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Size Characterization of Particulate Matter from a Kerbside in a Major Metropolis in India

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Abstract
PM_{10} and $PM_{2.5}$ samples were collected from a kerbside at a traffic junction in a major metropolis of India during month of December 2005 and their concentrations were calculated. The $PM_{2.5}$ fraction in PM_{10} varied from 18.7 to 72.6%. Such a large variation was correlated with meteorological variables. The major contributors of $PM_{2.5}$ to the sampling location were diesel and gasoline driven passenger vehicles exhaust emissions. In addition, heavy duty transport vehicles also contributed during the night hours.
Key words: PM $_{2.5}$, PM_{10}, Kerbside

Introduction
Atmospheric particulates are complicated pollutants because of the large variations in sources, energy structures, climatic conditions and living habits across the nation (Fang et al. 2009). The demographic growth of large cities is making the urban air quality more and more affected by traffic related pollutants. The urban particulate pollution is a complex air pollution caused by combustion of a variety of fuel and changing topography and meteorological factors that often accumulate pollutants in the city and prevent proper dispersion and dilution. Coal combustion, vehicular emissions and biomass burning are the major contributors. Exposure to particulate matter from roadways implies an increased exposure to PM_{10} and PM $_{2.5}$ emissions mainly from tailpipes, brake wear, tire wear and road dust (Amato et al. 2009; Furusjo et al. 2007; Charron and Harrison 2005). Such exposure causes adverse health effects and is linked to increase in respiratory illness (Curtis et al. 2006) pulmonary damage, and mortality among population (Brits et al. 2004; Celis et al., 2004; Dockery and Pope, 1994; Thomaidis et al. 2003; Yang et al. 2004; Zhao and Hopke, 2004). This paper presents a case study of $PM_{2.5}$ to PM_{10} ratio at a kerbside in a major Indian Metropolis.

Materials and Methods
In the present investigation, PM_{10} and $PM_{2.5}$ samples were collected from a kerbside on Mathura road near Ashram Chowk, a busy traffic junction in New Delhi (Figure 1). The samples were collected at a height of 3.0 m above the ground level. The PM_{10} samples were collected using Respirable Dust Sampler (model APM460NL of M/s. Envirotech Instruments Pvt. Ltd.) and $PM_{2.5}$ samples were collected using Federal Reference Method Sampler (model Partisol 2000 of M/s R&P). The Respirable dust sampler (RDS) draws ambient air through PM_{10} inlet at a flow rate between 0.9 and 1.2 m^3 per minute and collects PM_{10} on 400 cm^2 portion of a clean Glass fiber paper. The RDS was operated continuously for 24 hrs. However, the filter paper was replaced at intervals of 8 hrs as per Central Pollution Control Board (CPCB) norms and procedure.

The Partisol 2000, Federel Reference Method (FRM) sampler draws ambient air at 1 m^3/h and collects $PM_{2.5}$ sample on 47 mm diameter Teflon filter paper. Six samples each were collected simultaneously by co-locating the RDS and FRM sampler. December being the critical winter month in New Delhi for air pollution point of view, the samples were collected for six

days in December 2005. The sampling was started at 8:30 hours and continued till 8:30 hrs of the next day. Meteorological data for wind speed and wind direction for the sampling days were collected from India Meteorological Department.

