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Air Quality Characterization with Respect to Airborne Particulate Matter in Nawabganj, Dhaka

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Abstract
Air borne particulate matter samples ($PM_{10}$and $PM_{2.5}$) were collected simultaneously from Dhaka Southern Power Plant (DSPP) at Daulatpur in Nawabganj, Dhaka throughoutthe year 2016 (once in a month) using two Air Metrics MiniVol samplers. The samples were analyzed for particulate matter (PM) mass and black carbon (BC) concentrations. The concentration of organic carbon (OC) and total carbon (TC) were calculated. The average concentration of $PM_{10}$was 92 μg/m^3(minimum 39.2 μg/m^3 on July and maximum 203 μg/m^3on January) and $PM_{2.5}$ was 62.3μg/m^3(minimum 25.8 μg/m^3 on July and maximum 152 μg/m^3on January). The average BC concentration was 9.88 μg/m^3varying from 2.43 to 31.3 μg/m^3in $PM_{10}$and 10.8μg/m^3ranging from 2.97 to 27.0 μg/m^3in $PM_{2.5}$. The average OC concentration was 6.62 μg/m^3varying from 1.63 to 21.0μg/m^3in $PM_{10}$and 7.21 μg/m^3ranging from 1.99 to 18.2μg/m^3in $PM_{2.5}$. From the $PM_{2.5}$/$PM_{10}$and BC in $PM_{2.5}$/ BC in PM_{10}ratio it was observed that the percentage of $PM_{2.5}$ and BC in $PM_{2.5}$is very high. About 67.7% of $PM_{10}$was $PM_{2.5}$and 17.3% of $PM_{2.5}$was black carbon. The PM and BC concentrations were also studied with respect to the meteorological conditions (Humidity, wind speed, wind direction, visibility and rain fall). It is observed that the concentration of PM and BC is higher in winter season when relative humidity, rainfall, temperature and wind speed are lower.

Key words: PM_{10}, $PM_{2.5}$, Black Carbon , Organic Carbon,Total Carbon.

1. Introduction

Bangladesh is one of the most polluted countries in the world and the air pollution of Dhaka city is a prime concern now-a-days. But the rate of air dust particles varies from season to season. The major sources of air pollution are transportation engines, the amount of the released substance is relatively high in certain localities, so the harmful effects are more noticeable [1]. Basically, there are two major sources of air pollution in Bangladesh: industrial emissions and vehicular emissions. Normally the air quality of any particular area is determined by monitoring some parameters in the air of that area. The concentration of airborne particulate matter mainly PM2.5is taken as the major parameter for characterizing air quality [2] and it is very high in the air of Dhaka city [3,4] than the national ambient air quality standard limits of Bangladesh and NAAQ standards given by WHO. Air pollution is a major environmental risk to health. WHO reports that in 2012 around 7 millionpeople died -one in eight of total global deaths –as a result of air pollution exposure. In 2015,ambient air pollution was the fifth leading cause of death worldwide, according to a major new report. More than 4.2 million people died prematurely because of particulates and ozone in the air, mostly from coal burning, power plants, and home heating. Air pollution kills 15000 Bangladeshis each year and Dhaka city is one of the most polluted cities in the world. In Dhaka, Bangladesh, PM is the air pollutant that is most harmful to public health andthe environment when compared to other measured criteria pollutants [5]. People in urban areasare especially at risk, with around 85% exposed to fine particulate matter (PM2.5) at levelsdeemed harmful by then WHO. These particles are too small to seeor smell, but have a devastating impact. PM2.5can

