10 Air pollution with special reference to vehicular pollution in urban cities

Introduction

Air pollution has been aggravated by developments that typically occur as countries become industrialised: growing cities, increasing traffic, rapid economic development and industrialisation, and higher levels of energy consumption. The high influx of population to urban areas, increase in consumption patterns and unplanned urban and industrial development have led to the problem of air pollution. Currently, in India, air pollution is widespread in urban areas where vehicles are the major contributors and in a few other areas with a high concentration of industries and thermal power plants. Vehicular emissions are of particular concern since these are ground level sources and thus have the maximum impact on the general population. Also, vehicles contribute significantly to the total air pollution load in many urban areas.

Pressure

Increase in urban population

Between 1951 and 1991, the urban population has tripled, from 62.4 million to 217.6 million, and its proportion has increased from 17.3% to 25.7%.

Nearly two-thirds of the urban population is concentrated in 317 class I cities (population of over 100 000), half of which lives in 23 metropolitan areas with populations exceeding 1 million. The number of urban agglomerations/cities with populations of over a million has increased from 5 in 1951 to 9 in 1971 and 23 in 1991 (Pachauri and Sridharan 1998).

This rapid increase in urban population has resulted in unplanned urban development, increase in consumption patterns and higher demands for transport, energy, other infrastructure, thereby leading to pollution problems.

Increase in number of vehicles

The number of motor vehicles has increased from 0.3 million in 1951 to 37.2 million in 1997 (MoST 2000). Out of these, 32% are concentrated in 23 metropolitan cities. Delhi itself accounts for about 8% of the total registered vehicles and has more registered vehicles than those in the other three metros (Mumbai, Calcutta, and Chennai) taken together. Figure 10.1 shows the steep growth in the number of vehicles in India (Photo 10.1).

At the all-India level, the percentage of two-wheeled vehicles in the total number of motor vehicles increased from 9% in 1951 to 69% in 1997, and the share of buses declined from 11% to 1.3% during the same period (MoST 2000). This clearly points to a tremendous increase in the share of personal transport vehicles. In 1997, personal transport vehicles (two-wheeled vehicles and cars only) constituted 78.5% of the total number of registered vehicles.

Road-based passenger transport has recorded very high growth in recent years especially since 1980-81. It is estimated that the roads accounted for 44.8 billion passenger kilometer (PKM) in 1951 which has since grown to 2,515 billion PKM in 1996. The freight traffic handled by road in 1996 was about 720 billion tonne kilometer (TKM) which has increased from 12.1 TKM in 1951 (MoST 1996). In contrast, the total road network has increased only 8 times from 0.4

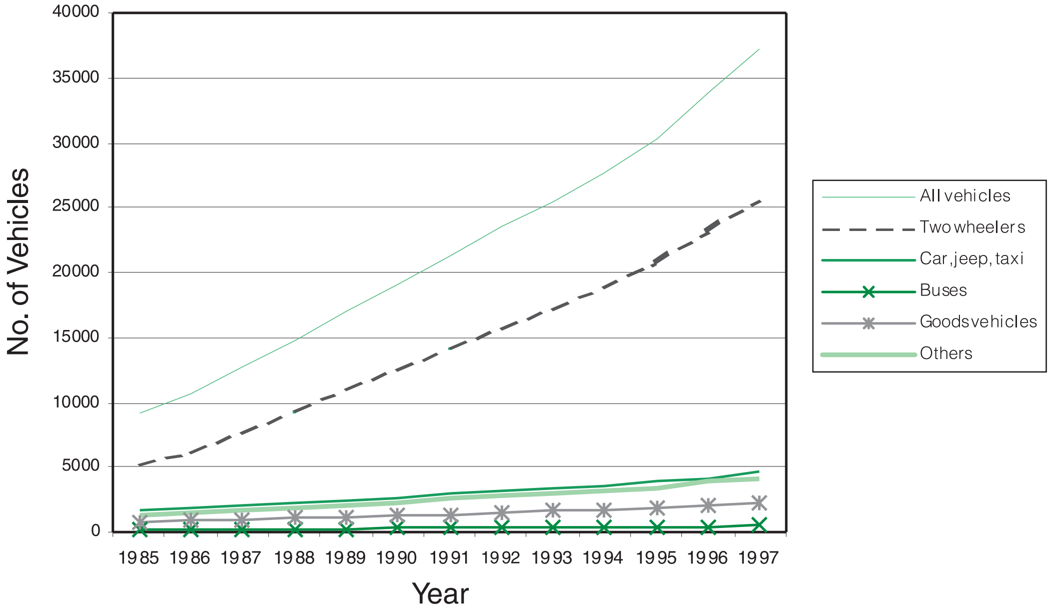


Figure 10.1 Vehicular growth in India

Photo 10.1 Vehicular growth in Delhi

million kms in 1950-51 to 3.3 million kms in 1995-96. The slow growth of road infrastructure and high growth of transport performance and number of vehicles all imply that Indian roads are reaching a saturation point in utilising the existing capacities. The consumption of gasoline and HSD has grown more than 3 times during the period 1980-1997. While the consumption of gasoline and HSD were 1,522 and 9,050 thousand tonnes in 1980-81, it increased to 4,955 and 30,357 thousand tonnes in 1996-97, respectively (CMIE 2000).

Increase in industrial activity

India has made rapid strides in industrialisation, and it is one of the ten most industrialised nations of the world. But this status, has brought with it unwanted and unanticipated consequences such as unplanned urbanisation, pollution and the risk of accidents.

