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Seasonal Variations of Particulate Matter, Black Carbon and Organic Carbon to determine the Status of Air Quality at Narayanganj and Munshiganj in Dhaka, Bangladesh

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Abstract

Airborne particulate matters ($PM_{10}$and $PM_{2.5}$) were collected through Eco Tech Air samplers from four different locations, Vati Bolaki and Gowal Gao in Munshiganj and Pachani and Chorhogla in Narayanganjduring the monsoon (August to September) and post-monsoon (November to December) seasons in the year 2016 in a cyclic order. During monsoon in Munshiganj, at Vati Bolaki,the average concentration of $PM_{10}$and $PM_{2.5}$were 33.9 $\mu g/m^3$ and 13.6 $\mu g/m_3$. At Gowal Gao, the average concentration of PM_{10} and $PM_{2.5}$ were found 34.0 $\mu g/m^3$ and 18.2 $\mu g/m_3$. The average concentration of black carbon and organic carbon of $PM_{2.5}$at Vati bolaki and Ghoyal gao are 2.72 $\mu g/m^3$, 1.82$\mu g/m_3$ and 3.19 $\mu g/m^3$, 2.13$\mu g/m^3$ respectively. During post-monsoon season, in Munshiganj, average concentration of PM_{10}in Vati Bolaki and Gowal Gao are 120 $\mu g/m_3$and 135 $\mu g/m_3$ and $PM_{2.5}$concentrations are 47.3 $\mu g/m_3$and 58.3 $\mu g/m_3$respectively. The average concentration of BC and OC at Vati bolaki is10.2 $\mu g/m_3$and 6.86 $\mu g/m_3$and at Ghoyal Gao is 16.3 $\mu g/m_3$and 7.28 $\mu g/m_3$. Hence, it has found that the PM, BC and OC concentrations in Munshiganj is higher during post-monsoon season than monsoon season. Similarly it has found that the pa..tedite maltee, BC and OC concentrations in Narayanganj is higher during post-monsoon season than monsoon season. From the meteorological studies, it has also found that PM concentration is higher with low value of humidity, temperature and wind speed.

Keywords: *Airborne particulate matter, PM_{10}, $PM_{2.5}$, black carbon, organic carbon.*

1. Introduction

Particulate matter pollution is a major concern in the large cities of Bangladesh. The situation of air pollution in Bangladesh isgetting worst day by day. The main contributors of air pollution are motor vehicles, brick kilns, diesel generators, biomass burning, dust and industries [1]. Among them, particulate matter pollution (atmospheric aerosol particles) plays an important rolein air status and climate changes. PM also known as particle pollution,is a complex mixture of extremely small particles and liquid droplets that get into the air. Some particles are released directly from a specific source, while others form in complicated chemical reactions in the atmosphere. Atmospheric pollution is a serious public health problem in the developing countries especially in Dhaka, Bangladesh due to the unplanned rapid growth of the city [1, 2]. Dhaka, with about 17 million people and 8% increase of population per year [3], is exposed to the high levels of trace metal pollutions from a variety of sources [1]. Due to the presence of high-level toxic elements, Dhaka has been considered as one of the most polluted cities in the world [3]. Air pollution in Bangladesh is mainly caused by traffics, brick kilns, industries, biomass burning, construction activity, soil dust, and also long range transport, etc. [4]. Trace metals levels have the high exceedances of WHO guideline values in South Asian countries (e.g., India and Pakistan) [5]. The present environmental condition especially atmospheric pollution in Bangladesh is not at all equilibrium.

