Influence of Asian Monsoon on the Trend, Chemical Composition, and Emission Sources of PM$_{2.5}$ in Bangladesh

Abdus Salam
Department of Chemistry
University of Dhaka
Dhaka – 1000, Bangladesh

3rd International Workshop on Atmospheric Composition and the Asian Monsoon (ACAM), 5-9 June 2017, Guangzhou, China
Overview of the Air Pollution Situation in Bangladesh

- Bangladesh is one of the densely populated country in the World with about 170 million people within about 144 thousand Km² area. GDP growth is about 6% - Economy is transferring from agriculture to industry.
- Capital Dhaka (with a population of about 17 million) and other cities (e.g., Narayangonj, Gazipur, etc.) in Bangladesh are in the top ranking cities for worst air quality by WHO.
- Sources of air pollution are mainly Traffics emission, Brick kilns, Industries, Constructions, Power plant, Biomass burning and Long range transport.
- Thousands of people were died each year in Bangladesh for both indoor and outdoor air pollution.
- Air pollution cost about 1% of our GDP growth.
## DEATH FROM POLLUTION, FORGONE LABOUR OUTPUT, TOP 10 COUNTRIES

<table>
<thead>
<tr>
<th>Country</th>
<th>TOTAL DEATHS FROM AIR POLLUTION 2013</th>
<th>Men annual ambient pm2.5 (OG/M3) 2013</th>
<th>TOTAL FORGONE LABOUR OUTPUT 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>16,25,164</td>
<td>54.36</td>
<td>44,567</td>
</tr>
<tr>
<td>India</td>
<td>14,03,136</td>
<td>46.68</td>
<td>55,390</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1,62,410</td>
<td>14.77</td>
<td>11,899</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1,56,191</td>
<td>46.18</td>
<td>6,582</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>1,54,898</td>
<td>48.36</td>
<td>2,579</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>1,04,379</td>
<td>14.23</td>
<td>8,604</td>
</tr>
<tr>
<td>Nigeria</td>
<td>97,248</td>
<td>29.51</td>
<td>7,338</td>
</tr>
<tr>
<td>United State</td>
<td>91,045</td>
<td>10.75</td>
<td>18,127</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>71,018</td>
<td>17.6</td>
<td>793</td>
</tr>
<tr>
<td>Vietnam</td>
<td>66,314</td>
<td>25.47</td>
<td>1,557</td>
</tr>
</tbody>
</table>
Year of Bangladesh can be divided into four seasons:

- Pre- monsoon (March-May)
- Monsoon (June-September)
- Post monsoon (October-November)
- Winter (December-February)

Average temperatures are varying:

- Between 8°C and 25°C in winter
- Between 25°C and 39°C in summer

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Map of Bangladesh showing two red cycles for two observatories (Dhaka and Bhola) operated by the Department of Chemistry, University of University.

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Dhaka Station (N 23° 43’ 40”; E 90° 23’ 52, 34.0 m asl)

NASA AERONET Sunphotometer,

PM$_{10}$ and PM$_{2.5}$ Sampler, Hi vol TSP Sampler,

Real time PM sampler (mass and number concentrations)

Gas analyzer

SPARTAN PM$_{2.5}$ and Nephelometer
Bhola Observatory

- About 1 km far from nearby roads
- No industrial emission
- Very low traffic emission
- Biomass burning for cooking and agricultural activities, fertilizers, etc
- Long range transports during winter

Bhola is an Island of the Bay of Bengal. It is most southern part of the country and also the biggest Island of Bangladesh. It is about 300 km far the capital city.

Latitude: N 22°10'01", Longitude: E 90°45' 00", Elevation: 10.0 meters.

Instruments: NASA Aeronet Sunphotometer, TSP sampler, Digitel PM$_{2.5}$ Sampler, CO monitor
Sources of air pollution: Traffic Emissions

- 20 years old vehicle banned
- Ban of leaded gasoline
- Trying to use low sulfur content fuel
- Improvement of traffic signals
- Ban of track and heavy duty vehicle during day time
- Change of holidays for shopping malls
- Change of routes of different bus lines

Severe traffic jams in the street of Dhaka
Brick kilns emissions

Coal is the main fuel for the brick Kilns, power plant, rice mills.

About 1200 hundreds in and around Dhaka mega city; and about 6000 brick kilns are in all over Bangladesh.

Coal has also high sulfur and Hg.

- Ban of biomass burning in the brick kilns
- Stack height not less than 120 ft
- Phase out of traditional kilns to relatively modern kilns (Hoffman, Zig Zag, Tunnel kilns.)
- Rules for not cutting soil from agricultural land or from hills.
- Rules also for setting the kilns location
Other Sources of Air Pollution in Bangladesh
PM$_{2.5}$ and PM$_{10}$ at Four Cities in Bangladesh

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Variation of PM$_{2.5}$ between 2014 and 2016 in Bhola, Bangladesh
Average CO concentrations from 2013 to 2016 in Dhaka, Bangladesh
Day and Night variation of monthly average CO concentrations in Dhaka, Bangladesh
# Carbonaceous species concentrations on 2003 and 2014 in Dhaka and Bhola

<table>
<thead>
<tr>
<th></th>
<th>Urban Dhaka (µgm$^{-3}$)</th>
<th>Rural Island Bhola (µgm$^{-3}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2003 (TSP)</td>
<td>2003 (TSP)</td>
</tr>
<tr>
<td></td>
<td>2014 (PM$_{2.5}$)</td>
<td>2014 (PM$_{2.5}$)</td>
</tr>
<tr>
<td>EC</td>
<td>22.0</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>2.80</td>
<td>0.60</td>
</tr>
<tr>
<td>OC</td>
<td>45.7</td>
<td>4.60</td>
</tr>
<tr>
<td></td>
<td>40.2</td>
<td>2.20</td>
</tr>
</tbody>
</table>

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Water Soluble ions in PM$_{2.5}$ composition in Dhaka, Bangladesh

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Water Soluble ions in PM$_{2.5}$ composition in Bhola, Bangladesh

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AOD in October and November

Dhaka

Bhola
AOD in February

Dhaka

Bhola
Influence of Monsoon on AOD values in Bangladesh

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Influence of monsoon on PM$_{2.5}$ in Bangladesh

PM$_{2.5}$ (μg/m$^3$)

Rainfall (mm)

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

0  100  200  300  400  500  600

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Conclusion

- Very high concentrations of particulate matters ($\text{PM}_{2.5}$ and $\text{PM}_{10}$) were observed both in Urban and Rural areas in Bangladesh.
- Long range transported air mass has significant impact on the air quality in Bangladesh.
- CO concentrations were lower than WHO limit value. The day time concentrations were lower than night times in Dhaka.
- AOD values at the coastal Bhola is one of the highest as a rural location during winter time, even higher at the end of winter (in February) due to change of wing direction.
- Monsoon has drastically reduce the pollution levels (CO, AOD and $\text{PM}_{2.5}$) in Bangladesh.
Our Collaborations

AERONET
AEROSOL ROBOTIC NETWORK

Department of State
United States of America

StratoClim

Stockholm University

ARCADIS
Infrastructure Water Environment Buildings

ICIMOD

Office of Naval Research
Science & Technology

CNR

Universiti Kebangsaan Malaysia
National University of Malaysia

TU Wien

SPARTAN: A Global Network to Evaluate and Enhance Satellite-Based Estimates of Ground-level Particulate Matter for Global Health Applications
Our Group Members
Thanks!