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cause or aggravate heart disease, asthmaand lung cancer [6]. There is a close, quantitative relationship between exposure tohighconcentrations of small particulates [7] (PM10 and PM2.5) and increased mortality or morbidity,both daily and over time. Conversely, when concentrations of small and fine particulates arereduced, related mortality will also go down –presuming other factors remain the same. Duringrecent years, the Government of Bangladesh has tried to control PM emissions coming fromanthropogenic sources [8].The presence of suspended particulate matter (SPM) in the air is mainly responsible for air pollution[9]. The suspended particular matter includes dust, smoke, soot, pollen and soil particles [10,11]. The presence of excess air borne particulate matter (both PM10 and PM2.5), (BC) and (OC) in the air is very harmful for human health [12]. The concentrationof these parameters in different regions of Dhaka is different. Hence it is necessary to monitor the concentrations of PM and BC in different regionswhichwouldbe helpful to provide necessary steps and cautions for different regions to minimize air pollution over the whole year. Therefore, for this purpose,the PM concentrations were monitored from the area of Dhaka Southern Power Plant (DSPP) at Daulatpur in Nawabganj, Dhaka throughoutyear 2016 (once in a month).

2. Materials and Method

2.1 Sampling Site Description

The sampling location was inside the Dhaka Southern Power Generations Ltd. The power plant is situated at Daulatpur, Nawabganj (latitude 23°40'12.60"N, longitude 90°16'57.50"E), Dhaka. The land of the power plant was lent from Rural Electrification Board (REB). There is a school as well as a graveyard to the north-west & north-east side of the plant respectively. There are agricultural lands on the west side and south side of the plant area. There are some scattered settlements at the north-east, east and south east of the plant area near the road side. The location is well communicated by both road and river ways. The sampling site is situated near Daulatpur Fairy Ghute. The distance between the plant area and main road is 150 foot and the distance of sampling site from Dhaka university area is 15 Km.

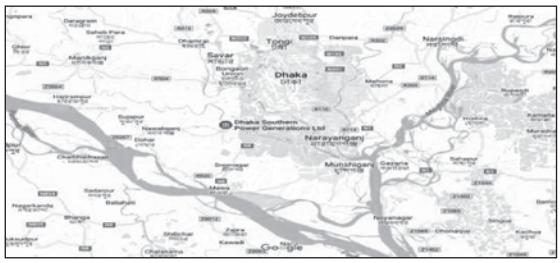

Fig. 1: Dhaka Southern Power Generation Ltd, Nawabganj.

2.2 PM measurement

The PM_{10} and $PM_{2.5}$ sampling were carried out for 24 hours by using two AirMetric MiniVol samplers once in month through the whole year 2016 (monthly value from January to December). For sampling with MiniVol sampler, the actual flow rate must be 5 liter per minute (lpm) at ambient conditions for proper size fractionation. The samplers were set up in the conventional manner with filters. The SPM samples were collected on Teflon (2.0 µm pore size) filters. The collected filters were stored at the refrigerator to minimize the possible loss of the substances until chemical analysis[13]. A Po-210 (alpha emitter) electrostatic charge eliminator was used to eliminate the static charge accumulated on the Teflon filters before each weighing. The difference in weights for each filter was calculated and the mass concentrations for each $PM_{2.5}$ and PM_{10} samples were determined. The BC concentrations were measured using a Diffusion Systems Smoke Stain Reflectometer (SSR) in the Chemistry Division of the Atomic energy Centre, Dhaka (AECD) laboratory. Secondary standards of known BC concentrations were used to calibrate the reflectometer [14]. The concentrations are defined based on the amount of reflected light that is absorbed by the filter sample and an assumed mass absorption coefficient. It is related to the concentration of light absorbing carbon through standards of carbon with known areal density. Iron (Fe) has a moderate light absorption coefficient and can have some limited influence on the BC value measured by reflectance. The uncertainty associated with the BC measurement is rather high (4–9%), and therefore, the influence of variation in Fe concentration on BC measurement has been neglected. The OC and TC

2.3 Traffic Volume

The sampling site is near the fairy ghat and main road. So, there are a huge number of vehicles and particulate matter concentration is also high. As only a few buses run on CNG and most of the buses and minibuses have diesel engines, so the concentration of BC and OC are also high.