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In the recent decades concern about the air pollution had been raised and (PM) in air pollution is stronglynumerous epidemiological, biomedical and clinical studies indicate that ambient particulate associated with increased cardiovascular disease such as myocardial infarction (MI), cardiac arrhythmias, ischemic stroke, vasculardysfunction, hypertension and atherosclerosis [6] . Ambient PM is defined as the material suspended in the air in the form of minute solid particles or liquid droplets, which are derived from both human and natural activities. It is a heterogeneous mixturewith varying size and chemical composition. In terms of their potential influence on health, they are classified as PM_{10}, $PM_{2.5}$and ultrafine particles (UFPs) subgroup according to their diameter. PM_{10}includes coarse particles with the aerodynamic diameter (AD) from 2.5 to 10 µm. The PM_{10}particles come from road and agricultural dust, tire wear emission, construction and demolition works or the mining operations [7]. In addition, the natural activity such as wildfires and windblown dust are also the sources for PM_{10}. Compared to PM_{10}, the primary contributors of $PM_{2.5}$ mainly come from the traffic and industry includes fuel combustion from power plant and oil refinery or the brake emissions of mobile. $PM_{2.5}$ indicates those fine particles with AD less than 2.5 µm. Based on numerous epidemiological studies and large clinical observation, the $PM_{2.5}$has been considered as the main culprit of the adverse cardiovascular effects of air pollution on human health [8]. These research worksinvolves the analysis of particulate matter concentration ($PM_{2.5}$and PM_{10}), OC, BC in samples collected from the Narayanganj and Munshiganj in Dhaka, Bangladesh and also studied the seasonal variation according to meteorological condition.

2. Materials and Method

In order to monitor the status of particulate matter, the samplings were done in four locations on (Table 1) every alternative day.

2.1 Description of Sampling Sites:

Pachani, Narayanganj: The samplers were placed at the roof of the mosque. The mosque is adjacent to the Meghna river. There are many boats which are driven by diesel engines. There are few houses at the west side of the mosque.

Chorhogla/Balirghat,Narayanganij : The Ecotech samplers were placed at open yard of the houses. The site is also adjacent to the Meghna river. People use wood for their cooking.

Gowal Gao, Munshigonj : Samplers were placed at open yard of the houses. The site is also adjacent tothe Meghna river. People use wood for their cooking.

Vati Bolaki Govt.primary School, Munshigonj: The samplers were placed at the roof of the mosque. The mosque is adjacent to the Meghna river. There are many boats which are driven by diesel engines.

Table 1. Sampling sites with GPS location and Position of samplers

Sampling site	Location	GPS	Position of Sampler
Point 1	Pachani, Mongoler Gao, Sonargaon, Narayanganj	N- 23º 36´ 30.6´´ & E- 90º 34´ 39.7´´	At the roof of Mosque
Point 2	Chorhogla/Balirghat, Kashimnagar, Sonargaon, Narayanganj	N- 23º 33´ 55.5´´ & E- 90º 33´ 37.7´´	At open yard near house
Point 3	Gowal Gao, Gozaria, Munshigonj	N- 23º 34´ 11.9´´ & E- 90º 35´ 20.3´´	At open space near house
Point 4	Vati Bolaki Govt.primary School, Hossendi, Gozaria, Munshigonj	N- 23º 35´ 16.7´´ & E- 90º34´ 36.2´´	At the roof of Mosque

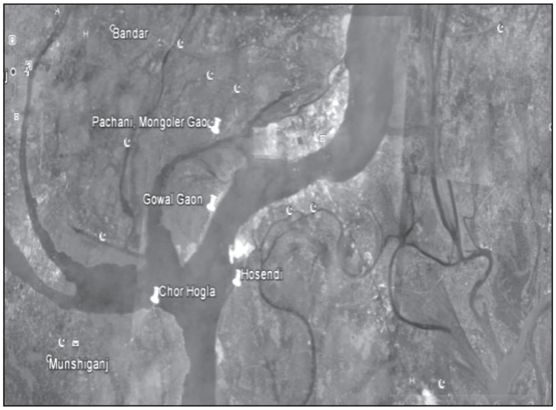


Fig. 1: Map of sampling site

2. 2 Description of the Samplers:

In ECOTECH AAS 217BL, which is responsible for PM_{10}, ambient air is sucked using low maintenance brushless and noiseless blower through corrosion free aluminum modular pipe and pass thorough a sharp cutoff cyclone which is based on the concept given by National Environmental Engineering Research Institute (NEERI) which divides the particulate matters in two fractions one below 10 microns and another above 10 microns. The respirable dust (below 10 microns) directly gets deposited on filter paper and the coarser dust (above 10 microns) collected in the cup fitted under the cyclone. In ECOTECH AAS 127 mini, which is responsible for $PM_{2.5}$, ambient air is sucked using low maintenance brushless and noiseless blower through corrosion free aluminum modular pipe and particles below or equivalent to 2.5 microns get deposited directly on filter paper. A time totalizer records the total running time of the blower. A programmable digital timer makes the instrument to stop and start as per requirements set in the timer. The sampling was continued from 8am to 8am up to the next day. The manometric systems indicate the rate of flow in cubic meter per minute which can be read directly on calibrated scale. Both samplers are USEPA recommended [9]. The PM sampling were done using EcoTech samplers (Model No. AAS 217 BL and AAS127 mini for PM_{10}, and $PM_{2.5}$ respectively) starting from 14 August to 7 September 2016 and 10 November to 9 December in a cyclic order from four locations.

