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CHARACTERISTICS OF CARBONACEOUS POLLUTANTS AT HIGH ALTITUDE STATION SINHAGAD IN INDIA

S. Kewat, P.D. Safai, B. Krishnakant, P.S.P. Rao, G.A. Momin and K. Ali

Indian Institute of Tropical Meteorology, Pune-8
Kewat@tropmet.res.in

Introduction

Aerosols have been a vital link between the source–transport-deposition of various pollutants in the atmosphere. Fine particles and droplets suspended in the atmosphere have a key role in environmental issues such as climate and human health. Aerosol Black Carbon (BC), the optically absorbing part of carbonaceous aerosols, is the major anthropogenic component of atmospheric aerosol system that has significantly different optical and radiative properties, compared to other constituents. All the recent major field campaigns of the last decade have ascertained the importance of BC in climate change studies [Ramanathan et al., 2001a]. Burning of biomass and fossil fuels, automobile exhaust, aircraft emissions and forest fires are the chief sources of BC. Studies on BC aerosols have been very few from the Indian region, especially from the high altitude locations. Therefore, extensive week-long measurements of aerosol Black Carbon and size separated aerosols (TSP, PM_{10}, $PM_{2.5}$ and $PM_{1.0}$), were carried out during April 2005 and December 2005, at a tropical hill station Sinhagad (18^0 $21^/$ N and 73^0 $45^/$ E, 1450 m amsl), India. This site could be considered as representative of regional aerosol climatology as it is away from major anthropogenic activities.

Location of site and methodology of sampling

Sinhagad is a historical fort situated on the hill at a mountain top in the Western Ghat region. It is located about 40 km by road, to the southwest of Pune. The top of the hill is flat terrain with an area of about 0.5 sq. km and is surrounded by other mountain peaks of comparable heights. The area is covered with vegetation during monsoon and post-monsoon season. Local inhabitants on the fort are very few. The only noticeable local source of pollution is wood burning, mainly for cooking. However, a few vehicles, mainly cars, jeeps and two-wheelers, enter the mountain but they have to stop at the entrance of the fort only.

Continuous observations on BC aerosols have been carried out by using an Aethalometer (Magee Sci., Inc., USA, Model AE- 42). In this method, atmospheric air is pumped through an inlet at the flow rate of about 3 LPM, which impinges on a quartz micro fibre strip. A light beam from a high intensity LED lamp is transmitted through the sample deposit on the filter strip, at 880 nm. The measurement of the attenuation of light beam is linearly proportional to the amount of BC deposited on filter strip. Observations were recorded at the time base of 5 minute interval. This technique is reported to have shown good comparison with the other ones used for monitoring of BC particles, like coefficient of haze tape sampler, particle soot absorption photometer, thermal oxidation /

reflectance technique, etc. (Allen et al., 1999; Babich et al; 2000). The data were corrected for change in flow speed due to high altitude of the station. Data on size separated (TSP, PM_{10}, $PM_{2.5}$ and $PM_{1.0}$) aerosols were obtained using an Aerosol Size Spectrometer (GRIMM, Model 1.108). This portable instrument gives single particle counts or masses and size classifications in 15 size interval (from 0.30 to > 20 μm size) in real time.

Results and Discussion

Concentrations of BC were high (3.2 $\mu g/m^3$) during winter and low (1.2 $\mu g/m^3$) during summer, which could be mainly due to the (i) NE winds during winter, coming from continental parts of Indo Gangetic Plains (IGP) and NE Indian regions that have been reported to be one of the potential emitters of combustion related aerosols and gases (Garg, et al, 2001; Venkataraman, et al, 2005). Whereas, during summer generally westerly winds (W/NW) predominate over this region, that bring in marine air masses from the Arabian sea which are occasionally mixed with continental air of the adjoining arid areas in NW India or even sometimes originate from coast of Iran and further travel through Arabian sea and Kutch region. Also in some cases air masses come from Gulf coast or from Mediterranean region. This is also observed from the air-mass backward trajectory analysis using NOAA Hysplit Model, plotted for 500 and 1500 m AGL height for the respective weeks in April and December, when the observations were undertaken at Sinhagad (Fig.1). (ii) Prevailing boundary layer characteristics, i.e. low mixing heights and low wind speeds during winter are conducive for the less dispersal of pollutants during winter. Whereas, during summer, high convective activity due to more temperature and wind speed, gives rise to more dispersal of particulate pollutants. Higher BC concentrations during winter have been also reported for Pune, which is about 40 km from Sinhagad (Safai, et al, 2007). However, the average BC at Sinhagad in winter is more as compared to that reported for Nainital, a high altitude station at the foothills of western Himalayas (Pant et al, 2006), where the average value was 1.36 $\mu g/m^3$. BC formed about 5 % of TSP during winter where as, during summer it formed 3.5 %. Pant, et al (2006) have reported about 5 % mass fraction of BC to total aerosol load at Nainital.

