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Ambient Respirable Particulate Matter and Toxic Metals in Kolkata City

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Presence of fine particulate matter (PM10) and toxic metals in ambient air is a matter of serious concern to human health. Studies on short term exposure to PM10 result in increased mortality, hospital admission, medication use, respiratory symptoms and reduced pulmonary function (Dockery and pope, 1994; Katsouyanni et al, 1995; Ostro et al; 1999). Various studies indicate that long term exposure to particulate matter has adverse effect on respiratory health as well (Abbey et al, 1998; Dockery et al, 1993) Some studies suggest that health effects are more strongly associated with exposure to airborne particulate matter less than 2.5 μm PM2.5 than with the coarse fraction of PM10 (Wilson & Suh,1997).Toxicological studies show that ultrafine particles exert a much stronger physiological effect than the same mass of coarse particles (Oberdorster et al, 1992; Donaidson et al, 1998).

Status of airborne metals in air environment of urban centers in India has reported, (NEERI Report 2001) RSPM concentrations in air of Indian metro cities are found to be exceeding the WHO guidelines. Status of airborne metals in Indian context and various strategic approaches for management of air pollution have been reported (Gajghate and Hasan, 1995, 1996, 1999). It is found that toxic metals are associated with fine particulate matter present in the ambient air of Indian urban agglomeration (Gajghate and Hasan, 1997,1999; Gajghate et. al., 1997). Lead along with other toxic elements has been observed to be present in considerable quantities in the ambient air Mumbai, Agra, Ahmedabad, Kochi, Kanpur and Delhi (Chelani et.al., 2001, Gajghate et.al., 1997, 1997, 2002, and 2004). Amongst the important urban centers like Delhi, Mumbai, Kolkata; Ahmedabad is receiving great attention because of rising pollution levels. The Kolkata is second most polluted cities in the India. Therefore, detailed study is undertaken for measurement of PM 10 and toxic metal at three different location in Kolkata city.

Kolkata is the capital of west Bengal and it is the most populous city in India. The city of Kolkata is surrounded on the west by the river Bhagirathi and on all other parts by urban semi-developed areas. The city has an area of about 104 sq. km. and the Kolkata metropolitan area covers 1295 sq. km. According to 2001 census, marked monsoon season. Monthly mean temperature range from 20 to 30 °C, and maximum temperature often exceeds 40 °C. During winter seasons predominant

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wind direction was observed mostly NW direction with an average speed of 5 km/ hours with 47% calm conditions. In Summer and Monsoon the predominant wind direction was S and SE with an average speed of 12 km/ hours and 8 km/ hours with 4% and 13% calm conditions respectively. The percentage relative humidity ranged from 46 to 96% in winter, 52 to 83% in summer and 65 to 97% in Monsoon. Kolkata with large industrial base for various industries contributing to atmospheric pollution, coupled with about 0.43 million slow moving, poorly maintained old vehicles plying on the streets aggravates the pollution load of the atmosphere. The long terms air quality trends established by NEERI NAQM programme (1990 – 2002) projected Kolkata as the highly polluted city of India. This indicated that atmospheric pollution in Kolkata is alarming and requires urgent abatement measures. The presence of toxic metals in the Kolkata atmosphere results, therefore, solely from manmade and automobile activities. The ambient air quality status is mainly attributed to frequent traffic halt, crawling speed, poor maintenance of vehicles and erratic driving pattern coupled with presence of high rise buildings, slow wind pattern and high temperature built- up within the city. The paper highlights the status with a special reference to seasonally and yearly PM10 and toxic metals in ambient air of three different activity in Kolkata city

MATERIALS AND METHODS

The three sites representing Industrial, Commercial, and Residential areas were selected to cover entire city to study ambient Respirable Particulate matter less than 10μm (PM10). PM10 samples were collected by operating Respirable Dust Samplers at an average flow rate of 1.2 m^3/min for 24 hrs. on pre-weighed glass fiber filter paper of 20 x 25 cm. size and reweighed after sampling in order to determine the mass concentration of the particles collected. The concentrations of particulate matter in ambient air were then computed on the net mass collected divided by the volume of air sampled. PM10 is characterized for toxic metals. A known area of the exposed filter paper were punched out from the filter paper and digested in concentrated HNO_3 acid by microwave digestion system. The content was filtered through Whatman paper no. 42 and final volume was made up to 100 ml by double distilled water. The filtrate was used to determine the metals including Cr, Cd, Fe, Zn, Pb, and Ni by Inductively Coupled Plasma-Atomic Emission Spectrometer (ICP-AES). The details of sampling procedures are given elsewhere (Katz, 1977; Markert, 1994).

