Study of Aerosol black carbon and Aerosol optical Depth over Ranchi during winter in Northern India

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ABSTRACT

Black Carbon (BC) aerosols are the main sunlight-absorbing component of atmospheric aerosols and Aerosol Optical Depth is the major factor to determining the light reaching the earth surface. The local weather and air quality over a region are greatly influenced by the Aerosol black carbon (BC) and Aerosol Optical Depth (AOD).Aerosol BC and AOD characteristics were measured using Aethalometer over Ranchi (23.42N, 85.33E and 650m above MSL). Temperature and humidity measurements using an automatic weather station. This paper presents the variation of concentration of BC and AOD in winter season month of December 2010, December is one of the coldest month of winter in northern India. B.I.T. Mesra in Ranchi comes under the non-polluted area; here the main sources of BC were biomass burning (being used for cooking and heating purpose in the villages/town) and vehicular emissions. In a very clean air location it may be as low as 0.500 µg/m³ and in a very polluted location it may be as high as 20 µg/m³. During the period from July-2010 to March 2011 the average monthly BC concentration varied between 1.1 to 8.1 µg/m³ and daily average value were found in the range of 1.0 to 18 µg/m³. Objective of this paper is to study of the variation of black carbon aerosol and Aerosol optical Depth and the effects of meteorological parameters (temperature and relative humidity) and AOD over the variation of black carbon aerosol.

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1. Introduction

Aerosols have been identified as the major source of uncertainty in the present day climate studies [Intergovernmental panel on Climate Change (IPCC),2007].Lack of adequate observational data, coupled with poor understanding of the spatiotemporal and vertical distribution of aerosol properties has been identified as the major cause for the uncertainty. Aerosol modulates Earth's radiation balance directly by scattering and by absorbing incoming radiation. In addition to their effect on radiation, they also serve as cloud condensation nuclei and thereby influence the number and size distribution of cloud droplets. This process can change cloud radiative properties, cloud lifetime, and precipitation properties, thus indirectly affecting the climate.

I am describe location and general meteorology of sampling sit in section 2., In section 3. Discuss data and its analysisand section 4. Conclude the result.

2. Location and General meteorology of the sampling site

The sampling site selected for the present work was Department of Applied Mathematics, Birla Institute of Technolgy, Mesra, Ranchi, which is located in the Northern India. It is 23.42N, 85.33E and 650m MSL.The Instrument used for continuous measurement of BC mass concentration was Aethalometer (AE-31), which is developed by Magee Scientific,

USA.Measurements of BC mass concentration were mainly based on the aerosol light absoption.BC from the ambient air accumulated on a quartz fiber tape. The measurement of BC concentration is taken at seven wavelengths 370,470,520,590,660,880 and 950nm.The measurement of the attenuation of light beam was linearly proportional to the amount of BC deposited on filter stripe. The Instrument was operated at the time base of 5 minute with a flow rate 4 LPM.Effect of meteorological parameters like temperature and relative humidity, data collected through 32m meteorological tower.

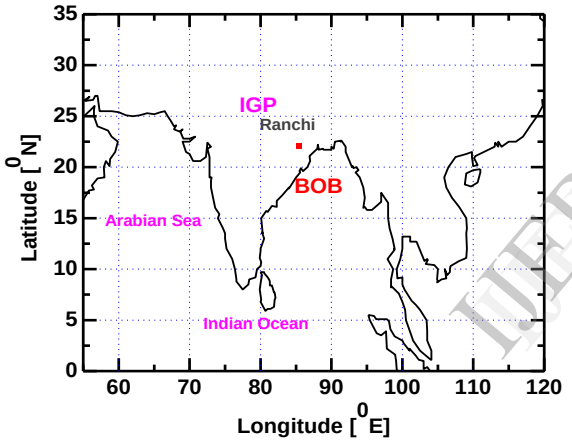


Fig. (1). Map of Indian subcontinent showing the observational site – Ranchi (23.42N, 85.33E and 650m MSL)

3. Results and Discussion

The monthly variation of black carbon is presented in **Fig2**.Average monthly BC concentration varied between 1.1 to 8.1 µg/m³.The monthly variation results showed higher concentration during winter as compared to monsoon. This may be due to the decrease of the average temperature which causes the decrease in wind speed in turn resulted in low transport of the black carbon because of low dispersion. In 2010 and 2011 highest monthly average was found in month of January. Diurnal variation of BC from July-2010 to March-2011are shown in **fig3**.During the period of observation daily average value were found in the range of 1.0 to 18 µg/m³.

