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Assessment of heavy metals in suspended particulate matter in Moradabad, India

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Abstract

Samples of suspended particulate matter (PM_{10}) were collected from three different sites in Moradabad, India. The sampling was done concurrently twice a week during the period of April 2011-March 2012. Elemental concentration of PM_{10} was analyzed using an Inductively Coupled Plasma Optical Emission Spectrophotometer (ICP-OES). The monthly mean concentration of PM_{10} (RSPM) ranged between 63-226µgm^{-3}, which was higher than the permissible limit of 100µgm^{-3} of National Ambient Air Quality Standards. The maximum concentration of Zn, Fe, Cu, Cr and Ni found in the Industrial area of the city was 21.24, 18.43, 15.23, 0.41, 0.03µgm^{-3}, respectively; whereas the maximum concentration of Pb (2.72µgm^{-3}) and Cd (0.20µgm^{-3}) was found in heavy density traffic area, denoted as commercial area. The study shows that high number of vehicles and the brassware industries are responsible for enhanced concentration of heavy metals in the Brass City.

Key words

Brassware industries, Heavy metals, Suspended particulate matter, Traffic density

Introduction

The rapid growth of urbanization and industrialization, where the progressive expansion of suburbs into closer proximity with industrial plants in certain areas, has led to the problem of air pollution (Molina and Molina, 2004). Atmospheric particulates with elevated metals may have a serious impact on human health (Liu *et al.,* 2009; Mavroidis and Chaloulakou, 2010). At present, metropolitan cities of India along with some industrial cities are suffering due to serious metallic air pollution problems as that of developed countries (Abdelaziz *et al.,* 2007; Kamavisdar *et al.,* 2010). Many heavy metals are essential for life, even though they occur only in trace amount in the body tissue. They can be regarded as toxic if they injure the growth or metabolism of cells when they are present above a given concentration (Xin Hu *et al.,* 2012). World Health Organization (WHO, 2006) has given the guidelines for air quality monitoring and Central Pollution Control Board (CPCB, 2007) has presented the deadly fact about air pollution level in few Indian cities.

The brassware industries are specialized in melting and casting metal into desired shapes and during the various processes, a large amount of metal fume is emitted which may act as a sensitizer and cause heart problems like allergy, asthma, dermatitis, bronchitis and cancer etc (Garcia *et al.,* 2011; Dubey *et al.,* 2012). Plants grown nearby industries are also suffering from serious pollution problem (Tripathi *et al.,* 2009; Saralathambavani and Kamala, 2010).

It is well known that automobiles are not only responsible for previous known forms of heavy metals pollution (Cu, Zn, and Pb), but also for the many other elements (Ali Aslan *et al.,* 2011). Vehicular traffic which is a great source of fine particulates is often enriched with potentially toxic trace elements in the urban environment (Sher and Hussain, 2006; Cicek *et al.,* 2008). Thus, the monitoring of airborne metals in the urban environment has become an essential part of environmental planning and control programmes in several countries.

The present study was undertaken to estimate the concentration of some heavy metals (Cd, Cr, Cu, Fe, Ni, Pb and Zn) in PM_{10} and efforts have been made to analyze and present the result of study to determine the level of PM_{10} in residential, commercial and industrial area of Brass City, Moradabad.

Materials and Methods

The study was carried out in Moradabad, the Brass city of India. Total 312 samples of PM_{10} were collected from each location, during April 2011- March 2012, broadly classified into residential, commercial and industrial areas. These locations were Police Training Centre, a residential area, Buddh Bazar, a very busy commercial site located on NH – 24 and Peetal Nagari, an industrial site having a large number of brassware industries.

