Indian Journal of Radio & Space Physics
Vol 43, December 2014, pp 340-348

# Contribution of vehicular emission on urban air quality: Results from public strike in Hyderabad

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*Received 23 June 2014; revised 2 December 2014; accepted 12 December 2014*

The aim of this study is to analyse the amount of atmospheric pollution caused by vehicular traffic and the public strike, during which vehicular traffic is highly curtailed, offers an excellent opportunity for our purpose. The present study is carried out through systematic ***in situ*** measurements of particulate matter (PM), black carbon (BC) and carbon monoxide (CO) over the urban region of Hyderabad, India during two public strikes on 24 December 2009 and 18-21 January 2010. The results of the study suggest that the pollutant concentration decreases to a considerable extent, especially for BC, particulate matter ($PM_{10}$, $PM_{2.5}$ and $PM_{1.0}$) and CO in both the cases indicating that vehicular emission alone is largest contributor to air pollution. A significant reduction of BC and PM (48% and 28%, respectively in first public strike and 27% and 30%, respectively in second public strike) was observed as compared to pre-strike period. A significant reduction of about 20% in CO concentration during strike period of 18-21 January 2010 was observed as compared to pre-strike period (14-17 January 2010).

**Keywords:** Air quality, Atmospheric pollution, Black carbon, Carbon monoxide, Particulate matter, Vehicular emission

**PACS Nos:** 92.60. Mt; 92.60.Sz

## 1 Introduction

One of the important sources of atmospheric pollution is vehicular emission. The combustion of fuels (gasoline, diesel oil, etc) within automobile engines releases a lot of harmful substances and gases into the atmosphere. Rapid urbanization together with industrialization and exponential growth in vehicular fleet are important factors for air pollution[1] in recent years. The number of vehicles have increased enormously in the recent years resulted in corresponding increment in air pollution. Air quality depends on the emissions from anthropogenic activities, topography and atmospheric circulation patterns[2]. Traffic is a major source of air pollution, mainly in towns and urban regions. Several previous studies in the urban region of Hyderabad focussed on the variation of aerosol optical properties associated with dust storm and biomass burning[3]. Considerable increment in black carbon (BC) mass concentration and aerosol mass loading were observed in the urban region of Hyderabad due to vehicular traffic[4]. Diurnal pattern in BC showed two peaks coupled with peak traffic hours (morning and evening) at Hyderabad[5]. Kapaka[6] reported that vehicular emissions account for about 60% of the total pollutants emitted when compared to other sources and they are dangerous to the society. The steep increase in vehicular population has resulted in corresponding increase in pollutants emitted by these vehicles. Air pollutants released from vehicular traffic in urban areas include nitrogen oxides, atmospheric aerosols, particulate matter, carbon monoxide and hydrocarbons. Recent studies based on the vertical profiles from the measurements of ozone and water vapour by Airbus in-service aircraft (MOZAIC) observations inticated strong seasonal variability of carbon monoxide (CO) and ozone ($O_3$) over Hyderabad[7,8]. Results from the recent studies indicate that mini multipurpose vehicles, in comparison, were the most significant hydrocarbon (HC) and nitrogen oxides ($NO_x$) emitters. Air pollution generally means unacceptable levels of gases such as CO, HC, $NO_x$ and particulate matter (PM) present in the air. BC is emitted into the atmosphere enormously by diesel vehicles and the burning of biomass including cooking stoves in the developing countries like China and India. Improving the efficiency of industrial combustion processes can reduce the trace gas emissions into the atmosphere. The air quality has decreased to alarming levels in most of the cities throughout the world. About 1.4 billion urban residents in the world, according to estimations from WHO, are breathing air whose quality falls below the World Health Organization (WHO) air quality standards. Like many other countries in the world, air pollution from vehicles is one of the most serious and rapidly growing problem in urban areas in India[9]. Currently, in India, air pollution is widespread in urban areas, where vehicles are the major contributors and in few other areas with high concentration of industries and thermal power plants. Assessment of vehicular contribution in air pollution over urban region is essential to understand the air quality. Hence, the present study focuses on changes in vehicular emissions over the urban region of Hyderabad under near laboratory conditions, created by the absence of vehicular traffic due to public strike. BC, PM and CO emissions were analyzed during public strike periods in comparison to pre and post-strike periods in order to understand the emissions from vehicles alone. Public strike in the present study, generally, means halt in transportation (motor vehicles and buses), severely impacting the daily lives of the people living in the affected area. Vehicular emissions are of particular concern since these are ground level sources and thus, have the maximum impact on the general population. Also, vehicles contribute significantly to the total air pollution in urban areas. The drastic increase in the number of vehicles has also resulted in significant increase in the emission load of various pollutants. Motor vehicle emissions usually constitute the most significant source of fine mode particles in an urban environment.

