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CHARACTERISATION OF PARTICULATE MATTER FOR TOXIC METALS IN AMBIENT AIR OF KOCHI CITY, INDIA

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Abstract. Measurement of respirable suspended particulate matter (RSPM) and analysis of toxic metals in air of Kochi city was carried out for a period of one year, 1997. Seasonal variations of RSPM and toxic metals are analysed to identify the influence of meteorological parameters. The air pollution problem with respect to RSPM and lead is moderately significant especially in winter season. The profile of other toxic metals in RSPM is not much significant. Domestic fuel used mainly coal/wood and petrol/diesel fueled motor vehicles are the major contributors to the RSPM and toxic metals. Various control strategies are delineated for reduction of ambient RSPM and toxic metals in air of Kochi city.

Keywords: AAS analysis, air pollution, lead, RSPM, seasonal variation

1. Introduction

India has 23 cities of population over one million people, and ambient air pollution levels exceed WHO health standards in many of them. Urban air pollution is worsening due to upward trends in power consumption, industrialization, and vehicle use. Five of the 10 largest cities in India: Mumbai, Delhi, Kolkata, Ahmedabad, and Kanpur have severe air pollution problems with annual average levels of suspended particulate matter (SPM) at least three times higher than WHO standards (NEERI, 2000). SPM concentration levels in various towns in Haryana sub-region of National Capital Region (NCR) in India exceeding the National Ambient Air Quality Standards (Bhanarkar *et al.*, 2002a). Brandon and Homman (1995) have reported that ambient air pollution levels exceeding WHO standards in 36 major Indian cities/town account for 40 350 premature death, 1 98 05000 thousand hospital admissions and sickness requiring medical treatments, and 1201 million incidences of minor sickness annually. NEERI (1998) estimated human health damage due to air pollution in National Capital Territory, Delhi at Rs. 1168 millions per year. Respirable suspended particulate matters (RSPM) have been linked with human morbidity and mortality (Dockery and Papes, 1994; Anderson *et al.*, 1992). Since 1990, measurement of atmospheric concentration of RSPM and toxic metals are being carried by NEERI in 10 major cities of India as a part of National Air Quality Monitoring programme. The RSPM samples were collected on 24-h basis, 8 days in each month throughout the

year. The profile revealed critical air quality with respect to RSPM in industrial locations of Kanpur, Ahmedabad, Delhi and Kolkata shared high levels of RSPM during 1997 (NEERI, 2001). It is experienced that the toxic metals are found to be associated with fine dust, which remains in air environment for longer duration under the prevailing meteorological conditions (Schroeder *et al*., 1987). It is further transported from one place to other and it contaminates into other pristine environment. Presence of the lead in the environment has led to an increasing awareness and concern about its detrimental effect on the ecosystem and human health (WHO, 1977; Mathur *et al*., 1997). It is found that toxic metals are associated with fine particulate matter present in the ambient air of Indian urban agglomerations (Negi *et al*., 1987; Sadasivan and Negi, 1990; Gajghate and Hasan, 1997 and 1999; Gajghate *et al*., 1997). In the city of Mumbai (India), lead along with other toxic elements has been observed to be present in considerable quantities in the ambient air (Khandekar *et al*., 1984; Chelani *et al*., 2001). Status of airborne metals in the environment of India and various strategies and approaches for its management has been reported (Gajghate and Hasan, 1995 and 1996; Bhanarkar *et al*., 2002b). The present study highlights the levels of ambient fine dust and toxic metals level in the ambient air of Kochi city during 1997.

2. Materials and Methods

2.1. Site characteristics

Captivating Kochi is a perfect reflection of the cosmopolitan society of state of Kerala (India). Here one can see the oldest Church in India, old Portuguese houses and palace, Chinese fishing nets, a 16th century synagogue, all in complete harmony. It is also known as the "Queen of the Arabian Sea". It has one of finest natural harbours in the world. Kochi, the commercial capital of the state and a major tourist center is known for its scenic beauty with beautiful lagoons and backwaters. Kochi is one of the most interesting towns in south India. Today Ernakulam–Kochi is a dynamic city with soaring land prices and rapidly industrializing suburbs. There is a range of good-value accommodation and some fascinating historic remains and a trading port since Roman times. It is Head Quarter of the southern command of Indian Navy, and has an airport and a railway terminus. Kochi has a population of 5 83 000 based on 1991 census. The annual rainfall varied from 475–600 mm and temperature varied from 22 to 32 °C in the city during 1997. The major measurement of industries of the city comprises a refinery and a fertilizer plant. The city also has several medium and small-scale industries.