2.4 Meteorological Condition

The climate of the whole year is divided into four seasons in Bangladesh. These are winter (December to February), pre-monsoon (March to May), monsoon (June to August), post-monsoon (September to November). The dispersion of PM strongly depends on the wind speed and direction [15]. Meteorology data for sampling dates were collected from Dhaka BMD station. As there is an impact of meteorology during winter season and wind blows from north and north-west direction (Figure 2), we have set up the PM samplers in the north-east direction.

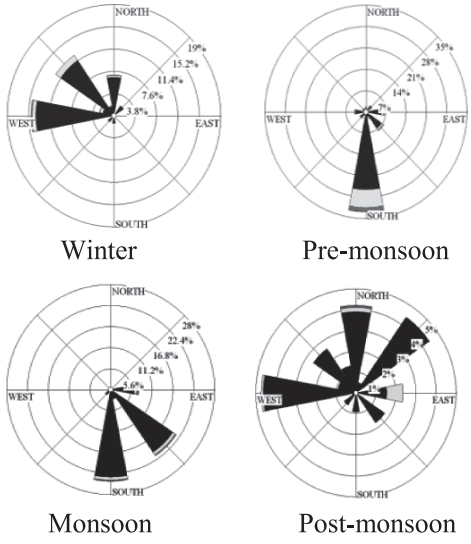

Fig. 2: Wind direction pattern for Dhaka

3. Results and discussion

3.1 PM, BC, OC and TC Concentration

The variation of the monthly average value of the concentration of $PM_{2.5}$ and $PM_{10}$of the year 2016 were plotted in a graph and theconcentration of BC and OC in $PM_{10}$and $PM_{2.5}$were plotted in another two graph (fig:4 for BC and fig:5 for OC).

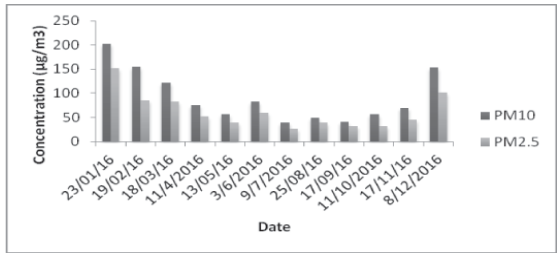

Fig. 3: The variation of the monthly average value of PM_{10} and $PM_{2.5}$ of the year 2016 at Nawabganj, Dhaka.

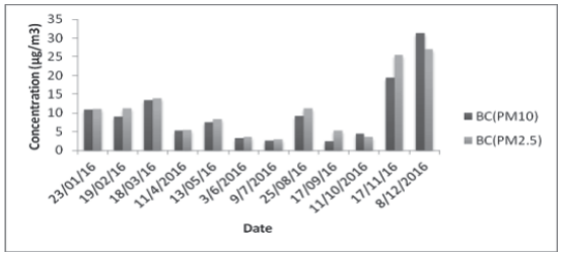

Fig. 4: The variation of the monthly average value of BC in PM_{10} and $PM_{2.5}$ of the year 2016 at Nawabganj,Dhaka.

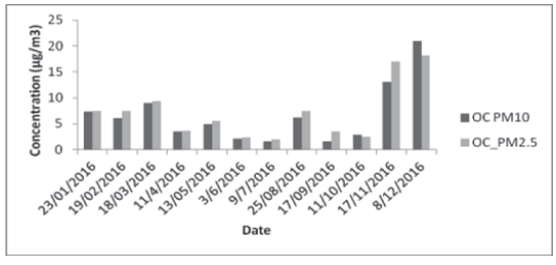

Fig. 5: Variation of the OC concentration (µg/m3) in PM_{10} and $PM_{2.5}$ collected from Nawabganj, Dhaka sampling location of the year 2016.