2.3 Meteorological Condition:

In Bangladesh, the climate is characterized by high temperatures and high humidity most of the year and distinctly marked seasonal variations in precipitation. Based on the meteorological conditions [10], the year can be divided into four seasons, pre-monsoon (March–May), monsoon (June-September), post-monsoon (October November) and winter (December–February) [11].The winter season is characterized by dry soil conditions, low relative humidity, scanty rainfall and low northwesterly prevailing winds. The rainfall and wind speeds become moderately strong and relative humidity increases in the pre monsoon season when the prevailing direction changes to southwesterly (marine). During the monsoon season, the wind speed further increases and the air mass is purely marine in nature. In the post-monsoon season, the rainfall and relative humidity decreases, as does the wind speed. The wind direction starts shifting back to northeasterly [12]. As there is an impact of meteorology during this monsoon season as wind blows from south-east direction (Figure 2), therefore the samplers were set up in the north west direction. The meteorological data used in this study were obtained from a local meteorological station.

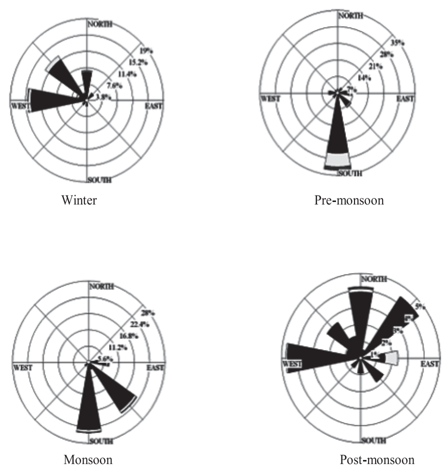


Fig. 2: Wind direction pattern

2.4 Measurement of PM Concentration:

PM Masses were measured in the Chemistry Division of the Atomic energy Centre, Dhaka (AECD) laboratory. The aerosol samples having

PM were determined by weighing the filters before and after exposure using a micro balance (METTLER Model MT5) maintaining room temperature approximately at 22º C and relative humidity at 50%.The air filters were equilibrated at constant humidity and temperature of the balance room before every weighing. A U-shaped electrostatic charge neutralizer (STATIC MASTER) was used to eliminate the static charge accumulated on the filters before each weighing. The difference in weights for each filter was calculated and the mass concentrations for each PM_{10} or $PM_{2.5}$ samples were determined. The concentration of (BC) in the fine fraction of the samples is determined by reflectance measurement using an EEL-type Smoke Stain Reflectometer. Secondary standards of known black carbon concentrations are used to calibrate the Reflectometer [13] OC is calculated from the BC [14].

3. Results and Discussion

Figure 3, 4, 6 and 7 shows the monthly average value PM_{10}, $PM_{2.5}$ and BC concentration in monsoon and winter season in Narayanganj and Munsiganj. From figure 3, 4, during the winter season, both Narayanganj and Munsiganj, the PM concentration exceeded the 24hr (the value of PM_{10} and $PM_{2.5}$ is 150 and 65 respectively) Bangladesh National Air quality Standards (BNAQS). From the figure 3, 4 and 5, observed that the concentration of $PM_{2.5}$ decreases with increasing wind speed and increasing humidity. On the other hand, PM_{10} mass concentration follows in the same trends with the variation of meteorological condition (figure 5). When humidity was increased, particulate matter was sattle down on the surface of the earth that's why the concentration $PM_{2.5}$ decreased with increasing humidity. Generally it is found that with the increase of wind speed during dry season, the $PM_{2.5}$ mass decreased and when the relative humidity becomes maximum, the fine PM concentration also becomes lower as the PM mass coagulates with water droplet. But with the decrease of humidity and lower wind speed, the fine PM concentrations also tend to increase.