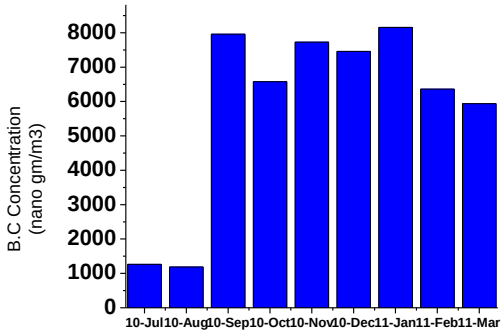
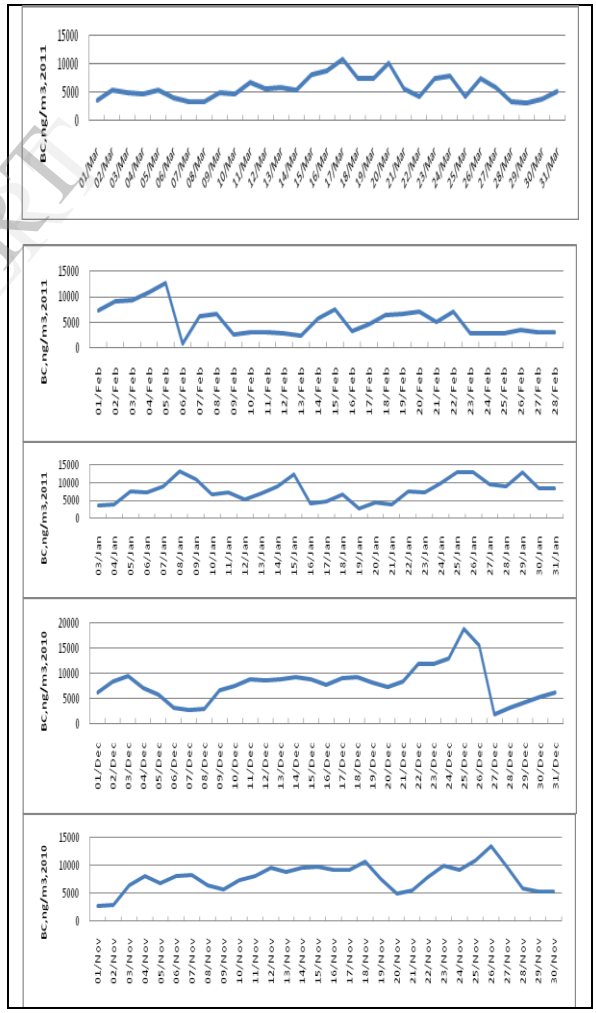


Fig2. Monthly average variation of black carbon aerosol during July-10 to March-11



