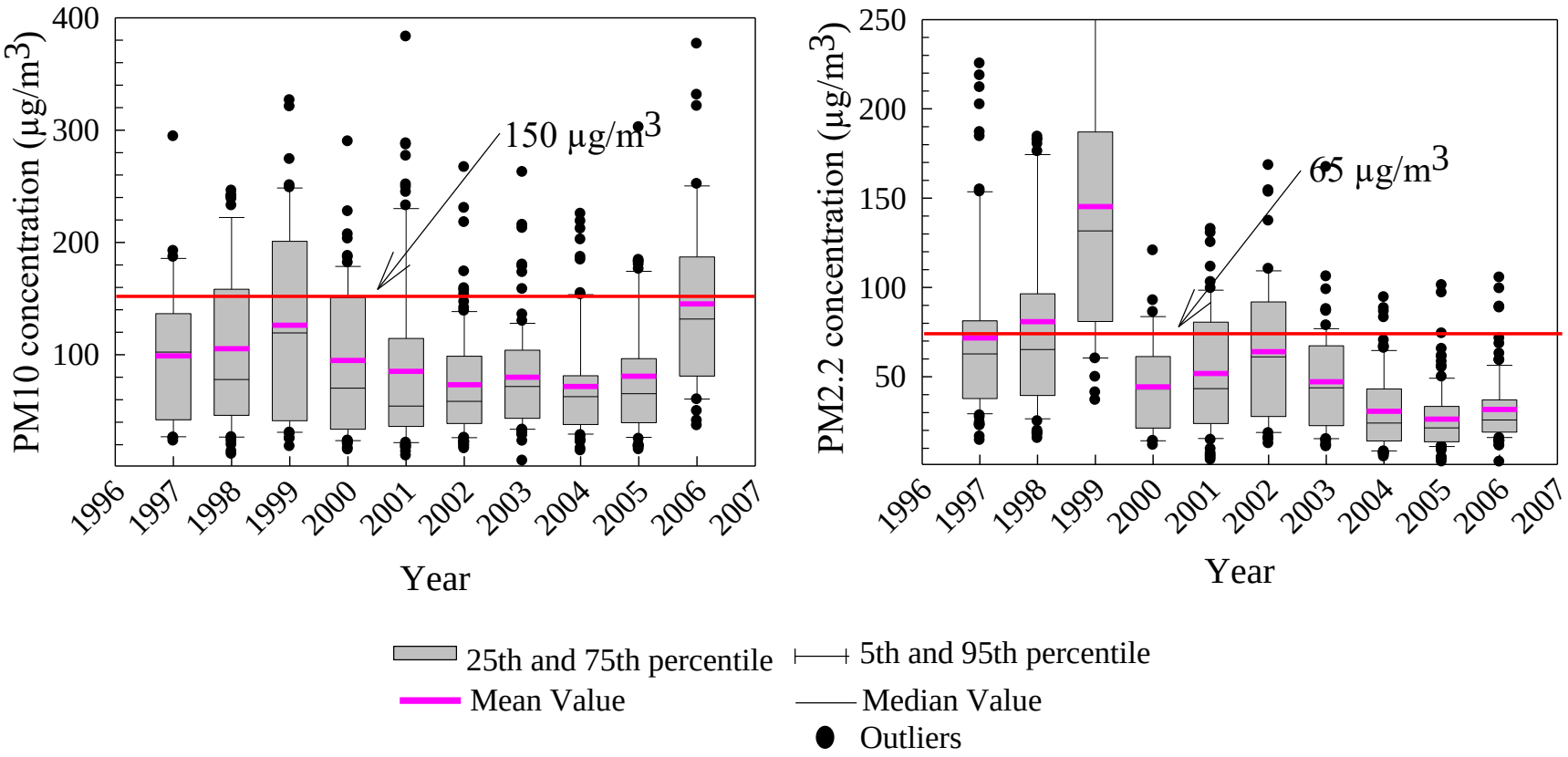
Mass and Elemental concentrations (ng m^{-3})in FPM and CPM of Dhaka cities

Parameter	Dhaka (204 samples)			
	FPM (PM2.2)		CPM (PM10-2.2)	
	Mean	STD	Mean	STD
Mass	22250	15411	42876	37094
BC	7887	3952		
Na	592	285	477	523
Mg	433	228	919	412
Al	502	331	2148	1228
Si	792	648	4459	2732
P	277	204	641	413
S	1292	776	1223	936
Cl	140	106	827	933
K	390	218	747	524
Ca	163	166	1385	818
Ti	16.9	17.9	150	105
Cr	7.99	7.76	25.2	127
Mn	8.87	5.57	30.7	18.8
Fe	207	132	1306	766
Ni	3.21	2.34	4.58	3.51
Cu	5.05	4.07	13.2	43.4
Zn	272	247	375	367
Br	10.6	7.87	17.4	28.5
Pb	164	557	124	350

PM Distribution at Semi-residential area in Dhaka



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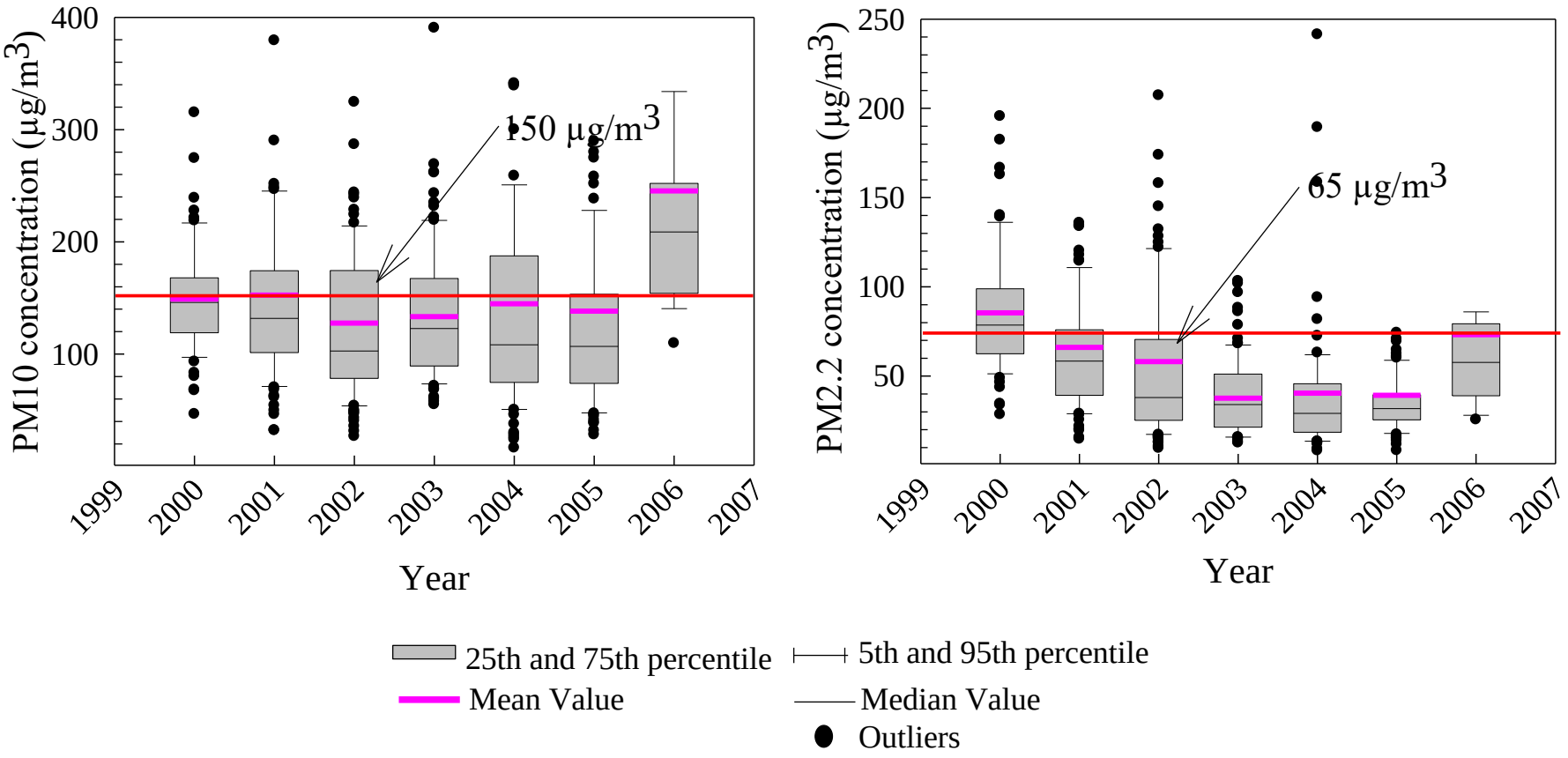
PM Distribution at a hot spot area in Dhaka