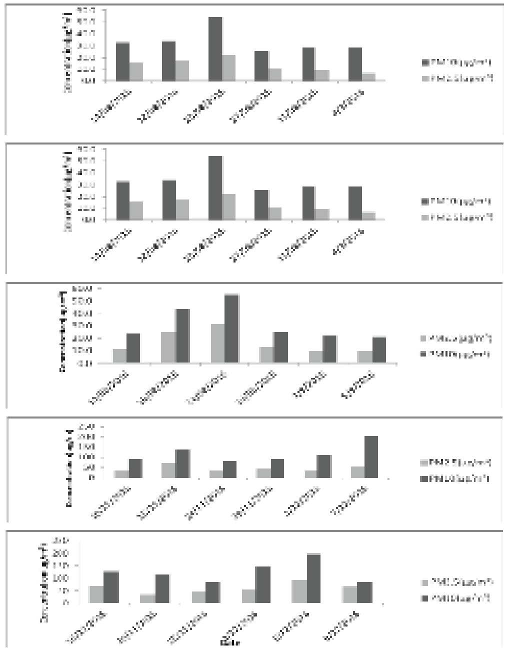


Fig. 3: Variation of PM_{10} and $PM_{2.5}$ with time from August to September and November to December in Munsiganj (Vatibolaki and Gowal gao).

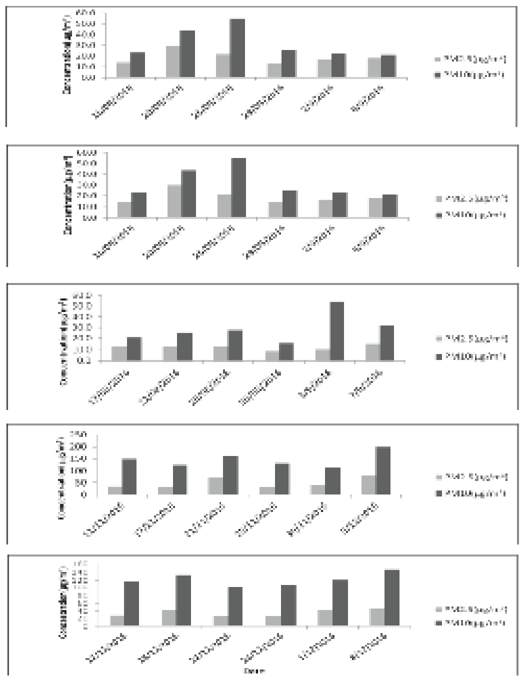


Fig. 4: Variation of PM_{10} and $PM_{2.5}$ with time from August to September and November to December in Narayanganj (Chorhogla and pachani).

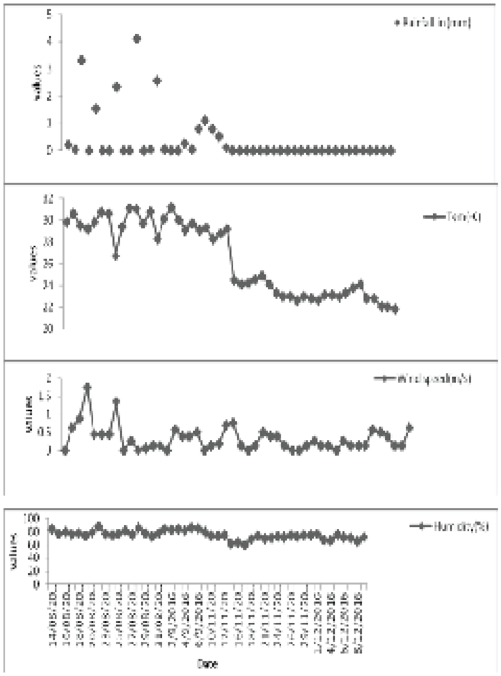
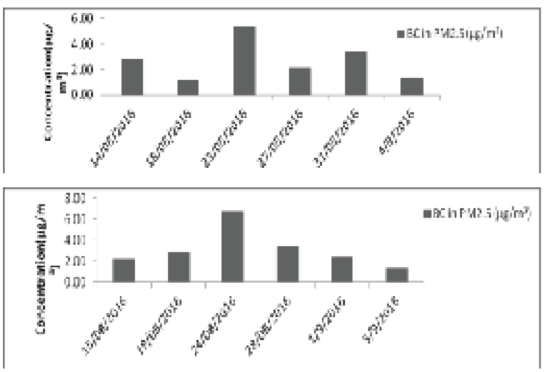