RESULTS AND DISCUSSION

The results of concentration of metal and PM10 measurements in three sites representing one each of industrial, Commercial and Residential areas for a period of one year. The concentrations of PM10 in different sites are shown in Figure 1.The profile of results showed that monthly average PM10 ranged from 80-245 μg/m3 at industrial site, 66 – 195 μg/m^3 at commercial and 45 – 159 μg/m^3 at residential site. The annual average concentration of PM10 were 153, 119 and 92 μg/m^3 at industrial commercial and residential location respectively. Higher concentration of PM10 was recorded during summer month followed by winter Figurs the seasonal variation of PM10. Data of the PM10 was evaluated for

seasonal analysis to asses the impacts of seasonal influence on build up of pollution level.

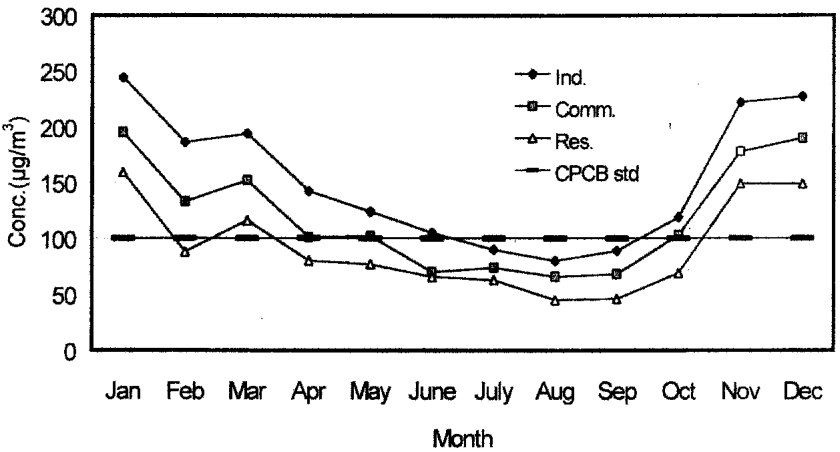

Figure 1. Status of monthly concentration of PM10 in three locations

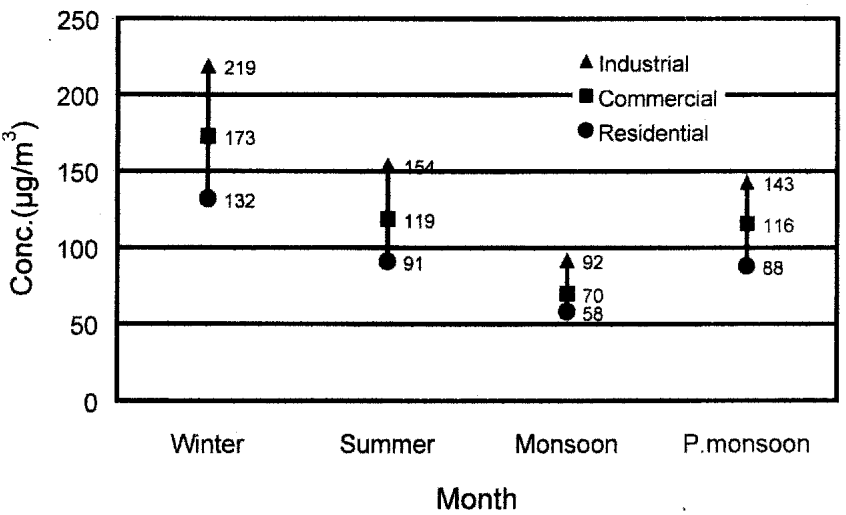

Figure 2. Seasonal variation of PM10 in Kolkata city

It can be seen from the Figure 2 that the maximum concentration of PM10 was observed in winter followed by summer, post monsoon. It is also observed that maximum concentration of PM10 in all the season ware highest in the industrial site followed by commercial and residential site. 219 $\mu g/m^3$ of PM10 in winter season, 159 $\mu g/m^3$ PM10 in summer and 149 $\mu g/m^3$ in post monsoon season was Recorded at industrial site which is highest among others location. Average concentration of toxic metal in three locations are shown in Table 1.

Average concentration of Fe in Industrial area was 0.394 and ranged between 0.003 and 2.088 $\mu g/m^3$. Average Pb concentration was found to be 0.406 and ranged 0.116 to 0.61 $\mu g/m^3$. Maximum was in month of March and minimum was in month of November. Average concentration of Cr was 0.008 $\mu g/m^3$ and it was observed between 0.001 and 0.015 $\mu g/m^3$ of minimum and maximum respectively. Maximum concentration was found to be in the month of January. The Cd concentration was between 0.001 and 0.012 $\mu g/m^3$. As regards to metal concentration the average concentration of Zn was 2.868 in Industrial site. The highest value was observed 5.9 $\mu g/m^3$ in January and minimum in the months of monsoon and post monsoon. Average concentration of Ni was 0.017 $\mu g/m^3$ and ranged between 0.002 and 0.044 $\mu g/m^3$.

