DISTRIBUTION OF PM$_{2.5}$ AND PM$_{10-2.5}$ IN PM$_{10}$ FRACTION IN AMBIENT AIR DUE TO VEHICULAR POLLUTION IN KOLKATA MEGACITY

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(Received 15 October 2004; accepted 20 December 2005)

Abstract. This research paper aims at establishing baseline PM$_{10}$ and PM$_{2.5}$ concentration levels, which could be effectively used to develop and upgrade the standards in air pollution in developing countries. The relative contribution of fine fractions (PM$_{2.5}$) and coarser fractions (PM$_{10-2.5}$) to PM$_{10}$ fractions were investigated in a megacity which is overcrowded and congested due to lack of road network and deteriorated air quality because of vehicular pollution. The present study was carried out during the winter of 2002. The average 24h PM$_{10}$ concentration was 304 $\mu$g/m$^3$, which is 3 times more than the Indian National Ambient Air Quality Standards (NAAQS) and higher PM$_{10}$ concentration was due to fine fraction (PM$_{2.5}$) released by vehicular exhaust. The 24h average PM$_{2.5}$ concentration was found 179 $\mu$g/m$^3$, which is exceeded USEPA and EU standards of 65 and 50 $\mu$g/m$^3$ respectively for the winter. India does not have any PM$_{2.5}$ standards. The 24h average PM$_{10-2.5}$ concentrations were found 126 $\mu$g/m$^3$. The PM$_{2.5}$ constituted more than 59% of PM$_{10}$ and whereas PM$_{10-2.5}$ fractions constituted 41% of PM$_{10}$. The correlation between PM$_{10}$ and PM$_{2.5}$ was found higher as PM$_{2.5}$ comprised major proportion of PM$_{10}$ fractions contributed by vehicular emissions.

Keywords: air quality, vehicular pollution, Kolkata city, PM$_{10}$, PM$_{2.5}$

1. Introduction

Kolkata, one of the megacities in India, which is overcrowded (population of more than 16 millions) and congested due to lack of road network and high number of vehicles. The city already besieged with rapid and unplanned urbanization, uncontrolled vehicular density, badly cared road space, low turnover of old vehicles and at the same time rapid pace of population growth degrade the air quality. The motorable road in the city is 1,300 km with estimated maximum vehicular carrying capacity of 0.35 million and currently, numbers of vehicles plying around the city are 1.06 million.

Among the air pollutants identified for adverse health effect, particulate should get special attention because of its strongest association with daily mortality rate. The relative strength of association of air pollutants with mortality were reported as follows: PM$_{2.5}$ $\geq$ PM$_{10}$ $\geq$ SO$_2$ $\geq$ H$^+$ $\geq$ O$_3$ $\geq$ NOx (Dockery et al., 1992). Dockery and Pope (1994) reported that for each 10 $\mu$g/m$^3$ increase in concentration of particulate matter (PM) less than 10 $\mu$ in diameter, there is an estimate of increase in mortality of 0.6–1.6% with an average increase of 1 percent (Ostro, 1996). The health impacts of finest particulate PM$_{2.5}$ is greater because it can penetrate deep
into unciliated and alveolar sections of the lung according to the particle diameter size (Spengler et al., 1990) (Table I).

Studies involving rats and humans suggest that some ultra-fine particles have extra toxicity compared to same materials as respirable but not ultra-fine particles when they are present in the lungs at the same mass dose (Ferrin et al., 1992; Ferrin 1994). This effect may be explained by the greater surface area of ultra-fine particles which could deliver more oxidative stress because of the greater surface area for release of transition metals or generation of free radicals by other means (MacNee and Donaldson 1999; Brown et al., 2001, Chan et al., 2004).

These findings have underlined the importance of study of ambient particles and need for monitoring PM$_{10}$ and its fraction PM$_{2.5}$ (fine particles) and PM$_{10-2.5}$ (coarse particles). The presented data are important for identification of how particles of different sizes are represented in PM$_{10}$ fractions observed at various monitoring stations and for quantification of the particulate load in the ambient air. The significance of the study is to provide guidelines to establish PM$_{2.5}$ standards, for Indian megacities, if formulated in future and suggests control measures of fine particles in ambient air.

In an effort to address some of these issues we conducted PM$_{10}$ sampling, using Andersen Cascade Impactor in different locations of Kolkata city in the month of November–December 2002. In this paper we use these PM data sets for estimating the relative contribution of fine (PM$_{2.5}$) and coarse particle (PM$_{10-2.5}$) to inhalable particle PM$_{10}$ and examine the relationship between PM$_{10}$ and PM$_{2.5}$.

2. Materials and Methods

2.1. Sampling sites and description

Kolkata, the City of Joy, capital of West Bengal is considered to be one of the most polluted megacities in India, located between 22° 32′ N and 88° 20′ E. As illustrated