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BLACK CARBON AEROSOL VARIATION AND ITS IMPACT OVER DELHI

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Abstract

Black Carbon (BC) aerosols, the optically absorbing carbonaceous aerosols released from the incomplete combustion of almost all fuels is an important aerosol constituent. It contributes about 10% of the Respirable Suspended Particulate Matter in urban polluted area. In this paper we present results from measurement on BC aerosols concentration over Delhi during June 2005 to January 2007 using an Aethalometer. The BC concentration shows temporal variations on diurnal as well as seasonal scales. The BC concentration shows strong anti-correlation with the mixing layer height measured simultaneously using an acoustic SODAR. Stronger anti-correlation is found with the ventilation coefficients obtained by multiplying the average wind velocity with the mixing layer height. The effect of BC aerosols over Radiative forcing over Delhi has also been estimated using the OPAC and the SBDART model.

Introduction

Black carbon, the graphitic form of carbonaceous aerosols is emitted into the atmosphere as by-product of all combustion processes such as industrial pollution, traffic, outdoors fires, household burning of coal and biomass fuels. Most of the BC is fine and accumulation size particles (radius <0.2micrometer) and are hydrophobic or weakly hydrophilic *(Jacobson, 2001)* have global residence times of about 1 week. The spatial distribution of BC aerosol is highly variable with the greatest concentration near the production region. It is removed by precipitation and by gravitational settling or sedimentation. Generally, it causes positive Radiation Forcing and reduces the solar radiation reaching the earth surface as much as 5% or 25 W m-2 and ultimately change the dynamics of the atmospheric boundary layer. The indirect effect is that BC nucleated or scavenged within other aerosols can alter microphysics of clouds. In atmosphere, BC doesn't exist freely; it is always bonded with some other aerosol particles such as sulphates, organics, ect. Atmospheric aerosols containing BC can absorb as much as 20-25% of the incoming solar radiation leading to heating of the particles and local warming of the boundary layer *(P.Hermann and G.Hanel, 1997).*

Instrumentation and Data Analysis

The study area Delhi, has a semi-arid climate. It has extreme weather conditions during peak summers temperature rises even beyond 45 ^{o}C. and in winter temperature may drop to below 5 ^{o}C. The rainy season is from July to September with average annual rainfall is ~670 mm. The measurements have been carried out from June 2005 to Jan 2007 in the premises of National Physical Laboratory located in Central Delhi using the Aethalometer model AE-21 of Magee Scientific, USA by measuring the attenuation of light transmitted through particles that accumulates on a quartz fiber filter. A vacuum pump draws air so that particles continuously accumulate on the filter paper. By using the appropriate value of the specific attenuation for that particular combination of filter and optical components, we can determine the BC content of the aerosol deposit at each time interval of 5 minute. The instrument has been operated round the clock with a flow rate of 2-liter min^{-1}. It has been factory calibrated with errors in the measurements are ~ ± 2 %. The planetary boundary layer height has been measured with SODAR an acoustic echo sounder, which is developed, designed and fabricated in the NPL. Highly directional short burst of sound energy are radiated into the atmosphere, which after scattering from atmospheric fluctuations of eddy sizes within the inertial sub range (0. 1-10m), are received by the receiving antenna. Information about nocturnal inversions can be immediately obtained by facsimile chart which reveals the height of boundary layer in the atmosphere, which is working 24 hrs daily from the site of NPL.

Results and disscussion

Figure 1 shows typical diurnal variation of BC concentration during March 22-31, 2006. The daily variation in concentrations were strongly affected by the diurnal variations in the mixing height. It shows enhancements during 0630 to 0930h in the morning hours with minimum occurring around 1530h. Again the BC concentration starts increasing around 2000h and goes on increasing till mid night and early morning (0130h). The average maximum morning value of BC concentration is 16854.6 ng/m3 (0730h) while the maximum value is 21468.3 ng/m3 on 22 March, 2007. The average minimum value 1598.6 ng/m3 has been recorded during 1530h. The morning and late evening enhancements mainly attributed due to the fumigation effect in the boundary layer and also due to the increase in vehicular traffic (*Latha K.M., K.V.S.Badrinath, 2005*) . The mid-night peak may be due to the lowering of mixing height The BC concentration remains almost constant till late noon. Low values of BC during afternoontime have been attributed to the dispersion of aerosols due to the turbulence set in by the solar heating which breaks the nighttime stable layer and due to increase in boundary layer height in addition to the low traffic density.