Fig. 5: Meteorological condition during sampling period

From Fig. 6 and 7, observed that black carbon concentration is increased in winter season than monsoon season. BC concentrations vary with temperature and wind speed accordingly seen from Fig. 5. It is also found that from the previous studies [15, 16] that the north-westerly wind in winter increased the concentration of $PM_{2.5}$ and BC [14]. Examining the meteorological condition it is seen that during winter, the wind mainly comes from north and northwest [17]. The concentration of BC in $PM_{2.5}$ more than the mass concentration of PM_{10} although the PM_{10} mass concentration is more than the $PM_{2.5}$ mass



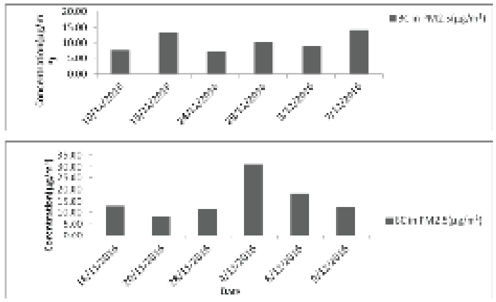


Fig. 6: Variation of BC with time from August to September and November to December in Munsiganj (Vatibolaki and gowal gao).

concentration in the same meteorological condition. This is happened because PM_{10} contains almost 60% soil particles. Soil contain large amount of iron particle which is a light absorbing elements, that" s why when PM_{10} sample was placed in Smoke Strain Reflecto-meter, it absorbed light and we did not get actual value of BC in PM_{10}. But in case of $PM_{2.5}$, we got the actual value of BC concentration [18].

From Fig. 8 and 9, in winter, the $PM_{2.5}/_0$ PM_{10} is low due to high PM_{10} [18]. According to meteorological condition the relative humidity and wind speed recorded high which helps to settle down PM_{10}. Due to high humidity and low wind speed, PM_{10} persist in the air and captured by the filter paper during monitoring time.

From figure 10 and 11, observed that OC have seasonal variations. From Fig.

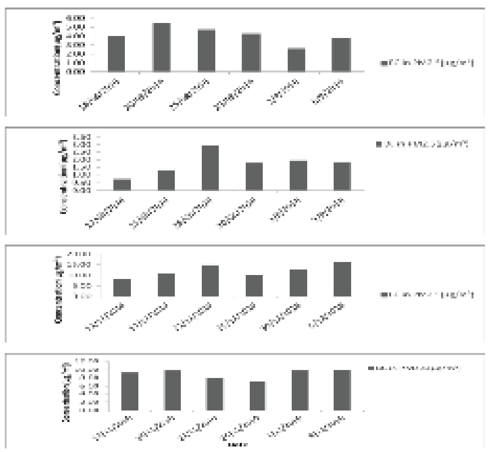


Fig. 7: Variation of BC with time from August to September and November to December in Narayanganj (Chorhogla and pachani)

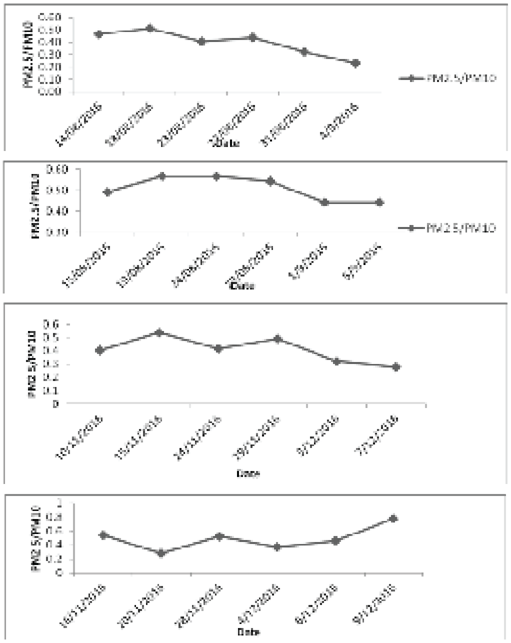


Fig. 8: Monthly ratio of $PM_{2.5}/PM_{10}$ with time from August to September and November to December in Munsiganj (Vatibolaki and gowal gao).

