H-O-7

ATMOSPHERIC PARTICULATE MATTER BEHAVIOR AT DELHI: STUDY OF PM_{10} AND $PM_{2.5}$ SIZE PARTICLES

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1. Introduction

Since 1980s, rapid urbanization and fast increase of traffic density and energy consumption have caused severe air pollution problems all over the globe. For the area of Delhi, the capital city of India, these problems are complicated and unique as it contains the combination of pollutions from coal combustion, natural mineral dust from nearby Thar Desert and motor exhaust due to extensively increasing number density of vehicle in the vicinity during the recent past (Singh et al., 2005. High concentrations of particulate matter and other gaseous pollutants (e.g., O3, SO2, and NOx) are frequently recorded in the urban atmosphere of Delhi (http://www.cpcb.nic.in).

Studies say that an exposure to high concentrations of fine particles may cause adverse potential health impact evidenced by higher hospitalizations and higher mortality rates. Due to this cause, a wide interest has gained among the environmental scientists during last three decades. The fine aerosol particles are a complex mixture of many species derived from various sources, and thus expect a deep understanding of their chemical and physical analyses are necessary for the purpose of source identification and pollution control. Although of utmost necessity, no such study has been reported by CPCB and other institutions around Delhi till date.

The sources, characteristics, and potential health effects of PM_{10} (particles with aerodynamic diameter less than 10 µm) and $PM_{2.5}$ (diameter less than 2.5 µm; Fine Particles) are very different; the latter can more readily penetrate into the lungs and are therefore more likely to have short- and long-term effects such as premature death, increased respiratory symptoms and disease, decreased lung functions and alterations in lung tissues. Various health effects of PM, from less serious to very serious ones, are associated with its specific chemical and physical (but mostly chemical) components (Wang et al., 2007; Kumar et al, 2007). Also, the particle size is also very important both in terms of deeper penetration into the lungs and as carriers of toxic air pollutants. High concentrations of carbonaceous aerosols were pointed out to be a major reason for large visibility degradation in Delhi (Sharma and Maloo 2005; Gupta and Kumar 2006). To understand such particles better for the region of Delhi, we had recently performed a two-years-long continuous sampling campaign of $PM_{2.5}$ and PM_{10} with a focused of the study on the seasonal variations of physical and chemical properties of the particle in the two size bins. The objectives of the present study, in this respect, are (1) to give ambient concentration levels and their seasonal variations, (2) to explore information on their emission sources provided by their characteristic molecular compositions. It is to be noted that the effect of these particles on human/ecological health is planned when the final analyses are completed.

2. Climate of Delhi and Experimental Details

Delhi (28^0, 35'N; 77^0, 12'E, 218 m asl), the capital of India experiences a severe weather swing between different seasons, i.e., hot and humid in summer while cold and dry in winter. The prevailing wind through the year is easterly, northerly and northwesterly, and it becomes the strongest in summer. During the pre-summer and summer season, dust storm events affect the climate of Delhi.

The sampling for this experiment was done on the Institute's roof-top (about 15m above the ground level), situated at thoroughly urbanized central part of Delhi. The area is primarily a didactical and residential area, and no large pollutant sources exist nearby to influence the sampling site directly.

Sampling of $PM_{2.5}$ was done by a Fine Particulate Sampler (APM 550; Envirotech Instruments Pvt. Ltd, designed by USEPA) and simultaneous collection of fine particles with aerodynamic diameter less than 2.5 microns was collected. The initial flow rate for this sampling was taken as $1m^3$ / hr which reduce when the filters got chock by fine particles concentration. A 47mm quartz filter (Whatman, UK) was used in each sampling. The sampling duration for a single sample was mostly 6hrs and 24hrs depending on weather conditions. Total 92 samples of both sizes (57 of $PM_{2.5}$ and 35 of PM_{10}) were collected during the two years period extending from January 2005 to December 2006. For seasonal analyses purposes, these samples are divided into four groups, i.e., the for winter (December to march), pre-monsoon (April to June), monsoon (July to September) and post-monsoon (October and November). A set of field blank samples (without pumping) was conducted in each season for calibration of the data.

