7th Regional Stakeholders Meeting Cum Coordination Meeting

Presented by
Dr. Bilkis A. Begum

19 May 2013

Impact of air pollution on visibility

The Great Smog of 1952 darkened the streets of London and killed approximately 4,000 people in the short time of 4 days (a further 8,000 died from its effects in the following weeks and months)
Smog is a mixture of Gaseous SO2 and Particulate Aerosols
If Smog is a yellowish or blackish fog, it would be formed by a mixture of particulates and ground level ozone.

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Impact of air pollution on visibility

Smog in New York City as viewed from the World Trade Center in 1988

Beijing air on a day after rain (left) and a smoggy day (right)

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Impact of air pollution on visibility

- **The visibility worsens during winter months.**
- **Almost in every winter months, we saw a dense smog episode that contributed to flight delays and a virtual halt of steamer movement in the rivers surrounding Dhaka.**

Reduced visibility due to smog in Dhaka during winter (left picture) compared to clear visibility during monsoon (right picture)

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Identification of Haze Creating Sources from Fine Particulate Matter in Dhaka Aerosol using Carbon Fractions Data

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Air Quality Parameters

- **PM (PM_{10}, $PM_{2.5}$)**
- **SO_x**
- **NO_x**
- **CO**
- **Ozone**
- **Trace elements in PM's etc.**

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Impact of Air Pollution

-Health Effect
-Visibility
-Production of crops
-Climate change

National Ambient Air Quality Standards for Bangladesh

Pollutant	Objective	Average
CO	10 mg/m^3(9 ppm)	8 hours
	40 mg/m^3(35 ppm)	1 hours
Pb	0.5 µg/m^3	Annual
NO_2	100 µg/m^3	Annual
PM_{10}	50 µg/m^3	Annual
	150 µg/m^3	24 hours
$PM_{2.5}$	15 µg/m^3	Annual
	65 µg/m^3	24 hours
O_3	235 µg/m^3	1 hours (d)
	157 µg/m^3	8 hours
SO_2	80 µg/m^3	Annual
	365 µg/m^3	24 hours

- ***The most serious pollutant of concern in Bangladesh, especially in cities, is the particulate matter (PM)***

- ***Experience in Dhaka, Bangladesh***

Air quality status in Dhaka

- Assessment of impact of different policy interventions (such as, unleaded gasoline, banning of two-stroke baby taxis, CNG adaptation)
- Assessment of ambient air quality particularly PM in Dhaka city
- Identification of potential sources, source locations
- Identification of haze creating sources from FPM
- Evidence of long range transport

Adaptation of policies taken by the Government to reduce the PM emission from motor vehicle

These are

- **banning of use leaded gasoline from July 1999**
- **improved training of engine mechanics, import and marketing of mineral oil without additives and set minimal standards for lubricants**
- **banning of two-stroke three-wheel taxis from January 2003 and removal of trucks and buses that were more than 20 years old**
- **a phased reduction of gasoline-powered by introducing CNG, &**
- **electronic traffic signals to increase the mobility of vehicles**.

Sample collection (*Research*)

Sampling locations

CAMS-2: Farm Gate area in Dhaka, a hot spot with very high pollutant concentrations because of the proximity of major roadways, latitude 22.22N, longitude 91.47E), 2000

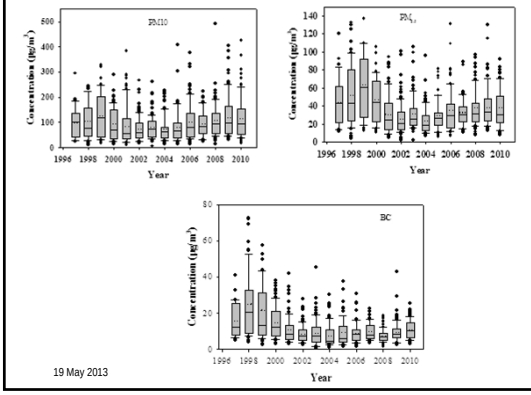
SR: Semi-residential (AECD) area, which is located within the Atomic Energy Centre, Dhaka University Campus with relatively less traffic, latitude 23.73N, longitude 90.38E, 1996