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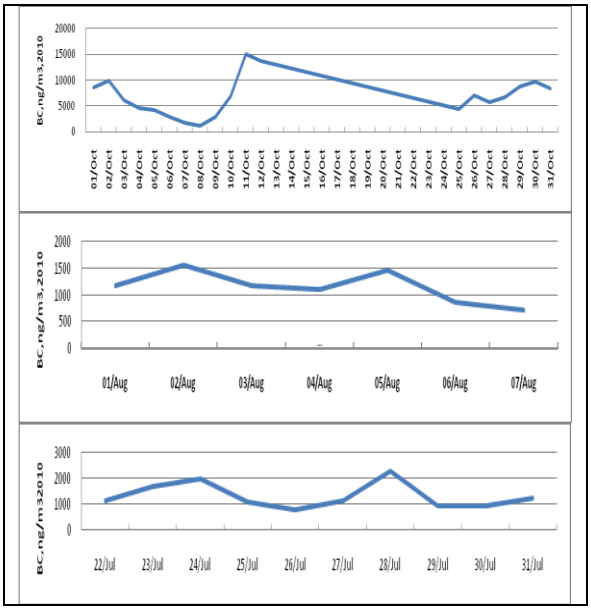
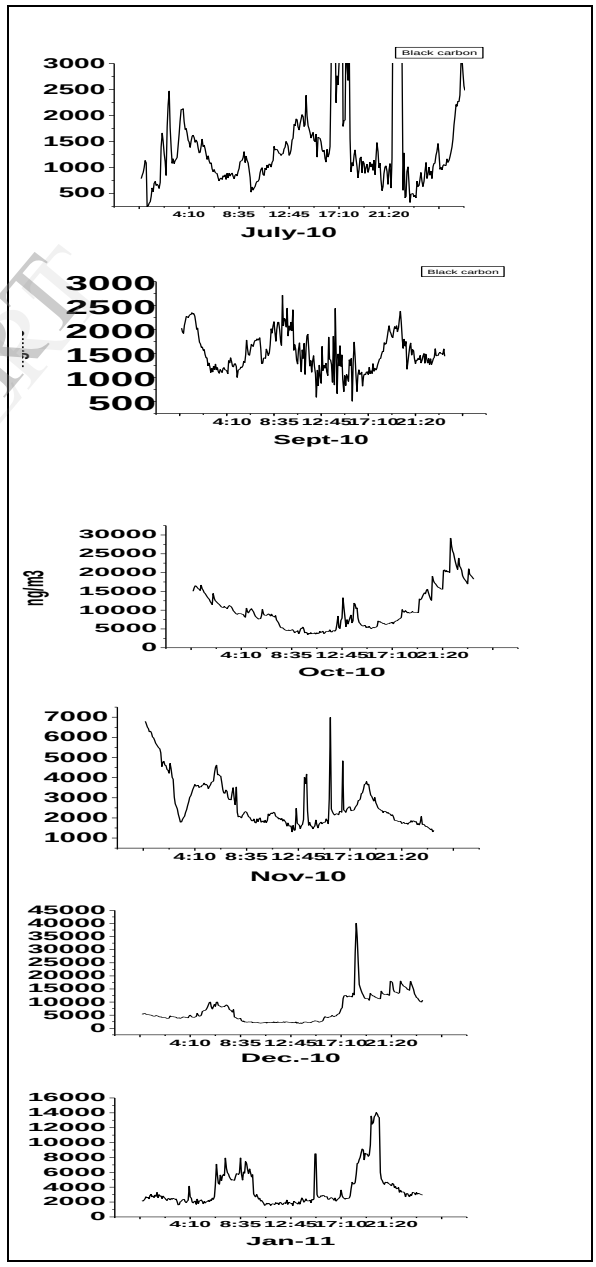


Fig.3 Diurnal variation of BC concentration from July-2010 to March-2011

The graphs shown and figure-4 provide the information about the variation of black carbon concentration with time in a day. High BC concentration was observed during early morning and late night with some exceptions. During early morning hours, high values of BC may attributed to the turbulence set-in by the solar heating which breaks the nighttime's stable layer and aerosols in the nocturnal residual layer are mixed up with those near the surface. Low values of BC during afternoon hours may be due the dispersion of aerosols caused by increased in boundary layer height in addition to the low traffic density. But in the month of March2010 Black carbon concentration high in the afternoon due duststrom and transportation of aerosol from other location. In July, the black carbon concentration was low in noon as compared to BC concentration in evening. High value of evening may also be because of the combustion of anthropogenic sources of fuel. In August, the BC concentration variation was similar but the concentration of the BC was slightly more than the July. In November, it was observed that the BC concentration was high at day fall and during night as compared to the concentration in day. The concentration is been increasing gradually from a low value during noon and attained peak during early morning. Diurnal variation of BC showed two peaks, one in morning and other in the evening. It indicate that the BC concentration is high during day fall and night due to prevailing low temperature,inturn making inhabitants to use anthropogenic sources for heating purposes. Above results/discussions are based on the assumption that the sources will emit the black carbon with same rate and the quantitatively. Diurnal variation of BC is totatally controlled by boundary layer conditions. Apart from this boundary layer variations, the effect of other factors may also be crucial factor such as fossil fuel burning and vehicular emission because are one of the major sources for black carbon aerosols.