2.2. Monitoring and analysis

A sampling network spread over Kochi city was operated activity zone wise to get entire coverage of ambient RSPM and metal concentrations. For Kochi city, three

sampling sites representing residential, commercial, and industrial activity were selected. RSPM were collected from these locations using Respirable Suspended Particulate Matter (RSPM) samplers operated at a rate of 1.5 m^3/min for 24 h on pre-weighed glass fiber filter of 20 cm × 25 cm size and filters were reweighed after sampling in order to determine the mass of the particles collected. The concentrations of particulate matter in ambient air were then computed by dividing mass by the total volume of air sampled. For the determination of metal concentration, the samples were prepared by taking 12 circles of 1″ diameter from the filter paper and digesting them in concentrated nitric acid using microwave digestion system. The content was filtered through Whatman paper No. 42 and final volume was made up to 100 mL by adding double-distilled water. The filtrate was used to determine the metals including Cr, Cd, Fe, Pb, Zn, and Ni by GBC 900 Atomic Absorption Spectrophotometer (AAS). The details of sampling procedure are given elsewhere (Katz, 1977).

3. Results and Discussion

Micrometeorology data regarding wind speed and wind direction was collected from Indian Meteorological Department. The examination of the wind speed and wind direction data of the year 1997 revealed that wind direction varied significantly during various seasons (Figure 1). The annual wind pattern showed that predominant

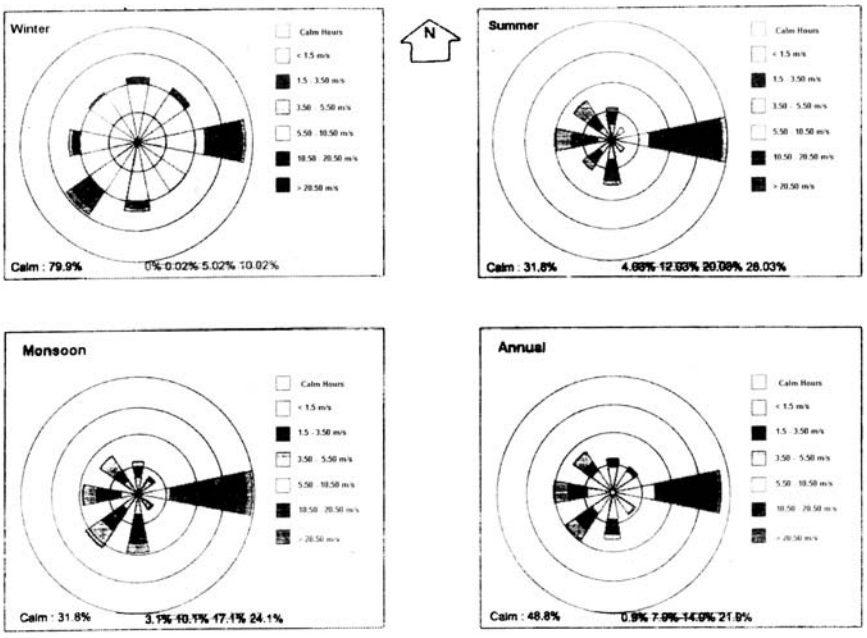


Figure 1. Seasonal and annual Windrose for Kochi during 1997.