Sampler: **Air Metrics and GENT** type sampler

Method of Analysis
Mass by weighing
BC by Reflectance measurement
Carbon fraction analysis by carbon analyzer
Elemental Concentration by PIXE & XRF

Location of sampling site at Dhaka

Variation of concentration with time



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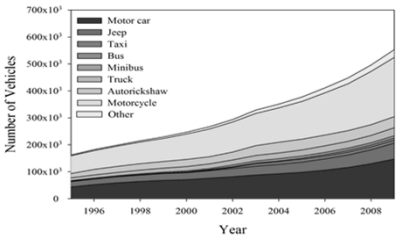
Year-by-year registration of vehicles in Dhaka City (Source: Bangladesh Road Transport Authority, 2010)



Truck & Motor cycles = 54% of the total fleet

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Brick Industry

Brick Production

15 billion bricks per year with an annual growth of about 7-8% & contributes 1% of the GDP. It consumes 2.2 million tons of coal and 1.9 million tons of fire wood.

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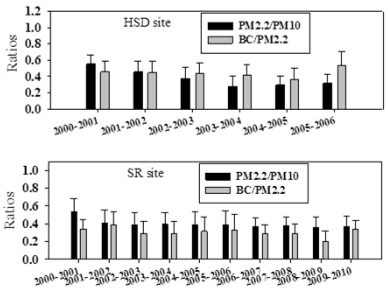
Ratios of PM2.2/PM10 and BC/PM2.2 over the collection periods from April 2000 to March 2006 and April 2000 to March 2010 at HS and SR sites



Hence, control of emission from the combustion sources is good achievement of policies adaptation

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Average source contributions derived from the PMF modeling

Source	Fine PM samples (µg/m³)					
	2001-2002		2005-2006		2007-2009	
	Mass	BC	Mass	BC	Mass	BC
Motor vehicle	*7.16*	*2.50*	*5.62*	*0.38*	*12.1*	*0.02*
Brick kiln	*2.23*	*1.37*	*11.1*	*4.14*	*7.59*	*7.41*
Metal smelter	1.87	0.00	1.94	0.53	-	-
Sea salt	0.19	0.00	0.60	0.00	2.12	0.00
Two Stroke/Zn	*1.75*	*1.11*	1.94	1.07	*1.49*	*0.62*
Soil dust	1.92	0.0	2.74	0.18	3.21	0.02
Road dust	3.63	1.63	5.14	1.09	4.97	0.57
Fugitive Pb			-	-	2.22	0.01
RM	*18.7*	*6.61*	*29.1*	*7.38*	*33.7*	*8.12*
MM	*22.1*	*7.90*	*30.5*	*9.23*	*37.3*	*8.21*

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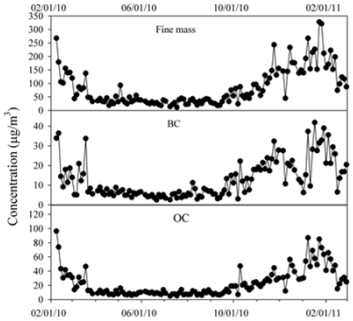
Variation of PM fraction (FPM), black carbon (BC) and organic carbon (OC) during 2010-2011 period



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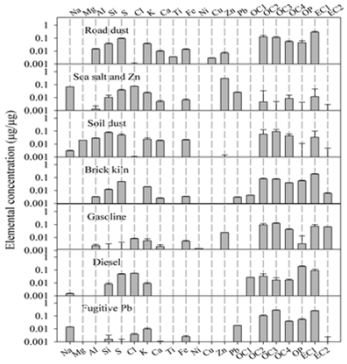
Source composition profiles for fine particulate matter using fractions of OC and EC