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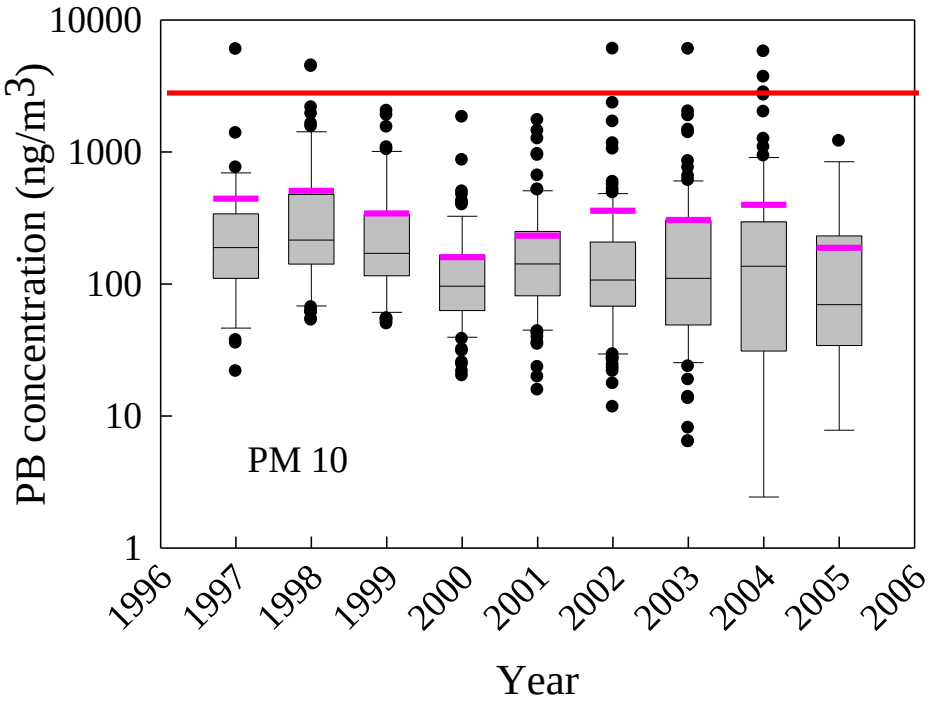
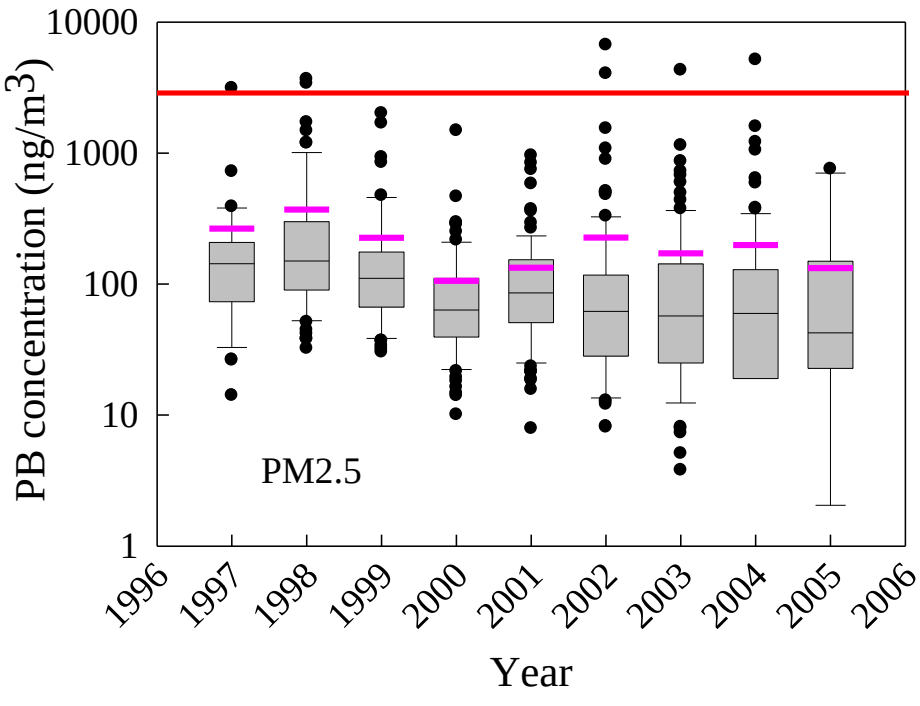
Pb Distribution at Semi-residential area in Dhaka





25th and 75th percentile
5th and 95th percentile
Mean Value
Median Value
Outliers

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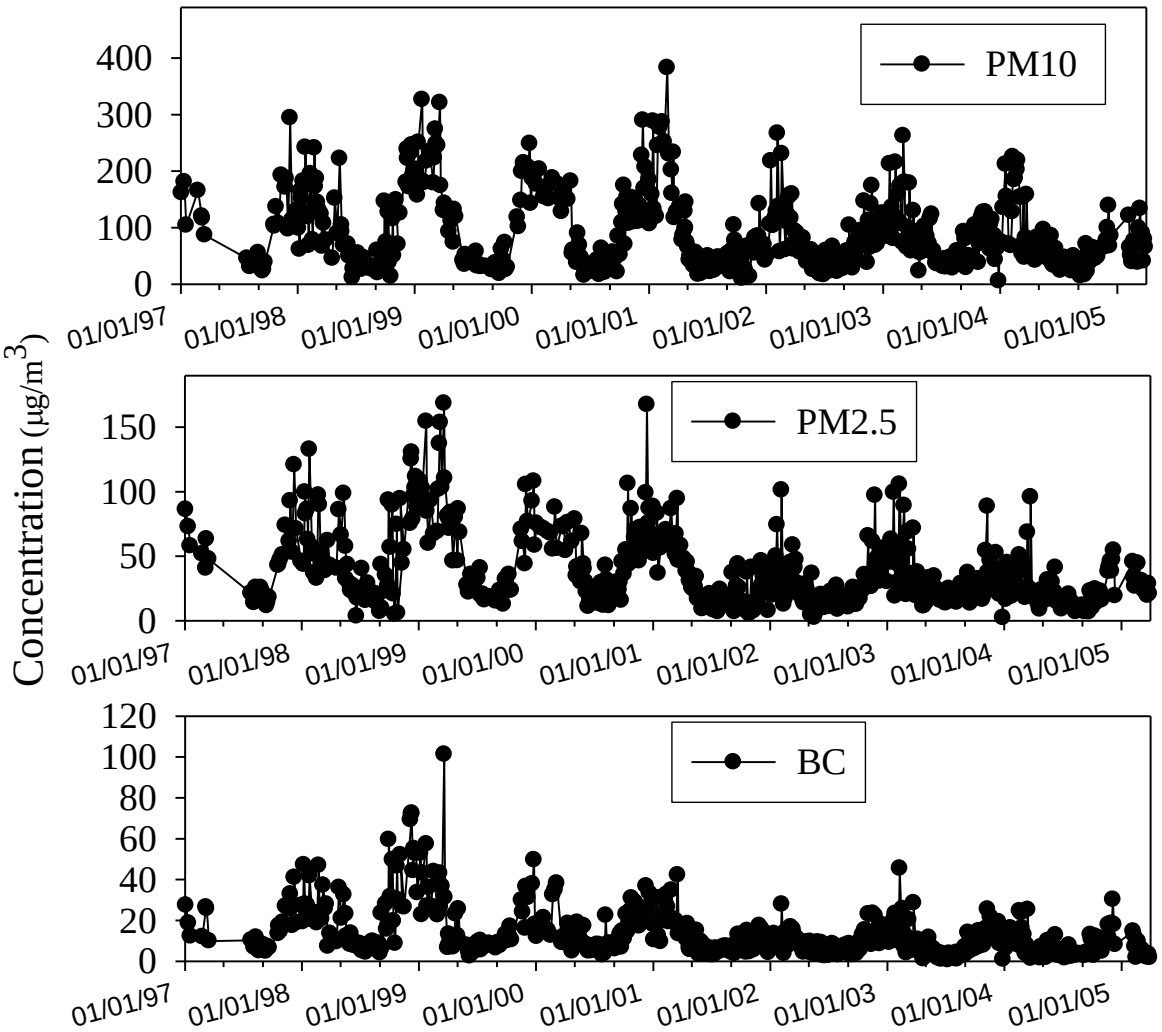
Time series pattern



