Bull. Environ. Contam. Toxicol. (2002) 68:347–354

DOI: 10.1007/s00128-001-0260-2

Bulletin of Environmental Contamination and Toxicology

Urban Ambient Air Quality and Its Management Strategy for a Metropolitan City in India

H. K. Gupta,[1] V. B. Gupta,[2] C. V. C. Rao,[1] D. G. Gajghate,[1] M. Z. Hasan[1]

[1] Air Pollution Control Division, National Environmental Engineering Research Institute, Nehru Marg, Nagpur-440 020, India
[2] School of Future Studies and Planning (Faculty of Engineering Sciences), Devi Ahilya University, Khandwa Road, Indore-452 017, India

Received: 12 March 2001/Accepted: 20 September 2001

Cities in developing country are growing rapidly in size and diversity. Increasing emission from vehicular traffic, industry, and refuse burning all poses potential risk for large air pollution exposure. The growth of economic development combined with the lack of emission control makes Asia's mega-cities prone to more serious air pollution problems than similar cities in industrialized nations. The air pollution problems in large Asian cities including Bangkok, Beijing, Mumbai, Calcutta, Delhi, Jakarta, Karachi, Manila, Seoul, and Shanghai have been reported in 20 mega-city report (WHO and UNEP 1992). In addition, Urban Air Quality Management Strategy (URBAIR) in Asia has studied air pollution status in Katmandu Valley, Jakarta, Metro Manila, and Greater Mumbai (World Bank Technical Paper nos. 378; 379; 380 and 381). The profile of pollution indicates that these cities have serious to moderate problems due to the high levels of Suspended Particulate Matter (SPM), SO_2 and Lead. There is substantial evidence from developed countries having strong correlation between exposures to ambient air pollution concentrations (Dockery et al. 1993; Pope et al. 1995; Schwartz 1991). Ostro (1999) also studied the link of mortality to SPM and respiratory illness from lead, SO_2 and other pollutants in United States. Status of air pollution levels and various strategic approaches for air management have been reported (Gajghate and Hasan 1995; 1996; 1999). India has twenty-three cities of over one million people and ambient air pollution levels exceeded 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 ten largest cities in India viz. Mumbai, Kolkata, Delhi, Ahmedabad and Kanpur have severe air pollution problems (NEERI 1996). As per a World Bank study (Brandon and Homman 1995) ambient air pollution levels (SPM, SO_2, Lead and NO_2) exceeding WHO standards in thirty-six major Indian cities and towns account for 40,350 premature deaths, around 1,98,05000 thousand hospital admissions and sickness requiring medical treatment and also 1201 million incidences of minor sickness annually. Parikh et al. (1994) estimated the cost of health damage due to air pollution in Mumbai. The study also estimated cumulative loss in property value in Chembur for every 100 μgm^{-3} increase in SPM concentration. Another case study (NEERI 1998) estimated human health damage due to air pollution in the National Capital Territory, Delhi. It is evident from these case studies that the country is paying a heavy price due to air pollution. However, annual average

Correspondence to: D. G. Gajghate

concentrations of SO_2 and NO_2 are generally low in relation to typical ambient standards.

Indore is a commercial capital of Madhya Pradesh, India. The rapid strides of industrialization in the last two decades have been responsible for the development of huge satellite industrial townships of Pithampur and Dewas which further resulted into the intense urbanization of the city. Rapidly growing city is an account of flourishing trade and commerce, Indore is located at 22° 43′ latitude (North) and 75° 57′ longitude (East) with general elevation of about 550 meters above MSL with its present population of 16 lakhs. The city enjoys the salubrious climate that is the characteristic of Malwa region with about 1050 mm of annual rainfall. The municipal limits of city stretch well beyond 143 square kilometer area with large number of industrial estates located in and around the city. The rises in vehicular population and congested traffic have eventually been resulted in higher level of air pollution. There are about 350 small, large and medium scale air polluting industries out of which about 150 are the pulse mills alone. This spews out a lot of dust in the ambient air and causes a lot of nuisance and annoyance to general public living in that area. Frequent public outcries in newspaper media in recent time are indicator of the rising problem of air pollution. Some information is available regarding air pollution at Indore in form of stray reports. There has been an extended air pollution monitoring program functioning under National Ambient Air Quality Monitoring (NAAQM) project with three stations in the city to keep on eye on the air quality since 1990 (CPCB 1995). In view of above, the assessment of air pollution in Indore along with other major urban cities is undertaken. From the available information, it is further attempted to identify the reasons behind the degradation of ambient air quality.