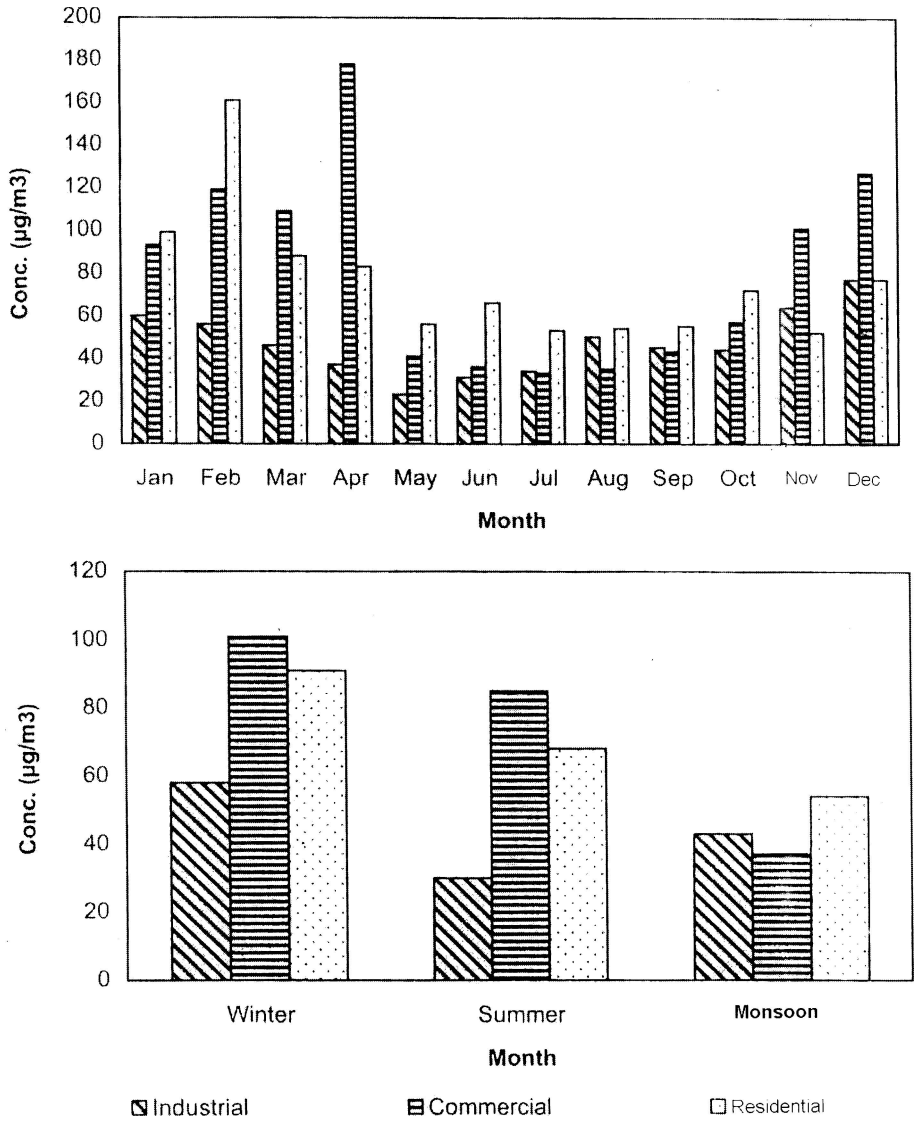