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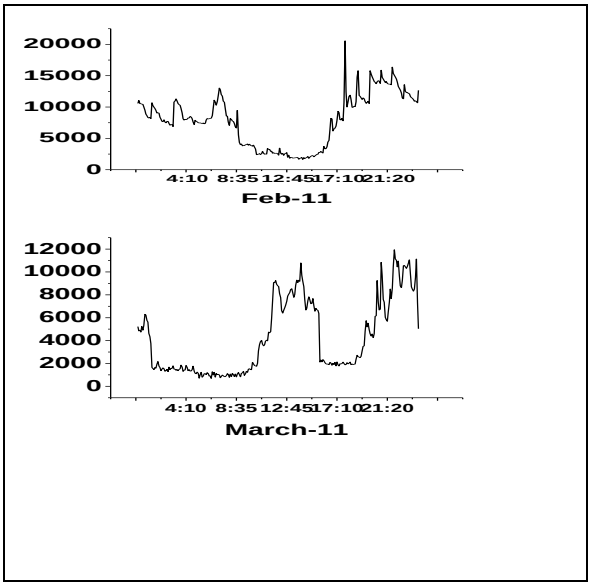


Fig 4: Hourly variation of BC concentration during different Month

Fig5. Shows the variation of BC concentration with respect to meteorological parameters(temperature and relative humidity).The black carbon concentration was generally increased with increase in the relative humidity(RH) and decrease in the temperature but the variation was not consistent because of the influence of other parameters like wind speed and direction. The Aerosol optical depth was increasing with black carbon aerosol and decreasing with BC.From the **fig.6** shows the variation of BC concentration during monsoon season. The figure clearly indicate that the rain fall produce a scavenging effect on the atmospheric aerosol concentration. Due to the rainfall, the aerosol present in the air got precipitate to ground. Days which experienced rain fall had low value of the BC concentration than the days without rainfall. High rainfall resulted in sudden decrease in BC concentration due to scavenging effect however the variation was not consitant because of the influence of the other parameters. Mean while the value of mass concentration of black carbon aerosol was also compared with other regions of India including other parts of India (Table.1).It was observed that average mass concentrations of BC in Ranchi are higher as compared to other city of India and other Indian continental locations.