From fig. 3 it is seen that $PM_{10}$and $PM_{2.5}$ both have the highest concentration on January and lowest concentration on July [16]. The concentrations of BC and OC in $PM_{10}$and $PM_{2.5}$are highest on December and lowest on September and July respectively[17]. It is because of the meteorological conditions. In Bangladesh, the temperature and humidity are high almost through the whole year. In the rainy season, wind speed and rainfall increase and the concentration of SPMs decreases. It is because the rainfall settle down the SPMs and the high wind speed blow off the SPMs and reduce the concentration at a particular area. concentrations were calculated.

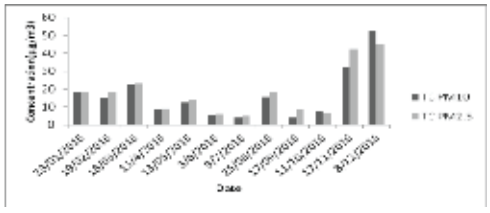

Fig. 6: Variation of the TC concentration (μg/m^3) in PM_{10} and $PM_{2.5}$ collected from the sampling site Nawabganj, Dhaka of the year 2016.

From Fig. 6, it is observed that TC concentration (sum of BC and OC) is high in December and low in July. The highest carbon concentration is due to the north westerly wind and as well as local effect. The ratios of $PM_{2.5}/PM_{10}$, BC in $PM_{2.5}$/BC in PM_{10} and BC in $PM_{2.5}/PM_{2.5}$ are plotted and their highest and lowest concentrations were analyzed with meteorological conditions.

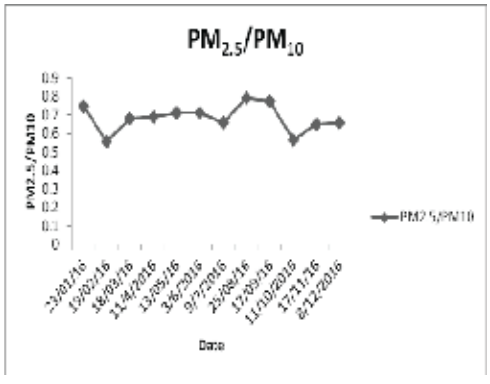

Fig. 7: Variation of ratios between $PM_{2.5}$ and PM_{10}

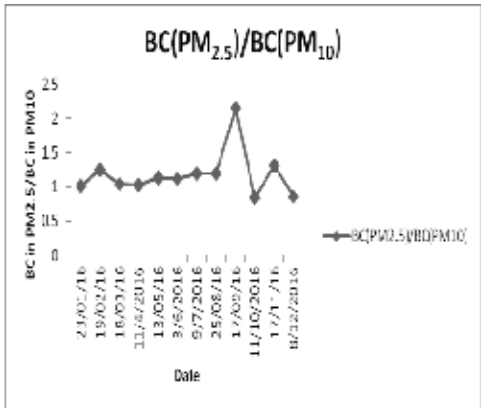

Fig. 8: Variation of ratios between BC in $PM_{2.5}$ of the year 2016. and BC in PM_{10} of the year 2016.

From the ratio graph of $PM_{2.5}$ /PM_{10} (fig:7), it is seen that in comparison with the particulate matter concentrations, $PM_{2.5}$ concentration is highest on August when the wind speed is very low and all the local dust particles from vehicles cannot travel away and contribute to the high $PM_{2.5}$ concentration. About 67.7% of PM_{10} was $PM_{2.5}$. From figure 8, it is seen that BC concentration in $PM_{2.5}$ is highest than the concentration of BC in PM_{10} in September. It is also because of low wind speed as fine particulate matters settle down and the BC ratio is high in fine particulate matter. BC concentration in $PM_{2.5}$ is higher in November than other season and about 17.28% of $PM_{2.5}$ was BC. It is because of low relative humidity and rainfall [18]. The variations of different meteorological parameters are given below in figure 9.