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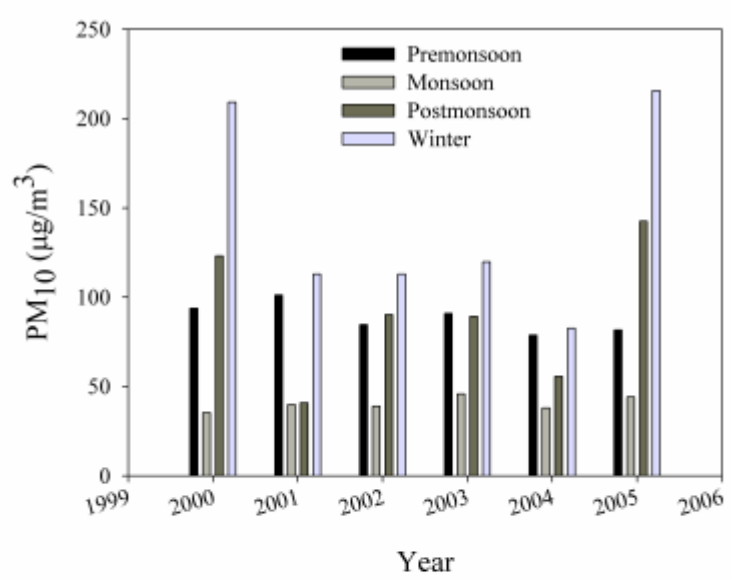
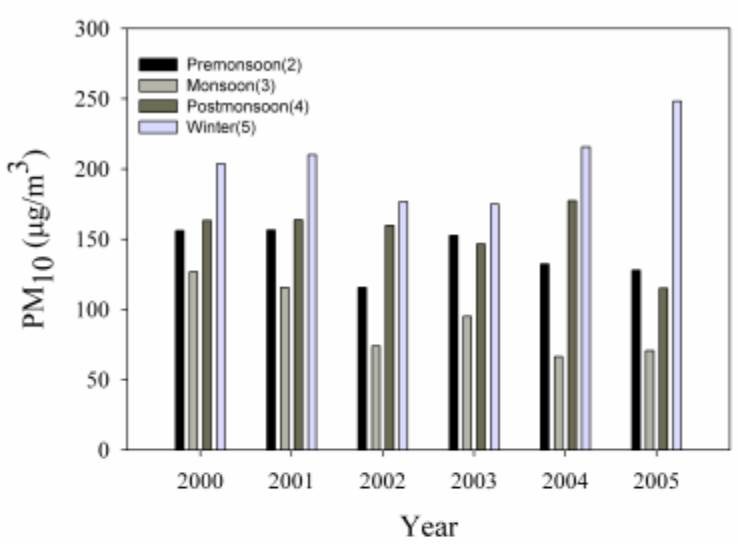
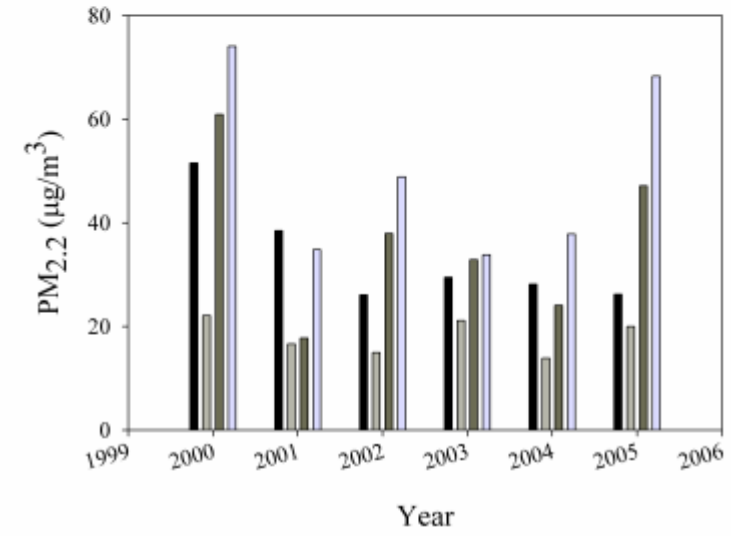
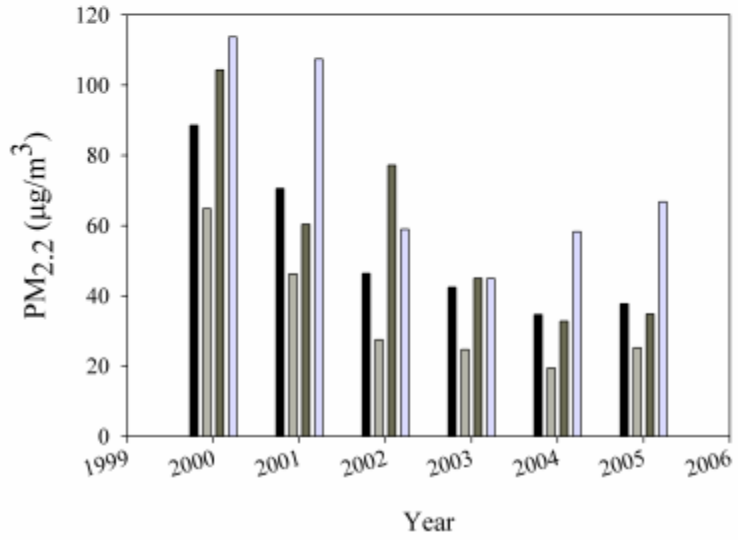
Seasonal variation of PM at SR and HSD site









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Identification of Local Source

Receptor Modeling

- Principal Component Analysis (PCA)
- Positive Matrix Factorization (PMF)

Receptor Modeling: Mass Balance

Receptor models are based on the assumption of mass conservation

Mass balance equation can be written to account for all m chemical species in the n samples as contributors from p independent sources

$$X_{ij} = \sum_{k=1}^{p} g_{ik} f_{kj} - e_{ij}$$

$$Q = \sum_{sample} \sum \left(e_{ij} / s_{ij} \right)^2$$

f_{ik} *is gravimetric mass conc.of ith element in kth source*
g_{kj} *is airborne mass conc. contributing from kth source to jth*

e_{ij} is the residuals

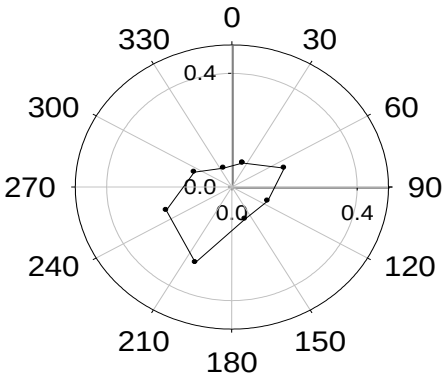
$$e_{ij} = x_{ij} - \sum_{k=1}^{p} g_{ki} f_{kj}$$

Where s_{ij} is the uncertainty in x_{ij}

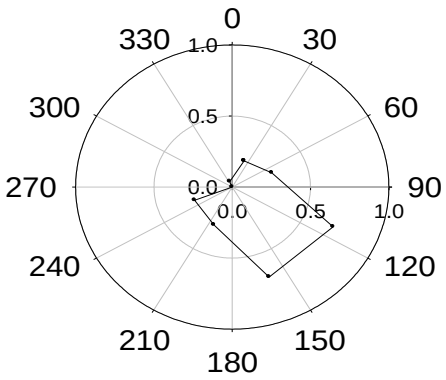
Where i=1,……., n samples, j=1,……., m species and k=1,……., p sources

Wind direction pattern (Data from BMD)