The CPCB (Central Pollution Control Board) has identified seventeen categories of industries (large and medium scale) as significantly polluting and the list includes highly air polluting industries such as integrated iron and steel, thermal power plants, copper/zinc/aluminium smelters, cement, oil refineries, petrochemicals, pesticides and fertiliser units.

The state-wise distribution of these pre-1991 industries indicates that the states of Maharashtra, Uttar Pradesh, Gujarat, Andhra Pradesh and Tamil Nadu have a large number of industries in these sectors. The category-wise distribution of these units reveals that sugar sector has the maximum number of industries, followed by pharmaceuticals, distillery, cement and fertiliser. It also indicates that agro-based and chemical industries have major shares of 47% and 37% of the total number of industries respectively. The status of pollution control as on 30 June 2000 is as follows: out of 1,551 industries, 1,324 have so far been provided the necessary pollution control facilities, 165 industries have been closed down and the remaining 62 industries are defaulters (CPCB 2000a). It may be noted that in some of the key sectors such as iron and steel, 6 out of 8 units belong to the defaulters category in terms of having pollution control facilities to comply with the standards. On the other hand, cement, petrochemicals and oil refinery sectors do not have any defaulters.

Small scale industries are a special feature of the Indian economy and play an important role in pollution. India has over 3 million small scale units accounting for over 40 percent of the total industrial output in the country (CII and SII 1996). In general, Indian small scale industries lack pollution control mechanisms. While the larger industries are better organised to adopt pollution control measures, the small scale sector is poorly equipped (both financially and technically) to handle this problem. They have a very high aggregate pollution potential. Also, in many urban centres, industrial units are located in densely populated areas, thereby affecting a large number of people.

Increase in power generation

Since 1950-51, the electricity generation capacity in India has multiplied 55 times from a meager 1.7 thousand MW to 93.3 thousand MW (MoF 2000). The generating capacity in India comprises a mix of hydro, thermal, and nuclear plants. Since the early seventies, the hydro-thermal capacity mix has changed significantly with the share of hydro in total capacity declining from 43% in 1970-71 to 24% in 1998-99. Thermal power constitutes about 74% of the total installed power generation capacity. However, increasing reliance on this source of energy leads to many environmental problems.

India's coal has a very high in ash content (24%–45%). The increased dependence of the power sector on an inferior quality coal has been associated with emissions from power plants in the form of particulate matter, toxic elements, fly ash, oxides of nitrogen, sulphur and carbon besides ash, which required vast stretches of land for disposal. During 1998-99, the power stations consumed 208 million tonnes of coal, which in turn produced 80 million tonnes of ash posing a major problem disposal (CPCB 2000b).

Thermal power plants belong to the 17 categories of highly polluting industries. As on 30 June 2000, out of the 97 pre-1991 TPP's, 20 plants had not yet provided the requisite pollution control facilities (CPCB 2000a) (Photo 10.2).

Domestic pollution

Pollution from different types of cooking stoves using coal, fuelwood, and other biomass fuels contributes to some extent, to the overall pollution load in urban areas. For example, in Delhi, the share of the domestic sector is about 7%–8% of the total pollution load (MoEF 1997). The main concern is the use of inefficient and highly polluting fuels in

Photo 10.2 Air pollution from TPP

the poorer households leading to a deterioration in indoor air-quality and health. However, a positive development in the domestic energy consumption is that liquefied petroleum gas is fast becoming the most popular cooking fuel, especially in urban areas, as it is cleaner and more efficient than traditional cooking fuels (Photo 10.3).

Photo 10.3 Indoor air pollution

Other sources

The problem of air pollution in urban areas is also aggravated due to inadequate power supply for industrial, commercial and residential activities due to, which consumers have to use diesel-based captive power generation units emitting high levels NO_X and SO_X. In addition, non-point sources such as waste burning, construction activities, and roadside air borne dust due to vehicular movement also contribute to the total emission load.

State

Air pollutant emission load

The direct impact of a growth in various causal factors/pressures is the increase in the emission loads of various pollutants, which has led to deterioration in the air quality. In India, there is no systemic time series data available related to air pollutant emission loads and trends. The availability of emission factors for Indian conditions is another issue that has not been given due attention so far.

TERI (1998) provides some broad estimates of the increase in pollution load from various sectors in India. The total estimated pollution load from the transport sector increased from 0.15 million tonnes in 1947 to 10.3 million tonnes in 1997. In 1997, CO claimed the largest share (43%) of the total, followed by NO_X (30%), HC (20%), SPM (5%), and SO_2 (2%). Likewise, in the thermal power sector, the total estimated pollution load of SPM, SO_2 and NO_X increased from 0.3 million tonnes in 1947 to 15 million tonnes in 1997. In 1997, SPM claimed the largest share (86%) of the total. In the industrial sector, the total estimated emissions of SPM from the 7 critical industries (iron and steel, cement, sugar, fertilisers, paper and paper board, copper and aluminium) increased from 0.2 million tonnes in 1947 to 3 million tonnes in 1997.

The World Bank (1996) study shows that pollution is concentrated among a few industrial sub-sectors and that a sector's contribution to pollution is often disproportionate to its contribution to industrial output. For example, petroleum refineries, textiles, pulp and paper, and industrial chemicals produce 27% of the industrial output but contribute 87% of sulphur emissions and 70% of nitrogen emissions from the industrial sector. Likewise, iron and steel, and non-metallic mineral products, produce about 16% of the industrial output but account for 55% of the particulate emissions.

