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# Fog and Aerosol Chemical Characteristic of Bangladesh During Winter Season

Mohammad Shohel* [a], Abdus Salam[a] , Hasina akter simol[b]
[a] Department of Chemistry, University of Dhaka, Dhaka-1000, Bangladesh
[b] Centre for advance research in science, University of Dhaka, Dhaka-1000, Bangladesh
*Email: shohel.wahid@gmail.com

## Introduction:

Fog is a lower atmospheric, near surface cloud, which is caused by a suspension of water droplets and is associated with visibility less than 1,000 m. Fog plays an important role in many environmental and ecological processes. Aerosols are responsible for heterogeneous nucleation through water drops, which is crucial for the formation of fog and other related phenomenon. Widespread fog formation during early morning and afternoon hours over Indo-Gangetic plains (IGP) is common phenomena during winter season. Atmospheric aerosols play an important role in perturbing earth's climate. The properties of aerosols such as size and chemical composition have a strong impact on the occurrence of fog. The physico-chemical interactions among gas particles and fog droplets can influence the composition of fog droplets. So, although fog cannot provide water quantities comparable to rain, but chemical composition of fog water can provide us with important information about the condition of lower atmosphere.

Fig.1: Terra-MODIS image (4:15 UTC, 8-01-2015) Centered at Dhaka showing fog over Bangladesh.

## Experimental:

Particulate materials(PM) were collected from two different locations of Bangladesh: Dhaka(23˚43'40" N, 90˚23'52" E) & Bhola(22˚10'01" N, 90˚45'00" E). Fog samples were collected from Bhola. Two locations are 177 km apart from each other. Dhaka is a mega-city and capital of Bangladesh. Bhola is an island of Bay of bengal.

Particulate material(PM) were collected with air particulate matter sampler (equipped with poly-carbonate filter holders system) on Quartz membrane filters during December to March, 2015. The average sampling period was approximately 24 hours (9:00 am-9:00 am). Fog samples were collected in a cylinder made of stainless steel during December to January, 2015. The cylinder was placed on the roof of a tower (height=18 meter) at every night. Due to the lower temperature at night, the fog water was naturally precipitated ,condensed and collected inside the cylinder.

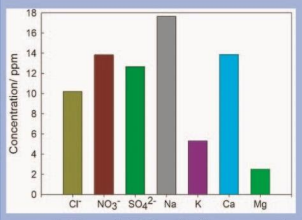
Concentration of water soluble anions & metals in fog water was determined by ion chromatography & Atomic Absorption Spectroscopy (AAS), respectively. The aerosol optical depth(AOD) was determined by Sun photometer (Aeronet, NASA).

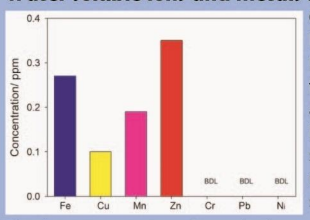

Fig.2 : Sampling location (marked by yellow board pin)

## Physical properties of fog water:

| Properties | Value/ Observation | Comments |
|---|---|---|
| pH | 6.91 (min= 6.64, max= 7.18) | Fog water was acidic in nature but in few case slightly basic |
| Electrical Conductivity (EC) | 154.78 µS/cm (min= 26 µS/cm, max= 230 µS/cm) | TDS (approx.) of fog water was 92.87 ppm. [TDS=0.6*EC(µS/cm)] |
| Color/ Appearance | Slightly turbid | Insoluble particulate material was present in the fog water |
| Odor | No distinct odor. | Absence of volatile/ odorous species |

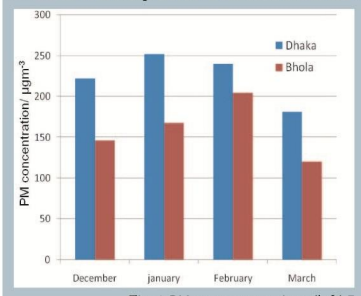
## Water soluble ions and metals in fog water:




