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A STUDY OF STATISTICAL DISTRIBUTION PATTERN OF $PM_{2.5}$ CONCENTRATION IN THE URBAN ENVIRONMENT OF DELHI

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ABSTRACT

A number of studies have shown that most of the particles originating from anthropogenic sources have an aerodynamic diameter less than 2.5 µm (Querol et al., 2001; Tiitta et al., 2002) and cause adverse impact on human health (Schwartz et al. 1996; Dockery and Pope, 1996; Spurny, 1998; Donaldson and MaCnee, 1999). It has been reported that the increase in the level of $PM_{2.5}$ is associated with increase in mortality (Borja-Aburto et al., 1998) and cardio respiratory hospitalizations (Burnett et al., 1999). In view of the adverse effects, the study of $PM_{2.5}$ is all the more pertinent. The present study attempts to develop the statistical distribution model fitting to $PM_{2.5}$ concentration monitored at 3 different sites in Delhi, India. Statistical distribution model of pollutants concentration reveals the frequency above threshold values, which in turn helps in assessment of air pollution with reference to air quality standards or the calculation of environmental damages to receptors. So far, most of the studies on statistical distribution models of air pollutants pertain to TSP, PM_{10}, SO_2, CO, NO_x, and O_3 but largely ignore $PM_{2.5}$ (Bencal and Seinfeld, 1976; Holland and Simons, 1982; Taylor et al., 1986; Sharma et al., 1999; Gokhale and Khare, 2007). The present study is an attempt to fill this gap.

The continuous monitoring of $PM_{2.5}$ concentrations was carried out at 1 minute interval using an E-sampler (Met One instruments, USA) at three different locations namely, JNU, Ashok Vihar and ITO in Delhi. It is to be noted that JNU and Ashok Vihar, both are residential site whereas ITO is a heavy traffic zone. All the measurements were taken during the month of September to November 2006. Observations (1 minute interval) taken at ITO during 17 September to 22 September 2006 shows typical variation marked with diurnal cycles having varying amplitudes ranging from a minimum of 0.014 mg/m^3 to the maximum of 0.307 mg/m^3 with mean 0.424 mg/m^3. At Ashok Vihar, measurements were taken during 18 October to 1st November 2006 which also includes the festival Diwali (21st October) in between. A sharp rise in $PM_{2.5}$ concentration has been observed on Diwali reaching up to 3.458 mg/m3 while rest of the days are marked with general trend of diurnal cycles with, mean 0.424 mg/m^3. Typical diurnal cycles have also been observed for $PM_{2.5}$ concentration at JNU, during 10 November to 15 November 2006 with mean 1.881 mg/m^3.

The goodness-of-fit tests have been used to identify the appropriate probability distribution model fitting to $PM_{2.5}$ concentration, which include KS (Kolmogorov-Smirnov), Anderson-Darling (AD), and Kuiper (K) statistics. Seven statistical distribution models namely, Normal, Exponential, Chi-square, Gamma, Weibull, Logistic and Lognormal have been attempted in order to identify the appropriate model. The parameters for the models have been estimated using maximum likelihood

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method. Based on KS, AD, and K statistics, weibull distribution model has been found to be the most suitable for the $PM_{2.5}$ concentration at JNU and Ashok Vihar sites while Gamma distribution has been found to be the most appropriate model at ITO site. Thus, Weibull distribution model seems to be the best fit for the distribution of $PM_{2.5}$ concentration at residential sites while gamma distribution model governs frequency distribution of $PM_{2.5}$ concentration at heavy traffic zone (ITO). The different nature of distributions at residential and heavy traffic zone may be attributed to traffic flow, its composition and associated emissions.

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