In addition to it, mass size distribution of aerosols as observed from data obtained by using low volume air sampler (Andersen Inc., USA) showed the dominance of coarse size particles during winter (58 %) than during summer (42 %). Also, mass median diameters (MMD) were 3.9 μm and 1.7μm during winter and summer. Generally, TSP and especially coarse fraction of it are higher during summer than winter but this is exception to it. The reason for this feature could be some major road repair activity undertaken at the fort during that period.

Fig. 2 shows the diurnal variation of BC along with other size separated aerosols during summer and winter season. Diurnal variation of BC is different than that observed at Pashan, Pune, a semi-urban location; where morning and evening peaks were observed during both summer and winter (Safai et al, 2007). At Nainital, afternoon BC peak is reported during winter, which is attributed to the changes in boundary layer (Pant, et al, 2006). The diurnal variation of BC at Sinhagad is similar to that reported at Nainital, during winter season. Also, in summer, it showed an afternoon peak (at around 12 to 14

hrs), similar to that in winter. However, the local burning activity practiced in the nearby surrounding for charcoal making (which started at noon and continued through to evening period), might have been responsible for the evening peak at around 20 hrs in summer. It is observed that variation of BC closely matched with that of $PM_{2.5}$ and $PM_{1.0}$. Also, BC showed a good correlation with $PM_{1.0}$ and $PM_{2.5}$ aerosols ($r = 0.90$ and 0.84, respectively for $PM_{1.0}$ and $PM_{2.5}$ during winter and $r = 0.68$ for both during summer), indicating fine size nature of BC. However, during winter it showed good correlations also with large size aerosols (TSP and PM_{10}), which shows its significant contribution to the total aerosol load particularly during this season.

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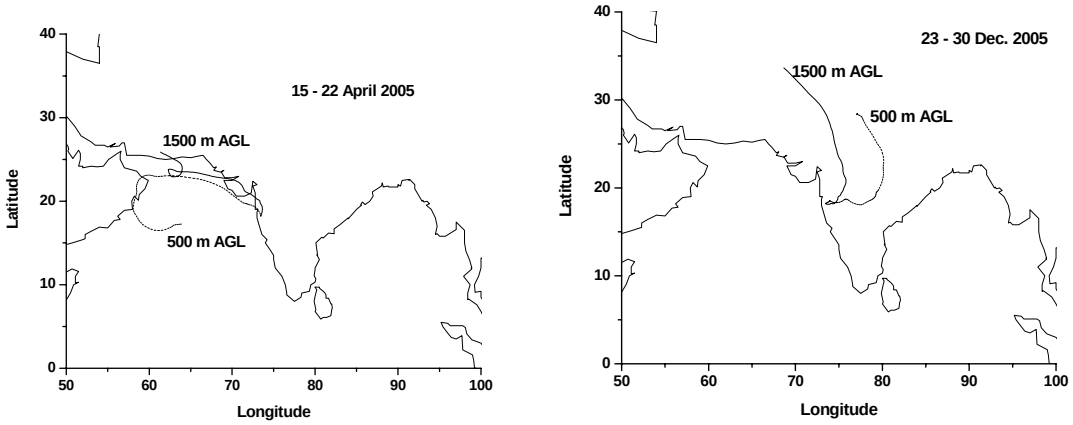

Fig. 1: Air-mass backward trajectories at Sinhagad using NOAA Hysplit Model for 500 and 1500 m AGL for 15-22 April and 23-30 December 2005.

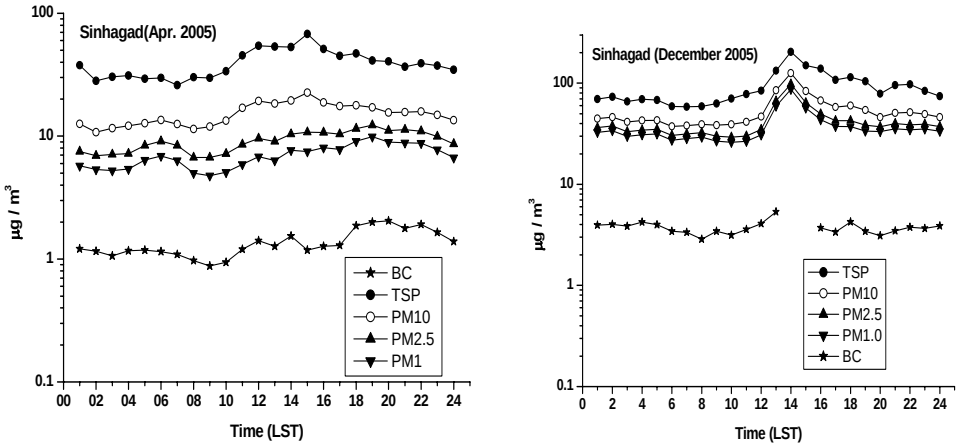

Fig. 2: Diurnal variation of BC, TSP, PM_{10}, $PM_{2.5}$ and $PM_{1.0}$ at Sinhagad during summer and winter season of 2005.