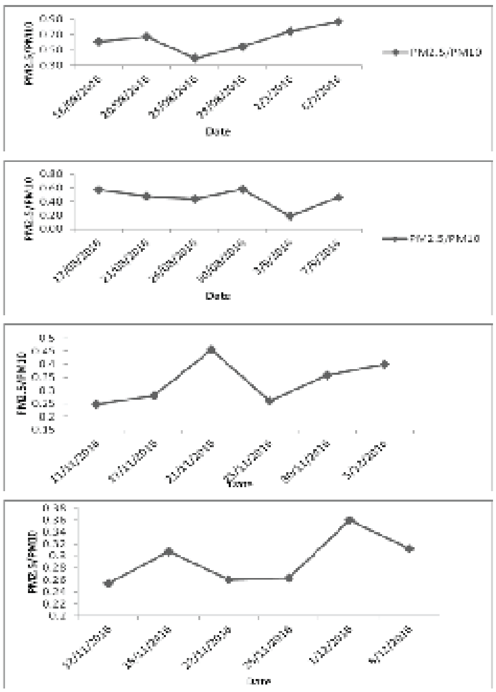


Fig. 9: Monthly ratio of $PM_{2.5}/PM_{10}$with time from August to September and November to December in Narayanganj (Chorhogla and pachani)

12 and 13, according to meteorological data the ratio between $BC/PM_{2.5}$ becomes high in monsoon season due to low $PM_{2.5}$, where as in winter season the ratio is low due to high $PM_{2.5}$ concentration[18]. The OC/BC ratio vary with temperature because of shifts in the gas/particle equilibrium of semi-volatile components. In winter season the OC/BC ratio is high due to low temperature and wind speed and monsoon season the OC/BC ratio is low due to high temperature and wind speed suggesting that higher ventilation, dilution and temperature may drive more of the OC to repartition into the gas phase [14,18].

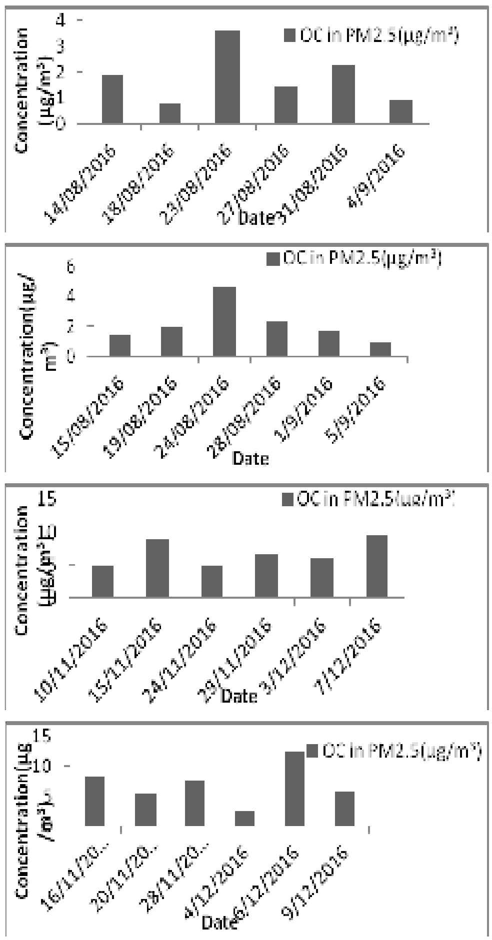


Fig. 10: Variation of OC with time from August to September and November to December in Munsiganj (Vatibolaki and gowal gao).