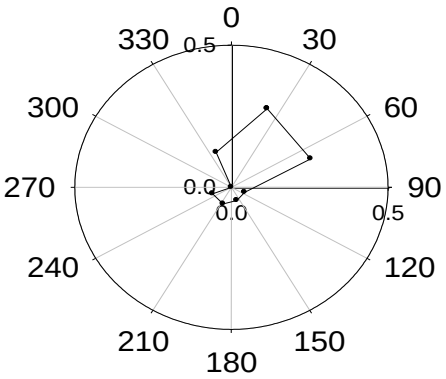
Pre-monsoon



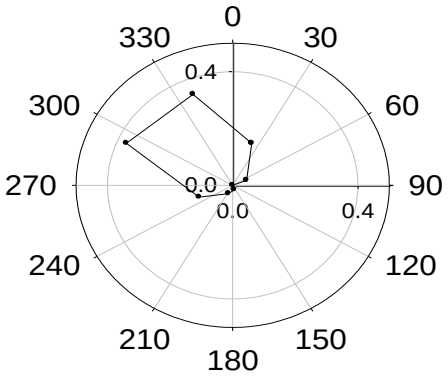
Monsoon



Post-monsoon



Winter



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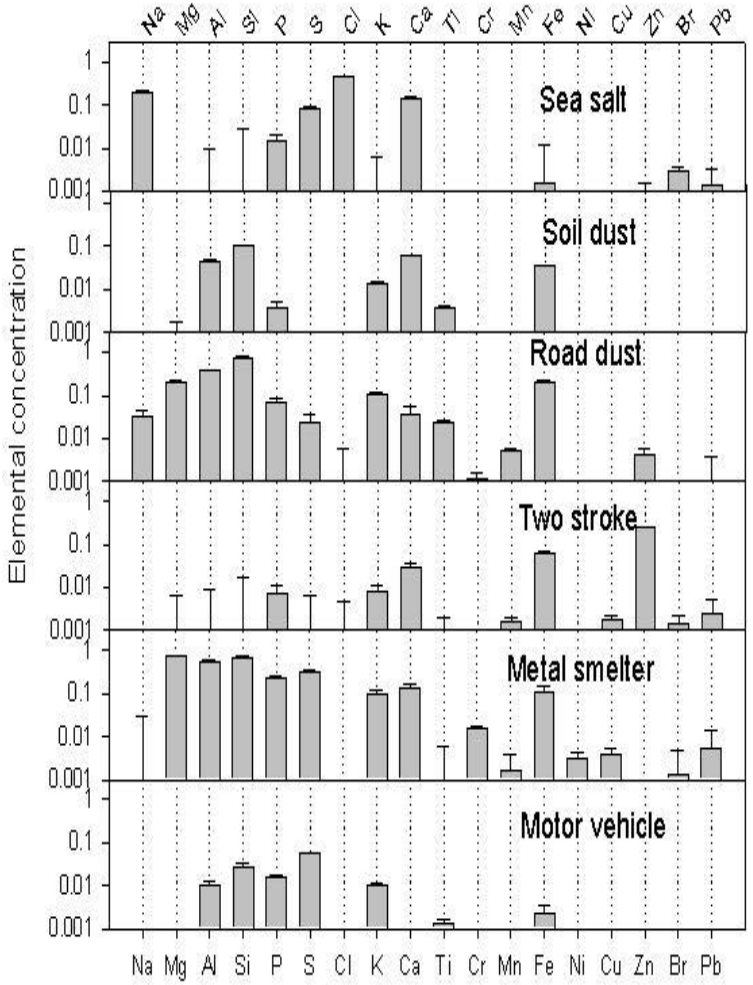
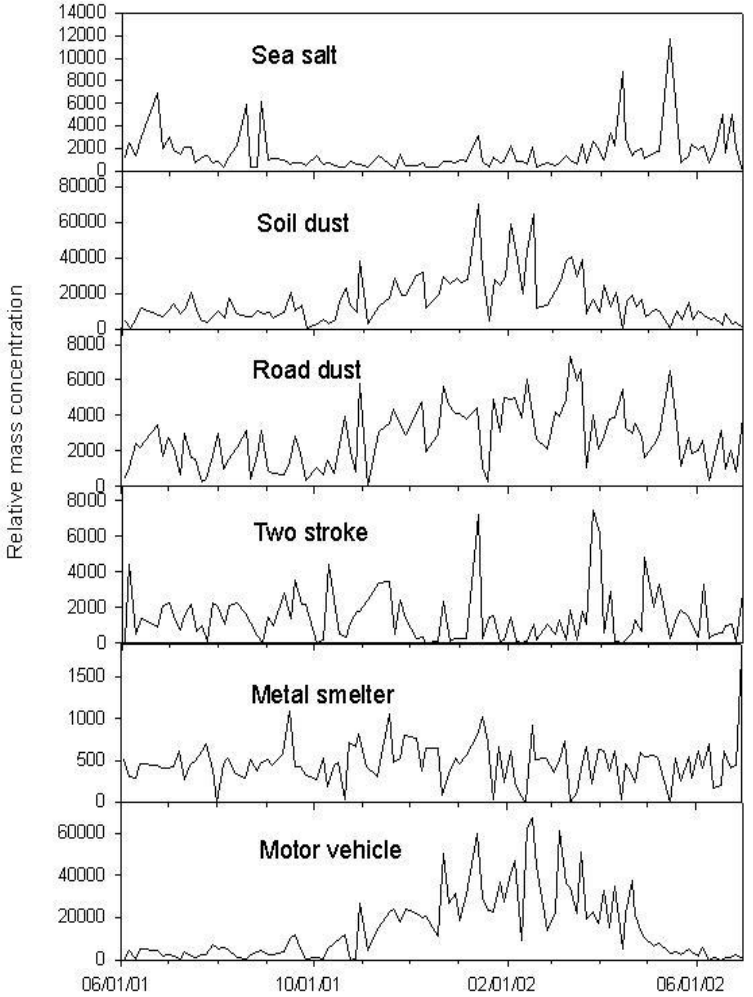
Source Fingerprints Obtained from PMF method

Compositions for CPM at semi-residential area in Dhaka



Time variations for CPM at semi-residential area in Dhaka



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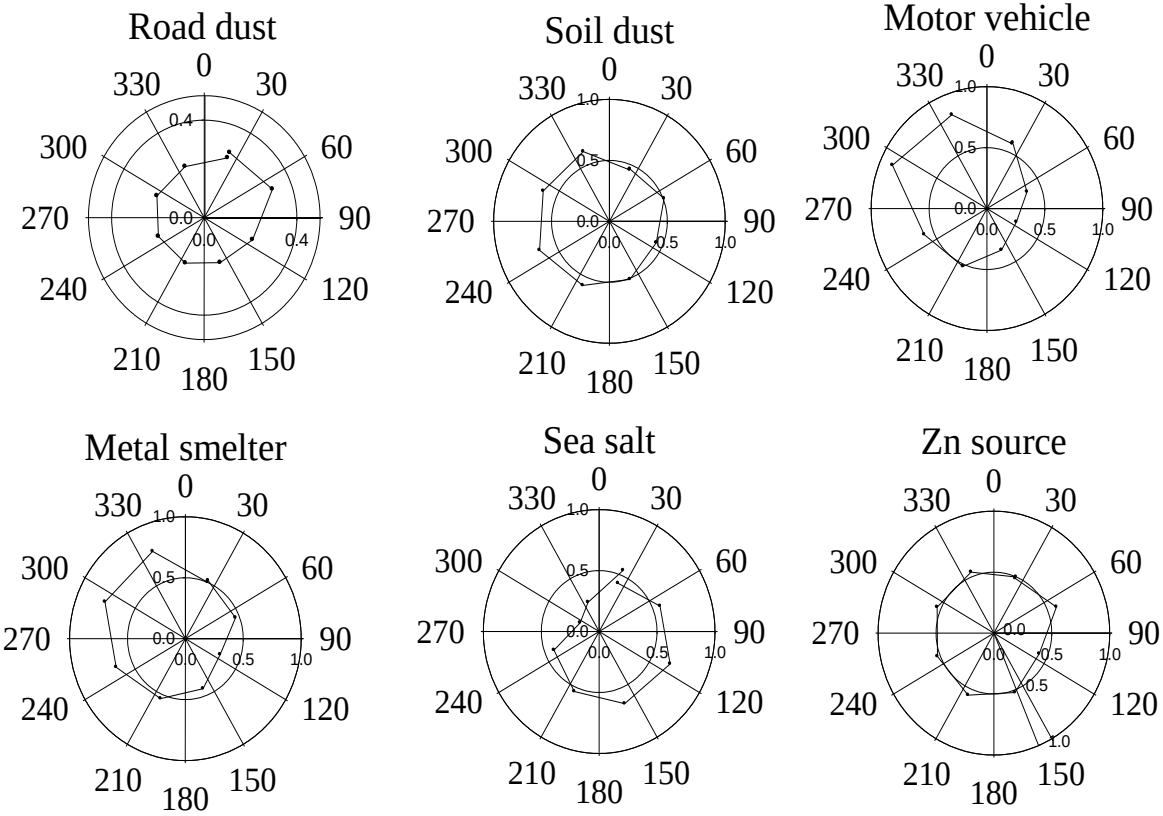
Conditional probability function (CPF) Coarse PM



