# ABSTRACT

Millions of people in the world are living under the risk of air pollution. The scenario in developing countries deserves a special mention as the effects of air pollution are more touching and intense. Like any other cities of the developing world, the urban cities of India had have been facing the ill effects of excessive population, unplanned development, growing industrialization and above all, severe pollution of air environment. However, the successful introduction and application of source apportionment techniques which may aid substantially in air quality management and planning is not getting adequate momentum. The present study stems from these ground realities.

Kolkata, the oldest and one of the biggest metropolitan city of India, have been under the cloud of air pollution plumes over the past decades. The present study was aimed in generating a baseline data source of the air pollutants, their seasonal and spatial variations and quantitatively apportions the sources by a modeling process. Models like CMB (chemical mass balance), PCA (principal component analysis)/APCS (absolute principal component scores) were used for this purpose. It has been felt that such a compiled database may help in formulating an environmental management plan for the effective management of the area.

This study covered a typical area of Kolkata, including residential, commercial and industrial sites with high pollution and population density. Concentrations of ambient $SO_2$ (sulfur dioxide), $NO_2$ (nitrogen dioxide), $NH_3$ (ammonia), $PM_{10}$ (particulate matter which passes through a size selective impactor inlet with a 50% efficiency cut–off at 10 μm aerodynamic diameter), TSP (total suspended particulate matter) and vehicular traffic count were measured from a network of three monitoring sites. Meteorological parameters (wind speed, wind direction, rainfall, temperature and relative humidity) were collected simultaneously from Indian Meteorological Department, Kolkata. Monitoring was done once in a week for 24 h at residential and industrial sites, while 8 h at commercial site.

The daily average concentrations of $SO_2$, $NO_2$, $NH_3$, $PM_{10}$ and TSP were observed as 12.3±9.2, 32.5±14.2, 36.6±19.7, 140.1±43.1 and 268.4±86.1 μg/m$^3$ at

residential site, while corresponding values for industrial site were 21.3±15.7, 48.9±9.8, 32.7±13.5, 196.6±88.2 and 363.5±157.9 μg/m$^3$ respectively. At commercial site, 8 h average concentrations of $SO_2$, $NO_2$, $NH_3$, $PM_{10}$ and TSP were 15.5±11.9, 47.1±19.2, 33.9±17.3, 131.3±43.5 and 276.1±71.4 μg/m$^3$, respectively.

The results of the study derives significance as approximately 85% of the monitored $PM_{10}$ data at residential area (Kasba) and 70% at industrial area (Cossipore) exceeded National Ambient Air Quality Standard (NAAQS) as specified by Central Pollution Control Board, India. The percentages of TSP data exceeding NAAQS in residential and industrial areas were approximately 80% and 20%, respectively. The concentrations of ambient gaseous and particulate pollutants were observed higher in winter season irrespective of the monitoring sites and duration of sampling. The particle size analysis exhibited variations of $PM_{10}$ at residential (52% of TSP), commercial (51% of TSP), and industrial (54%) sites.

Measurements of major polycyclic aromatic hydrocarbon compounds (fluoranthene, pyrene, benzo(a)anthracene, benzo(b)fluoranthene and benzo(a)pyrene), metal constituents (chromium, zinc, lead, cadmium, nickel, manganese and iron), carbonaceous species (inorganic carbon, organic carbon and total carbon) and anions (fluoride, chloride, nitrate, phosphate and sulfate) of particulate matters deposited on quartz microfibre filter papers were performed at residential and industrial sites of the study area for all $PM_{10}$ and selected TSP samples. The major PAH compounds of $PM_{10}$ was BbF with concentrations of 0.03±0.02 μg/m$^3$ and 0.02±0.02 μg/m$^3$ at residential and industrial sites, respectively. Observations also identified zinc imparts maximum contribution to $PM_{10}$ among measured metals having concentrations of 0.48±0.21 μg/m$^3$ and 0.53±0.33 μg/m$^3$ at residential and industrial sites. Sulfate of $PM_{10}$ was found in maximum concentration among anionic species with 1.19±0.60 μg/m$^3$ and 1.67±0.40 μg/m$^3$ at residential and industrial sites, respectively.

Significantly higher weekday values of gaseous pollutants, particulate matters and vehicular traffic counts were also observed. Spearman's rank correlation analyses showed that the measured gaseous and particulate pollutants have inverse correlation with wind speed, rainfall, temperature and relative humidity.

The identification of major sources of particulate matters and finding their contributions had also been performed in the present research work. Source apportionment study using chemical mass balance model identified that the most dominant source of $PM_{10}$ throughout the study period at residential site was coal combustion (42%), while it was vehicular emission (47%) at industrial site. The dominant source of TSP was identified as coal combustion (37%) at residential site, while it was soil dust (36%) at industrial site. A quantitative estimation by principal component analysis (PCA)/absolute principal component scores (APCS) identified solid waste dumping (36%) as a major source of $PM_{10}$ at residential site and vehicular emission (37%) at industrial site. The marker species observed in road dust of TSP at residential site are total carbon, organic carbon, iron and sulfate, while those at industrial site were total carbon, inorganic carbon, organic carbon and iron. The marker species of soil dust in TSP obtained were total carbon, organic carbon, chloride and sulfate at residential site, while total carbon, inorganic carbon, organic carbon, zinc and iron were identified at industrial site.

*Keywords:* Aerosol; Air quality; Chemical mass balance; Gaseous pollutants; Meteorological parameters; Principal component analysis; Source apportionment; Statistical analysis; Urban region; Weekday; Weekend.