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BLACK CARBON AEROSOL MASS CONCENTRATION VARIATIONS IN ANANTAPUR

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Introduction

Aerosols influence climate directly by scattering and absorbing solar radiation (Charlson *et al., 1992*), indirectly by acting as cloud condensation nuclei; there by affecting the droplet concentrations, optical properties, precipitation rate and lifetime of clouds (Rosefield, *2000*) and semi-directly by evaporating the clouds (Ackerman *et al., 2000*). Black Carbon (BC), the optically absorbing part of carbonaceous aerosols, is the major anthropogenic component of atmospheric aerosol system which has significantly different optical and radiative properties, as compared to the other normal constituents. The chief sources of BC are, burning of biomass and fossil fuels, automobile exhaust, aircraft emissions and forest fires. Atmospheric BC directly accounts for the reduction in incoming short wave solar radiation, leading to the heating of atmosphere. BC is easily inhaled and can be a health hazard as it mostly occurs in the sub micron range (Harvath, *1993*).The present study provides an account of BC mass concentration variations over a semi-arid region of Anantapur.

Methodology and Datasets

Simultaneous measurements of BC mass concentration (M_b), total aerosol mass concentration (M_t), aerosol optical depth (τ_p) and meteorological parameters were carried out at an altitude of ~10 m above (331 m above mean sea level) using an Aethalometer (AE-21), 10 channel Quartz Crystal Microbalance (PC-2 of California Measurements Inc., USA), ten filter Multi Wavelength Solar Radiometer (MWR) developed at SPL, VSSC, Trivandrum and an Automatic Weather station (ASTRA Microwave products Ltd.) respectively.

Aethalometer provided automatic, continuous and near real time measurements of Black Carbon (BC) mass concentration. The instrument aspirates ambient air through an inlet tube connected to a pump. The particles impact on a quartz filter tape, the change in transmittance of which after each collection interval is calibrated in terms of the mass of BC. The instrument was operated at a flow rate of 3 LPM; and at a time base of 5 min, so that BC estimated are available every 5 min, on all the days and the round the clock. The QCM was used to measure both total mass concentration (M_t) and mass size distribution (m_{ci}) of aerosols on the size range 0.05 to 25 μm over 10 size bins. It operated at a flow rate of 0.24 l min^{-1} and sampling was done at nearly hourly intervals, manually round the clock, with the sampling duration of 6 min, when the ambient RH < 75%.

A ten channel Multi Wavelength Solar Radiometer (MWR) was also operated at the same station during the same period on all clear days and the data was used to estimate the columnar optical depths (τ_p) at ten selected narrow wavelength bands centered at 380,400,450,500,600,650,750,850,935 and 1025 nm, with a band width (full width half

maximum) of 6-10 nm and over all field of view of ~2^0. Meteorological data on air temperature, relative humidity, wind speed, wind direction and rainfall were carried out using a meteorological station established at the same station.

Results and Discussions

Diurnal Variation of BC

Figure.1 shows diurnal variations of BC mass concentration with two maxima peaks during morning 06:00 –08:00 local time (LT) and evening 19:00-21:00 LT. BC shows higher variability during the night time and early morning hours when values as high as up to 50 μg m^{-3} has been observed. BC concentration starts rising gradually after the sunrise and attains a peak at 07:00 LT. The high concentration of BC in morning hours, higher than the corresponding late evening values, is mainly because of two reasons. First, increased anthropogenic activities such as biomass burning for heating purpose and commencement of the industrial activities, vehicular emissions during the morning hours emit more BC. Secondly, due to the turbulence set-in by solar heating which breaks-up the night time stable layer and subsequently aerosols in nocturnal residual layer are mixed with those near surface, known to be fumigation effect (Stull, *1998*). During daytime increased mixing within the turbulent boundary layer as temperature increases leads to fast dispersion of BC aided by relatively higher wind speed, thus reducing its near surface concentration. In evening, boundary layer mixing again decreases due to inversion and as result BC gets trapped near the surface and attains maximum value around 19:00-21:00 LT. As the night progresses, the anthropogenic activities and the vehicular emissions get reduced, as a result BC concentration decreases.