3. Results and Discussion

Day to day variation in concentrations of $PM_{2.5}$ and PM_{10} during 2005 and 2006 is shown in figure 1. The average concentration of $PM_{2.5}$ and PM_{10} were found 72.37±41.08µg/m^3 and 173.41±80.04µg/m^3, respectively, which are higher (approximately double) than the Indian national air quality standards i.e. 100µg/m^3 (provided by Central Pollution Control Board, New Delhi) and than the global standard values of $PM_{2.5}$ (65µg/m^3) and PM_{10} (150µg/m^3) (US EPA,1997). CPCB (2006) reports also show the same behavior around Delhi with respect fine particulate. The seasonal averaged concentrations of $PM_{2.5}$ shows highest values during winter (89µg/m^3), followed by post-monsoon (88µg/m^3), pre-monsoon (57 µg/m^3), and monsoon (35 µg/m^3). For PM_{10}, the variation is dominated during pre-monsoon (206µg/m^3), followed by post-monsoon (196 µg/m^3), winter (157µg/m^3) and monsoon (105µg/m^3). The high concentration of PM_{10} in pre-monsoon was related to the frequent intrusion of mineral dust from western and north western India where the Thar desert are located.. However, the concentration of $PM_{2.5}$ was higher during winter period, which are caused by the combination of the elevated emissions (from fossil fuel and coal burning) and meteorological conditions (precipitation, temperature, wind speed, water vapor and low mixing/ inversion layer). The low inversion layer limits the dilution and dispersion of fine pollutants during winter season. Khemani et al 1985 reported a very high loading of total suspended particulate matter during the pre-monsoon season for Delhi region. The high mixing with free troposphere and washout due to rain-showers might cause the low concentration of $PM_{2.5}$ and PM_{10} during monsoon season. For individual months, the concentration of $PM_{2.5}$ shows a marked peak in December and minimum concentration in the months of August and September during trough moving around Delhi. However, the concentration of PM_{10} shows the highest peak in April and the lowest in monsoon. The ratio of mean value of $PM_{2.5}$ / PM_{10} was 0.41 with remarkable seasonal variation varying between 0.21 and 0.72.

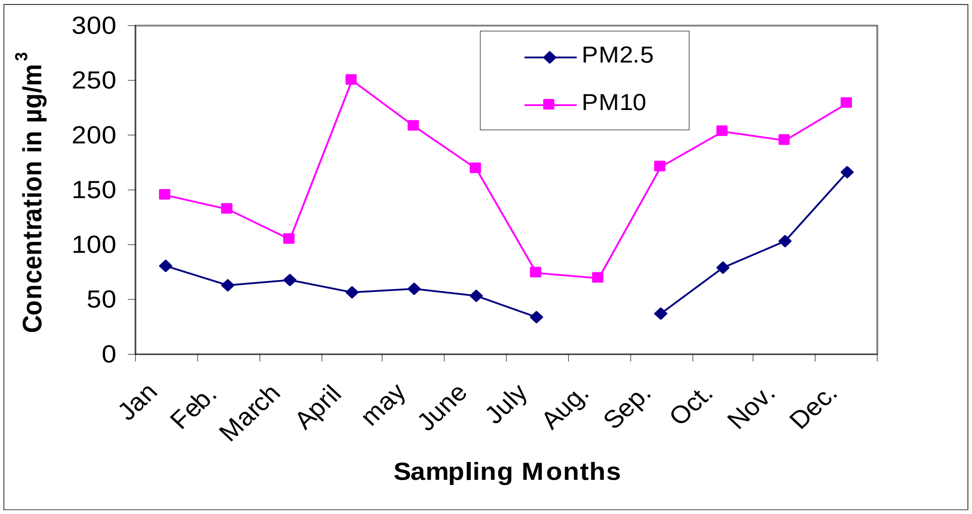

Figure 1: Seasonal variations of concentrations of $PM_{2.5}$ and PM_{10}

For further analyses, the data were grouped into four categories such as low, moderate, high and critical levels of RSPM (Fig.2) according to CPCB instructions. RSPM levels were found in critical mode (83%) in residential area.