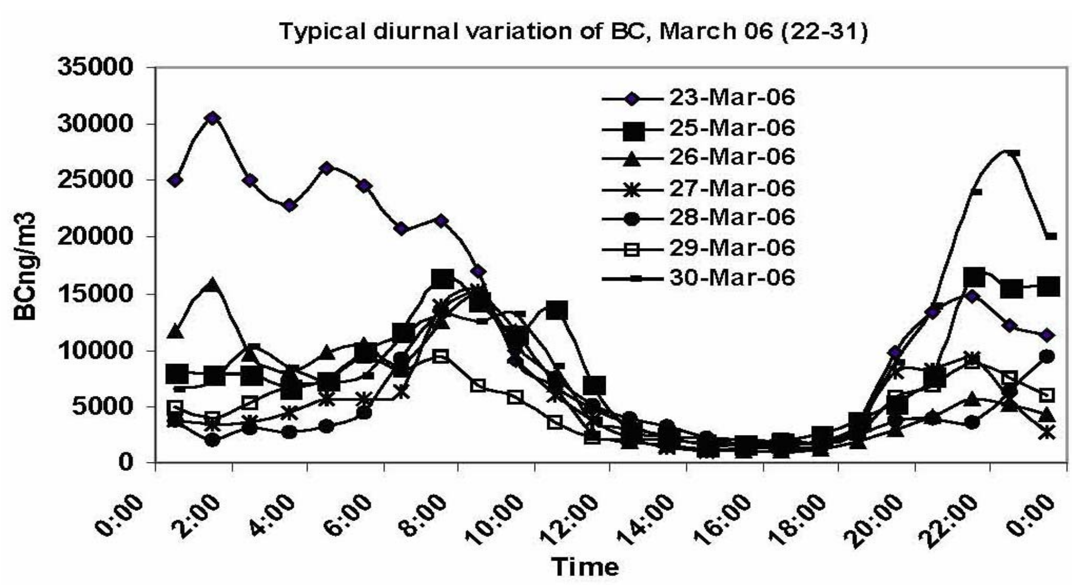

Fig 1: Diurnal variation in BC Concentration on clear days during March, 2006

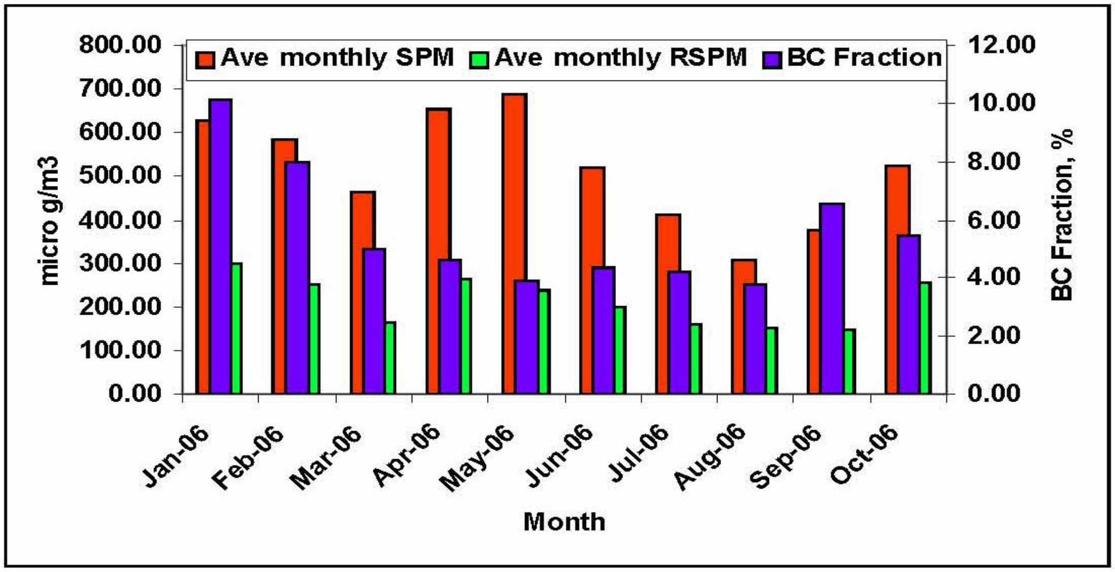

Fig 2: Average monthly Suspended Particulate Matter (SPM), Repairable Particulate Matter (RSPM) and BC fraction.

