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STUDIES ON BLACK CARBON (BC) VARIABILITY OVER NORTHERN INDIA

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ABSTRACT

In recent years, the mass concentration of black carbon (BC) aerosol has been increased tremendously resulting into severe fog (winter period) and atmospheric heating thus playing a major role in global warming. So keeping in views all these fatal consequences, the proper measurement of BC mass concentration and its decisive analysis have become very crucial. Therefore the extensive measurement of aerosol BC mass concentration was being carried out by using the instrument Aethalometer at IT-BHU, located in the Indo-Gangetic plane of northern India. So far, the continuous observations for the winter periods have been collected and analyzed thoroughly. The daily average values are significantly high in the early morning hours and at the night hours due to the stable atmospheric boundary layer causing very little dispersion of BC. However, the monthly average values show that the BC mass concentration continuously increasing due to the lowering of temperature and creation of shallow atmosphere. It is expected that for the upcoming months i.e. for winter period the BC mass concentration is going to be higher due the substantial accumulation of BC thus causing severe fog which is completely lashing normal life. Along with this, the meteorological parameters (wind speed, wind direction, % RH, and rainfall status) were also being taken into account since these are the major influencing factors. At present an endeavor was being planned to explore the major contributor of BC in the Varanasi region.

Key words: Black carbon, Varanasi region, Global warming.

INTRODUCTION

Black carbon (BC) is a major anthropogenic component of aerosol system, emitted into the atmosphere by the incomplete combustion of fuels, biomass burning and by the industrial, vehicular and anthropogenic activities. Black carbon aerosol having different optical and radiative properties distinguishes it from other types of aerosol. Due to its large absorption over a wide wavelength range, it could offset significantly or even reverse the "white house" effect due to aerosol scattering[1,2]. The optical property of black carbon aerosol leads into absorption of solar radiation thus resulting into extinction of sunlight.

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Experimentally it has been found that black carbon aerosol has the positive value of radiative forcing i.e. 0.5 w/m^3, which confirms that BC has the ability to trap the heat within the atmosphere, which mainly characterises the radiative property of black carbon aerosol.[3] In present scenario, the global warming has become a major issue causing environmental perturbation all around. The increasing concentration of black carbon aerosol is responsible for the global warming causing physical, chemical and physiological adverse effects. So presently, the collection and data analysis of BC concentration is being done since October 08 under Indian Space Research Organization–Geosphere Biosphere Program (ISRO-GBP). The main objective of this study is to present the results based on continuous measurement of mass concentration of black carbon in Indo-Ggangetic plane Varanasi. In this paper, we are first time presenting the BC concentration for Varanasi region using the instrument aethalometer and it was found around 5-34 μg/m^3 from Oct. 08 to Jan. 09. Recently, Tripathi et al.[4] have measured surface BC concentration in an industrial site at Kanpur for one month (December 2004) period during ISRO-GBP land campaign and then higher BC concentration around 6-20 μg/m^3 was found in December 2004.

Sampling site

The sampling site selected for present work was Department of Chemical Engineering, Institute of Technology, Banaras Hindu University, Varanasi, which is located in the Indo-Gangetic plane. It is 25^0 19'N, 83^0 E, 80.7 m above MSL and 10 Km from Varanasi cantonment.

EXPERIMENTAL

The instrument used for the continuous measurement of BC mass concentration was Aethalometer (AE-30) which is developed by Magee Scientific, USA[5]. Measurements of BC mass concentration were mainly based on the aerosol light absorption. The instrument draws ambient air from 15 m above the ground using an inlet tube and pump. BC from the ambient air accumulated on a quartz fibre tape. The measurement of BC concentration was taken at seven wavelengths 370, 470, 520, 590, 660, 880, 950 nm. The measurement of the attenuation of light beam was linealy proportional to the amount of BC deposited on filter strip. The instrument was operated at the time base of 2 minute with a flow rate 3 LPM.

Effect of meterological parameters like temperature, relative humidity, wind velocity, wind speed and rainfall were investigated during day time. Temperature and relative humidity was measured using instrument humidity & thermometer meter respectively. Data of wind velocity, wind speed and rainfall was collected from the weather center located at the Department of Geophysics, Banaras Hindu University.

Observations and data analysis

After the continuous measurements of mass concentration of black carbon using the instrument Aethalometer, we collected the reading from Oct. 08 to Jan. 09. The collected data was further analyzed thoroughly and we studied the variation of black carbon concentration as hourly mean variation, diurnal mean variation and monthly mean variation. The hourly mean variation of black carbon concentration is indicated in the Fig. 1 and 2 for morning hours and night hours, respectively.