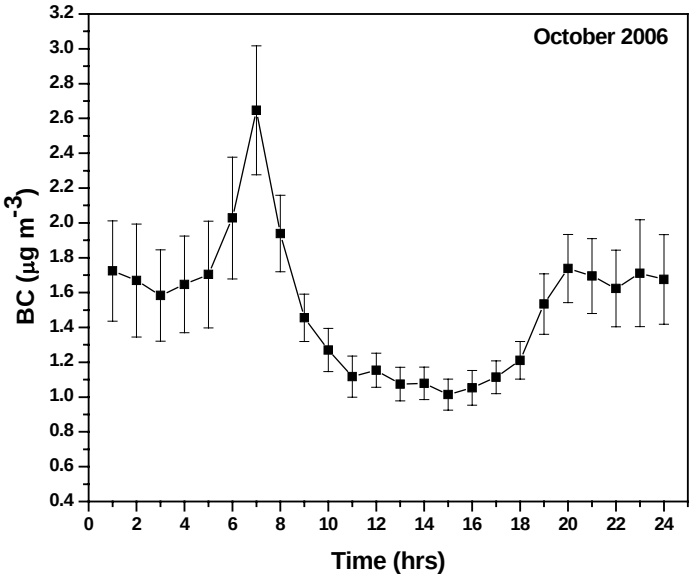

Fig.1. Diurnal variation of average BC for the period 1st to 31st October 2006.

Daily average variations of BC concentration over Anantapur is shown in Fig.2. It can be seen that BC concentrations are observed to be high on certain days. It is expected that high concentrations during those days may be attributed due to high vehicular emissions and biomass burning. Figure 3, shows the diurnal variations of meteorological parameters data on air temperature, relative humidity, wind speed and wind direction over the observation site.

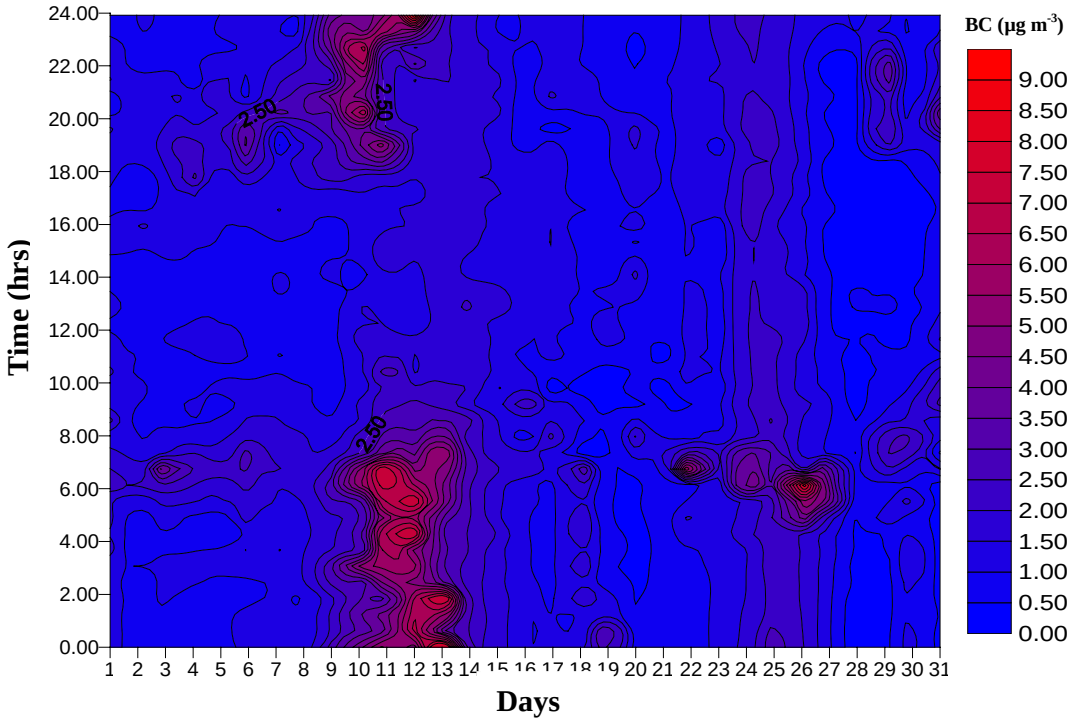

Fig.2 Daily average variations of BC concentration for the period 1st -31st October 2006.

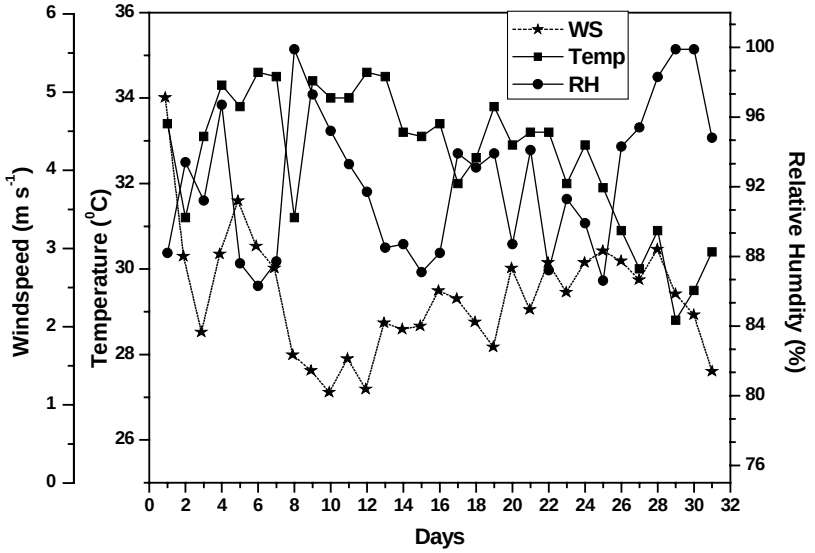

Fig.3. Daily average variations of wind speed (WS), temperature (Temp) and relative humidity (RH) for the period 1st – 31st October 2006.