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Average source contributions (μg/m3)derived from the PMF modeling

Source	Modeling with OC & EC			Modeling with fraction of OC &EC		
	Mass	OC	EC	Mass	OC	EC
Road dust	3.34	0.57	0.50	6.59	1.91	1.92
Sea salt & Zn	3.21	0.00	0.00	4.42	0.26	0.05
Soil dust	14.5	4.40	2.39	4.03	0.78	0.14
Motor vehicle	36.0	9.28	3.01			
Brick kiln	24.5	7.95	6.29	31.2	7.91	5.99
Gasoline				5.39	1.40	0.75
Diesel				16.8	4.73	1.54
Fugitive Pb				7.9	3.77	1.98

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Which sources are related to worsen the Visibility

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Aerosol Extinction coefficient from visibility observations

- ***According to the Koschmieder (1926) theory, the visual range of an object viewed against the horizon sky, VR (km), is inversely proportional to the horizontal extinction coefficient, $B_{ext}(km^{-1})$,***
  $B_{ext}=K/VR$.
- ***Where K=Koschmieder constant which is equal to 3.92 (real target is not black, small, angular in size)***

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Visibility

- **Particle size depends on**
  -Particle composition
  -Relative humidity
- **Reflective Index**
  -Particle composition

Thus, particle composition is a key determinant of extinction

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Means and standard deviations of visibility, and extinction efficient in different season during study period

Season	Visibility	B_{ext}
	Km	Km^{-1}
Pre-monsoon	5.14±0.45	0.76 ±0.07
Monsoon	5.46±0.38	0.72 ±0.05
Post-monsoon	4.93±0.68	0.81 ±0.11
Winter	3.34±0.01	1.34 ±0.70

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Results of the Stepwise Multiple Linear Regression Analyses

Source	Coefficient Estimate (m^2/g)	Standard Error (m^2/g)	T Statistic	P-Value
Road dust	62.1	10.1	6.18	0.00
Brick kilns	6.60	1.00	6.42	0.00
Gasoline	27.2	5.60	4.88	0.00
Diesel	6.80	1.10	6.11	0.00
Pb	7.80	3.20	2.39	0.02

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Long Range Transport

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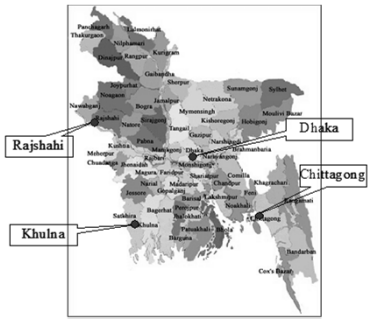
Map of sampling locations in Bangladesh



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Seasonal variation of $PM_{2.5}$ (µg/m3) in four stations

Year	Season	Rajshahi	Dhaka	Khulna	Chittagong
		Mean±STD	Mean±STD	Mean±STD	Mean±STD
2010-11	Monsoon	-	**30.3 ±11.6**	-	-
	Post-monsoon	127 ±66.4	68.6 ±32.7	51.3 ±29.3	-
	Winter	**277 ±94.0**	**104 ±49.8**	**120 ±72.9**	**113 ±47.4**
2011-12	Pre-monsoon	143 ±79.6	50.0 ±35.5	42.5 ±28.9	56.6 ±39.4
	Monsoon	**55.4 ±26.5**	**26.8 ±10.5**	**19.6 ±11.8**	**11.7 ±2.32**
	Post-monsoon	109 ±31.8	65.8 ±21.4	63.1 ±37.8	60.5 ±45.9
	Winter	**271 ±140**	**101 ±23.6**	**84.6 ±52.6**	**33.7 ±0.71**
2012	Pre-monsoon	151 ±77.5	39.1 ±23.1	-	-
	Monsoon	**100 ±28.2**	**41.3 ±11.1**	-	-