Vehicular emissions

The drastic increase in number of vehicles has also resulted in a significant increase in the emission load of various pollutants.

The quantum of vehicular pollutants emitted is highest in Delhi followed by Mumbai, Bangalore, Calcutta and Ahmedabad. The daily pollution load generated due to automobiles in 12 metropolitan cities is shown in Table 10.1. Carbon monoxide (CO) and hydrocarbons (HC) account for 64% and 23%, respectively, of the total emission load due to vehicles in all these cities considered together (CPCB 1995).

Apart from the concentration of vehicles in urban areas, other reasons for increasing vehicular pollution are the types of engines used, age of vehicles, congested traffic, poor road conditions, and outdated automotive technologies and traffic management systems.

Vehicles are a major source of pollutants in metropolitan cities. In Delhi, the daily pollution load has increased from 1,450 tonnes in 1991 to 3,000 metric tonnes in 1997 (MoEF 1997). The share of the transport sector has increased from 64% to 67% during the same period while that of the industrial sector (including power plants) has decreased from 29% to 25% (MoEF 1997) (Photo 10.4).

Ambient air quality

Under the National Ambient Air Quality Monitoring (NAAQM) network, three criteria air pollutants, namely, SPM, SO_2, and NO_2 have been identified for regular monitoring at all the 290 stations spread across the country.

CPCB (2000c) analyses the status and trends of air quality at various cities in India for the period 1990-98. Figures 10.2 to 10.4 show the minimum, maximum and annual averages of SPM, SO_2, and NO_2 in 16 cities in the country between 1990 and 1998. The most prevalent form of air pollution appears to be SPM although there are many stations at which SO_2 and NO_2 levels exceed permissible limits. The high influx of population to urban areas increase in consumption patterns, unplanned urban and industrial development and poor enforcement mechanism has led to the problem of air pollution.

The government has taken a number of measures such as legislation, emission standards for industries, guidelines for siting of industries, environmental audit, EIA, vehicular

Table 10.1 Estimated vehicular emission load in metropolitan cities, 1994

	Vehicular pollution load (tonnes per day)					
Name of the city	*Particulates*	*SO_2*	*NO_X*	*HC*	*CO*	*Total*
Delhi	10.30	8.96	126.46	249.57	651.01	1046.30
Mumbai	5.59	4.03	70.82	108.21	469.92	659.57
Bangalore	2.62	1.76	26.22	78.51	195.36	304.47
Calcutta	3.25	3.65	54.69	43.88	188.24	293.71
Ahmedabad	2.95	2.89	40.00	67.75	179.14	292.73
Pune	2.39	1.28	16.20	73.20	162.24	255.31
Madras	2.34	2.02	28.21	50.46	143.22	226.25
Hyderabad	1.94	1.56	16.84	56.33	126.17	202.84
Jaipur	1.98	1.25	15.29	20.99	51.28	88.99
Kanpur	1.06	1.08	13.37	22.24	48.42	86.17
Lucknow	1.14	0.95	9.68	22.50	49.22	83.49
Nagpur	0.55	0.41	5.10	16.32	34.99	57.37
Grand total	35.31	29.84	422.88	809.96	2299.21	3597.20

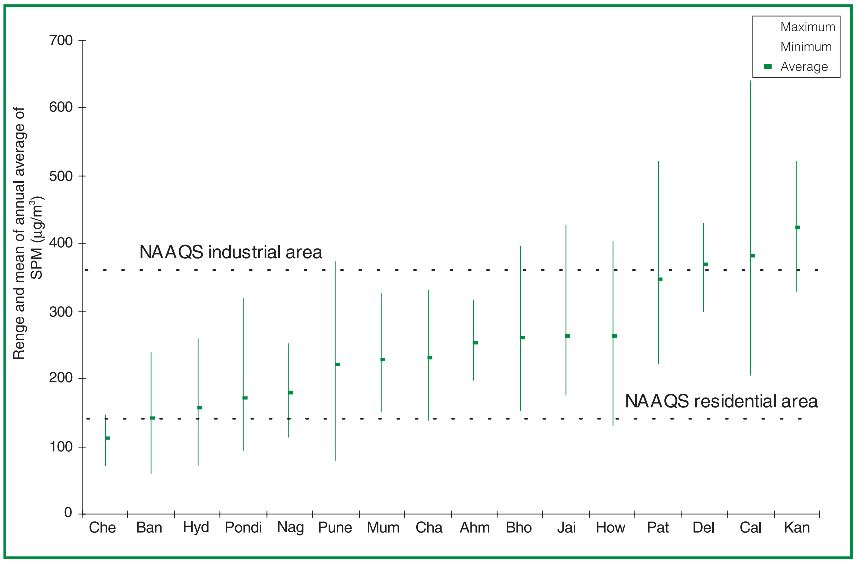
Source CPCB 1995

Photo 10.4 Vehicular pollution in urban cities

pollution control measures, pollution prevention technologies, action plan for problem areas, development of environmental standards, and promotion of environmental awareness. However, despite all these measures, air pollution still remains one of the major environmental problems. At the same time, there have been success stories as well such as the reduction of ambient lead levels (due to introduction of unleaded petrol) and comparatively lower SO_2 levels (due to progressive reduction of sulphur content in fuel).