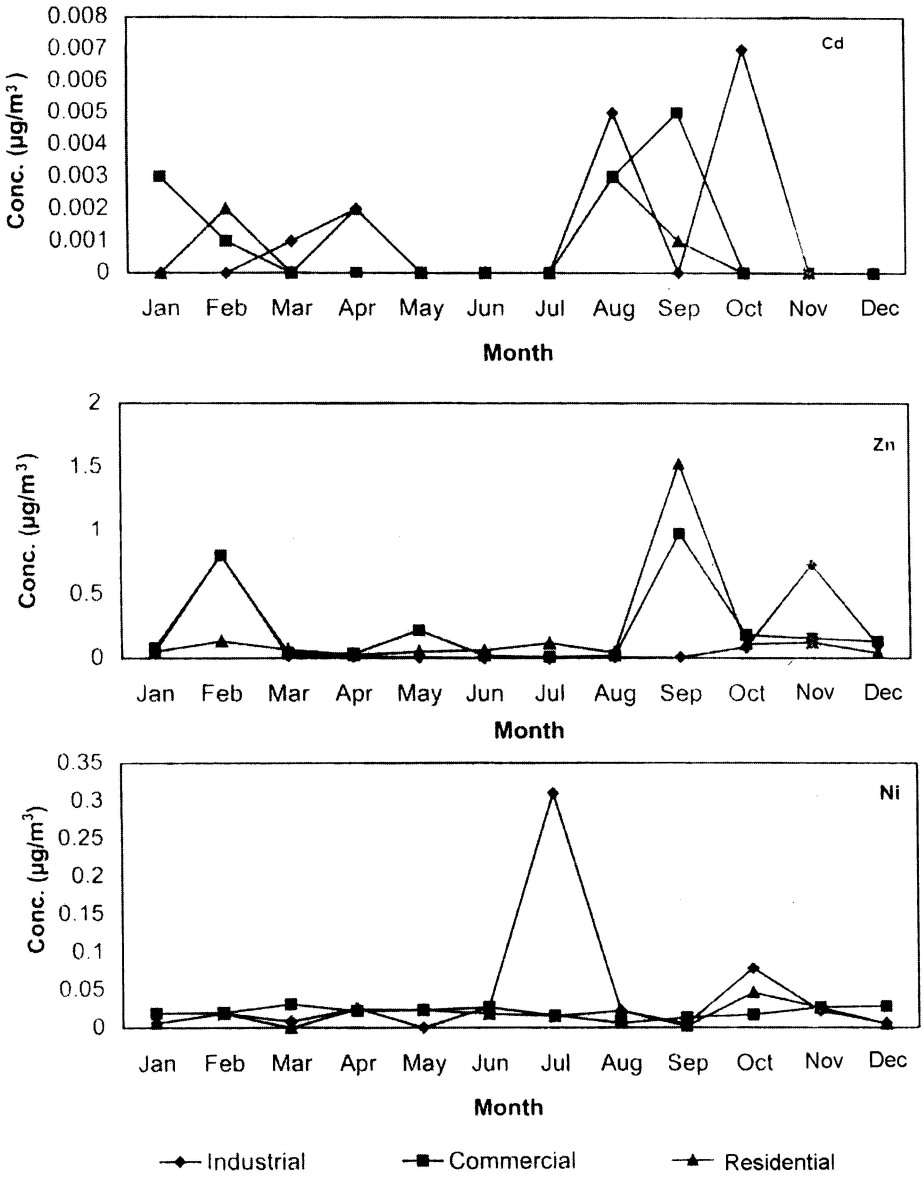