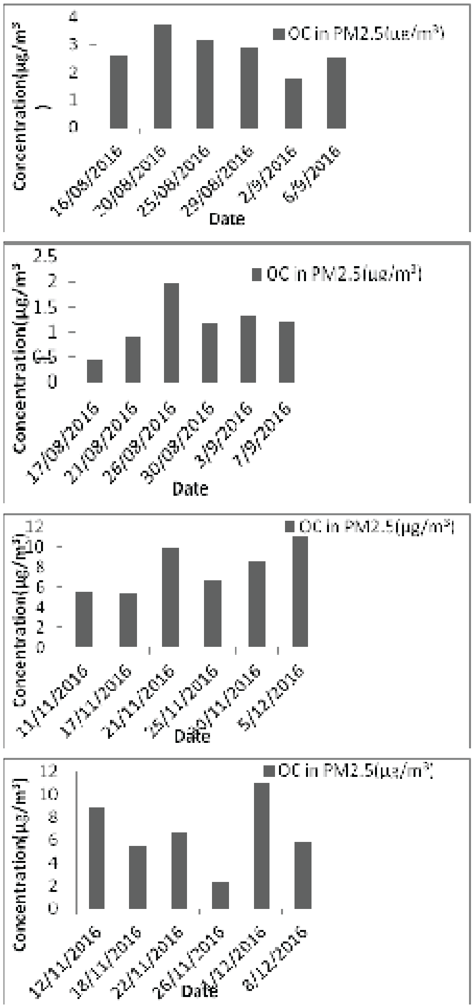
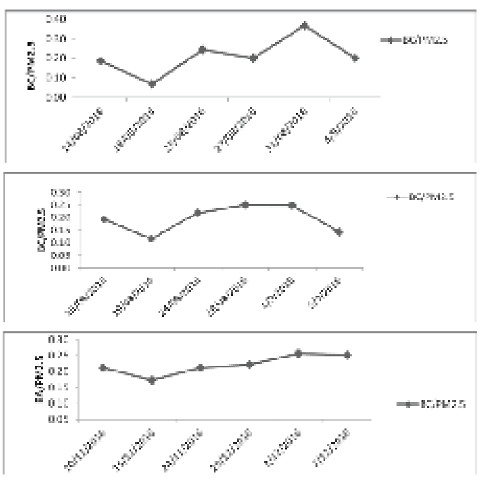


Fig. 11: Variation of OC with time from August to September and November to December in Narayanganj (Chorhogla and pachani)



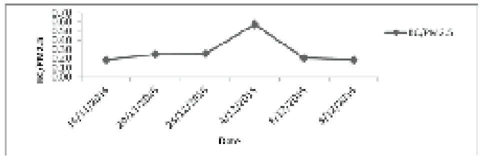


Fig. 12 : Variation of ratio of Black carbon and $PM_{2.5}$ with time from August to September and November to December in Munsiganj (Vatibolaki and Gowal gao).

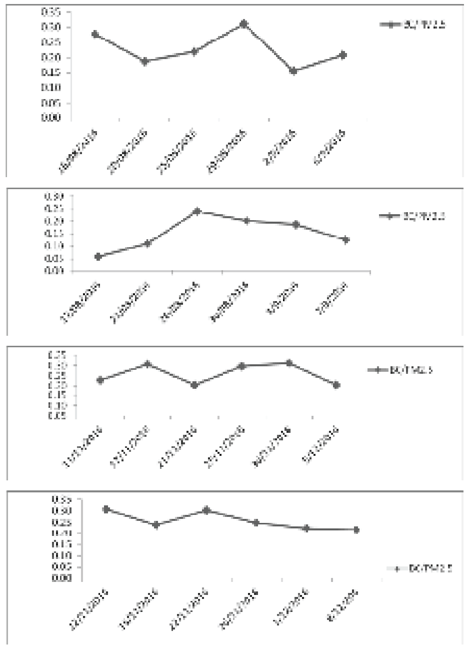


Fig. 13: Variation of ratio of Black carbon and $PM_{2.5}$ with time from August to September and November to December in Narayanganj (Chorhogla and pachani)

4. Conclusion

In winter season, the PM, BC and OC concentrations are higher and lower in the monsoon season. It was found that high PM concentrations were found only in winter season. The results of the present study shows that significant low fine PM concentrations in study areas. This is due tometeorological effect as well as less anthropogenic activities in those areas. It was found from source apportionment study that about 50.4% of total fine PM came from biomass burning/brick kilns. The OC/BC ratio correlated with wind speed and temperature. It has also found that concentrations of O_3, CO,

$SO_2$and $NO_x$are lower than the corresponding BNAAQS . In Bangladesh, there is no thermal power plant or big industry that would emit pollution. So to minimize the concentration of airborne particulate matter in air the government should reduce the diesel running vehicles, pollution from brick kiln and also take necessary steps to reduce dust particles in the air.

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