SPM

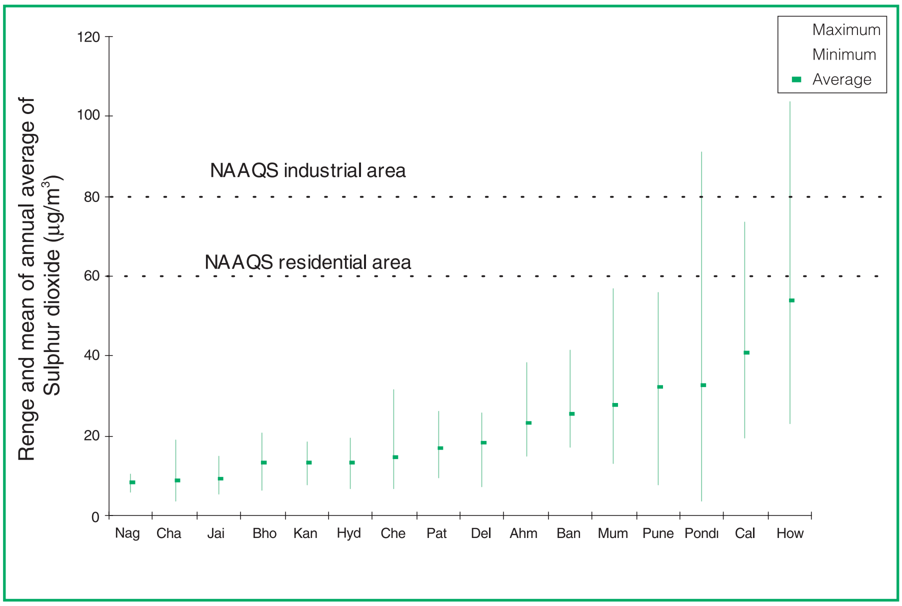
Suspended particulate matter is one of the most critical air pollutants in most of the urban areas in the country and permissible standards are frequently violated several moni-



Che – Chennai; Ban – Bangalore; Hyd – Hyderabad; Pondi – Pondicherry; Nag – Nagpur; Pune – Pune; Mum – Mumbai; Cha – Chandigarh; Ahm – Ahmedabad; Bho – Bhopal; Jai – Jaipur; How – Howrah; Pat – Patna; Del – Delhi; Cal – Calcutta; Kan – Kanpur.

Figure 10.2 Range and mean of annual averages (1990-98) of SPM in various cities

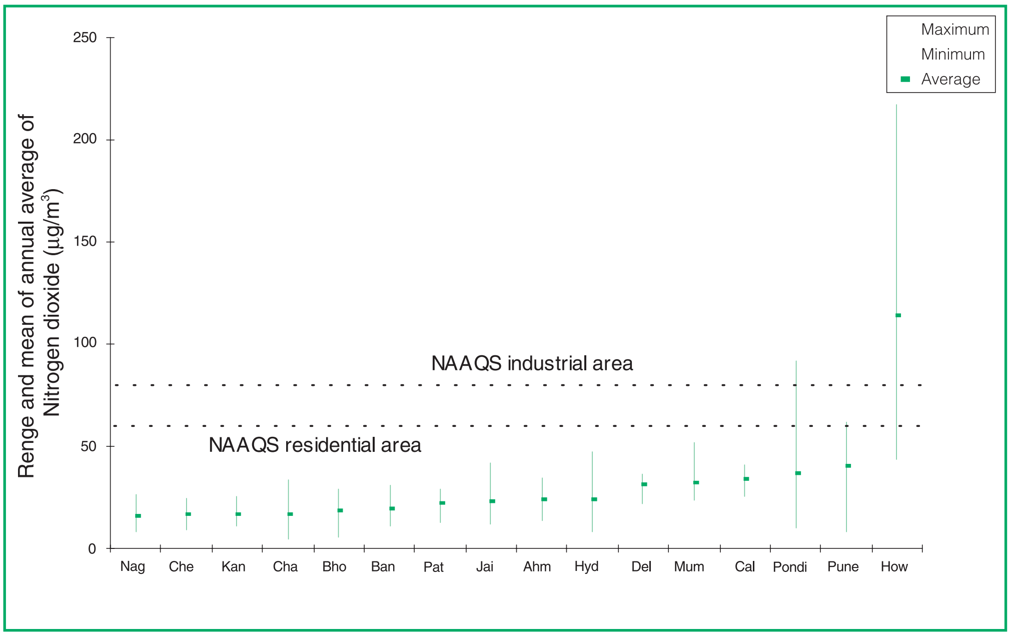
Source CPCB 2000c



Nag – Nagpur; Cha – Chandigarh; Jai – Jaipur; Bho – Bhopal; Kan – Kanpur; Hyd – Hyderabad; Che – Chennai; Pat – Patna; Del – Delhi; Ahm – Ahmedabad; Ban – Bangalore; Mum – Mumbai; Pune – Pune; Pondi – Pondicherry; Cal – Calcutta; How – Howrah.

Figure 10.3 Range and mean of annual averages (1990-98) of SO_2 in various cities

Source CPCB 2000c



Nag – Nagpur; Che – Chennai; Kan – Kanpur; Cha – Chandigarh; Bho – Bhopal; Ban – Bangalore; Pat – Patna; Jai – Jaipur; Ahm – Ahmedabad; Hyd – Hyderabad; Del – Delhi; Mum – Mumbai; Cal – Calcutta; Pondi – Pondicherry; Pune – Pune; How – Howrah.