Figure 2. RSPM concentrations in the air of Kochi at three sites during 1997.

wind direction was from East with calm conditions around 49% during 1997. In winter, summer and monsoon seasons, the predominant wind direction was easterly and calm conditions was around 80%, 32% and 32%, respectively most of the time.

RSPM monitoring was carried out at three sites, which represent industrial (I), commercial (C) and residential (R) area in the city of Kochi. The study revealed that monthly average of RSPM level ranged from 23–77 $\mu g/m^3$ at industrial site, 33–178 $\mu g/m^3$ at commercial, and 52–161 $\mu g/m^3$ at residential site (Figure 2). The data revealed that the higher concentration of RSPM in industrial, commercial

and residential area was observed during the winter season. Seasonal mean RSPM concentration at industrial, commercial and residential sites were found 58, 101, 91 during winter, 30,85,64 during summer and 43, 37, and 54 during monsoon season, respectively. The levels of RSPM violated the CPCB standard at commercial and residential sites during the December, February, March and April months.



(a)

Figure 3. Metal concentrations in the air of Kochi at three sites during 1997.

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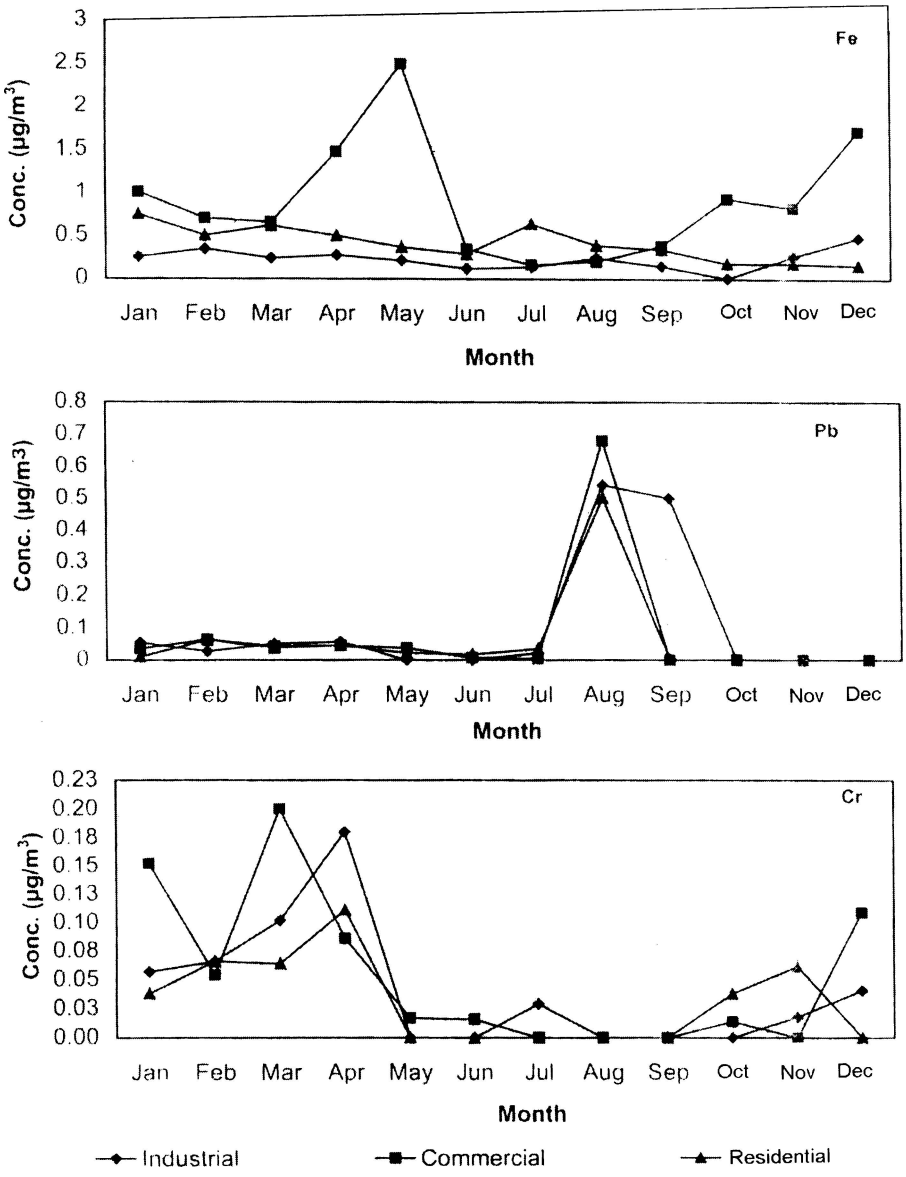
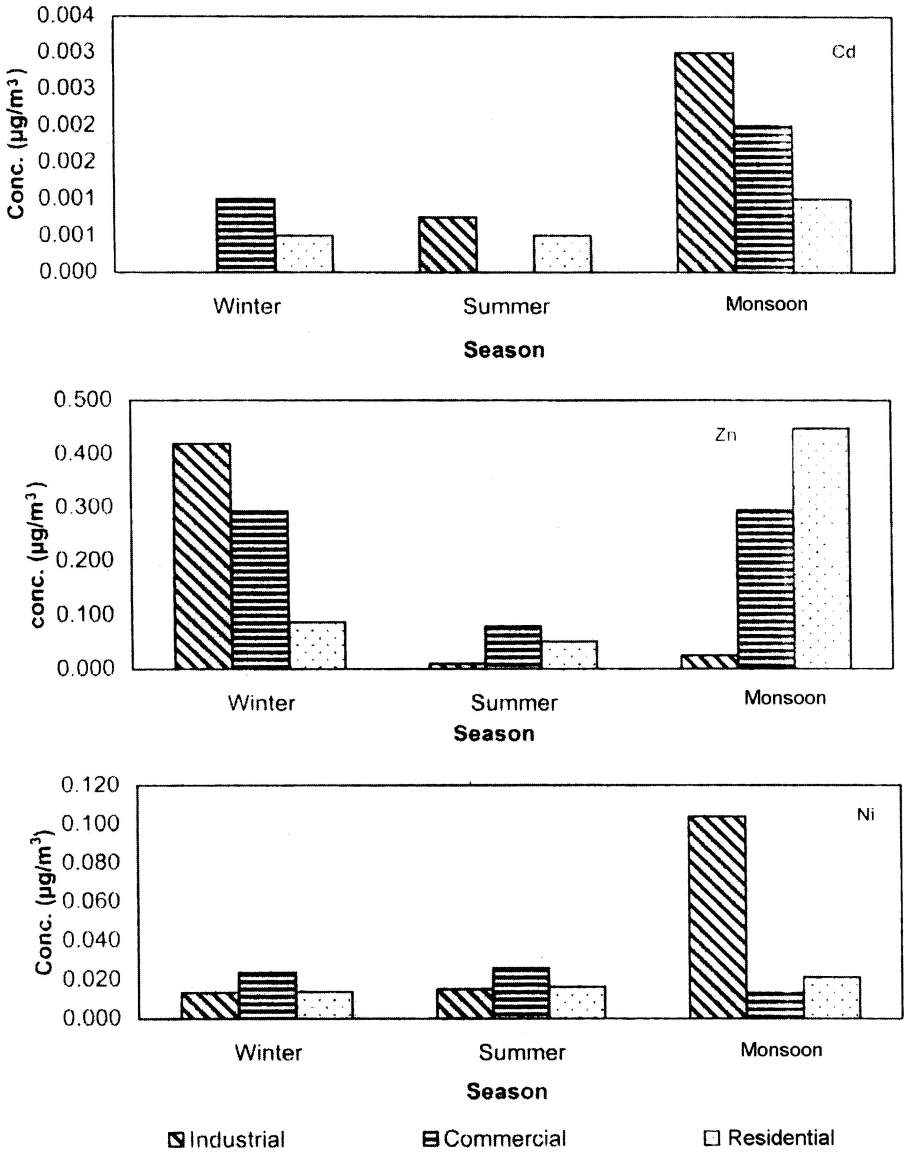


