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

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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 aethelometer 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/Aethelometer_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

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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 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. 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 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. 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. 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-

![Graph showing variations of black carbon before, after and during strike periods.](image-url)
Diacetylphloroglucinol-producing pseudomonads do not influence AM fungi in wheat rhizosphere

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Natural agroecosystems are directly dependent on beneficial microorganisms present in bulk soil and rhizosphere for soil health and plant productivity. With the current thrust on use of microbial inoculants, especially the biological control agents, it is necessary to assess their negative influence on such beneficial forms as AM fungi since they help the plant withstand various stresses. Among other molecules, pseudomonads present in the rhizosphere secrete the antifungal, 2,4-diacetylphloroglucinol (DAPG) and are currently in great demand as bioinoculants. Based on the cultural, biochemical, and molecular tools we show that DAPG producing pseudomonads recovered from wheat rhizosphere do not adversely affect AM colonization. Evaluation of such effects on non-target organisms will help early acceptance of microbial inoculants in future.

CONSIDERABLE research efforts are underway globally to exploit the potential of fluorescent pseudomonads (FLPs) in maintenance of soil health and as crop protectants, since they represent not only a dominant bacterial group in the rhizosphere ecosystem but are also metabolically and functionally most versatile\textsuperscript{1}. Earlier studies with FLPs in our group have provided an effective background to support exhaustive exploitation of their gene pool for the benefit of the farming community\textsuperscript{2,4}. It is well established that FLPs effectively colonize wheat rhizosphere and exert positive influence on plant growth\textsuperscript{5}. However, current emphasis relies on the selection of promising isolates from the rhizosphere by screening of a large gene pool for multiple functional traits\textsuperscript{6}. Among these traits, antagonism towards phytopathogenic fungi has been studied extensively\textsuperscript{7}. However, it is only recently that concern has been shown in field release of isolates that secrete antifungals, including, 2,4-diacetylphloroglucinol (DAPG), since such isolates could also inhibit beneficial, naturally-occurring forms such as arbuscular mycorrhizal (AM) fungi\textsuperscript{3}. Considering the likely negative influence of some FLPs on beneficial forms, here we describe characterization of DAPG producers from marginal wheat fields and their influence on indigenous fungi as a prelude to field use of effective isolates for improved soil health and plant productivity.

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