## 2 Study area

In southern peninsular India, Hyderabad is one of the metropolitan city covering an area of 625 km with a population of 6,290,397 people. It has been classified as an A-1 city in terms of development priorities, due to its size, population and impact. It has an average elevation of about 541 meters above the sea level. Hyderabad has a tropical savanna climate with hot summer season from March to May, monsoon season from June to September and post monsoon from October to December and pleasant winter in January and February. In the morning and evening, the climate is, generally, cooler because of the city's high elevation. Figure 1 represents the study region. The State Road Transport Corporation runs a fleet of 19,000 buses, the largest in the world, in which Hyderabad has the third largest bus station facility in Asia, with 72 platforms for 89 buses to transport passengers at a time. The number of vehicles reached 2.4 million by March 2011 as shown in http://hyderabad.trafficpolice.co.in. In the present paper, the analysis of vehicular emission is carried out on the premises of the National Remote Sensing Centre at Balanagar, situated within the urban center of Hyderabad, India.

## 3 Datasets and Methodology

The focus was on measuremet of three pollutants, viz. BC, CO and particulate matter of three different sizes at study site. BC measurements were carried out using seven channels Aethalometer (model AE31, Magee Scientific, USA). This instrument uses quartz fiber filter tape through which air is passed for a fixed amount of time (typically 5 minutes) with a selected constant flow rate (2.9 liter per minute). At the end of each measurement cycle, changes in the filter transmission at seven wavelengths (370, 470, 520, 590, 660, 880 and 950 nm) are recorded. The 880 nm channel is considered as a standard channel for BC measurement, as fossil fuel sources have more sensitivity to 830 nm spectral channels compared to other aerosol species[10]. Uncertinities associated with BC measurements by Aethalometer is around 10% as reported by the manufacturer.

Particulate matter (PM) in different sizes ranging from 0.30 to 20 µm were measured using GRIMM aerosol spectrometer model 1-108 (Ref. 11). The GRIMM instrument works on the principle of counting number of particles as it crosses a focused laser beam. Ambient air is drawn into the instrument by a mass flow controlled pump and passed through a light beam produced by a laser diode. Scattering induced by particles of various sizes is measured by a photo-diode detector, amplified and finally binned to give the distribution of particulate matter in 15 different grain-size classes in the size range 0.30 - 20 µm.

In addition to the above measurements, simultaneous measurements of CO have been carried out using a CO analyzer (CO11M). It is a component of motor vehicle exhaust, which contributes about 56% of all CO emissions nation wide. In cities, 85 to 95% of all CO emissions come from motor vehicle exhaust.