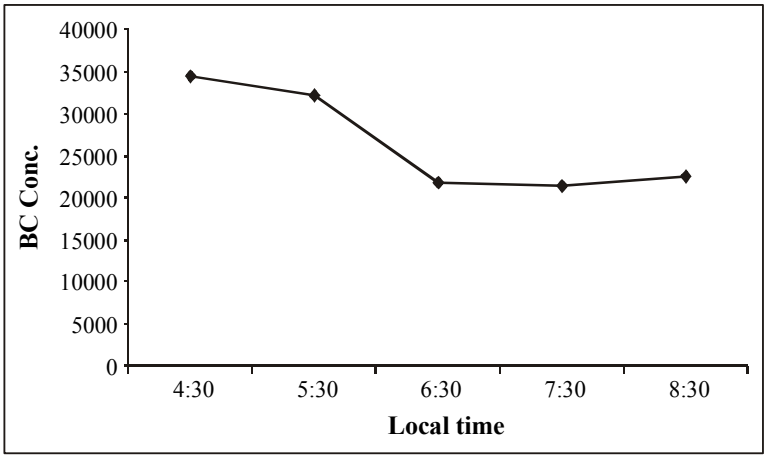

Fig. 1: Hourly mean variation of black carbon conc. (ng/m^3), morning hours measured on 29 Dec. 08

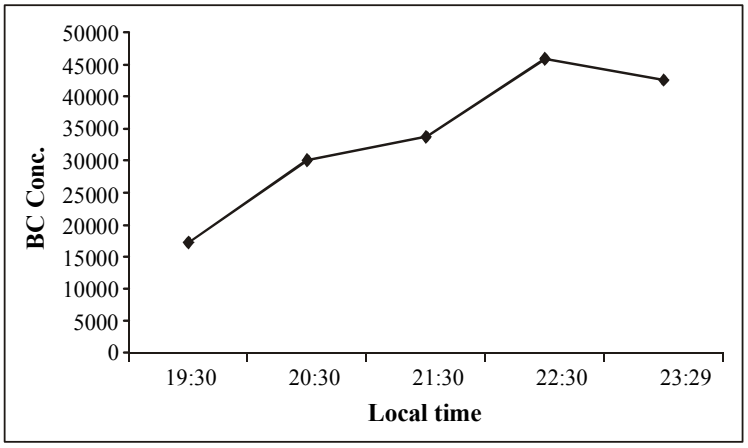

Fig. 2: Hourly mean variation of black carbon conc. (ng/m^3), night hours measured on 29 Dec. 08

While the diurnal variation of black carbon depicted in the Fig. 3. Monthly mean variations of black carbon have been plotted for the month of December and given in the Fig. 4.

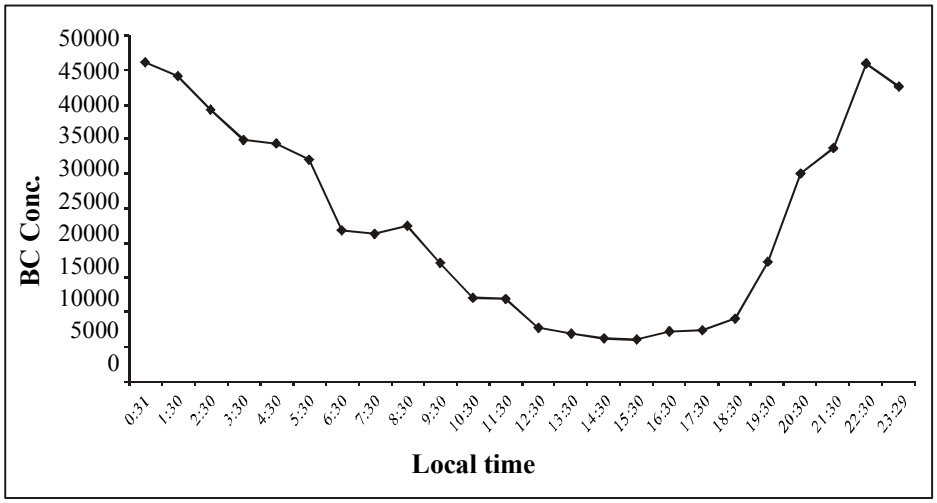

Fig. 3: Diurnal mean variation of black carbon (ng/m^3), measured on 29 Dec. 08

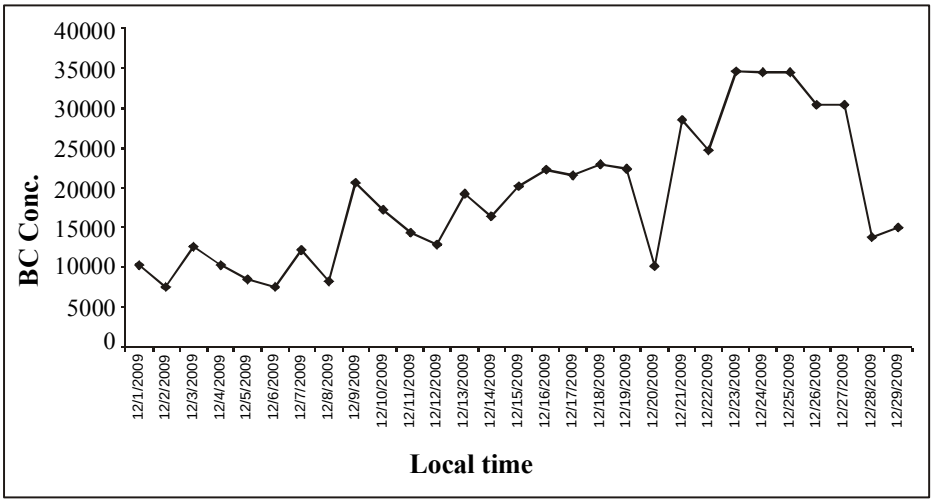

Fig. 4: Monthly means variation of black carbon (ng/m^3) for the month of Dec. 08