MATERIALS AND METHODS

A network spread over Indore city was operated zone wise activity to get entire coverage of ambient air quality criteria pollutant. City of Indore was selected on the basis of (i) representative of major regional group (ii) high rate of industrialization and urbanization (iii) representing the regional to climatic characteristics of India. In Indore city, three sampling sites representing residential, commercial and industrial activity zones were selected. Four major air pollutants viz. SPM, PM 10 (Particle size < 10 micron), SO_2 and NO_2 representing the basic air pollutants in the region were identified for Air Quality Monitoring. The samples for SPM and PM 10 were collected using High-Volume Sampler and Two Stage Fractionator Sampler respectively operated at a rate of 1.5 m^{-3} min^{-1}. SPM and PM 10 concentration were determined by collecting the particulate matter for each on pre-weighed glass fiber filter paper and re-weighed after sampling in order to determine the mass concentration of the particles collected. The concentration of particulate matter in ambient air was then computed on the net mass collected in proportion to volume of air sampled. The gaseous samples (i.e. SO_2 and NO_2) were collected by drawing air at flow rate 0-5 liter per minute (LPM) through the respective absorbing media. The samples for gaseous pollutants as well as SPM and PM 10 were collected as per standard procedures (Katz 1977).

RESULTS AND DISCUSSIONS

The annual average concentrations of SPM in ambient air of Indore city remained well above promulgated standard for industrial, commercial and residential areas. The result showed that the concentration of SPM ranged from 296 to 670 μgm^{-3}, 242-519 μgm^{-3} and 225-433 μgm^{-3} in industrial, commercial and residential areas respectively. The activity wise analysis of SPM pollution indicates that industrial zone recorded larger SPM levels followed by commercial and residential, confirming the source apportionment to Dal (Pulse) mills activity in industrial zone (Fig. 1a). The seasonal variations of SPM profile (Fig. 3a) indicate that Indore city experienced high SPM concentration in the winter months. The annual average of SPM concentration for consecutive years of 1990-1997 projected that SPM pollution trend was in decreasing order. This city is known to be an industrialized and commercialized city and the increased SPM level may also have significant contribution from vehicular activities apart from industrial sources. The ambient SPM concentration levels of Indore city are compared with other metro-cities of India (Fig. 2). Indore city having annual average SPM concentrations of 465 μgm^{-3} ranks 1st among 10 metro-cities of India. The annual SPM profile of Indore is higher than all 10 major cities of India during the year 1995, however Indore ranks 2nd taking an account of SPM values in 1996.With regard to annual average concentration of SO_2, 80 μgm^{-3} and 60 μgm^{-3} is the limit as promulgated by CPCB for industrial and commercial / residential areas.

The concentration was far below the standard and consequently never exceeded this level at any sites of study area over the year 1990-1997. The yearly average concentration of SO_2 was in the range 5-10 μgm^{-3}, 6-18 μgm^{-3} and 7 to 24 μgm^{-3} for residential, commercial and industrial activities respectively. The results indicate that trends of SO_2 over the year 1990-97 are in decreasing order (Fig. 1b). The monthly average concentration of SO_2 revealed that the highest concentrations of SO_2 were observed in the winter months followed by summer and monsoon months. The area wise concentration of SO_2 showed that the SO_2 levels did not vary significantly in industrial, commercial and residential zones. Seasonal variations of SO_2 levels indicated that highest concentration of SO_2 was observed in industrial areas (Fig. 3c).

Annual average NO_2 concentrations at three monitoring sites did not show alarming level. The profile of NO_2 levels over the year 1991-1997 was well below the air quality standards of CPCB for industrial, commercial / mixed areas. The annual average NO_2 levels varied between 8 μgm^{-3} and 30 μgm^{-3} at all sites over the study period (Fig. 1d). The profile of NO_2 levels revealed that the trends of NO_2 level showed decreasing pattern. The seasonally variations data projected that NO_2 levels were higher in post-monsoon season followed by winter and pre-monsoon (Fig. 3d). It was also seen that concentrations of NO_2 were more in