Figure 10.4 Range and mean of annual averages (1990-98) of NO_2 in various cities

Source CPCB 2000c

tored locations. Its levels have been consistently high in various cities over the past several years.

The annual average minimum and maximum SPM concentration in residential areas of various cities ranged from 60 $\mu g/m^3$ (at Bangalore during 1991) to 521 $\mu g/m^3$ (at Patna during 1995), while in industrial areas the annual average ranged between 53 $\mu g/m^3$ (Chennai during 1992) and 640 $\mu g/m^3$ (Calcutta during 1993). The mean of average values of SPM for nine years (1990 to 1998) ranged between 99 $\mu g/m^3$ and 390 $\mu g/m^3$ in residential areas and between 123 $\mu g/m^3$ and 457 $\mu g/m^3$ in industrial areas indicating that the annual average limit of suspended particulate matter for residential areas (140 $\mu g/m^3$) and for industrial areas (360 $\mu g/m^3$) had been frequently violated in most cities.

The maximum suspended particulate matter (SPM) values were observed in Kanpur, Calcutta, and Delhi, while low values have been recorded in the south Indian cities of Chennai, Bangalore, and Hyderabad.

The SPM non-attainment areas are dispersed throughout the country. The states with maximum SPM problems are Gujarat, Maharashtra, and Madhya Pradesh, where SPM problems are high to critical in a large number of cities. The widespread criticality of the SPM problem in the country is due to the synergistic effects of both anthropogenic and natural sources. Some of these are extensive urbanisation and construction activities, vehicular pollution increase, extensive use of fossil fuel in industrial activities, inadequacy of pollution control measures, biomass burning, presence of large acid and semi-acid area in north-west part of India, increasing desertification, and decreasing vegetation cover.

SO_2

The annual average level fluctuation of SO_2 was highest in residential areas of Howrah (West Bengal) recording between 40.6 $\mu g/m^3$ and 103.8 $\mu g/m^3$ while it was quite low in residential areas of Nagpur, Chandigarh, and Jaipur (below 10 $\mu g/m^3$). Among the industrial areas, the recorded sulphur dioxide levels were high at Pondicherry, Calcutta, Mumbai, and Howrah, and low at Nagpur, Jaipur, and Chandigarh. Thus, based on the mean average sulphur dioxide value, Nagpur, Chandigarh and Jaipur are cities with the least problems related to sulphur dioxide in the ambient air, while the problem is significant in Howrah, Calcutta, and Pondicherry, where annual average limits (60 and 80 $\mu g/m^3$ for residential and industrial areas) have been violated many times during the past several years.

The sulphur dioxide levels have generally attained air quality standards in the country except some cities of dense urban and industrial activities like Dhanbad (Bihar), Ahmedabad, Ankleshwar, Vadodara and Surat (Gujarat); Nagda (Madhya Pradesh); Pondicherry; and Howrah (West Bengal). Some of the measures taken such as cleaner fuel quality (reduction of sulphur content in diesel) and switch over to cleaner fuel option have contributed t lower SO_2 ambient levels.

NO_2

The air quality monitoring data indicate that the annual average nitrogen dioxide has been well within the annual average limit (60 $\mu g/m^3$ for residential area and 80 $\mu g/m^3$ for industrial areas) at most urban cities except in some years in residential areas of Howrah, Vishakhapatnam, Kota, and industrial areas of Howrah. The annual average concentration has been low at Nagpur, Chennai, Kanpur, and Chandigarh while levels are moderate in other cities.

The nitrogen dioxide non-attainment areas were at Vishakhapatnam (AP), Jabalpur (MP), Pondicherry, Alwar, Kota, Udaipur (Rajasthan) and Howrah (West Bengal). The criticality of problem was observed at Vishakhapatnam, Kota, and Howrah.

Status of other air pollutants

The salient results of additional parameters at some stations in the metropolitan cities of Delhi, Calcutta, Mumbai, and Chennai for the years 1996-97 are as follows (CPCB 1998):

- The annual mean concentration of respirable particulate matter (RPM) is much higher than the prescribed limits of 120 μg/m^3 (industrial) and 60 μg/m^3 (residential and other uses) in Delhi and Calcutta. However, RPM in Mumbai and Chennai is not very high but is greater than prescribed ambient air quality standards.
- Though particulate lead in the ambient air of Calcutta and Delhi is higher as compared to the other two cities (Chennai and Mumbai), it is well within the prescribed limits for the different area classes.
- The concentration of polycyclic aromatic hydrocarbons (PAHs) is showing an upward trend. However, at present permissible limits for PAHs have not been notified.

It may be noted that lead free gasoline has been introduced throughout the country w.e.f. February 1, 2000, and in all metropolitan cities since 1995. This has resulted in a downward trend in the lead concentrations in the ambient air (CPCB 2000c).

Air quality at traffic intersections

Air quality monitoring conducted at different traffic intersections in Delhi (MoEF 2000a) revealed the following:

- Respirable particulate matter was excessively high at all the monitoring locations.
- Sulphur dioxide was recorded within limits at all the locations.
- Nitrogen dioxide was recorded well within the limits except a few locations.
- The carbon monoxide levels at most locations was much higher than the prescribed permissible limit. This is because of high traffic density and large number of motor vehicles operating on the roads.