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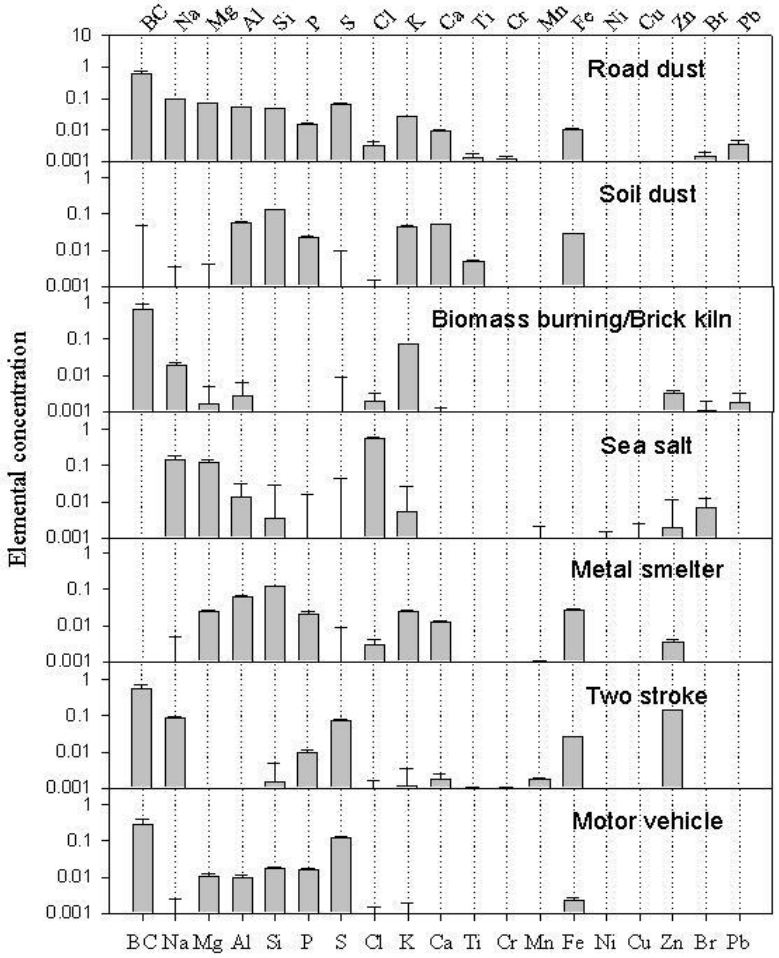
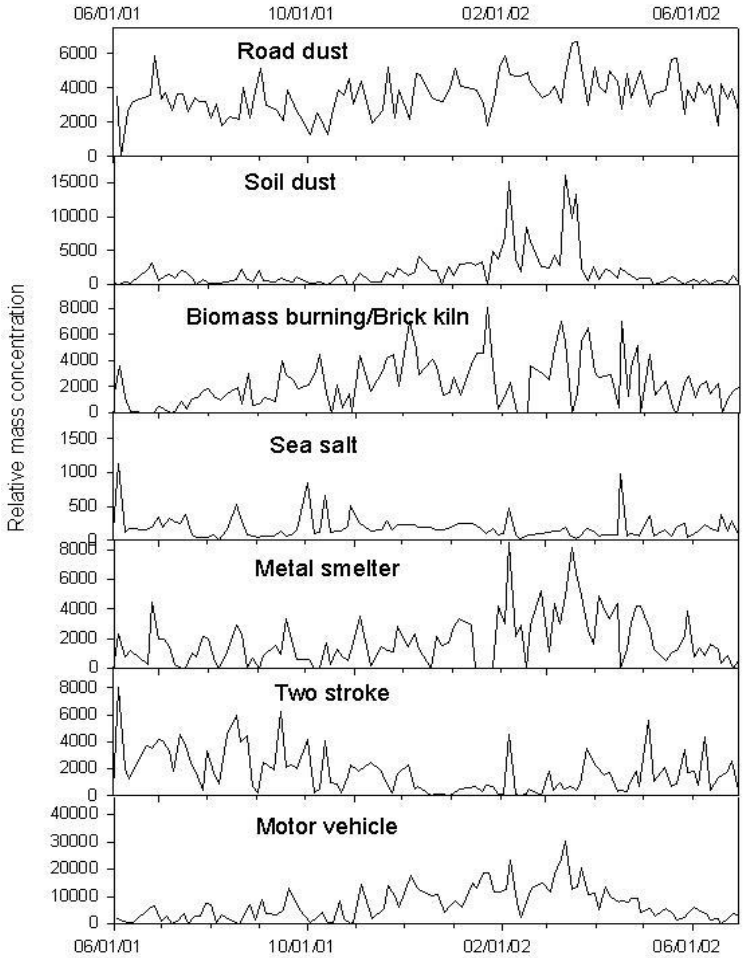
Source Fingerprints Obtained from PMF method

Compositions for FPM at semi-residential area in Dhaka



Time variations for FPM at semi-residential area in Dhaka



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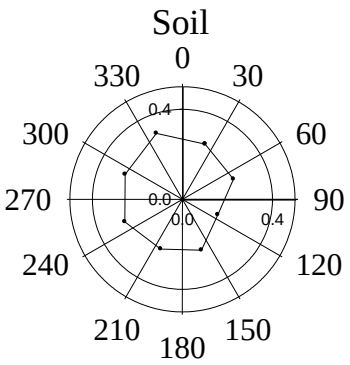
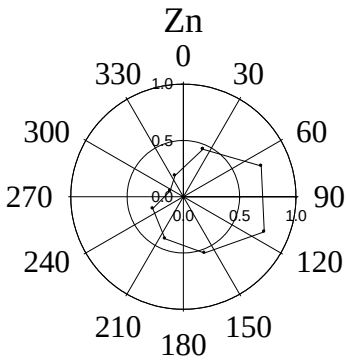
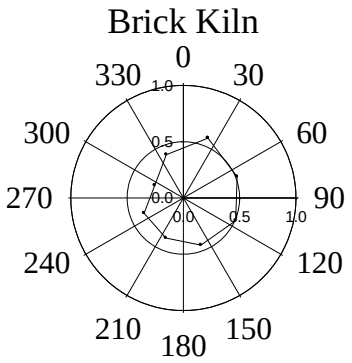
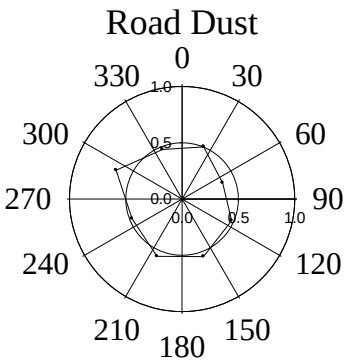
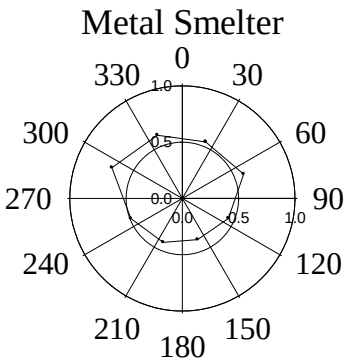
CPF for Fine PM

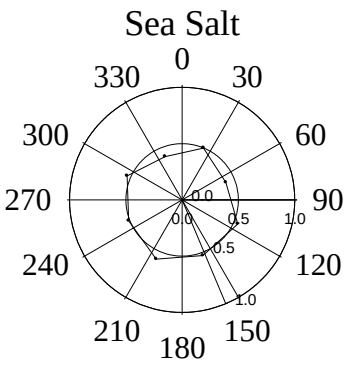


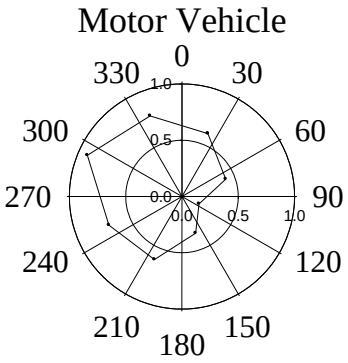












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Average percent contribution of sources for two sites in the Dhaka (PMF modeling results)