Concentration of anions in fog water were, in the order $NO_3 > SO_4 > Cl$. In contrary, concentration of metals were, in decreasing order Na>Ca>K>Mg>Zn>Fe>Mn>Cu. The probable source of Ca and K is from the soil, with Ca and K being suspended in the lower layer of the atmosphere and settling on the condenser surface. The presence of higher Na compared to other species, and to a lesser extent Mg corresponds to the sea salts. Although, the concentration of Na is approximately 2 times higher than Cl-, which means that there is some other sources of Na. Concentration of total cations and anions were 1.80 and 0.78 mEq/L, respectively. So, there were some other anionic species, whose concentration was not determined. And its worth mentioning that the metals were detected by AAS, which could be another reason for ion imbalance. The concentration of total species in fog water was 76.89 ppm, which is less than the approximate value of TDS (92.87 ppm).

## PM mass comparison between Dhaka and Bhola:



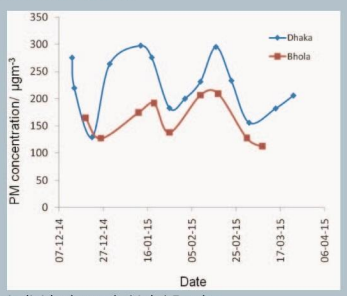
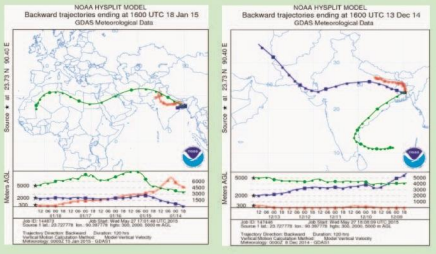




Fig. 4: PM mass comparison (left) For individual month, (right) For the whole sampling period.

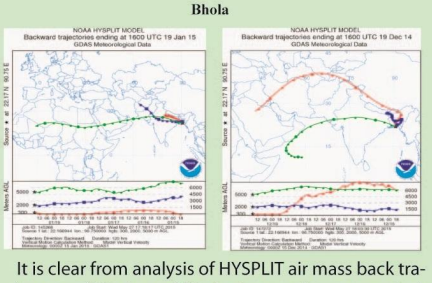
The average PM concentration (December-March) of Dhaka and Bhola was 224.67 & 158.00 µgm-3, respectively. So, the PM concentration of Dhaka was 29.67% higher than Bhola during winter. The Fig. 4(right), shows that there is a very good correlation in PM concentration of Dhaka and Bhola with respect to date (except a few points). Fig. 4(left) shows that PM concentration of Dhaka was higher during January compared to other 3 months. In case of Bhola, PM concentration was higher during February.

## Air mass trajectory analysis:

Dhaka

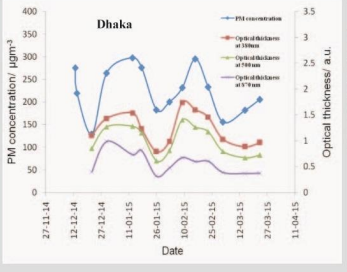


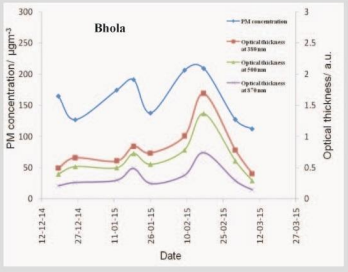

Bhola




It is clear from analysis of HYSPLIT air mass back trajectory of Dhaka and Bhola that northwestern winds were dominant over the region during sampling period.

## Comparison between AOD and Particulate mass:




It can be inferred from the figures that, except few points, there is very good correlation in between AOD and PM concentration. The PM and AOD of both sampling site shows two maxima; one in the middle of January and another in the middle of February.

## Conclusion:

The different chemical and physical characterization of fog water reveal that, the fog water was slightly acidic in nature. It contained insoluble particulate materials, but was odorless. The predominant anionic species in fog water was $NO_3$,$SO_4$ & Cl . Among the metals, the concentration of Na and Mg were much higher than the others. The possible sources of different metals were discussed. The average PM concentration of Dhaka was much higher than the Bhola. There was very good correlation in between PM concentration and AOD of Dhaka and Bhola. The air mass trajectory analysis showed that, northwestern winds were dominant over the regions during sampling period.

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