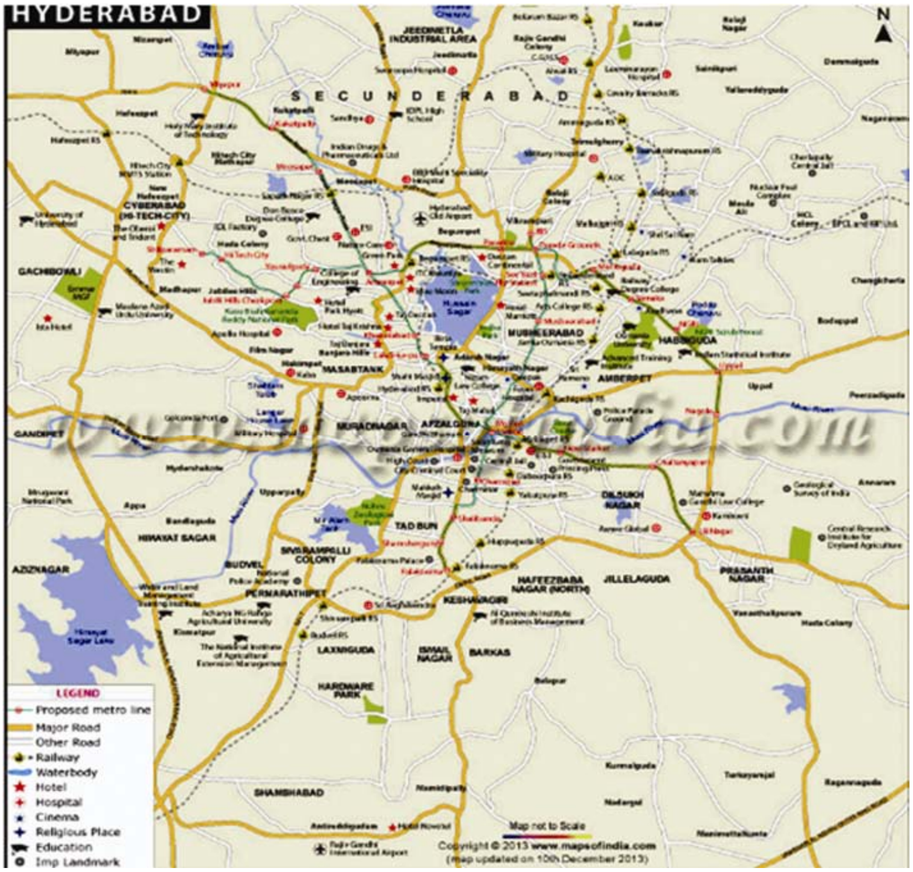


Fig. 1 — Location map of study area

These instruments provide simultaneous observations of black carbon aerosol mass concentration, aerosol particle number density and CO in different spectral bands required for understanding urban air quality and studying their interrelations. The sources of pollution are either man-made or natural. It appears that rapid urbanization, increased mobility and the use of private transport have created a significant negative impact on the urban environment.

## 4 Results and Discussion

As maximum contribution to air pollution is from vehicular emission[12] and number of vehicles is growing rapidly, the variations in PM, BC and CO associated with emissions from vehicles over Hyderabad, India during public strikes are analyzed and compared with pre and post strike periods in the present study. The impact of vehicular shut down is evaluated during two public strikes: on 24 December 2009 (case 1); and continuously for 4 consecutive days during 18-21 January 2010 (case 2). All the ground based measurements are divided in three groups: (i) pre-strike (23 December 2009 in case 1 and 14-17 January 2010 in case 2); (ii) public strike, representative of the duration of the strike; and (iii) post-strike (25 December 2009 in case 1 and 22-25 January 2010 in case 2). The data used in the present study has been collected and analyzed from 0900 to 1700 hrs LT for PM whereas continuous data with 5 minutes interval is collected for BC and CO, respectively.

Figure 2 (a-b) shows the BC aerosol mass concentration during the study period. A sudden decrease in BC concentration (48% and 27% in case 1 and case 2, respectively) as compared to pre strike is observed, which is mainly due to the withdrawal of a potential source of atmospheric pollution from the urban environment[13,14], whereas 53% and 68% reduction has been observed for the same cases compared to post strike period. A sharp peak in BC occurred during morning and evening hours and has

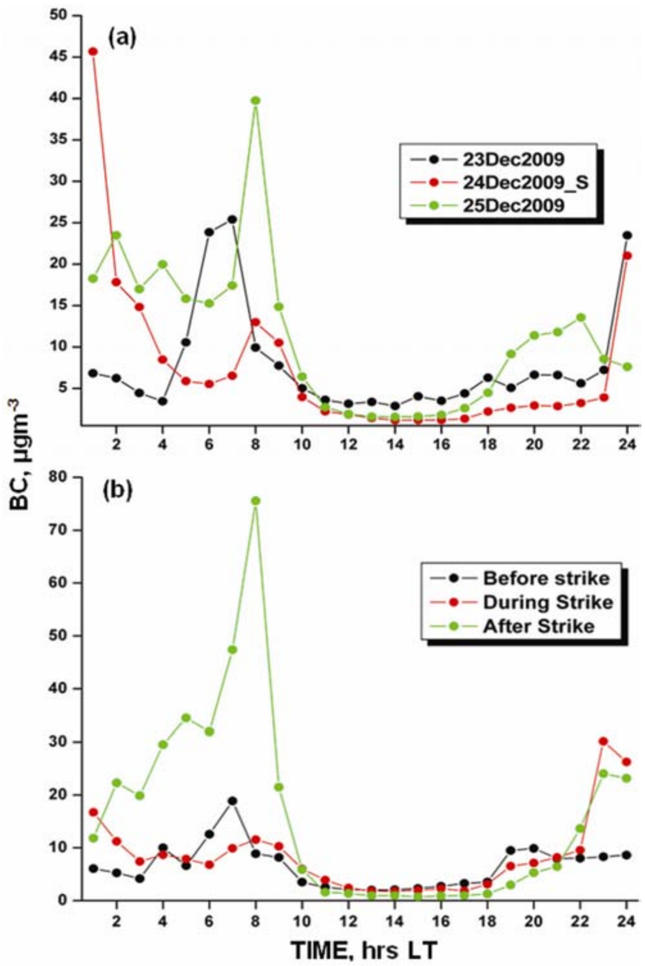


Fig. 2 — Diurnal Variation of BC concentration for: (a) case 1 and (b) case 2

been attributed to traffic patterns in the city area[13] on normal days. But, small peak was observed for the strike period on case 1 as compared to pre and post strike (normal days); whereas in case 2, morning peak was completely absent on strike days than normal days. Since anthropogenic activities such as biomass burning, industrial emissions and vehicular combustion can influence the characteristics and distribution of aerosols of different types. During pre-strike and post-strike period, BC variations showed different variation in second peak occurring in the afternoon hours.