Source profile	HSD (Dhaka)	SR (Dhaka)
	Coarse particles	
Sea salt	9.41	4.45
Soil dusts	48.7	43.0
Road dusts	-	7.30
Two stroke engine	12.9	3.78
Metal smelter	-	1.21
Motor vehicle	23.4	40.2
Resuspended/Fugitive Pb	2.29	-
Civil construction	3.2	-
	Fine Particles	
Road dusts	-	19.4
Soil dusts	1.00	10.2
Biomass burning/Brick kiln	37.5	11.9
Sea salt	-	1.00
Metal smelter	-	9.96
Two stroke engine	2.41	9.36
Motor Vehicle	43.0	38.2
Resuspended/Fugitive Pb	3.32	-
Others	12.7	-

Regional Source (PSCF Modeling)

Identify possible source locations of atmospheric aerosols by combining meteorology with measured pollutant characteristics

The Potential Source Contribution Function (PSCF) value for the cell is defined as

$$PSCF(i, j) = m(i, j) / n(i, j)$$

n(i,j) = number of endpoints (from back trajectory calculation) that fall in the cell

m(i,j) = number of endpoints concentrations higher than an criterion value (e.g. average concentration)

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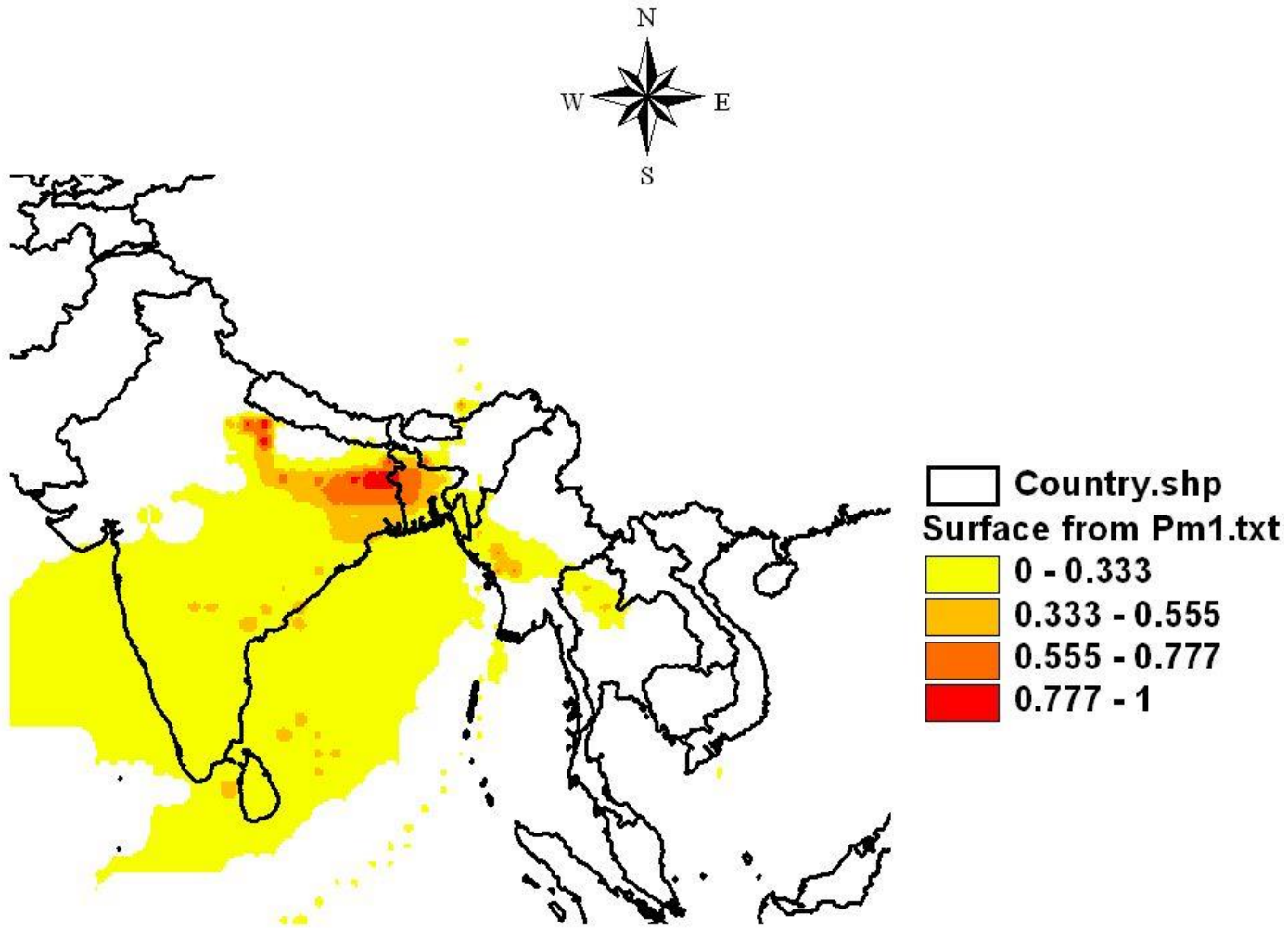
PSCF Calculation

- Back Trajectory by HYSPLIT (Vertically mixed model)
- Starting at 1,000m above ground level used (for homogeneous vertical mixing and to diminish surface friction)
- Five-days back trajectory 1 hour interval (120 endpoints)
- Sampling days: May 2001-March 2005
- Grid Size: 1° x 1° (2160 Cells approx 70x70km)
- Over 25,000 trajectory endpoints terminates within the grid cell; average 12 endpoints per cell

PSCF: Fine PM (May 2001 to March 2005)



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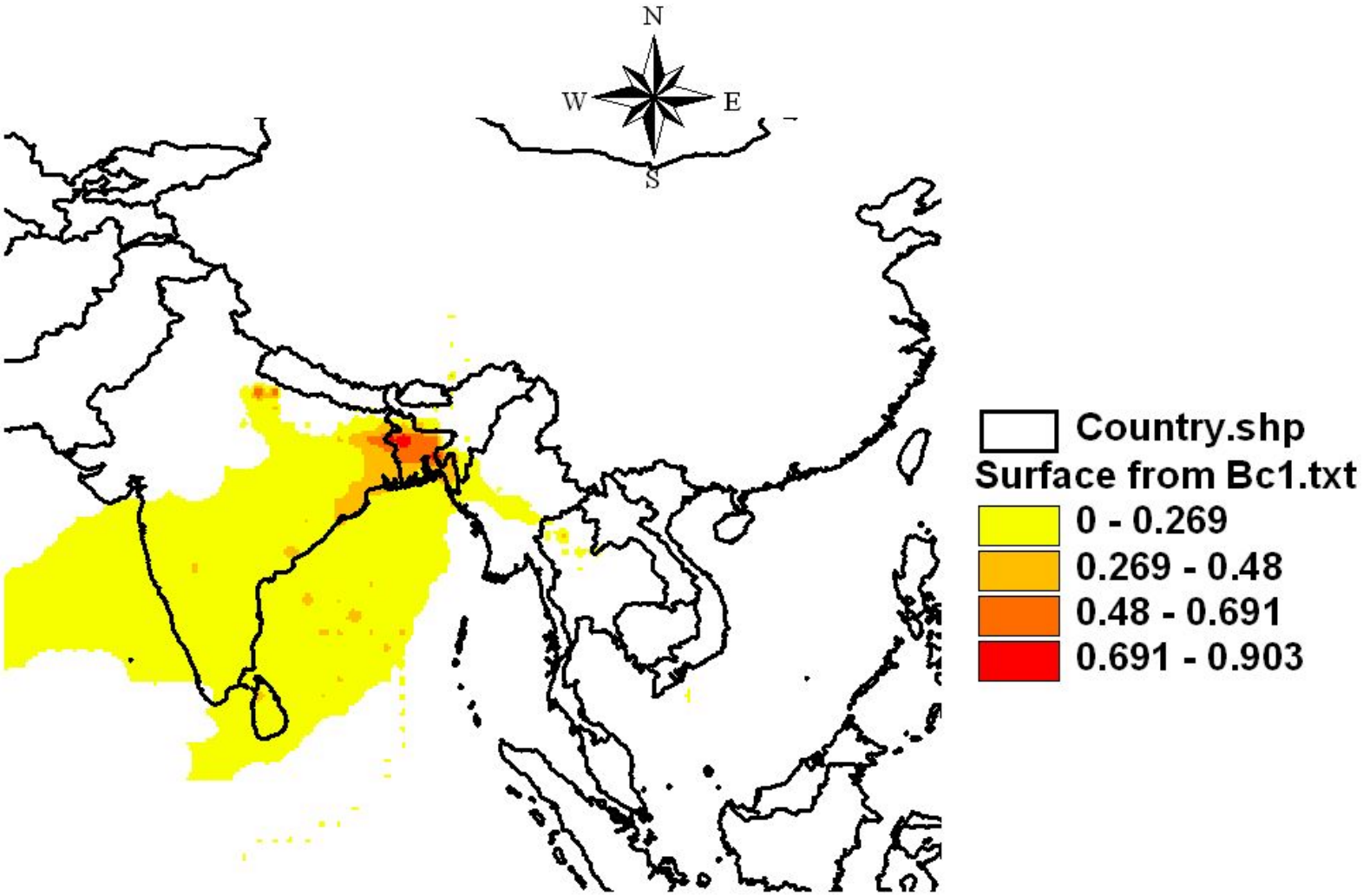
PSCF:BC (May 2001 to March 2005)