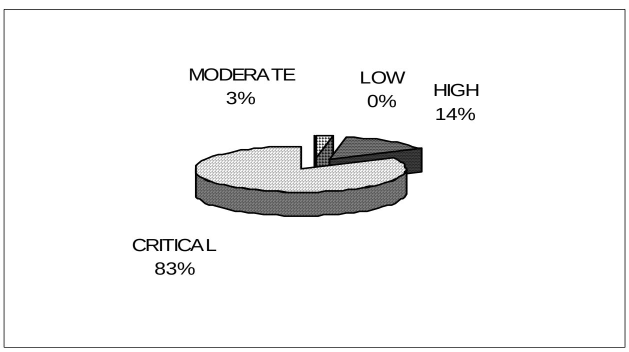

Figure 2: Percentage contribution of RSPM in different mode

The ratio values at different stations in India and abroad (Delhi, Raipur, Kanpur, Zurich, Beijing, and Taipei) are shown in Fig. 3. In Indian region, the ratio values are low due to dominance of PM_{10}, which is generally generated by wind-driven desert-dust in the coarse fraction. However the $PM_{2.5}$ concentrations are due to combustion processes. The ratio values of Delhi are comparable with Raipur, where enormous burning of fossil fuels by various industries and thermal power plants is witnessed. At Zurich, the ratio was approximately doubled; it may be due to the low concentrations of coarse particle fraction in the atmosphere. At Beijing and Taipei, it was seen that the fine particle concentrations was more as compared to Delhi but due to high coarse particle, more ratios values are observed.

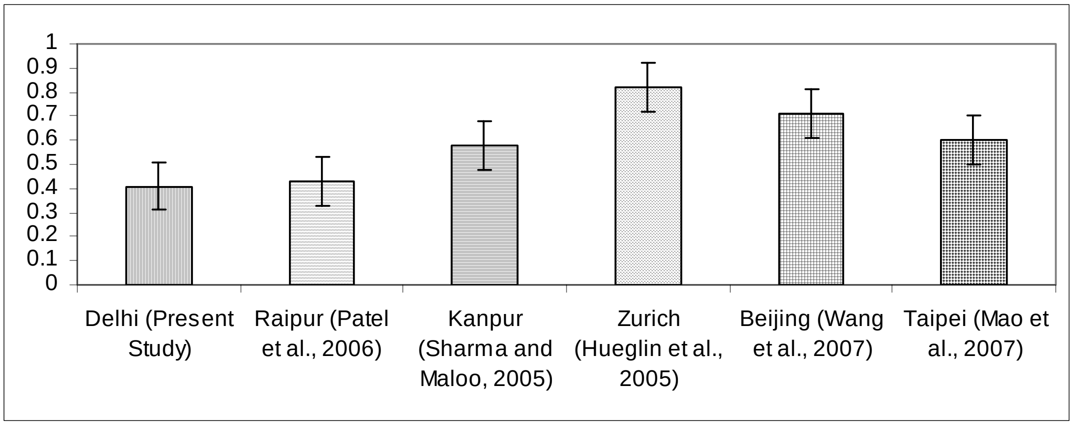

Figure 3: The ratio of $PM_{2.5}$ and PM_{10} at different station.

4. Conclusions

The annual average mass concentrations of $PM_{2.5}$ and PM_{10} were 72.37µg/m^3 and 173.41µg/m^3 respectively at urbanized central Delhi. $PM_{2.5}$ and PM_{10} concentrations had a seasonal variation in order: winter > post monsoon > pre-monsoon > monsoon and pre-monsoon > post-monsoon > winter > monsoon, respectively. These variations were regulated by the emission strength and the meteorological conditions. The level of PM_{10} was found 83% in critical mode in this study. The ratio between PM_{10} and $PM_{2.5}$ is found low in comparison to various other locations because the PM_{10} is generally dominant, especially during the pre-monsoon.

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