Impact of diesel vehicular emissions on ambient black carbon concentration at an urban location in India

K. Madhavi Latha[†], K. V. S. Badarinath[†,*] and K. Krishna Moorthy[#]

[†]National Remote Sensing Agency, Balanagar, Hyderabad 500 037, India
[#]Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram 695 022, India

Vehicular emissions in the urban areas are known to contribute significantly to aerosol black carbon (BC) loading to the atmosphere. Quantification of BC emissions is important from the climate research point of view, as the BC aerosols strongly absorb solar radiation. A case study has been carried out in an urban area, Hyderabad, to assess the impact of emissions associated with truck transport on ambient BC concentration. The study was carried out during the recent nationwide truck strike of April 2003. The results indicate a significant reduction in the BC loading associated with withdrawal of the trucks. The decrease was gradual, while the recovery was almost immediate.

ATMOSPHERIC aerosol black carbon (BC) is known to be a significant absorber of solar and terrestrial radiation and is recognized as a potent greenhouse species of atmospheric aerosols[1,2]. BC is emitted into the atmosphere as a by-product of all combustion processes (vegetation burning, industrial effluents and motor-vehicle exhausts). It is one of the important constituents of ambient particulate matter[3]. BC is chemically inert in the atmosphere and predominantly is in the submicron size; its main atmospheric sink is wet deposition[4]. While scattering aerosols increase the atmospheric albedo tending to cool the earth, BC absorbs radiation causing a warming. The darker grey particles are, the more solar energy they can absorb, thereby heating the atmosphere[5]. BC aerosols originating from fossil-fuel combustion and biomass burning, and carbonaceous aerosols contain BC directly emitted during the combustion process (primary aerosols) and organic matter vapour (secondary aerosols)[6]. In this communication we present the results of a case study conducted in an urban area, Hyderabad, Andhra Pradesh to assess the impact of emissions from diesel truck transport on aerosol BC concentration.

Continuous measurements of aerosol BC have been carried out using an Athelometer model AE-21, of Magee Scientific, USA. The aethalometer makes measurements of mass concentration of aerosol BC by measuring the attenuation of light transmitted through a quartz filter tape on which the ambient particles are made to impinge. The reduction in the transmission consequent to the collection of particles is calibrated in terms of the mass concentration of BC. More details are available elsewhere[7,8] (http://www.mageesci.com/Aethalometer_book_2009.pdf). The study area was located within the urban area of Hyderabad (17°10′–17°50′N and 78°10′–78°50′E), which is the fifth largest city in India (Figure 1). Measurements were

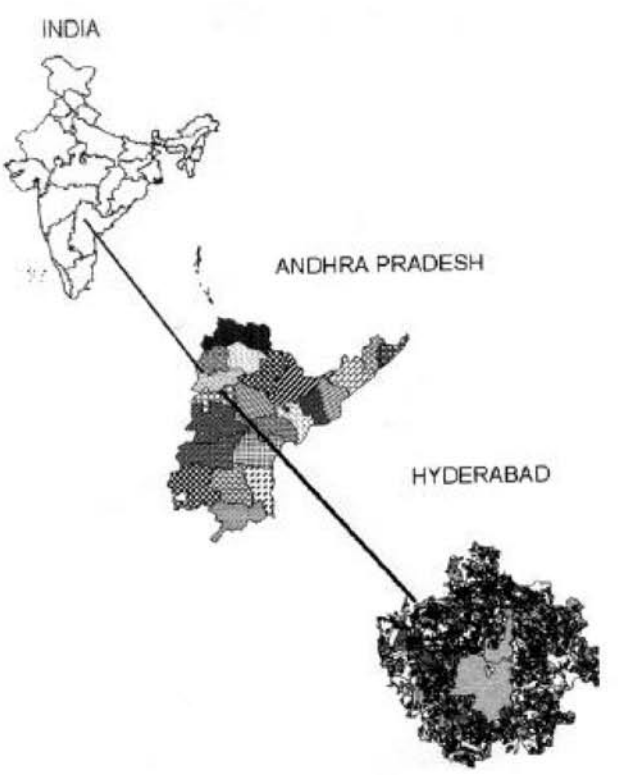

Figure 1. Location map showing the study area.

*For correspondence. (e-mail: badrinath_kvs@nrsa.gov.in)

carried out in the premises of the National Remote Sensing Agency, Balanagar (17°28′N and 78°26′E) located well within the urban centre. The twin cities of Hyderabad and Secunderabad extend up to 16 km. Two highways pass through the east and north of the sampling site at a distance of around 500 m. During the study period, truck operations over the entire country (India) remained totally suspended in response to a nationwide strike call by the operators, from April 13 onwards. Hyderabad has a fairly large influx of trucks transporting commercial goods. The trucks traffic is estimated to be on an average ~ 19% of the total vehicular density of Hyderabad (RTA report). The emissions from all these automobiles would add significantly to the total BC concentration of the ambient. Thus the withdrawal of trucks during the strike resulted in reduction of the total BC emissions, because diesel trucks are known to be stronger sources of BC than petrol vehicles. Further, BC emissions (particularly from heavy-duty diesel engines of trucks) increase with increase in ambient air temperature and this would also be important during the dry months[9]. Though the strike was called-off totally on 23 April 2003, in Andhra Pradesh on 21 April itself, partial resumption of truck traffic took place. The traffic was fully restored from 23 April onwards. During the above period, aethalometer data were available almost regularly, and the data collected during the period 1 to 25 April 2003 are examined for assessment of impact.