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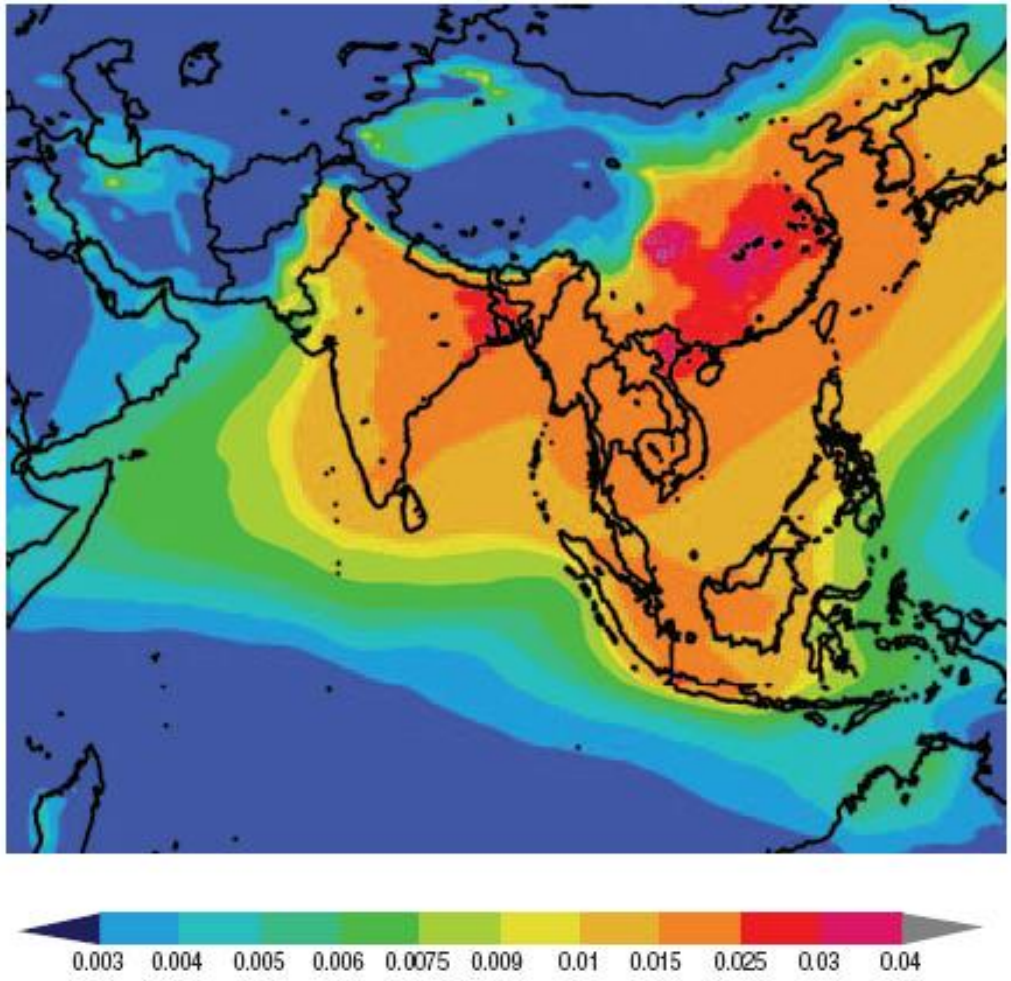
The simulated annual mean optical depth of BC aerosols for 2004-2005 using the regional aerosol/chemical/transported model described by Ramanathan and Carmichael, Nature GeoScience, 1, 221-227 2008.



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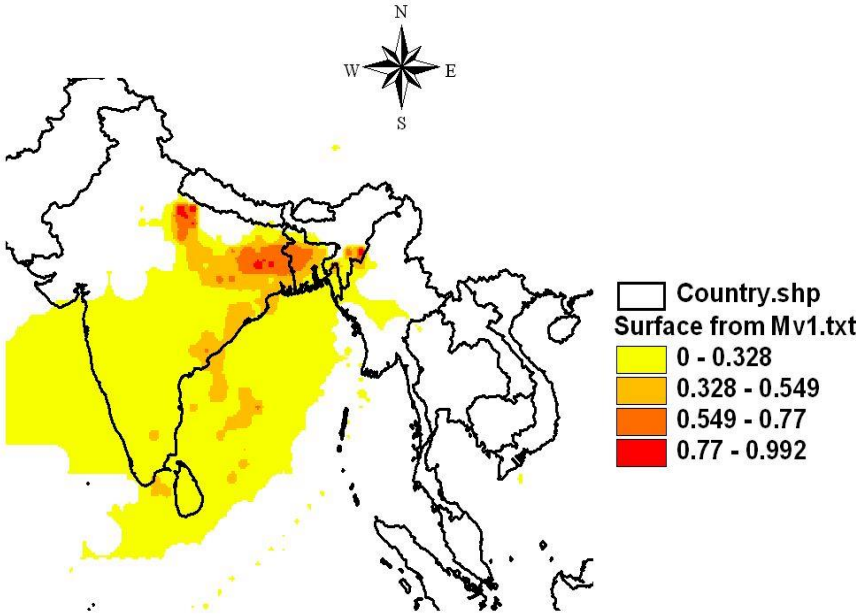
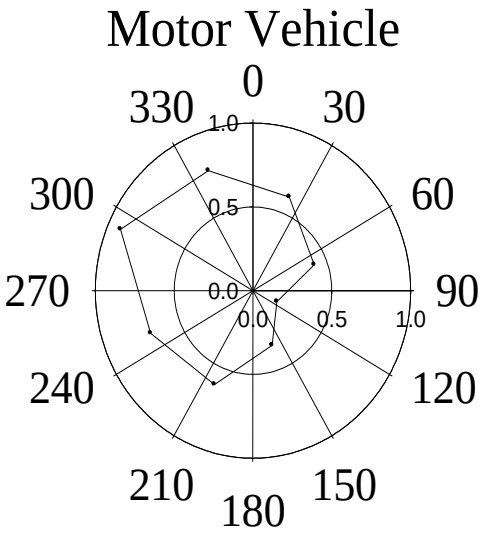
PSCF: MV


N
W
E
S
Country.shp
Surface from Mv1.txt
0 - 0.328
0.328 - 0.549
0.549 - 0.77
0.77 - 0.992