Earlier studies on automobile exhaust[15,16] suggested that diesel trucks/heavy vehicles have much higher BC emission potential than light engines. High BC concentrations also occur in the early morning due to increased human activities in the urban area, which might be the reason for slight peak during a strike on both the cases. At noon, enhanced height of the mixed layer leads to the dispersion of the pollutants and the ventilation of the air. During the study period, it is observed that the pollutants (BC, PM and CO) exhibit both diurnal and day-to-day variations. These pollutants (BC, PM and CO) were measured on 5-min interval. Figure 2 shows the BC relative contribution to vehicular emissions. As the Sun rises, the surface heating enhances the mixing-height level, thus favoring the mixture and diffusion of the air pollutants[4,17,18]. To assess the CO contribution from vehicular alone, CO data on both the case studies is analyzed. The Fig. 3(a-d), left panel shows the Julian day variations of CO; and the right panel shows the temporal variation of CO. High levels of CO during morning and late evening hours are observed.

Variations in BC, PM and CO on normal days (pre and post strike) may be due to combinations of anthropogenic emissions, boundary layer processes as well as local sources and wind patterns[17,18]. Figure 3 shows that 20% CO concentration has been reduced during strike as compared to pre (14-17 January 2010) and post strike (22-25 January 2010) in case 2, whereas 45% CO concentration is reduced on 24 December 2009 as compared to 25 December 2009 (post strike) in case 1. The CO concentration data is not compared with 23 December 2009 (pre strike) due to its non-availability in case 1.

The diurnal variations in PM shown in Figs (4 and 5) indicate that pollution levels increase during the early morning hours and stay confined to the boundary layer on normal days. The same pattern is followed for both strike cases with lower concentration values in both the cases. Concentrations are higher after 06:00 hrs LT indicating minor impacts from traffic emissions and further it depends on traffic intensity and vehicle types[19].

Julian day variations of PM [Figs (6 and 7)] suggest 17, 20 and 28% reduction in $PM_{1.0}$, $PM_{2.5}$ and $PM_{10}$, respectively during the strike period as compared to pre strike period in case 1, whereas 19, 44 and 30% reduction in $PM_{1.0}$, $PM_{2.5}$ and $PM_{10}$, respectively in case 2. Goyal *et al.*[20] showed that heavy commercial vehicles mainly emit PM. Hence, results of the present study for PM during strike might be associated with absence of heavy commercial vehicles. Similarly, 10% reduction is observed in all types of PM in case 1 as compared to post strike,