Measures such as stringent emission norms for vehicles, cleaner fuel quality, inspection and maintenance programmes are expected to make some contribution towards improvement in the air quality. However, in the absence of mass transport system, the tremendous increase in personal vehicles is a cause for concern.

Air pollution and health impacts

In India, millions of people breathe air with high concentrations of dreaded pollutants. The air is highly polluted in terms of suspended particulate matter in most cities. This has led to a greater incidence of associated health effects on the population manifested in the form of sub-clinical effects, impaired pulmonary functions, use of medication, reduced physical performance, frequent medical consultations and hospital admissions with complicated morbidity and even death in the exposed population. As per a World Bank (1993) study, respiratory infections contribute to 10.9% of the total burden of diseases, which may be both due to presence of communicable diseases as well as high air pollution levels, while cerebro vascular disease (2.1%) ischemic heart disease (2.8%) and pulmonary obstructions (0.6%) are much lower. The prevalence of cancer is about 4.1% amongst all the diseases indicating that the effects of air pollution are visualised on the urban population (CPCB 2000c).

A WHO/UNEP study compared standardised prevalences of respiratory diseases in different areas of Mumbai, classified according to ambient average concentrations of sulphur dioxide. The study revealed a relatively higher prevalence of most respiratory diseases in polluted urban areas than in the rural control area (WHO/UNEP 1992, cited in Repetto 1994).

In India, in a study of 2031 children and adults in five mega cities, of the 1852 children tested, 51.4% had blood lead levels above 10 μg/dl. The percentage of children having 10 μg/dl or higher blood lead levels ranged from 39.9% in Bangalore to 61.8% in Mumbai.

Among the adults, 40.2% had blood lead levels of about 10 μg/dl (George Foundation 1999, cited in CPCB 2000c).

Brandon, Hommann, and Kishor (1995) estimated the total magnitude of economic costs associated with environmental degradation in India. Using the 1991-92 air pollution data for particulates, SO_2, NO_X, and lead from 36 cities, health impacts were estimated in terms of reductions in morbidity and mortality if pollutant levels in these cities were reduced to the WHO annual average standard. The total health costs due to air pollution were estimated to be $517-2102 million. Also, the physical impacts were in terms of 40,000 premature deaths avoided.

TERI (1998) estimated the incidence of mortality and morbidity in different groups in India due to exposure to PM_{10} and translated these impacts into economic values. The results indicated 2.5 million premature deaths and total morbidity and mortality costs of Rs 885 billion to Rs 4250 billion annually.

Noise pollution

Studies by the CPCB on the ambient noise levels show that they exceed the prescribed standards in most of the big cities. The major sources of noise are vehicles and industrial manufacturing processes (MoEF 1998).

Other impacts

Some of the other impacts due to air pollution include damage to materials, impact on vegetation (including yield loss), and physical and aesthetic effects (such as reduction in visibility).

Response

Existing policy response

Legislation

The government has formulated a number of legislations, policies, and programmes for protecting the environment. Some of these related to air pollution are the Air (Prevention and control of pollution) Act, 1981 and the Environment (Protection) Act, 1986. India has also adopted the Male declaration on Control and Prevention of air pollution and its likely transboundary effects for South Asia in April 1998.

Ambient air quality standards

Ambient air quality standards (both short-term, i.e., 24 hourly, and long-term, i.e., annual) have been laid down for industrial, residential/rural/other, and sensitive areas with respect to pollutants such as SO_2, NO_X, SPM, RPM, Pb, and CO. Ambient air quality standards for NH_3 have also been notified.

Guidelines for siting of industries

Guidelines for siting industries are prescribed so that the possible adverse effects on the environment and quality of life can be minimised. Some natural life-sustaining systems and specific land-uses are more sensitive, and that has been taken into account while specifying the minimum prescribed distance for siting a given industry.

Environmental impact assessment (EIA)

EIA is mandatory for 29 specific activities/ projects and also for some of the activities to be taken up in identified areas such as the coastal zone, Doon valley, etc. The procedure for examining the impact of different activities includes the preparation of EIA report, holding of a public hearing and examination by a duly constituted expert committee (MoEF 1999). Also, MoEF has taken up carrying capacity-based regional planning studies in certain selected areas of the country.

Emission standards for industries

The CPCB has laid down the maximum permissible limits for different pollutants for many categories of industries that contribute to air pollution. The standards have been notified by MoEF under the Environment (Protection) Act 1986.

Environmental audit

Submission of an environmental statement by polluting units to the concerned State Pollution Control Boards has been made mandatory under the Environment (Protection) Act, 1986.

Zoning atlas for siting of industries

In order to delineate the areas that are suitable for industrial siting, a district-wise zoning atlas project has been taken up by the CPCB that zones and classifies the environment in a district. The industrial zones are identified based on the sensitivity and pollution-receiving potential of the district (MoEF 2000a).

Development of pollution prevention technologies

Industries are encouraged to use cleaner and low waste or no waste technologies to reduce waste generation and the emission of pollutants. Various pollution prevention technologies are being developed and promoted (CPCB 2000c). A good scope exists for the demonstration and replication of cleaner technologies in clusters of small-scale industries such as foundry (Howrah), pottery (Khurja), and glass (Firozabad).

Beneficiated coal

The Ministry of Environment and Forests has made it mandatory for thermal power plants located beyond 1000 km from the coal pit-head, or in urban, ecologically sensitive or critically-polluted areas, to use beneficiated/ blended coal containing ash not more than 34%, with effect from June 2001. The power plants using FBC (Fluidized Bed Combustion) and IGCC (Integrated Gasification Combined Cycle) combustion technologies are, however, exempted to use beneficiated coal irrespective of their locations (CPCB 2000b).