Motor Vehicle
0
30
60
90
120
150
180
210
240
270
300
330
1.0
0.5
0.0
0.0
0.5
1.0

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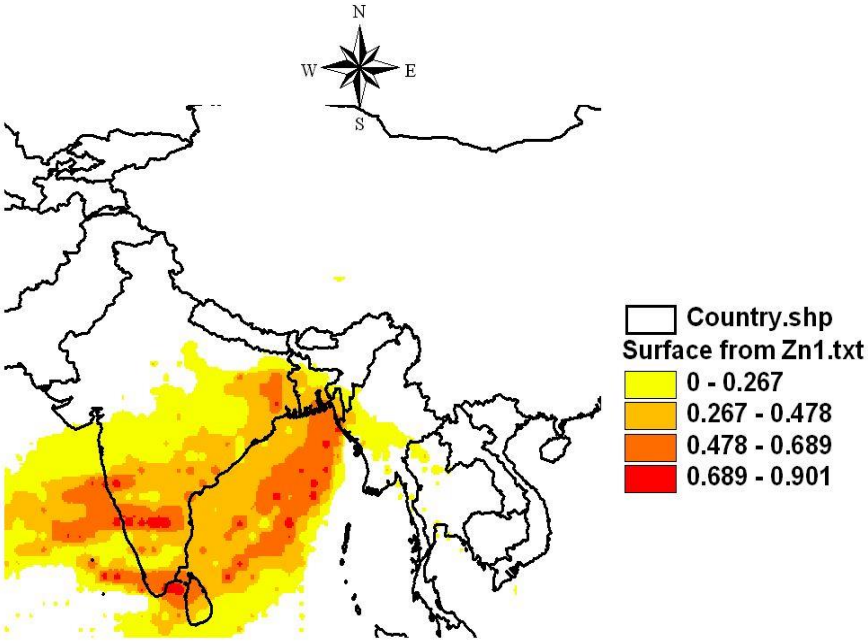
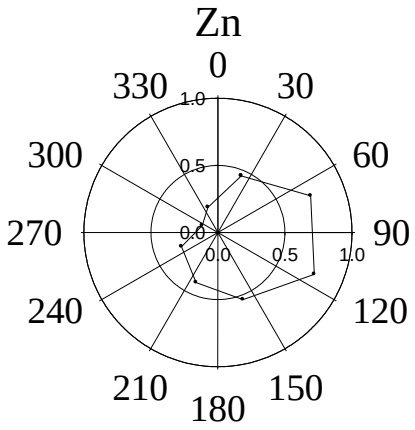
PSCF: Zn


N
W
E
S
Country.shp
Surface from Zn1.txt
0 - 0.267
0.267 - 0.478
0.478 - 0.689
0.689 - 0.901


Zn
0
30
60
90
120
150
180
210
240
270
300
330
1.0
0.5
0.0
0.0
0.5
1.0

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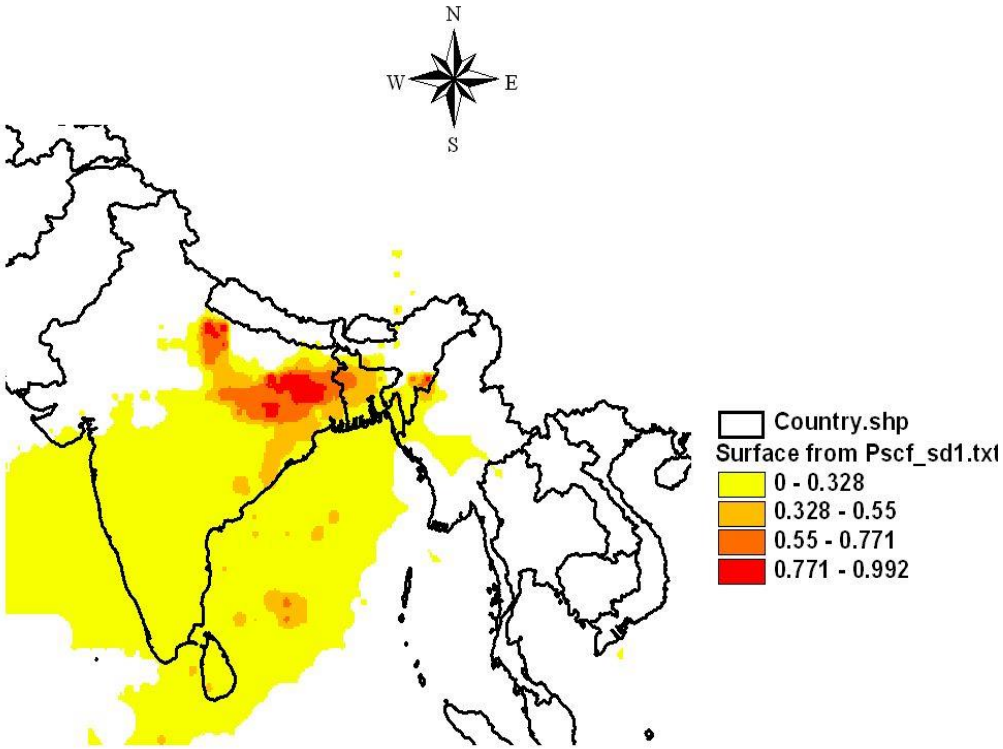
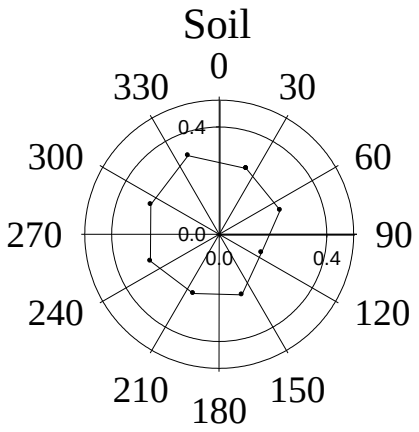
PSCF: Soil dust





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List of Publications

1. Swapan K. Biswas, S.A. Tarafdar, A. Islam and M. Khaliqu-zzaman, Investigation of Sources of Atmospheric Particulate Matter (APM) at an Urban area in Bangladesh, Technical Report, AECD/CH/55, **2001.**
2. Swapan K. Biswas, A. Islam, S.A. Tarafdar and M. Khaliquzzaman , Consequences of Introducing Unleaded Gasoline in Bangladesh, Proc. Int. Seminar on Air Pollution in Dhaka City, 30 October **2001.**
3. Swapan K. Biswas, Further studies and Action essential to reduce atmospheric lead in Dhaka The Daily Star, 25 October **2002**.
4. Swapan K. Biswas, S.A. Tarafdar, A. Islam, and M. Khaliquzzaman, H. Tervahattu, K. Kupiainen, Impact of Unleaded Gasoline Introduction on the Concentration of Lead in the Air of Dhaka, Bangladesh, ***J. Air & Waste Manage. Assoc.*** **2003**, **53** 1355–1362
5. Swapan K. Biswas, Bilkis A. Begum, M. Khaliquzzaman, A. Islam and S.A. Tarafdar, Characterization of Air pollution at urban sites at Dhaka and Rajshahi in Bangladesh, Proceedings of the Silver Jubilee Conference, **2003**, ***Bangladesh Chemical Society.***
6. Bilkis A. Begum, Eugene Kim, Swapan K. Biswas, and Philip K. Hopke, Investigation of sources of atmospheric aerosol urban and semi-urban areas in Bangladesh by positive matrix factorization, ***Atmospheric Environment***, **2004**, **38**, 3025-3038.

List of Publications cont'd

7. Bilkis A. Begum and Swapan K. Biswas, Characteristics of PM2.2 and PM2.2-10 in the Atmosphere of Dhaka City, ***Nuclear Science and Applications***, **2004**, **13**, 9-19.
8. Shahana Akhter, Md. Aminul Islam, A.K. Showkot Hossain, S.M. Abdul Quadir, Amir H. Khan, Bilkis A. Begum, M. Khaliquzzaman, Swapan K. Biswas, Air Quality Monitoring program in Bangladesh: Trends Analysis of Criteria Pollutants and source apportionment of particulate matter in Dhaka, Bangladesh***, CAI-Asia web site, baq2004.org,*** **2004.**
9. Bilkis A. Begum, Swapan K. Biswas, Eugene Kim, Philip K. Hopke and M.Khaliquzzaman, "Investigation of sources of atmospheric aerosol at a hot spot area in Dhaka, Bangladesh", ***J. Air and Waste Management Association***, **2005**, **55**, 227-240.
10. Pentti Paatero, Philip K. Hopke, Bilkis A. Begum**,** Swapan K. Biswas, A graphical diagnostic method for assessing the rotation in factor analytical models of atmospheric pollution, ***Atmospheric Environment,*** **2005, 39,** 193-201.
11. Bilkis A. Begum and Swapan K. Biswas, Comparison of PM collection efficiency of Gent and Airmatrics MiniVol Portable Air Sampler, ***Nuclear Science and Applications***, **2005**, **14**, 79-83.
12. Bilkis A. Begum and Swapan K. Biswas, Receptor modeling for characterization of Air Particulate Matter, Technical Report, AECD/CH/59, **2005**

List of Publications cont'd

13. Bilkis A. Begum, Swapan K. Biswas, P.K. Hopke, Temporal variations and spatial distribution of ambient PM2.2 and PM10 concentrations in Dhaka, Bangladesh, ***The Science of the Total Environment***, **2006**, **358**, 36-45.
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Thanks