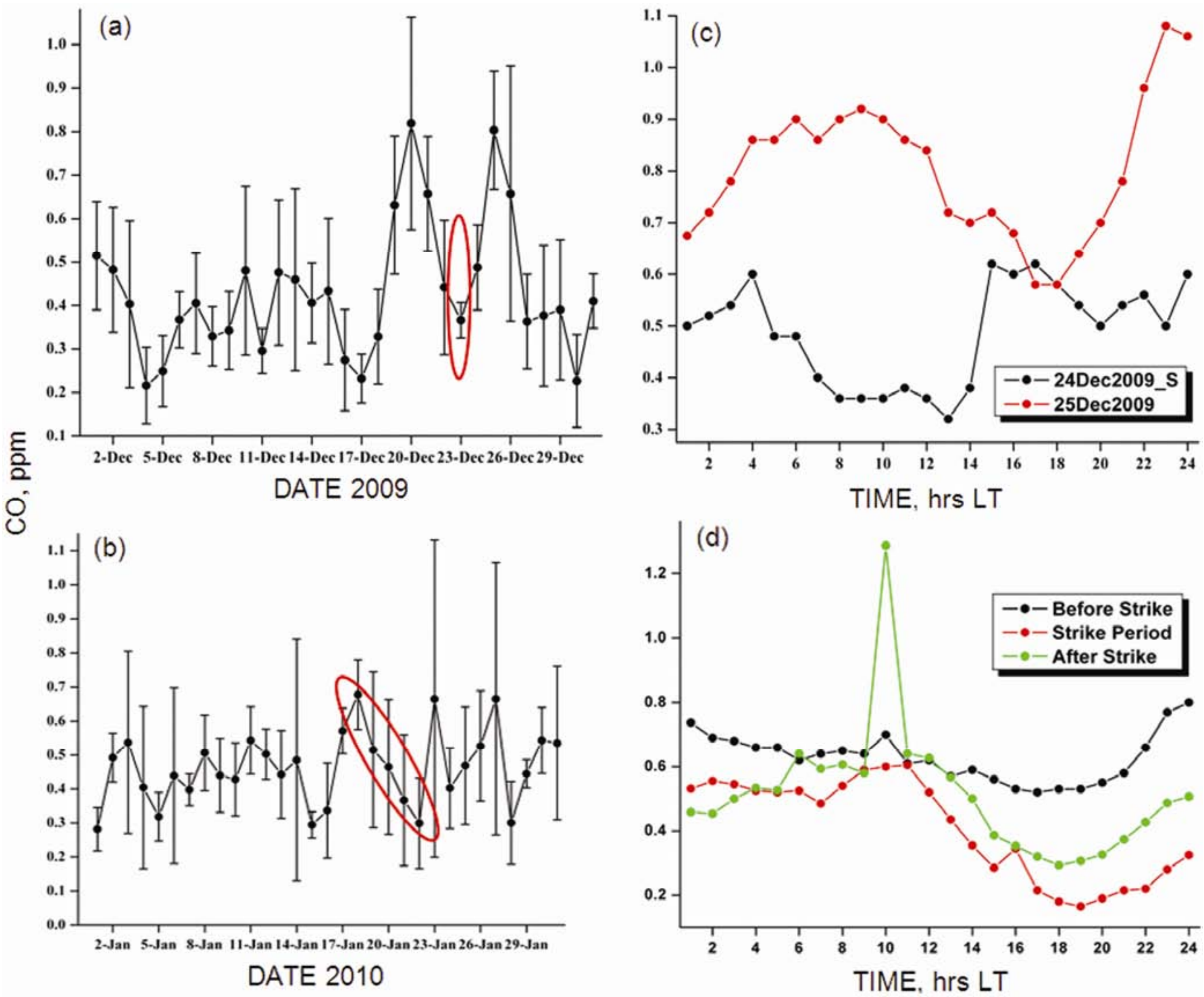


Fig. 3 — (a and b) Daily variation of CO in case 1 and 2; and (c and d) diurnal variation of CO in case 1 and 2

whereas in case 2, 60% reduction is observed in $PM_{1.0}$ and $PM_{2.5}$, respectively and 43% reduction in $PM_{10}$. The peak timings are well matching with starting and closing hours of most of the offices in Hyderabad. The analysis of current study indicates that vehicular traffic is one of the major sources of air pollution and has noticeable impact on air quality. Source apportionment of ambient fine particles showed that emissions from vehicles are a major source of high $PM_{2.5}$ concentrations in megacities such as Beijing[21,22] and Shanghai[23].

The management of the vehicular pollution emissions has key role in air quality. The present study is useful for developing effective strategies for improvement of urban air quality by controlling on-road vehicle emissions systematically and cost-effectively. The diurnal variation of emissions of pollutants, viz. BC, CO and PM shows two peaks during the day, which indicate the peak traffic hours on normal days. But a considerable amount of reduction in BC, PM and CO is observed in the present study due to changes in vehicular emissions as a result of public strikes. The overall results of the study indicate that urban area of Hyderabad is under considerable influence of vehicular emissions.