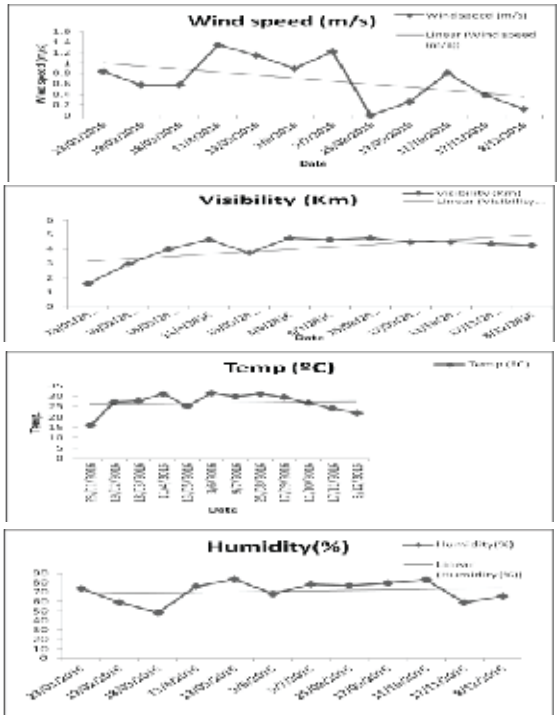

Fig. 9: Variation of different meteorological conditions on the sampling dates.

From these graphs we can say that wind speed, temperature, visibility, humidity and rainfall everything is lower in the winter season and also the north and northwest wind contribute to the highest PM, BC and OC concentrations [11]. On the other hand, in the monsoon and post-monsoon period these parameters have higher values and south and southeast wind direction is responsible for the lower SPMs concentrations [19, 20].

3.2 Comparison of the PM Concentration of the Sampling Site with other CAMS Site of Dhaka

Data of the PM concentrations of Nawabganj was compared with the other CAMS site of Dhaka and their variation data is given below :

Month	Sampling site (Nawabganj)		CAMS-1 (Sangshad Bhaban, Sher-e- Bangla Nagar)		CAMS-2 (Firmgate)		CAMS-3 (Darus-Salam)	
	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
January	152	203	167	241	158	DNA	212	335
February	86	155	128	DNA	153	DNA	DNA	285
March	83.1	122	DNA	DNA	97.4	DNA	113	270
April	52.2	75.6	37.1	DNA	53.1	DNA	44.7	105
May	40.0	56.3	46.1	DNA	61.6	92.3	50.5	100
June	58.8	82.8	28.2	#DIV/0	DNA	60.9	31.7	71.8
July	25.8	39.2	18.3	DNA	DNA	33.1	19.2	44.3
August	39.1	49.3	DNA	DNA	DNA	DNA	31.9	70.2
September	31.9	41.3	DNA	DNA	DNA	DNA	32.7	62.6
October	31.9	56.4	DNA	DNA	DNA	85.4	44.1	91.7
November	45.6	70.1	DNA	DNA	DNA	139	105	188
December	101	153	DNA	DNA	DNA	DNA	169	272

DNA= Data not available due to malfunction of the analyzer/ sensor/ poor data capture value/ due to station not within monitoring network due to malfunction of DAS. Source: Reports and publications of CASE (Clean air & sustainable environment), Ministry of Environment and Forests, Government of the Peoples Republic of Bangladesh.

From the above table we can see that, PM concentrations (both $PM_{2.5}$ and PM_{10}) are highest on January and lowest on July at any region of Dhaka and the concentrations are lower in the sampling site than other regions. It is due to the low population density of the sampling site. And also the number of vehicle is lower than the other CAMS sites of Dhaka [21, 22].

4. Conclusion

The PM, BC and OC concentrations are higher in the winter season and lower in rainy season. The low wind speed, rainfall, temperature and north northeast wind direction are the main causes for the higher SPMs concentration in the winter In rainy season due to heavy rainfall the SPMs settle down and high wind speed blow off the SPMs from particular region to another.

That's why the concentrations are low in rainy season [7]. So, to reduce the concentration of SPMs in the air the government should reduce the diesel running vehicles, pollution from brick kiln, wood burning and adopt another policies to reduce dust particles in the air [4].

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