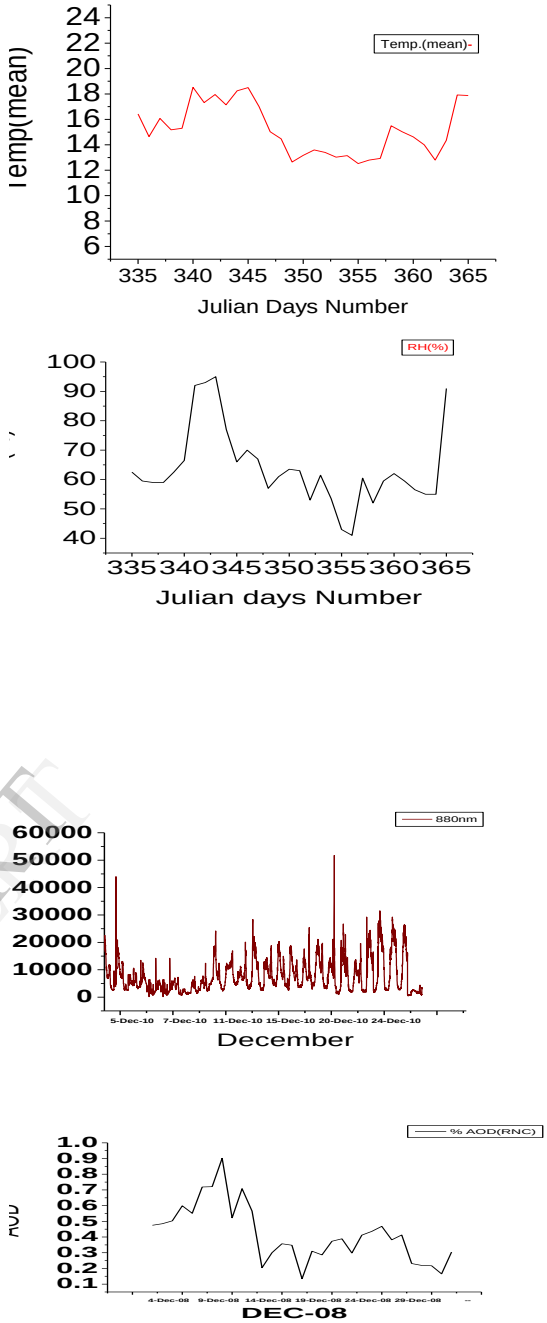
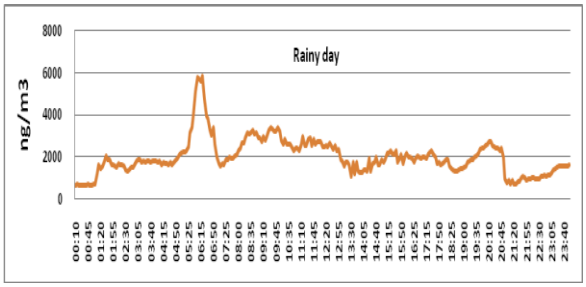


Fig 5. Variation of BC concentration with respect to metrological parameter (temperature and relative humidity) and AOD during month of December.



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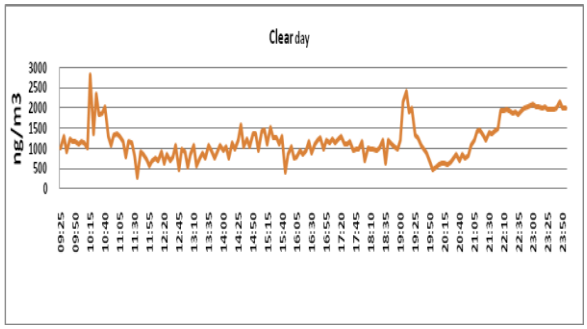

Fig.6.Scavenging effect of the rainfall on the atmospheric aerosol concentration.