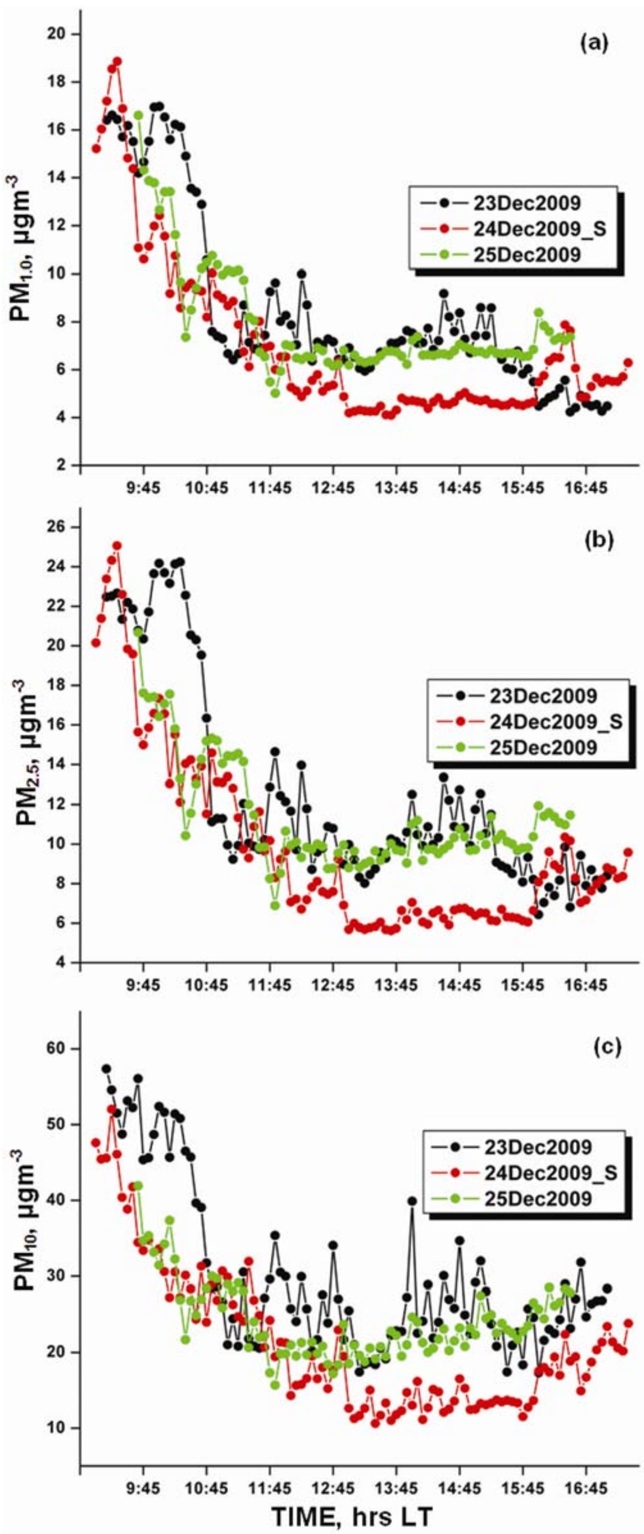


Fig. 4 — Diurnal variation of: (a) $PM_{1.0}$, (b) $PM_{2.5}$, and (c) $PM_{10}$ during 23-25 December 2009