PM_{10} samples were collected with the help of Respirable Dust samplers (APM – 460 NL, Envirotech , New Delhi) twice a week on pre-weighed (W_1) glass microfibre filters (GF/A – Whatman) of 8×10 inc size with air flow rate of 1-1.5 $m^3 min^{-1}$. After sampling, the filters were reweighed (W_2) in order to determine the mass of the particles collected. The sampling duration for PM_{10} was 8 hr, total three samples were taken in a day (24 hr). For heavy metal analysis, 36 samples were taken from each site, three samples in a month. Total 108 PM_{10} samples were selected to which known portion of the fiber filter papers covered by particulates digested by nitric acid and perchloric acid at 140 ºC hot plate. Residues were then redissolved in 0.1M HCl and a blank was also prepared using the same area of unexposed glass fiber filter paper and by repeating the same procedure. These were cooled, filtered and made to 50 ml by adding distilled water. Concentrations of heavy metals were analyzed by Inductively Coupled Plasma-Optical Emission Spectrophotometer (ICP-OES; Spectro Analytical Instruments, West Midlands, UK) from samples collected for each site at Metal Handicraft Service Centre, Peetal Nagari, Moradabad (Ministry of Textiles, Govt. of India).

Summary statistics was used to obtain the means and standard deviations for RSPM (PM_{10}) and trace metals. One–way analysis of variance (ANOVA) was applied to detect the significant difference among metals and within metals ($p < 0.05$). Correlation matrix was used to determine the relative association among metals ($p \leq 0.001$).

Results and Discussion

The Police Training Centre is a residential area (PTC) and its monthly average concentrations of PM_{10} was reported in the range of 63-177µgm^{-3} (Fig. 1). The presence of PM_{10} at this concentration might be due to spreading of ground sediment material into the environment. Tandon *et al.* (2008) also reported sweeping as a source of respirable particulate matter in the atmosphere.

In commercial area (Buddh Bazar), the average concentration of PM_{10} was found in the range of 101-244µgm^{-3} (Fig. 1). This high value may be due to pollution from the generator and vehicular emission. The traffic derived aerosol particles were emitted into the atmosphere due to abrasion process of automobile components such as the brake or tyre wear (Suzuki et al., 2009; He and Lu, 2010).

In industrial area (Peetal Nagari), the concentration of PM_{10} was found in the range of 154-254µgm^{-3} (Fig. 1). This area is surrounded by many small scale brassware industries along with heavy vehicles in narrow lanes. The road dust and metal fumes add maximum aerosol in to the atmosphere (Salve *et al.,* 2006). The maximum concentration was found in Industrial area (254µgm^{-3}) and minimum concentration was found at residential site (63µgm^{-3}). At all the locations the value of PM_{10} was above the prescribed National Ambient Air Quality Standard (CPCB, 2009) of 100 µgm^{-3} for industrial, residential, rural and other area, respectively.

Considerable differences were noted with respect to the metal content in samples from PTC, Buddh Bazar and Peetal Nagari. The concentration of heavy metals such as Cd, Cu, Fe, Ni, Cr, Pb and Zn are given in Table 1 at different sampling sites. Among the trace metals, Zn contributed the maximum concentration with annual average of 11.86µgm^{-3} followed by Fe (9.63µgm^{-3}), Cu (7.64µgm^{-3}), Pb (1.94µgm^{-3}), Cr (0.22µgm^{-3}), Cd (0.10µgm^{-3}) and Ni (0.01µgm^{-3}), respectively. The trace metals in PM_{10} showed the following trend : Zn > Fe > Cu > Pb > Cr > Cd > Ni (Table 1). Among the three monitoring sites, the highest concentration of Zn, Fe, Cu, Cr and Ni was found at Peetal nagar, which may be attributed to melting of Brass sillies and different activities carried out in industrial area. As mentioned earlier, the melting of Brass sillies emit a large amount of metal fumes known as Zinc flares which are injurious to human as well as plants (Tripathi *et al.,* 2010; Anabela et al., 2012) and it is reported that hotter metals emit more metal fumes (Shah and Phadke, 1995). In these industries, Brass (60% Cu and 40% Zn) and German silver (55% Cu, 35% Zn and 10% Ni) are the main alloys used for moulding purpose in making brassware items and other utensils in Moradabad. Brassware industries which are specialized in cutting, grinding, scraping, polishing etc., are the major cause of high concentration of these metals (Tripathi *et al.,* 1990). The dust associated with toxic metals remains in air for longer duration and therefore causes severe health problems to urban population (Cirera *et al.,* 2009; Shah *et al.,* 2012).