(b)

Figure 3. (*Continued*)

The annual average of RSPM was 47, 81 and 76 μg/m^3 at industrial, commercial, and residential respectively. The levels of RSPM are not high during the monsoon and summer seasons, however, exceeded the CPCB standards at commercial sampling locations especially in winter seasons. Further, annual average concentration of RSPM exceeded the CPCB standards at commercial and residential sites.

Vehicular activities apart from localized industrial and domestic emission may be contributing to high levels of RSPM (World Bank, 1997). The monthly average concentrations of six metals are delineated in Figures 3a and 3b. Monthly average concentrations of Pb over a year ranged from 0.022 to 0.54, 0.004 to 0.68 and 0.010 to 0.500 μg/m^3 at industrial, commercial, and residential sites,



(a)

Figure 4. Seasonal variations in metals at three sites in Kochi.

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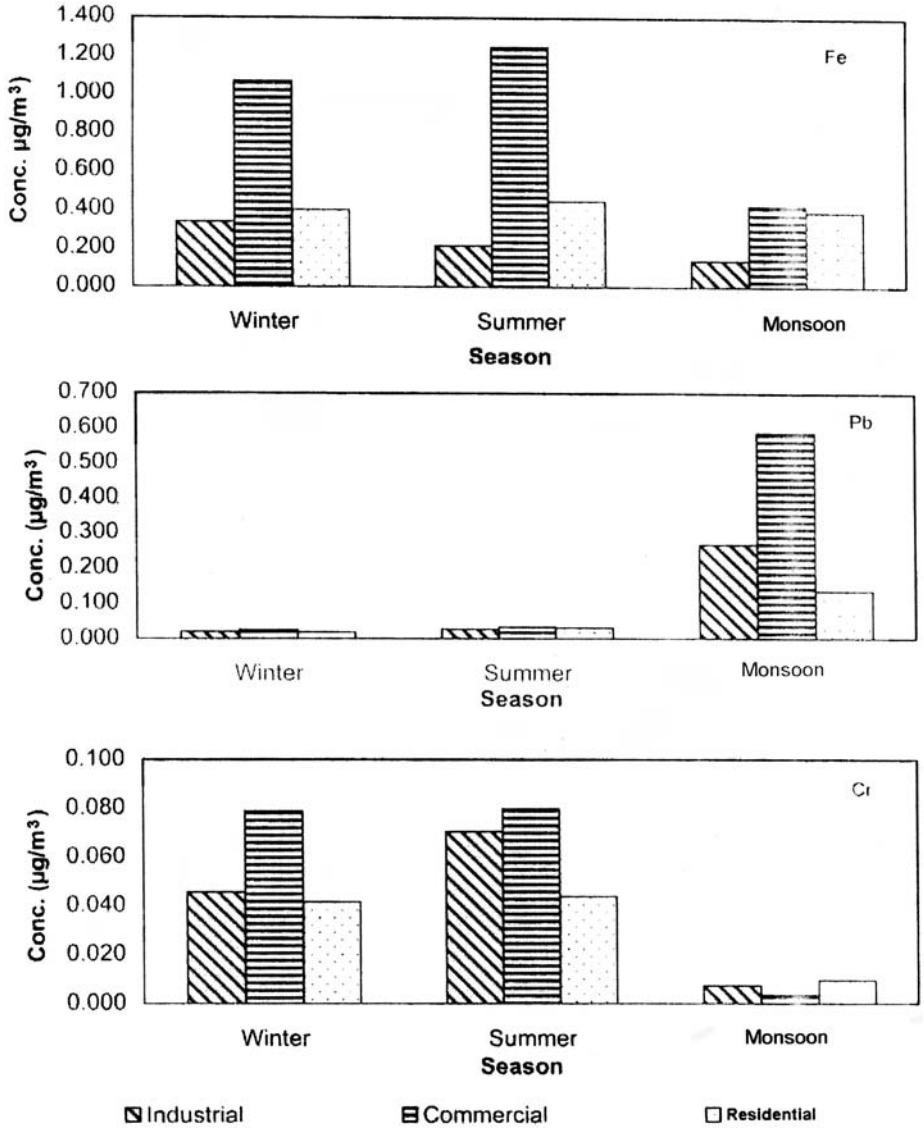

(b)

Figure 4. (*Continued*)

respectively. Lead in the atmosphere contributed principally from vehicular activities. Nickel in the atmosphere originates from the combustion of fossil fuels, smelting and crystal sources (Chow *et al*., 1992). Monthly mean concentration of Ni varies from 0.005 to 0.310, 0.006 to 0.031 and 0.002 to 0.111 $\mu g/m^3$ at industrial, commercial, and residential sites, respectively. The level of cadmium in the ambient air of Kochi city was found insignificant. The Cd, Cr, and Ni are there

from industrial activities and contributed by localized industries. Zinc originates from coal combustion, smelting operations, incineration, and wood combustion. The monthly mean concentration of Zn varies from 0.005 to 0.80, 0.008 to 0.972 and 0.024 to 1.524 $\mu g/m^3$ at industrial, commercial, and residential sites, respectively. The high concentration of Zinc is attributed to high rate of soil erosion. Monthly mean concentration of Fe varies from 0.012 to 0.482, 0.166 to 1.719 and 0.162 to 0.751 $\mu g/m^3$ at industrial, commercial and residential sites respectively. While observing the seasonal variations in the trace elements (Figures 4a and 4b), high levels of cadmium, nickel, zinc, and lead at industrial, commercial sites were observed in monsoon seasons. However, iron and chromium was maximum at the three sites in winter and summer seasons. The results reveal that the levels of the Cr, Cd, Zn and Ni are contributing marginally except Pb in commercial area.

4. Conclusion

It may be concluded that there may be industrial sources, which contribute to regular emission of RSPM and other toxic elements. Autoexhaust is the main source contributing to RSPM and lead in the ambient air. In Kochi, ambient air quality with respect to RSPM and toxic metals has moderate problem as compared to other big cities of India. However, swelling of urban population, increased vehicular traffic, and unplanned development of industrial activities in and around the city will lead to severe air pollution problem in near future. Therefore it is advocated that urban air quality management should be formulated. In light of that, the study for carrying capacity of greater Kochi is already in progress to formulate the control measures for reduction of the RSPM emission level. The unleaded petrol and low sulphur diesel should be made available at all outlets of Kochi city as one of the control measure for the abatement of pollution. Development and widening of internal roads and disciplined traffic will reduce congestion and reduction of pollution concentration built up at the inhalation level. Raising public awareness about dangers of RSPM and toxic metals in ambient air will help in the improvement of urban air quality. It is also advocated to grow plantation along the roadsides to arrest the pollution from mobile sources.

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