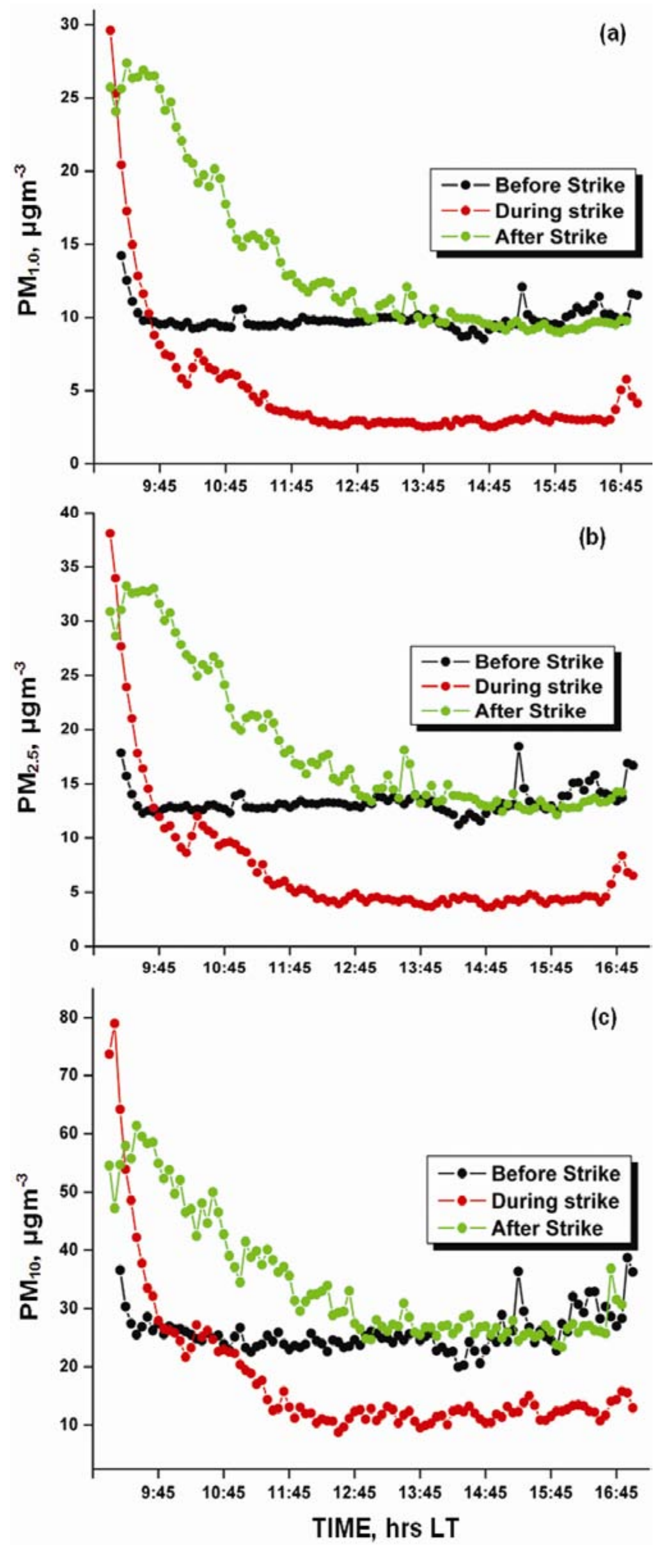


Fig. 5 — Diurnal variation of: (a) $PM_{1.0}$, (b) $PM_{2.5}$, and (c) $PM_{10}$ during January 2010

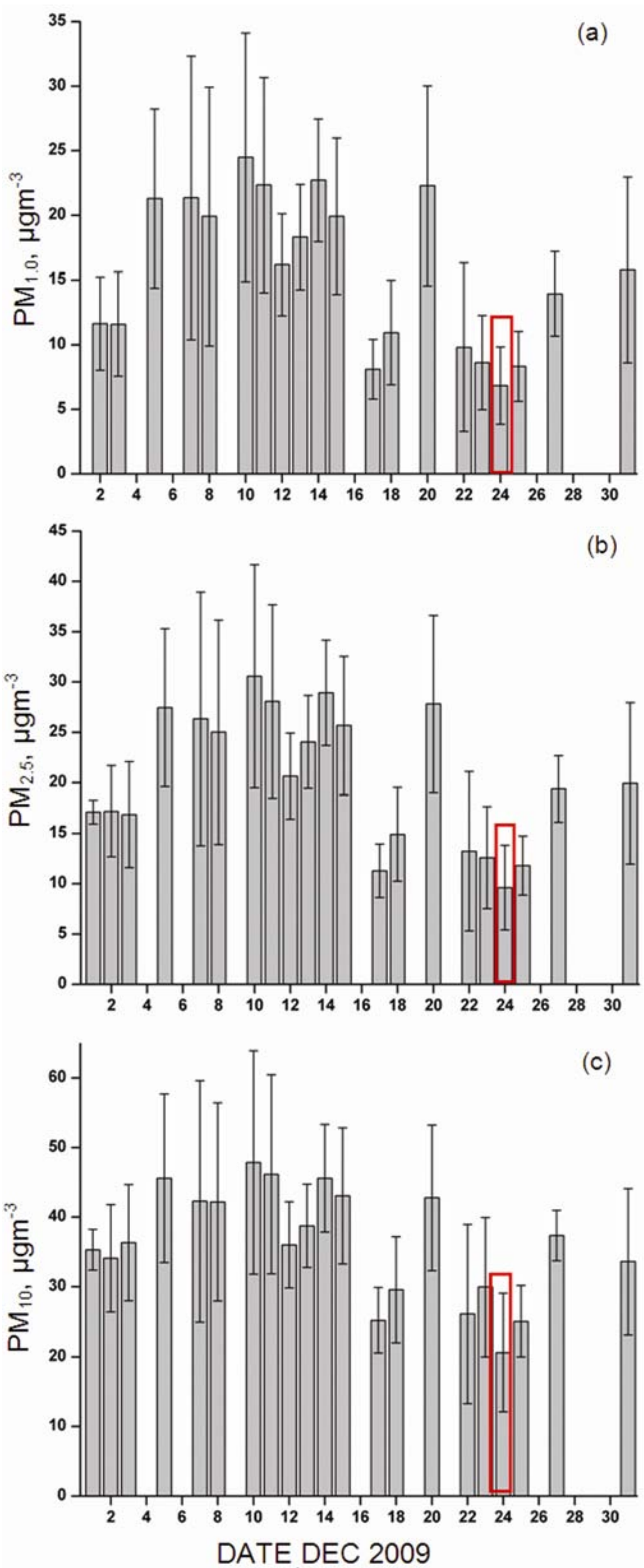


Fig. 6 — Daily variation of: (a) $PM_{1.0}$, (b) $PM_{2.5}$, and (c) $PM_{10}$ during December 2009