Pollution control in problem areas

Twenty-four problem areas have been identified in the country for pollution control through concerted efforts involving all the concerned agencies / industries. Action plans have been prepared and are being implemented (MoEF 2000a).

Epidemiological studies

MoEF has initiated the environmental epidemiological studies in 7 critically polluted areas viz. Vapi (Gujarat), Angul-Talcher (Orissa), Chembur (Mumbai), Cochin (Kerala), Kanpur (UP), Mandi-Govindgarh (Punjab), Najafgarh drain basin Delhi and also in Pune. The details of epidemiological studies undertaken / under progress are given in Annexure I (Table 10.2). The initial feedback from the studies indicate that the incidence of symptomatic morbidity (eye irritation, respiratory problem, and skin lesion / irritation) is high in areas of industrial activity. However, no conclusive data on morbidity and mortality rates could be established having direct correlation with the environmental pollution (MoEF 2000b).

Control of vehicular pollution

The various measures taken by government to mitigate emissions from transport sector are as follows:

Stringent emission norms. The mass emission standards for new vehicles had been first notified in the year 1991 in India. Stringent emission norms along with fuel quality specifications were laid down in 1996 and 2000. Euro I norms are applicable from 1 April 2000 and Euro II norms will be applicable all over India from 1 April 2005. However, in the case of the NCR, the norms were brought forward to 1 June 1999 and 1 April 2000 for Euro I and Euro II, respectively (CPCB 1999, SIAM 1999).

Cleaner fuel quality. To conform to the stringent emission norms, it is imperative that both fuel specification and engine technologies go hand in hand. Fuel quality specifications have been laid down by the BIS (Bureau of Indian Standards) for gasoline and diesel for the period 2000-2005 and beyond 2005 for the country (BIS 1997a, BIS 1997b).

Given the increased usage of diesel in our country, it becomes necessary to reduce its sulphur content. In a recent directive by the Supreme Court, the Ministry of Petroleum and Natural Gas is to supply diesel with 0.05% m/m sulphur to the NCT by 31 December 2000 and entire NCR from 30 June 2001. For gasoline, lead has been phased out in the entire country w.e.f. 1 February 2000. Similarly the benzene content is to be reduced and by 1 October 2000, gasoline with 1% benzene is to be supplied to the whole of the NCT region. For NCR, it should be supplied by 31 March 2001 (CPCB 2000c; CSE 2000). Later, it has to be extended to other parts of the country as well.

Inspection and maintenance (I&M). The first and most important step towards emission control for the large in-use fleet of vehicles is the formulation of an inspection and maintenance system. It is possible to reduce 30-40% pollution loads generated by vehicles through proper periodical inspections and maintenance of vehicles (CPCB 2000c). I&M measures for in-use vehicles are an essential complement to emission standards for new vehicles. In India, the existing mechanism of I&M is inadequate. Thus, there is a great need to establish effective periodic I&M programmes.

Other stringent measures in certain areas. On 1st April 1999, the specifications for 2T oil became effective. In order to prevent the use of 2T oil in excess of the required quantity, premixed 2T oil dispensers have been installed in all gasoline stations of Delhi (CPCB 1999). Other measures include bans on commercial vehicles more than 15 years old, a ban on the registration of new auto-rickshaws with front engine, replacement of all pre-1990 autos and taxis with new vehicles using clean fuels; and the removal of 8 year old buses from the roads unless they use CNG or some other clean fuel. It is also planned that all buses in Delhi are to switch over to CNG instead of diesel by 31 March 2001 (CPCB 1999).

Role of the judiciary

In recent years, the judiciary has played a prominent role in environmental protection. A number of judgements relating to stringent vehicle emission norms, fuel quality, introduction of cleaner fuels, phasing-out of older vehicles, and shifting of hazardous industries have provided a great deal of momentum to the efforts for improvement of air quality.

Policy gaps

- Prevention based environmental policy needs to be strengthened. Issues such as cleaner technology and land use planning incorporating environmental considerations need to be given priority.
- Effectiveness and impact of various policy measures not assessed.
- No separate transport policy exists at the national and state levels.
- No well defined policy to promote private participation in public transport.
- Lack of coordination between various government agencies to improve transport services.

Knowledge/information/data gaps

- Strengthening of monitoring at hotspots/ traffic intersections; more stations to be established and frequency of monitoring increased.
- Additional air quality parameters need to be monitored such as ozone, benzene, PAH, $PM_{2.5}$, dry deposition of sulphates and nitrates.
- Private/Community participation in monitoring activity.
- Emission factor development for various activities.

- Emission load mapping at regular intervals for all the urban areas.
- Air pollution modelling as a tool for forecasting and urban planning.
- Strengthening of information on number of vehicles on road, vehicle usage, etc.

Policy recommendations

Despite the aforementioned legislative/policy measures as well as a host of other decisions taken by the government, air pollution remains a major concern. Besides continuing and consolidating the ongoing schemes/ programmes, new initiatives and definite programmes need to be formulated for the efficient management of urban air pollution.