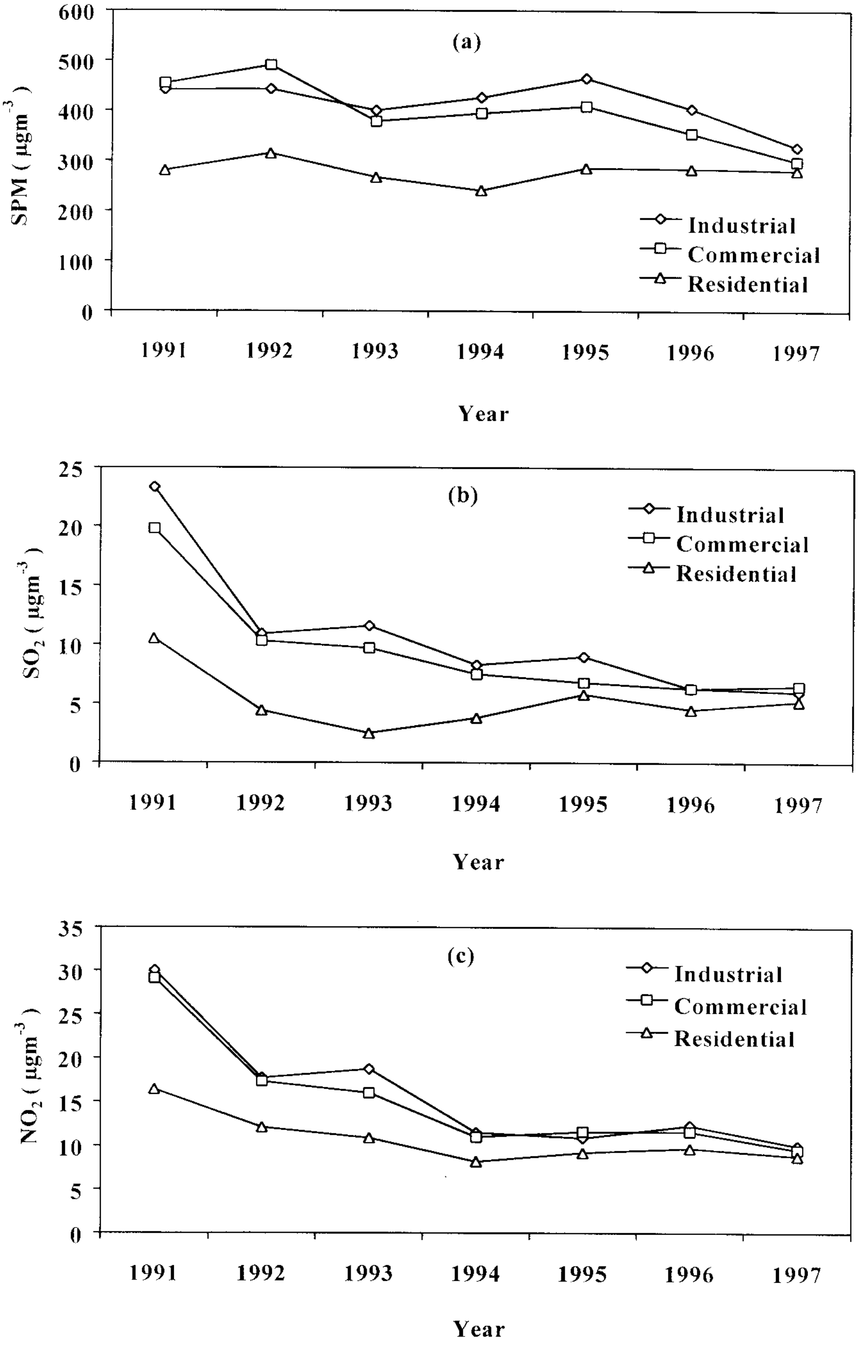

Figure 1. Ambient SPM, SO_2 and NO_2 concentration in three areas of Indore city

industrial and commercial areas, which may partly be contributed by industrial activities and also by prominent vehicular source in the study area.