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The mean, standard deviation and threshold value of fine PM and BC concentrations (µg/m3) during sampling period

Parameter	Statistics	Rajshahi	Dhaka	Khulna	Chittagong
Fine PM	Mean	155	65.1	64.7	73.3
	Median	121	56.0	52.0	74.2
	STD	112	41.2	56.8	50.7
	Threshold Value	379	147	178	175
BC	Mean	13.1	7.20	5.84	4.32
	Median	10.8	7.40	5.20	3.32
	STD	7.05	3.31	3.58	2.67
	Threshold Value	27.2	13.8	13.0	9.66

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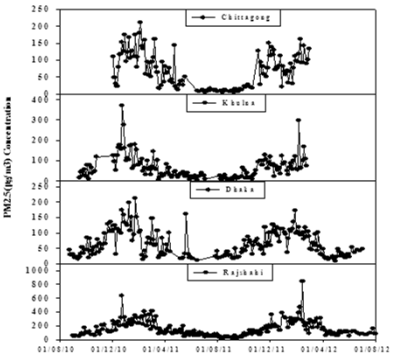
Variation of PM2.5 concentrations with time in four cities



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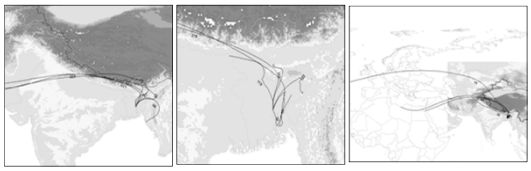
Air parcel movement (Backward trajectory)



***Typical wind directional pattern during December, January and February respectively (*During the winter time wind mainly comes from northwest direction, e.g. Dhaka)**

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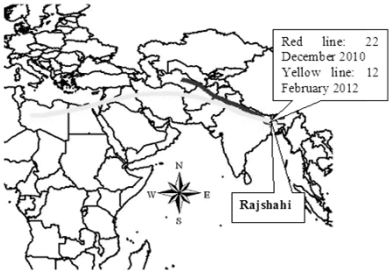
Air parcel backward trajectories showing the long range transport of fine PM



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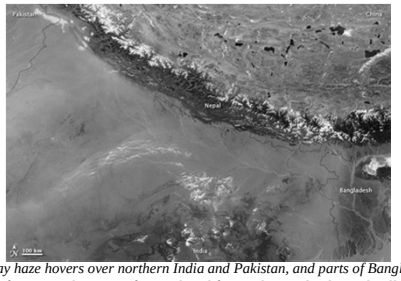
Pollution and fog mixed at the base of the Himalayas in India in early December 2010

http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=47742



Dull gray haze hovers over northern India and Pakistan, and parts of Bangladesh which results from a combination of agricultural fires, urban and industrial pollution, and a regional temperature inversion.

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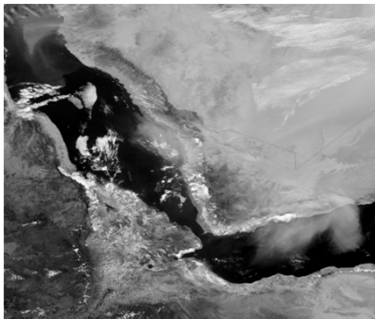
Dust storm over the Arabian Peninsula

http://thewatchers.adorraeli.com/2012/02/06/dust-storm-in-saudi-arabia



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Transboundary Evidence

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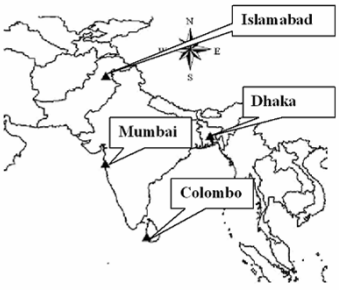
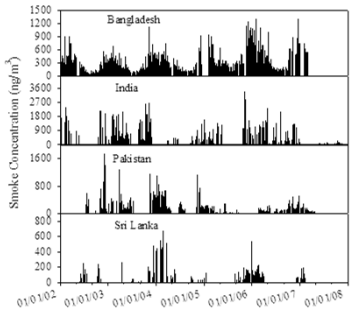
Sampling sites of Neighboring Countries