Vehicular pollution control

Since vehicles contribute significantly to the total air pollution load in most urban areas, vehicular pollution control deserves top priority. A practical strategy should be devised that reduces both emissions and congestion, using a mixed set of instruments, which are dictated by command and control, and/or the market based principles. Some of the these are:

- Augmentation of public transport system.
- Mass Rapid Transport System may be considered for the fast expanding and major urban areas in the country.
- Incentives and regulations affecting vehicles with a view to reducing the rate of growth in ownership of personal vehicles.
- Traffic planning and management. Also, construction of express highways linking major urban areas should be undertaken.
- Taxes on fuels, vehicles—the revenue so generated could be used for pollution control measures.
- Further tightening of emission norms and fuel quality specifications.
- Greater promotion and use of alternative fuels such as CNG/LPG/Propane/ battery operated vehicles. Expansion of CNG dispensing facilities and increased fiscal incentives for CNG kits.
- Replacement of two-stroke engines.
- Curbing fuel adulteration—state-of-the-art testing facilities and deterrent legal action.
- Strengthening of inspection and maintenance (I&M) system: The I&M system, comprising inspection, maintenance, and certification of vehicles, is crucial for regulating pollution for the large fleet of in-use vehicles. It should include testing of various elements of safety, road worthiness and compliance to pollution norms.

Industrial pollution control

- Thrust for cleaner technologies
  - Waste minimisation technologies involving process change, raw material substitution, improved housekeeping, etc.
  - Waste utilisation technologies involving reclamation and utilisation of wastes as secondary raw material
  - Flue gas desulphurisation
  - Combustion modification for NO_x reduction
  - Incentives for the development and adoption of clean technology and emission reduction

- Database on clean technology
  - Database on available technologies, their performance, sources, investment required, etc, should be created, regularly updated, and widely disseminated

- Strengthening of emission standards
  - Emission standards for various categories of industries need to be strengthened. To shift from pollution control to pollution prevention, rules related to load based standards instead of concentration based standards need to be enforced.

- Appropriate siting of high pollution potential industries/projects
- Fiscal incentives for pollution prevention and control measures

Other pollution abatement measures

- Strengthening of monitoring network
  - The monitoring network requires a massive quality control programme and expansion of its operations to cover new stations as well as more pollutants (e.g., RPM_{10}, $RPM_{2.5}$, O_3, Pb, CO, and hydrocarbons such as benzene and PAHs) on a regular basis. Smaller cities should also be covered so that preventive measures could be taken before the pollution problem becomes acute.

- Information dissemination/mass awareness/training
  - State-of-the-art technology should be used for wider dissemination of environmental information. Transparency and access to the data to be improved. Measures such as pollution bulletins and air pollution forecasts should be started on a regular basis
  - Massive thrust should be provided to mass awareness campaigns involving community organisations such as residents associations, students, voluntary bodies and NGOs. Strategic action plans for implementation should be devised
  - Support measures such as training and education for the industry, governmental agencies, and the public, as well as greater coordination among institutions, are important

- Air quality management strategy
  - A comprehensive urban air quality management strategy should be formulated that includes information related to urban planning, ambient air quality, emission inventory, and air quality dispersion models.
  - Effectiveness of EIA as a tool and environmental audit needs to be critically assessed
  - Systematically planned emission load mapping studies should be undertaken at regular intervals. Development of emission factors for Indian conditions should be taken up

- Fiscal measures
  - Economic instruments need to be in place to encourage a shift from curative to preventive measures, internalisation of the cost of environmental degradation, and conservation of resources. The revenue generated may be used for enforcement, collection, treatment facilities, and research and development.
  - Incentives for environmentally benign substitute, technologies and energy conservation

- Promotion of renewable energy sources such as hydro, wind, and solar
- Use of cleaner fuels like LPG and kerosene for domestic consumption would reduce indoor air pollution
- Air quality standards should be based on local dose-response relationships for which appropriate environmental epidemiological studies should be undertaken
- Non-point sources of pollution also to be controlled such as pollution from generators, waste burning, etc
- Increase in green cover. Appropriate design of green belts/barriers and proper selection of plant species
- Noise pollution is also a major problem in metro cities and adequate preventive and control measures need to be taken.
- Enforcement mechanism
  - Significant improvements in the enforcement mechanism required to ensure that the policies are implemented both in letter and spirit
  - Wherever necessary, the policies/standards need to be reformulated keeping in mind the fast-changing scenario

- An effective environment management plan should be devised that includes environmental strategy, regulation, institutional capacity-building, and economic incentives and penalties.

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Annexure I

Table 10.2 Details of epidemiological studies undertaken/ under progress

Name of the area for environmental epidemiological study	*Name of the institute carrying out the study*	*Source of funding*
Chembur	KEM Hospital, Mumbai	MoEF
Vapi	NIOH, Ahmedabad	MoEF
Greater Cochin	Medical College, Thiruvananthapuram	MoEF
Angul-Talcher	NIOH (Reg. Off.) Calcutta	MoEF
Kanpur	ITRC, Lucknow	MoEF
Mandi-Govindgarh	PGI, Chandigarh	MoEF
Najafgarh Drain Basin	AIIMS, Delhi	MoEF
Delhi (respiratory morbidity due to air pollution)	VP Chest Institute, Delhi	WHO
Delhi (effect of lead on children)	AIIMS, Delhi	WHO
Epidemiological studies in industrial complex in Pune	Ramazini Research Institute of Occupational Health Services, Pune	MoEF
Epidemiological study on the prevalence of pulmonary and extra pulmonary silicosis in quarry workers around Delhi	AIIMS, Delhi 1997-98	WHO

Source MoEF 2000b