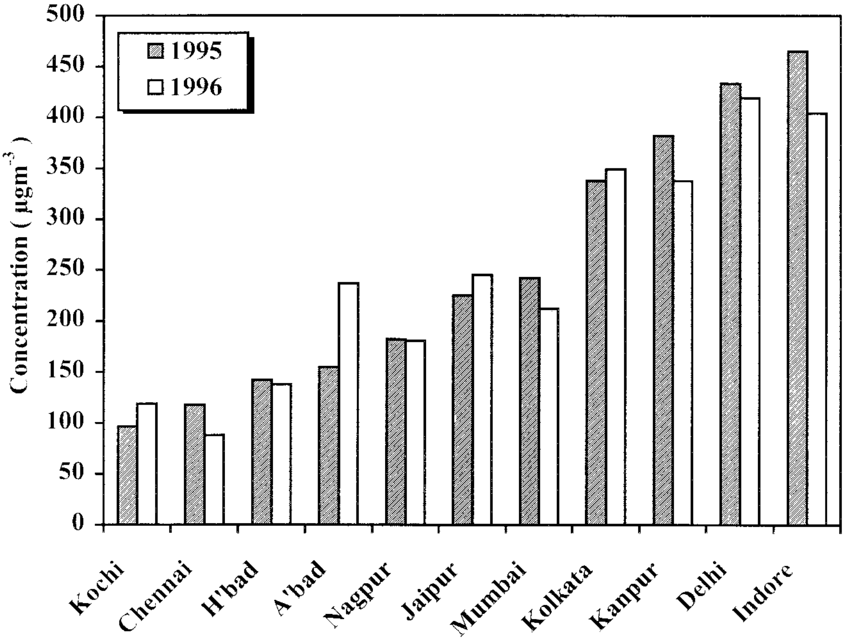

Figure 2. Comparison of annual SPM average of Indore with other major cities, India

The Respirable Particulate Matter (PM 10) in air has been associated with health impairment and increase in mortality, morbidity and asthma (Dockery and Popes 1994). The profile of PM 10 in study area at all sites is alarming. PM 10 data revealed that PM 10 level exceeded the air quality standards promulgated by CPCB for industrial and mixed areas. This high concentration of PM 10 in ambient air is likely to be due to auto-exhaust activity, localized activity of pulse processing in mills. The monthly average levels of PM 10 were 253-602 μgm^{-3}, 167-467 μgm^{-3} and 145-346 μgm^{-3} at industrial, commercial and residential areas respectively (Fig. 3b). The concentration of PM 10 was highest in industrial area followed by commercial and residential areas. The highest PM 10 concentration recorded was 450 μgm^{-3} at industrial site during the winter season. The concentration of PM 10 varied from 157 μgm^{-3} at residential and 450 μgm^{-3} as highest level in industrial area. It is seen from the results that level of SPM, NO_2 and SO_2 are improved over the time due to timely taken stringent emissions control to the industries and vehicular actives by the regulatory agencies. However, SPM levels were not reached to the level of safety for the health of ecology, property and human beings.