Aerosol Optical Depth and Black Carbon

A scatter diagram of simultaneous estimates of τ_p at 500 nm and surface black carbon concentration (M_b) is shown in Fig. 4. Notwithstanding the fair amount of scatter (which is expected as BC is not the only contributor to τ_p), τ_p is found to increase with M_b. A linear regression analysis yields

$$\tau_p = \tau_{p0} + (0.0259 \pm 0.0085)M_b \qquad (1)$$

With a correlation coefficient of 0.29, which is quite significant, and $\tau_{p0} = 0.2662$. The τ_{p0} is the optical depth mainly due to be of non-local origin. Even though τ_p is column optical depth and BC is surface concentration, both can correlated as τ_p measurements were carried out during day time profiles shows that there were no strong inversions aloft. This excludes aerosol layers aloft, so that the variation in the surface can be taken as representative of the variations in the column (in the free troposphere).

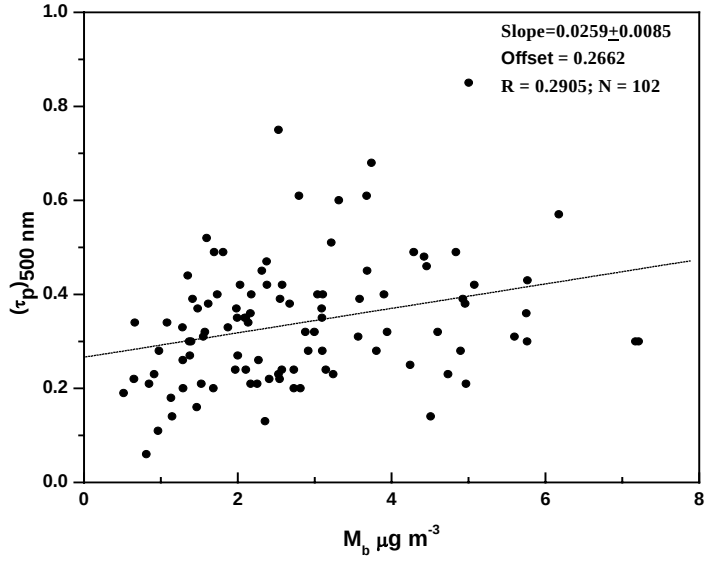

Fig. 4. Scatter diagram of aerosol column optical depth at 500 nm versus black carbon surface mass concentration.

Black Carbon and Total Mass Concentrations:

In Figure 5, the ambient M_t from QCM is plotted is against the corresponding value of M_b from Aethalometer as a scatter plot. A good positive correlation is noticeable; and the correlation coefficient of 0.501 is quite significant, considering that there are 49 data pairs and also that BC is only one of the several possible constituents of atmospheric aerosols. The mass fraction of BC to total mass is obtained by making a best fit to the data through origin. (as BC is a universal component of the aerosol system).

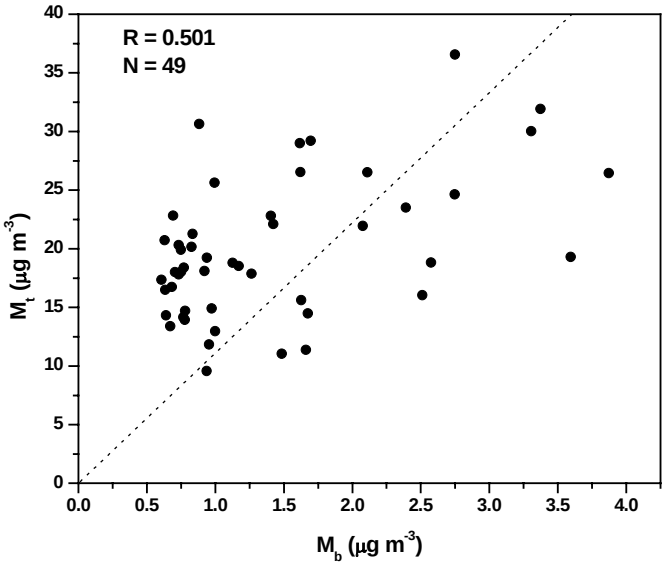

Fig.5. Scatter plot of total aerosol mass concentration verses black carbon mass concentration during the period August 2006 to February 2007.

Acknowledgements

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