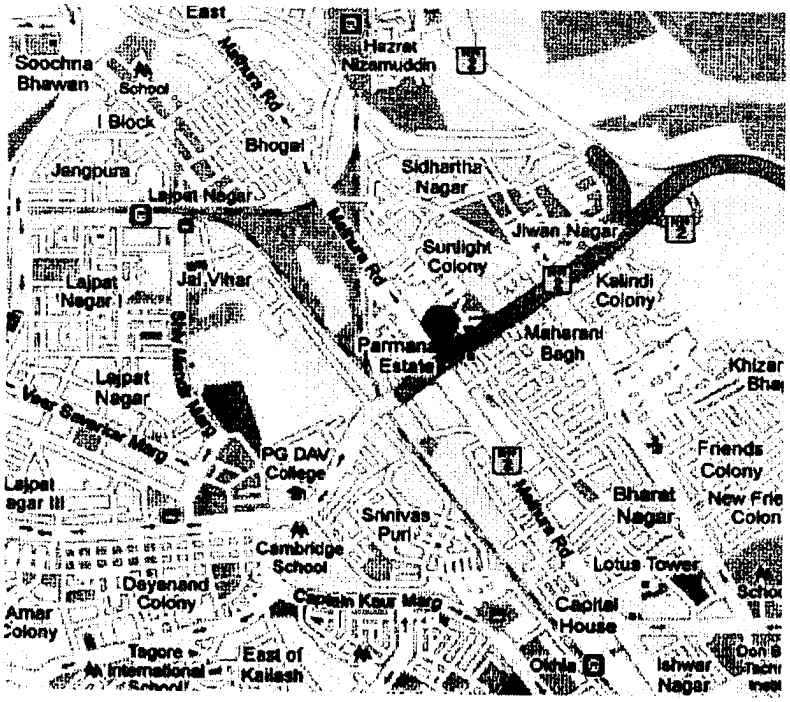

Figure 1: Location of Sampling Station

Results and Discussion

The concentrations of PM_{10} and $PM_{2.5}$ and $PM_{2.5}$ fraction in PM_{10} are presented in Table 1. The observed large variation in $PM_{2.5}$ fraction in PM_{10} ranging from 18.7-72.6 % was further investigated using the meteorological data for the sampling days as shown in Table 2. The highest concentration of PM_{10} (810 $\mu g/m^3$) occurred on 4th sampling day while that of $PM_{2.5}$ (236 $\mu g/m^3$) on 2nd sampling day.

Table 1: Concentration of PM_{10} and $PM_{2.5}$

Sr. No.	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	$PM_{2.5}$ in PM_{10} (%)
1.	384	229	59.6
2.	325	236	72.6
3.	653	149	22.8
4.	810	184	22.7
5.	464	87	18.7
6.	518	173	33.4

Table 2: Synoptic Hour Meteorology during the Sampling Period

Sr. No.	Wind direction/wind speed (Km/h) 08:30	11:30	14:30	17:30	20:30	23:30	02:30	05:30
1.	2/W	12/NNW	12/NW	calm	calm	calm	Calm	calm
2.	2/NW	16/NNW	14/NW	calm	calm	calm	Calm	4/W
3.	4/W	12/NW	14/NW	2/NW	calm	calm	4/NW	4/W
4.	8/W	22/NW	30/NW	10/NW	4/WNW	4/WNW	6/NW	8/W
5.	12/W	20/NW	20/NW	4/W	8/NNW	6/W	Calm	calm
6.	Calm	6/NW	6/NW	calm	calm	calm	Calm	Calm

The high $PM_{2.5}$ fraction (59.6-72.6 %) during first two sampling days in Table 1 can be attributed to prevailing calm conditions (Table 2) which is favourable for buildup of $PM_{2.5}$ dominantly originating from fuel combustion sources. Subsequently during 3rd -5th sampling days, setting up of winds (4-30 km/h) have caused dilution of $PM_{2.5}$ on one hand and increase in the concentration of PM_{10} due to intrusion of road dust on the other. On the sixth sampling day, the concentration of $PM_{2.5}$ increased again due to prevailing calm conditions. However, the concentration of PM_{10} also remained high due to trapping of road dust particulates in the ground level inversion.

Conclusion

The dispersion of particulate matter in the atmosphere is governed mainly by the prevailing meteorological conditions. The calm wind condition and ground level inversion prevalent in winter months are the main cause of buildup of $PM_{2.5}$ in the urban atmosphere.

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