Perspectives of SPARTAN from Dhaka, Bangladesh: Atmospheric Pollutions, Monitoring and Characterizations

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Background

- Bangladesh is a Southeast Asian country with very high population (about 200 million) within very small active land area. Economy has shifting from agriculture to industries.

- Megacity Dhaka is also the topmost polluted city in the world causing serious health problem. The estimated costs is up to 7.4% of GDP growth (about $14 billion loss and 96,000 premature deaths annually).

- Air quality during wintertime in Dhaka is extremely poor, where the levels of PM$_{2.5}$ is frequently exceeding the WHO 24-hour guideline value (5 µgm$^{-3}$) by a factor of up to 100.

- Sea level rise due to 1.5ºC increase of global temperature will result into inundation of a large area of Bangladesh, soon forcing rehabilitation of about 41 million people from the southern coastal areas.
Rapid Urbanization with Insufficient Planning, Modern Lifestyle, Changes the economy Changes from Agriculture to Industries.
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<td>39.2</td>
<td>44.5</td>
<td>54.1</td>
<td>29,136,808</td>
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Major Sources of Air Pollution in Bangladesh

1). Traffic emission
2). Indoor cooking – Natural gas or biomass
3). Garbage or agricultural waste burning
4). Industrial Emission – Brick kilns and others
5). Construction activities
6). Regional transported pollution
7). Street dusts
Atmospheric Chemistry Research Group, Department of Chemistry, University of Dhaka, Bangladesh.

Operating two observatories (Urban Dhaka and regional background coastal Island of the Bay of Bengal - Bhola).

25 People (PhD/MS/4th Year Projects students/research associates/faculties) are working in our group on different aspects of atmospheric chemistry and air Quality.

Planning to establish one more station at the most northern part of the country - Dinajpur.
Bhola Observatory - Island of the Bay of Bengal Observatory
AirPhoton Devices from SPARTAN Network in Dhaka, Bangladesh
Air quality monitoring Network in Bangladesh and Southeast Asia with Duke University supported by US State Department
Transported airmass strongly affect the air quality in Bangladesh during winter period from November to February - regional haze transported from IGP region to the Bay of Bengal passing over Bangladesh. Sometimes PM$_{2.5}$ goes up to 500 µg m$^{-3}$. 
Diurnal profiles at Darus-Salam for November to March: (a) PM2.5 concentrations and (b) ERA5 boundary layer heights. The box plots show median, interquartile range, data range, and outliers. Stars show hours with values above the y axis (7 for PM$_{2.5}$, 14 for boundary layer height)
Trend of PM$_{2.5}$ with strong seasonal variation
Long-term Trends of Gaseous Pollution in Dhaka

Figure 1. Mean PM$_{2.5}$ mass concentrations at SPARTAN sites with standard error bars shown. Overlaid green bars show total measured trace metal mean mass concentrations for each site.

Figure 4. Concentrations of As in PM$_{2.5}$ samples taken from SPARTAN sites, with standard deviation bars shown. Dotted red line represents 1:100,000 excess lifetime risk of cancer due to As exposure (6.6 ng/m$^3$). Dotted black line represents 1:1,000,000 excess lifetime risk of cancer due to arsenic exposure (0.66 ng/m$^3$).
Brick kilns Emissions

Table 3  Pollutant measurements from stack emission of three types of kilns in Greater Dhaka region, Bangladesh. All units are in mg/m³

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>FCK</th>
<th>Zig-zag</th>
<th>Hoffmann</th>
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<td>BC</td>
<td>$16.6 \pm 7.1$</td>
<td>$11.8 \pm 4.2$</td>
<td>$8.9 \pm 4.4$</td>
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<tr>
<td>PM$_{2.5}$</td>
<td>$141 \pm 86$</td>
<td>$128 \pm 72$</td>
<td>$109 \pm 53$</td>
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<tr>
<td>CO$_2$</td>
<td>$525 \pm 201$</td>
<td>$699 \pm 267$</td>
<td>$2350 \pm 783$</td>
</tr>
<tr>
<td>CO</td>
<td>$264 \pm 75$</td>
<td>$177 \pm 81$</td>
<td>$74 \pm 21$</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>$578 \pm 354$</td>
<td>$332 \pm 196$</td>
<td>$316 \pm 219$</td>
</tr>
<tr>
<td>VOC</td>
<td>$2320 \pm 2560$</td>
<td>$25266 \pm 3563$</td>
<td>$22939 \pm 2760$</td>
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<tr>
<td>NO$_x$</td>
<td>$0.74 \pm 0.63$</td>
<td>$1.6 \pm 0.75$</td>
<td>$1.2 \pm 0.58$</td>
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</table>

All samples are presented in their averaged values from specific kilns.
Toxicity potential (TP) values of indoor air quality indicators of PM$_{2.5}$ and PM$_{10}$ at post-monsoon and winter seasons at three different hospitals in Dhaka, Bangladesh, during 2019/2020.

Toxicity Potential (CP)

The Toxicity Potential (TP) is defined as:

\[ \text{Toxicity Potential (TP)} = \frac{C_p}{S_p} \]  \hspace{1cm} (1)

Here $C_p$ is the measured concentrations of the pollutants and $S_p$ is the standard guideline value of 25 $\mu$g$^{-3}$ for PM$_{2.5}$ and 50 $\mu$g$^{-3}$ for PM$_{10}$ (WHO 2006).
Evolution of economic burden (% GDP attributed to ambient air pollution) associated with criteria pollutants PM$_{2.5}$, PM$_{10}$, CO, O$_3$, NO$_2$, and SO$_2$ in Dhaka for 2008-2019 of people aged 15-64 years.
Research Collaboration/Funding Support

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

Department of State
United States of America

College of Engineering
University of Wisconsin–Madison

Duke University

University of Surrey

University of Bristol

Akita Prefectural University

NASA

AERONET AEROSOL ROBOTIC NETWORK

Stockholm University

Academia Sinica
Group Members in our Atmospheric Chemistry Research Laboratory, Department of Chemistry, University of Dhaka, Bangladesh
Thanks