Figure 2 shows the variations of daily average BC concentrations for the period 1 to 25 April 2003. The points are the daily mean BC concentrations and the vertical bars through them are the standard error. In Figure 2, the first bar represents the average BC concentration before the strike days (1–12 April). From the second bar onwards, the average day BC concentration on each day has been plotted (13–25 April). The days lying between the two vertical arrows indicate the total duration for which the truck strike was on normally, while the dashed arrow indicates partial resumption of truck traffic within Andhra Pradesh. Figure 2 shows the signature of impact of the truck strike, with a sudden decrease in the BC concentration on the day the strike started. On the subsequent days after 13 April 2003, BC concentration continued to decrease, though more gradually to reach the lowest BC concentration (17 ng m^{-3}) on 21 April eight days after the trucks were withdrawn. The sudden decrease in BC is attributed to the withdrawal of a potential source, while the gradual decrease subsequently is a result of the finite residence time of BC because of which the BC already in the ambient takes a finite amount of time to get removed from the atmosphere. Studies conducted earlier on automobile exhaust[9] have shown that diesel trucks/heavy vehicles have much higher BC emission potential than lighter petrol engines. The month of April is the hottest period for Hyderabad, with the maximum temperature going up to 40°C and minimum temperature, in the vicinity of ~ 22°C.

Several studies have shown that in the absence of strong precipitation, atmospheric BC has typical lifetimes ranging from 1 week to 10 days[6]. An earlier impact study at Thiruvananthapuram associated with induction of BC into the atmosphere, has shown that it takes more than a week for the effect of impact to become normal[10]. Thus the gradual decay observed in our study is mainly due to BC residence time. The other vehicular traffic and normal urban activities maintain the high BC level seen through-

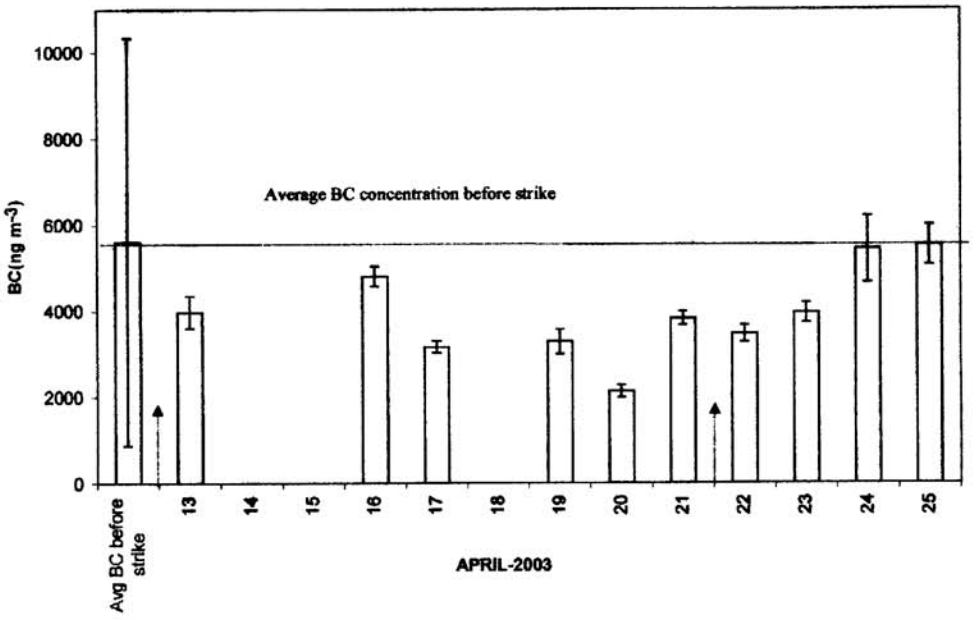

Figure 2. Variation of black carbon before, after and during strike periods.

out the study. Figure 2 also shows that ambient BC level responds immediately to the resumption (even though it was only partial and confined to within the state from 21 April onwards). The strike was called off nationwide on 23 April; BC had responded immediately to the increase in the influx of trucks and reached values as high as 4500 ng m^{-3} on 24 April and continued to do so on subsequent days.

Our study has shown that the exhaust from diesel trucks contributes significantly to the ambient BC concentration at the urban centre of Hyderabad. Even though there is a sudden decrease in the BC concentration associated with the cut-off of a potential source component, the full impact is felt much later due to the finite atmospheric residence time of BC. The recovery due to resumption of truck traffic is almost instantaneous.

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