RESULTS AND DISCUSSION

For the last four months (Oct. 08 to Jan. 09), it has been observed that the value of the mass concentration of black carbon aerosol in Varanasi region was found to be increased

progressively as the days were advancing particularly in winter seasons. For the month of October the mass concentration of black carbon aerosol was around 5 μg/m^3, while in the month of January it was increased to 25 μg/m^3 showing the maximum value around 34 μg/m^3 on 25 Dec. 08. We got extensively higher value of BC concentration in the month of December due to the lowering of the temperature, resulting into little dispersion of accumulated black carbon aerosol. We also observed that the atmospheric temperature in the month of December was much lower as compare to the month of January that is why we were having higher value of black carbon concentration in the month of December. During the study of diurnal variation from Fig. 3, we observed that the mass concentration of black carbon concentration was higher in morning hours and night hours, due the shallower of atmospheric boundary layer which results in confinement of black carbon aerosol, thus consequent increase in its concentration. In afternoon hours the BC concentration was decreased due to the increase in the boundary layer height and increased convective activity. Apart from these boundary layer variations the effect of traffic intensity was also crucial factor as vehicular emissions are one of the major sources for BC aerosols. So with the present study it can be predicted that for the upcoming months the values of black carbon concentration are going to be decreased due to rise in the temperature. Mean while, the value of mass concentration of black carbon aerosol was also compared with the Kanpur city, which is also in Indo-Gangetic plane of India where it was around 10 μg/m^3 in the month of December. Thus in this paper, we are presenting the range of black carbon concentration 5-34 μg/m^3 from Oct. 08 to Jan. 09 in the region of Varanasi as shown in Table 1.

Table 1: Average BC concentration at the different location of India

Location	Period	BC Concentration (μg/m^3)
Varanasi[a]	Oct. 08 to Jan. 09	5-34
Trivandrum[b]	20 Feb. 05 to 16 March 05	0.3-6
Hyderabad[c]	Jan. to July 2003	0.5-68 (dry season), 0.5-45 (wet season)
Kanpur[d]	Dec. 2004	6-20
Pune[e]	Jan. 05 to Dec. 05	4.1 (average)

[a]Present study; [b]Babu et al.(2002)[6]; [c]Latha and Badrinath (2003)[7];
[d]Tripathi et al. (2004)[4]; [e]Safai et al. (2006)[8]

CONCLUSION

(i) Average BC concentration in Varanasi region is much higher as compared to other locations and it was around 5-34 μg/m^3 (Oct. 08 to Jan. 09).

(ii) BC shows well defined diurnal variations. This is due to local factors and boundary layer dynamics.

(iii) Share of BC to total mass concentration was more in morning and night hours which was 23.68 % and 30.38 %, respectively and very low at afternoon 7.45%.

(iv) BC mass concentration was increasing day by day from October to December and then decreased in January due to the sudden rise in temperature.

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REFERENCES

1. S. E. Schwartz, The White House Effect-Short Wave Radiative Forcing of Climate by Anthropogenic Aerosols-An Overview, J. Aerosol. Sci., **27**, 359-382 (1996).

2. J. M. Haywood and K. P. Shine, Multi-spectrum calculations of the radiative forcing of Tropospheric Sulphate and Soot Aerosol using a Column Model. Q. J. R. Mereorol. Soc., **123**, 1907-1930 (1997).

3. S. K. Sathesh and K. K. Moorthy, Radiative Effects of Natural Aerosols: A Review, Atmospheric Environ., **39**, 2089-2110 (2004).

4. S. N. Tripathi, Sagnik Dey and V. Tare, Aerosol Black Carbon Radiative Forcing at an Industrial City in Northern India, Geophysical Res. Lett., **32**, 1-4 (2004).

5. C. Liousse, H. Cachier and S. G. Jennings, Optical and Thermal Measurements of Black Carbon Aerosol Content in Different Environments: Variation of the Specific Attenuation Cross Section, Sigma. Atmospheric Environ., **27A**, 1203-1211 (1993).

6. S. Suresh Babu, M. K. Krishna, Aerosol Black Carbon Over a Tropical Coastal Station In India, Geophysical Res. Lett., **29**, No. 23, 1-4 (2002).

7. K. M. Latha and K. V. S. Badrinath, BC Aerosols Over Tropicalurban Environment: Acase study, Atmospheric Res., **69**, 125-133 (2003).

8. P. D. Safai, S. Kewat, P. S. Praveen, P. S. P. Rao, G. A. Momin, K. Ali and P. C. S. Devara, Seasonal variation of Black Carbon Aerosols Over a Tropical Urban City of Pune, India Atmospheric Environ., **41**, 2699-2709 (2006).

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