Maximum concentration of Pb and Cd was observed at Buddh Bazar which falls under heavy traffic density area (Table 1). The concentration of Pb in higher amount is mainly due to vehicular emission (Tripathi, 1994; Lili Xia and Yuan Gas, 2011). Western European countries introduced unleaded fuel in the late 1980s and a number of countries now market only unleaded gasoline though there are many other countries including India, that have switched to unleaded gasoline without eliminating the sale of leaded gasoline. Therefore, lead pollution due to lead gasoline still occurs in cities (Prajapati *et al.,* 2009; Andra *et al.,* 2011). The major source of lead accumulation in human in developing countries was found to be airborne and 90 % of which comes from leaded gasoline (MECA, 2003). Cadmium, one of the most dangerous pollutants for organism, is mainly derived from combustion of accumulators and carburetors of vehicles (Divrikli *et al.,* 2006). It is a major industrial pollutant particularly in areas associated with smelting of zinc and heavy road traffic (Hassan *et al.,* 2009). Tyre dust originat from tyres of vehicles contains many toxic metals (Adachi and Tainosho, 2004). Traffic pollutants contain potentially toxic metals like lead, cadmium, copper and zinc which are injurious to health (Kramer *et al.,* 2010).

In order to establish inter–element relationships in atmospheric samples, correlation coefficient for eight metals were calculated and a strong correlation was found between Cu-Zn (r=0.708), Fe-Zn (r=0.692), Cu-Fe (r=0.679), Fe-Ni (r=0.612) (Fig. 2). These values were significant at $p \leq 0.001$ level. Based on the correlation study it may be concluded that the four metals viz. Zn, Ni, Fe and Cu might originate from similar sources, probably by the industrial emission especially the metallurgical / electroplating units located in the industrial area of the city (Zereini et al., 2005; Shah and Shaheen, 2008) or other anthropogenic activities. Significant ($p<0.05$) difference is observed between metals (F=3.118). Degrees of freedom between metals and within metals were noted 6 and 14

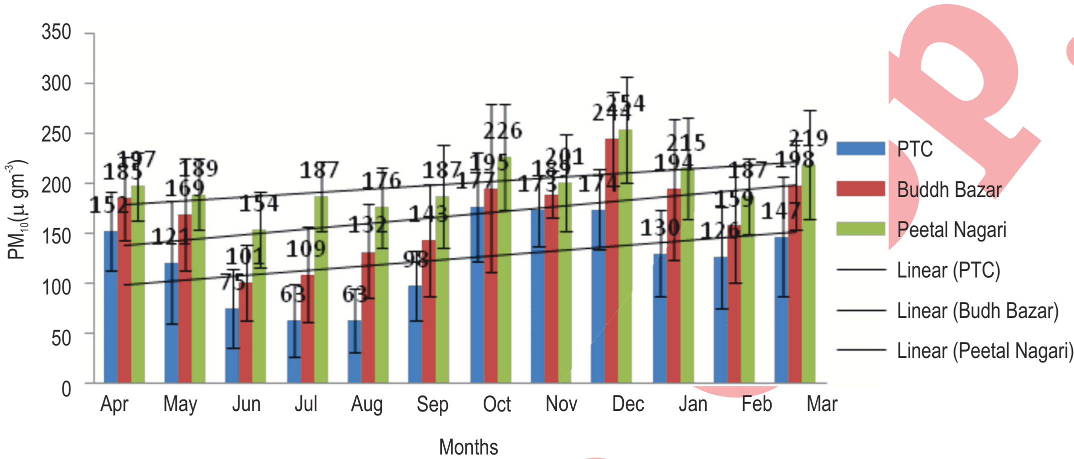

Fig. 1 : Values of suspended particulate matter (PM_{10}) during one (2011-2012) year at three locations of Moradabad. Values are mean ± SD of 312 samples.