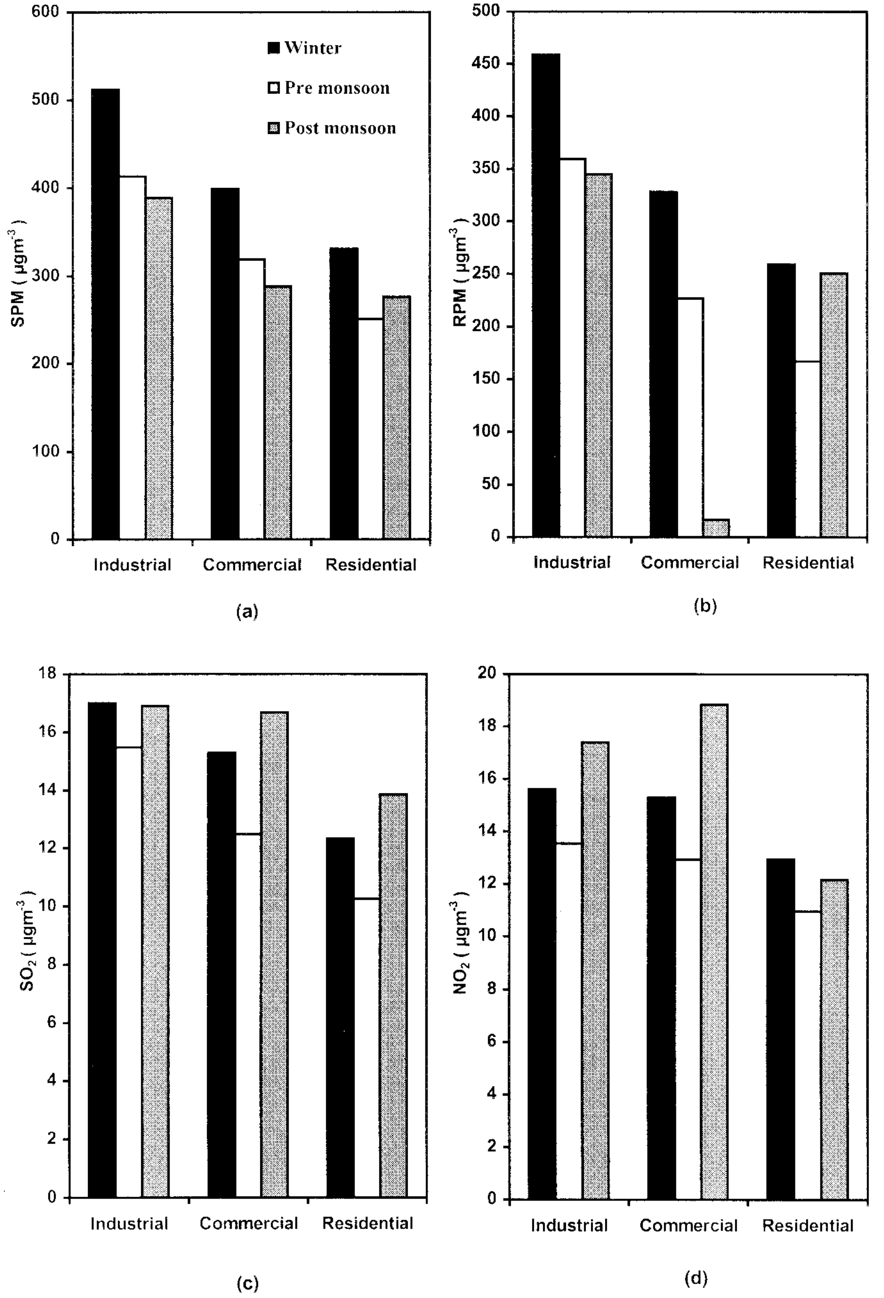

Figure 3. Seasonal variation profile of major pollutants

Rapid growth of industries without control options is attributed tremendous amount of SPM levels in ambient air of study area. Health consequences are considered worthy of urgent attention and air pollution levels need to be controlled. Urgent attentions are required for controlling industrial emission, prevention of vehicular emission by technological interventions to reduce their emissions. Air pollution management of urban air quality by not only monitoring and assessment of air quality but also provides management approaches by deriving policies and strategies through the management system such as emission inventories, effectiveness of control options, enforcement of control equipments and compliance of air quality standards. Control at sources is the only strategy for air pollution abatement. Replacement of old vehicles with new vehicles fitted with catalytic converter and use alternative cleaner fuels are to be considered for the reduction of vehicular pollution. It is also advocated to grow the trees along the roadside for mitigating the pollution from mobile sources. Emissions from area sources are to be reduced by use of cleaner fuel i.e. solar energy and LPG. The effectiveness of air quality management is based on the coordination, which facilitates strategy implementation, public awareness and participation programme.

Acknowledgment. The authors are grateful to Dr. R. N. Singh for his interest, encouragement and according permission to publish the paper.

REFERENCES

Brandon, Carter Kirsten Homman (1995) The cost of inaction: Valuing the economy-wide cost of environmental degradation in India. World bank, Washington DC

CPCB (1995) Ambient Air Quality Status: Central Pollution Control Board, New Delhi, India

Dockery DW, Schwartz J, Spengler JD (1993) Air pollution and daily mortality: associations with particulates and aerosols: Environ Res 59: 362-73

Gajghate DG, Hasan MZ (1995) Status of aerosol with specific reference to toxic trace metals constituents in urban air environment. J Chem Environ Sci 4: 67-74

Gajghate DG, Hasan MZ (1996) Approaches for management of air pollution and control strategy, Proceeding of third international conference on Environmental Planning and Management held at Nagpur, India 169-175

Gajghate DG, Hasan MZ (1999) Ambient lead levels in urban areas. Bull Environ Contam Toxicol 62: 403-408

Katz M (1977) Standard methods for air sampling and analysis, 2nd edition, APHA, Press Inc Spring Field, VA

NEERI Report (1990-1996): Ambient Air Quality Status for Ten Cities of India

Ostro, Bart (1994) Estimating the health effects of air pollutants: A method with an application to Jakarta: Policy research paper 1301: World Bank, Washington DC

Parikh et al (1994) Economic valuation of air quality degradation in Chembur, Bombay India: A Project Under The Metropolitan Environmental Improvement Programme Sponsored by World Bank IGIDR: 885-86

Pope C, Arden, III, Michael J Thun, Mohan M Namboodiri, Douglas W Dockery, John S Evans, Frank E, Speizer, Clark W Health (1995) Particulate air pollution as a predicator of mortality in a prospective strategy of U.S. Adults: American Journal of Respiratory and Critical Care Medicine ISI: 669-79

Schwartz Joel, Douglas W Dockery (1992a) Increased Mortality in Philadelphia Associated with Daily Air Pollution Concentration. American Rev Resp Dis 125: 600-604

WHO/UNEP Report (1992): Urban air pollution in mega-cities of the World. World Health Organization and United Nations Environment Programme, Blackwell Publishers, 108 Cowley Road Oxford OX4 1JF Cambridge UK

The World Bank (1997) Urban air quality management strategy in Asia (URBAIR) 1818 H Street NW, Washington DC: 20433 USA