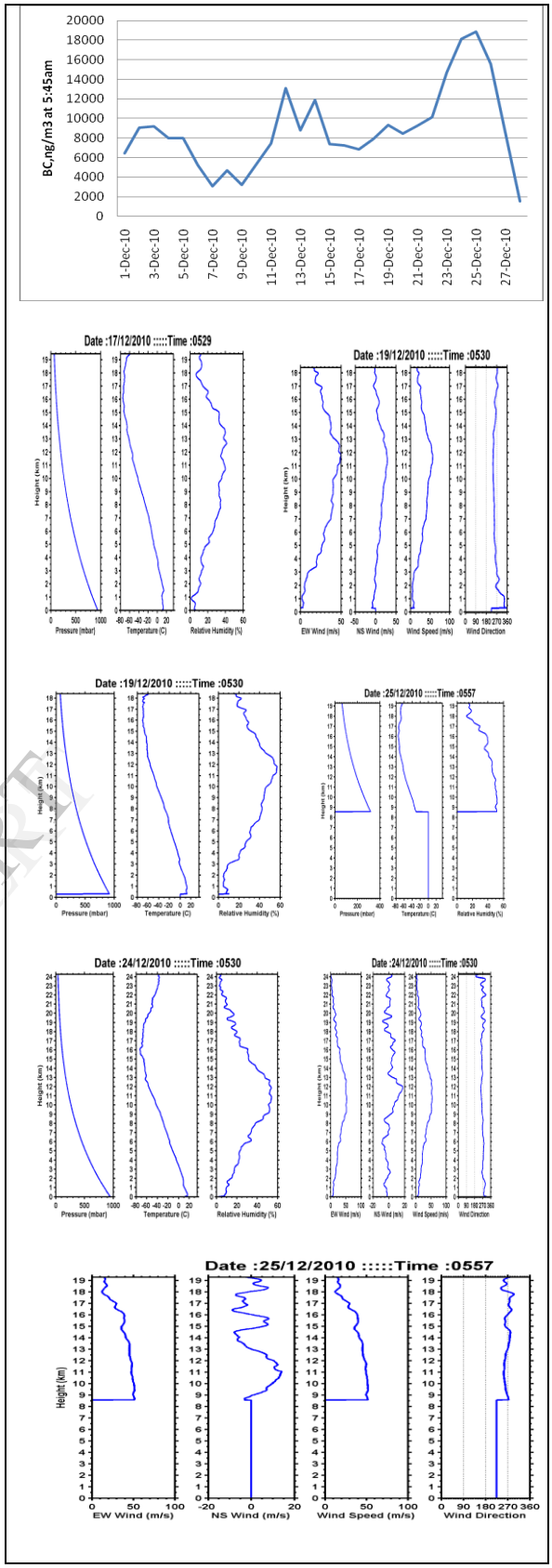

Fig7. Variation of BC concentration at morning 5:45(December) with respect to metrological parameter of upper boundary layer (Radiosonde data)

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Fig.7 Shows the variation of BC concentration at morning 5:45am during month of December with respect to meteorological parameters(Sonde data).The black carbon concentration was compared with data 17/12/2010,19/12/2010 at lower BC and 24/12/2010,25/12/2010 at higher BC ,observation indicate generally increased with increase in the relative humidity(RH) and decrease in the temperature but the variation was not consistent because of the influence of other parameters like wind speed and direction at height below 12km .

Table1. Mass concentration of black carbon aerosol are compared with other regions of India

Location	Period	BC concentration (μg/m³.)
Ranchi	July10 to March-2011	1.0-18(Daily average),1.1-8.1(Monthly average)
Varanasi	Oct -08 to March-2010	2-40(Daily average),3.6-25.4(Monthly average)
Trivandrum	20 Feb.05 to 16 March 05	0.3-6
Hyderabad	Jan to July 2003	0.5-68(dry season),0.5-45(wet season)
Kanpur	Dec.2004	6-20
Pune	Jan.05 to Dec.05	4.1(average)
Anantapur	Jan-08 to Dec.09	2.74±0.63(annual average)
Northern BoB close to India	Oct.2003	1.8±1.6
Shillong	2008	~5(annual Mean)
Hanle in Himalaya	Aug.-Dec.2009	.06(Mean)
Dehradun	2007-2009	4.39(Mean)
Mohal-Kullu(H.P)	July09-March2010	2.7-8(Monthly mean)

Source- Scientific Progress Report-2010(ARFI & ICARB)

Conclusion:

1. Average BC concentration in Ranchi region is significantly higher as compared to BC concentration reported from other location of India.
2. BC showed well defined diurnal variations. This is due to local factors and boundary layer dynamics.
3. High BC concentration was observed when the humidity of air was and high and vice versa.
4. Average BC Concentration in Ranchi region is significantly large fractuation in winter season (December) as compared temporal variation on that time.
5. The aerosol number concentration and AOD measurements would be helps us to find the role of boundary layer dynamics in the above typical temporal and monthly variations of BC at BIT Mesra, Ranchi site. Moreover, it is proposed to study the impact of aerosols and trace gases on the biodiversity dynamics in and around Ranchi and other parts of Northern India.
6. Winter season that may cause adverse effect to the agricultural crops and also to the human health. Increased aerosol loading may likely affect the rainfall which is responsible for the observed drought conditions over the Indian subcontinent. Detailed analysis of AOD, crop yields and rainfall data are required to understand the impact of increasing aerosol loading over the Northern India.

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Acknowledgement

The authors express sincere gratitude to GBP Programme of Space Physics Laboratory for providing the required meteorological data from ARFI network and Birla Institute of Technology, Mesra, Ranchi for allowing working in its premises and providing the facilities and necessary data to main author.

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