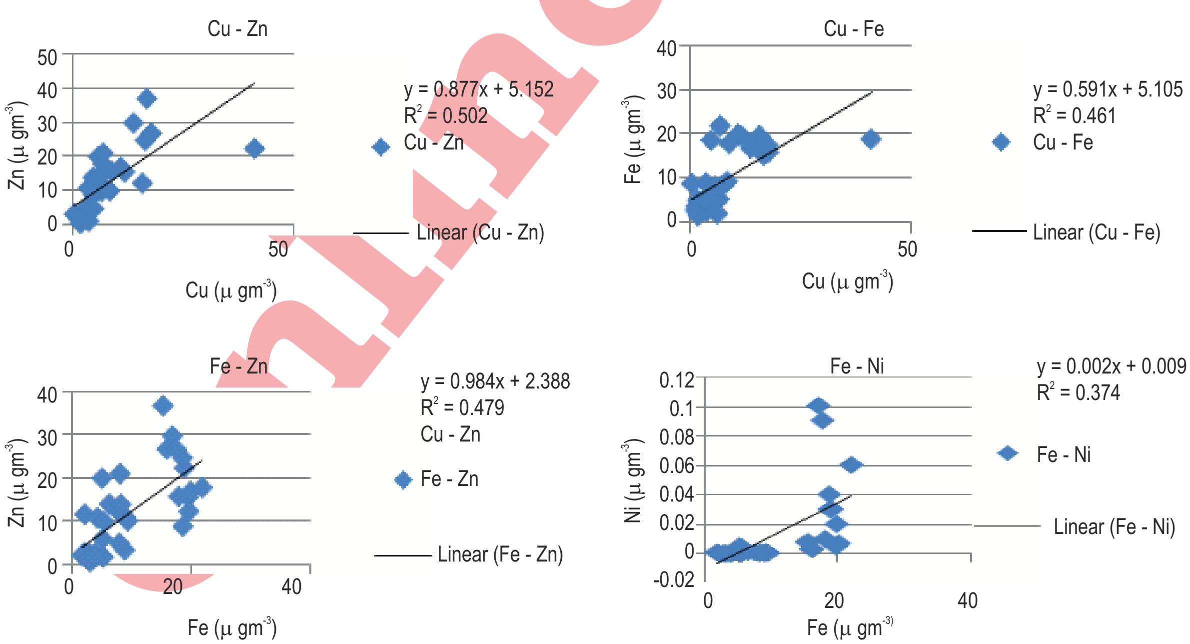

Fig. 2 : Relationship between element concentrations in suspended particulate matter (PM_{10}) of three locations of Moradabad

Table 1 : Values of metal concentrations (µgm^{-3}) in suspended particulate matter (PM_{10}) collected from three locations of Moradabad

Metals	PTC	Buddh Bazar	Peetal Nagari
Cd	0.001±0.002	0.20±0.21	0.41±0.34
Cr	0.01±0.03	0.24±0.27	15.23±9.16
Cu	2.1±0.84	5.60±1.48	64.54±20.07
Fe	3.9±1.90	6.55±2.18	18.43±1.83
Ni	0.0002±0.0002	0.001±0.001	0.03±0.03
Pb	1.01±0.36	2.72±1.21	2.1±0.77
Zn	2.10±0.72	12.26±4.76	21.24±8.02

Values are mean of 36 samples ± SD

respectively. Based on the correlation data, it was possible to suggest that metal concentrations in the PM_{10} of different locations vary considerably depending upon the proximity to sources of PM_{10} emission.

From the present study it is concluded that industrial activities like melting of brass sillies and traffic emissions add large quality of pollutants day by day, resulting in the elevation of suspended particles level. Based upon the above facts, Peetal Nagari was found to be the most polluted site and Police Training Centre was least polluted site in Moradabad.

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