5 September 2013

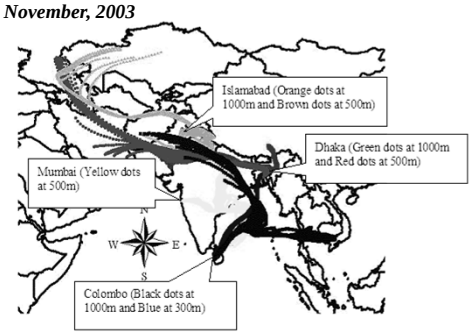
Time series plots of fine Smoke contribution



5 September 2013

Air parcel back trajectories showing the likely sources areas for smoke

3 to 15 November, 2003



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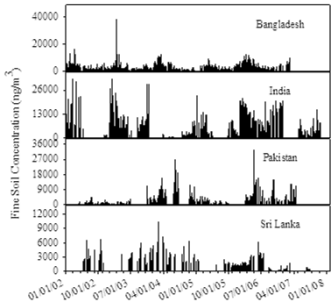
Time series plots of fine soil concentrations in Bangladesh, India, Pakistan and Sri Lanka



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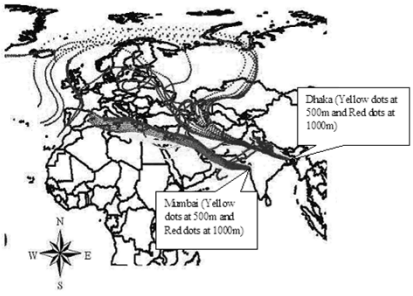
Air parcel back trajectories showing long range transport of soil dust in Bangladesh and India in February 2003



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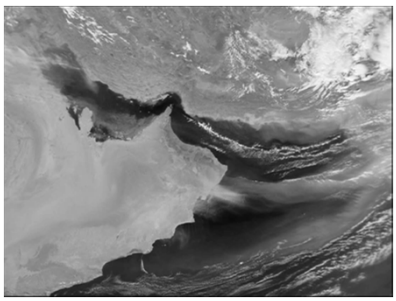
Thick plumes of desert dust blew over Oman and across the Gulf of Oman toward Iran and Pakistan on February 18 2003. (http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=10917)



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HAZE OCCURRED IN SINGAPORE IN OCTOBER 2006, AND WAS CAUSED BY SMOKE FROM FIRES IN INDONESIA BEING BLOWN BY SOUTH-WESTERLY WINDS.

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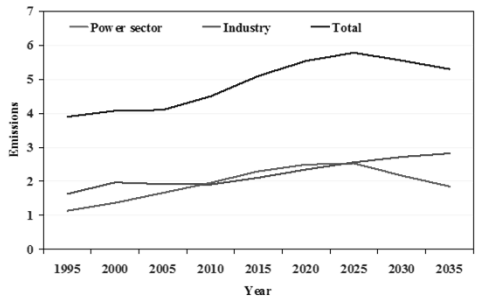
SO_2 Emissions (Million Tons) (India)



Ref: 7th AIM International Workshop, NIES, Tsukuba, Japan, March 15-17, 2002

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Conclusions

To address the air pollution issues locally

a) Emission from Motor vehicles

b) Reduction of soil dust including road dust from road and

c) Replacement of existing brick kiln with energy efficient and environment friendly brick production technology, cook stove and rice parboiling system.

It is also necessary to address the air pollution issues regionally due to Transboundary Effect which increase local air pollution

a) Coal-fired power plants in India using high S coal in India

b) Similar problem with BC, biomass/agricultural waste

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Thank You

END

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