In fig 2, monthly variation in SPM concentration, RSPM concentration along with BC fraction has been shown. The values of SPM and RSPM has been taken from Central Pollution Control Board (CPCP). The average SPM is highest during May but RSPM values are also high during winter. The average monthly variation of BC for 24-hour period shows that in general winter season has much higher BC concentration in comparison to summer season. This may be due to reduced convection activity and low boundary layer height during winter. The BC concentration generally found below 10 μm^{-3} .The mass fraction of BC to RSPM is generally less, it contributes ~6 %. However , during January, contribution of BC to RSPM was observed to be the maximum ie 10.12 % and during monsoon it was minimum (average 3.79%)

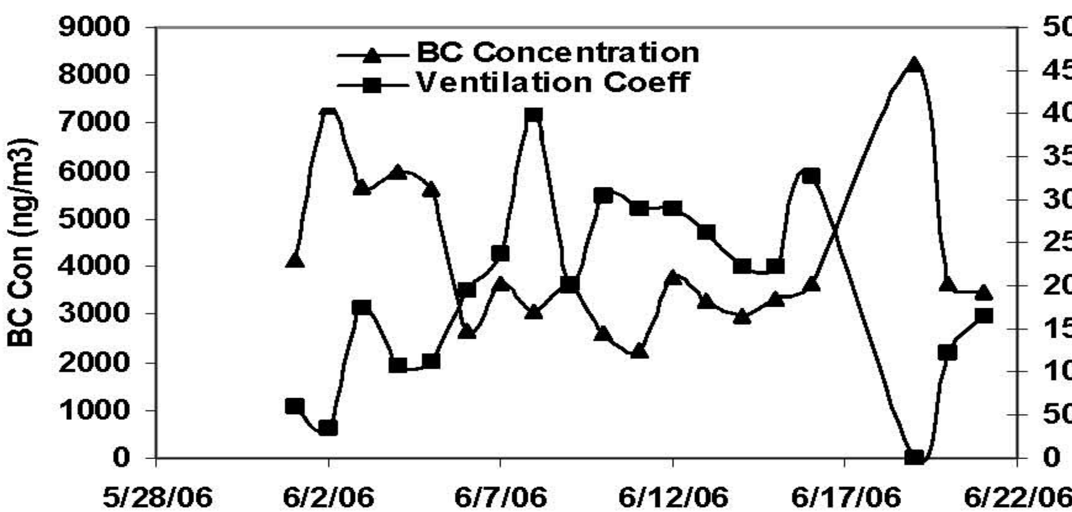

Fig.3: Comparison of BC concentration with Ventilation Coefficient

Figure 3 shows the variation of ventilation coefficient and BC concentration for the month of June 2006 measured during the day-time (11:00-18:00). The ventilation coefficient is obtained by the product of average wind speed and the mixing layer height. A clear anti-correlation (correlation coefficient -0.76) between the two is observed and indicates that the BC concentration largely depend on the Ventilation Coefficients.

Conclusions

BC concentration has been measured at semiarid mega city, Delhi, India by an Aethalometer. The key findings of this study are:

1. BC exhibited a distinct strong diurnal variation with the highest concentration occurring 0630h to 0930h and again at around 2000h till midnight. Lowest concentration at about 1530h. The diurnal pattern was largely a result of changes in the mixing heights.

2. Higher concentrations are found for winter season, foggy weather conditions and during evening till early morning hours in the diurnal cycle. The average BC concentration is below 10 μm^{-3}. The average BC fraction is 5.6%.

3. The anti correlation in between the BC concentration and Ventilation Coefficient as because BC is highly affected by the mixing layer height.

References

1. Herman P. and G. Hanel, Wintertime optical properties of atmospheric properties of atmospheric particles and weather, *Atmospheric Environment*, 24, 4053, 1997

2. Jacobson, M.Z (2001), Strong radiative heating due to the mixing state of black carbon in atmospheric aerosols, *Nature*, 409(6821), 695-697,2001.

3. Latha K.M., K.V.S.Badrinath, Seasonal variations of black carbon aerosols and total aerosols mass concentrations over urban environment in India, *Atmospheric Environment*, 39 (2005) 4129-4141