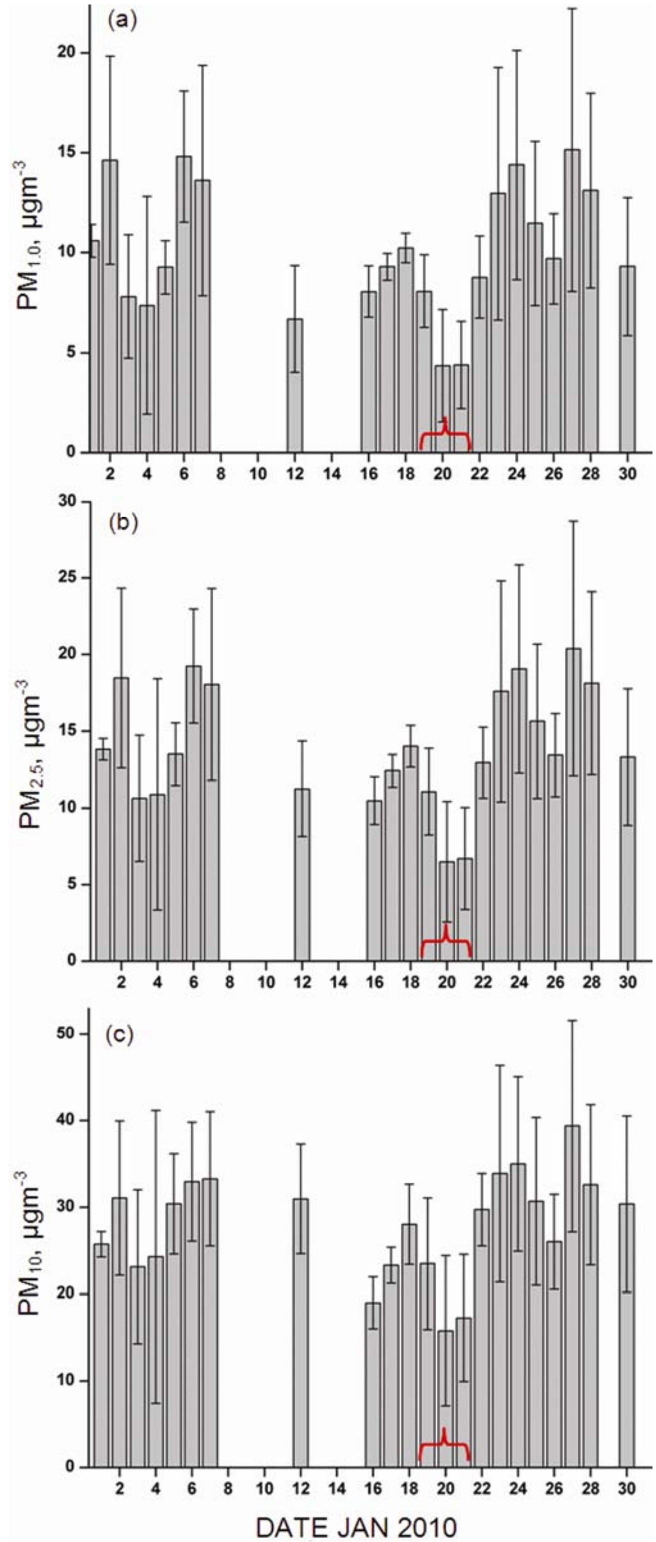


Fig. 7 — Julian day variation of: (a) $PM_{1.0}$, (b) $PM_{2.5}$, and (c) $PM_{10}$ during January 2010

## 5 Conclusions

Impact of traffic emission on the pollution was analyzed using ground based instrumentation data during two public strike periods. The results of the present study suggested that controlling vehicular traffic can have an immediate impact on improving air quality even among the most polluted urban cities in the world. The results of the present study show that the emissions from vehicles alone over the urban region of Hyderabad are as:

(i) BC concentration values were observed to be low in both cases of strikes.

(ii) Particulate matter ($PM_{1.0}$, $PM_{2.5}$ and $PM_{10}$) during the general strike period was low suggesting relative clean atmospheric conditions.

(iii) Similarly, CO is reduced by considerable amount (20%) during the strike period of 18-21 January 2010.

## Acknowledgement

The authors thank the Director, NRSC and Deputy Director, Earth Climate Science Area (ECSA) and Group Director, Atmospheric & Climate Science Group (ACSG) for necessary help at various stages. The activity has been supported by Aerosol Radiative Forcing over India (ARFI) under ISRO-GBP. The authors would like to thank late Dr K V S Badarinath for his valuable guidance and support at each and every stage.They would also like to thank the reviewers and the editor for their suggestions in improving the manuscript to the present form.

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