In Residential area, the average concentration of Zn was 0.997 $\mu g/m^3$ and highest concentration 3.753 $\mu g/m^3$ in month of January and it was minimum in the month of monsoon and summer season. Average concentration of Ni was 0.02 $\mu g/m^3$, highest concentration of Ni was 0.061 in December and minimum was in month of post monsoon. Average concentration of Fe was found 0.137 $\mu g/m^3$, and ranged was 0.003 and 0.845. Average concentration of Pb was 0.184 $\mu g/m^3$. Highest concentration was 0.36 in December and minimum in month of monsoon and post monsoon. Average concentration of Cr and Cd was 0.005 and 0.006 $\mu g/m^3$ respectively. Highest concentration of Cr was found in May and Cd was in August and September.

In commercial area, the average concentration of Ni and Cr was observed 0.516 and 0.008 $\mu g/m^3$ respectively, whereas the higher concentration was observed 0.85 and 0.01 $\mu g/m^3$ in month of January for Ni and June for Cr. Average concentration of Fe and Pb was found 0.305 and 0.419 $\mu g/m^3$, the highest value of Fe and Pb was 1.506 and 0.65$\mu g/m^3$ in March and January. Average concentration of Zn and Cd was observed 2.54 and 0.007 $\mu g/m^3$ respectively. The highest concentration Zn and Cd was observed as 6.87 and 0.02 $\mu g/m^3$ in December .

Seasonal variation of toxic heavy metals, namely Ni, Cr, Fe, Zn, Cd, Pb are shown in Table 2. The average concentration of metals was found to be maximum during winter month. In winter season Zn concentration was highest (6.87 $\mu g/m^3$) in Residential area as compared to Industrial and Commercial areas. In monsoon season, Zn concentration was highest in residential area and minimum in Industrial area. Cd concentration was insignificant. Whereas during summer Pb concentration was highest in commercial site (0.716 $\mu g/m^3$), Fe and Zn concentration was found 0.615 and 0.869 $\mu g/m^3$ at Industrial area respectively. Concentration of Cr & Ni was insignificant.

Based on study, it is seen that ambient PM 10 is the major problem in Kolkata city. As regards to toxic metals like Zn, Fe was found in high concentration however the concentration of Cr, Cd, Ni are insignificant. The concentration of Pb is marginal. The high concentration of PM10 caused by slow moving vehicle, congestion traffic and small scale industrial activities. To arrest the ambient elemental levels and PM10, immediate control measure to be implemented like Euro III emission norm to vehicles. The policies on control of emissions from small scale industries need to formulate on urgent basis. The cleaner fuels is

required to be supply to the entire city. Awareness regarding the pollution effects and maintain of individual vehicles among the users is to be raised.

Table 1. Concentration of toxic metals ($\mu g/m^3$) in three locations.

Metals/Location		Industrial	Commercial	Residential
Ni	Avg.	0.017	0.516	0.02
	Range	0.002-0.04	0.001-0.85	0.002-0.061
Cr	Avg.	0.008	0.008	0.005
	Range	0.001-0.015	0.003-0.01	0.001-0.01
Fe	Avg.	0.394	0.305	0.137
	Range	0.003-2.08	0.003-1.51	0.003-0.845
Pb	Avg.	0.406	0.419	0.184
	Range	0.116-0.61	0.032-0.65	0.015-0.36
Zn	Avg.	2.869	2.54	0.997
	Range	0.003-5.9	0.003-6.87	0.003-3.75
Cd	Avg.	0.005	0.007	0.006
	Range	0.001-0.012	0.001-0.02	0.001-0.015

Avg. - Average

Table 2. Seasonal variation of toxic metals ($\mu g/m^3$).

Sites/ Parameter	Summer			Monsoon			Winter		
	Ind	Res	Comm	Ind	Res	Comm	Ind	Res	Comm
Fe	0.615	0.257	0.003	0.138	0.027	0.003	0.429	0.127	0.25
Pb	0.558	0.097	0.716	0.21	0.156	0.003	0.449	0.299	0.131
Cr	0.01	0.008	0.019	0.005	0.004	0.019	0.008	0.003	0.008
Cd	0.007	0.006	0.043	0.003	0.009	0.077	0.006	0.004	0.015
Zn	0.869	0.03	0.116	0.003	0.487	0.209	5.9	3.753	6.87
Ni	0.019	0.028	0.009	0.02	0.012	0.005	0.012	0.021	1.508

Ind – Industrial; **Res** – Residential; **Comm** - Commercial

It is also advised to develop the Green Belt in the city using the plants having higher tolerance for air pollutants. The widening of roads to be given priority to reduce the congestion of vehicular traffic. The urban traffic management to be design properly to improve the ambient PM10 and metal concentration in the city of banning of plying 15 year old two wheeler and 8 year old cars, introduction of

the Kolkata. The further study is needed for details emission inventory of industrial, areas and automobiles for preparation of emission load scenario and accordingly, the measures to be tailored.

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