

Air Pollution Through Vehicular Emissions in Urban India and Preventive Measures

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Abstract. Most Indian cities are experiencing rapid urbanization and a majority of the country's population is expected to live in cities within a span of next two decades. The rapid development in urban India has also resulted in a tremendous increase in the number of motor vehicles and in some cities this has doubled in the last decade. This is the main source of air pollution and poor ambient air quality impacting millions of dwellers. This article presents a review of the vehicular emissions in urban Indian cities and the various measures adopted for their reduction. Government has revised the emission norms four times since 2000 and cleaner fuels have been introduced along with improved emission control devices. Future strategies like use of alternative fuels and spreading awareness amongst citizens will further help reduce vehicular emissions.

Keywords: Vehicular emission, emission control, pollution norms.

1. Introduction

Currently, in India, there is a high influx of population to urban areas, which has led to growing cities, sharp increase in traffic, trajectory growth, rapid economic development and industrialization, and higher levels of energy consumption. This unplanned urban and industrial development has led to the problem of air pollution. The major contributors to this widespread air pollution in urban areas is vehicular emission which is of great concern, as these are ground level sources and have maximum impact on the general population.

2. Cause of Vehicular Pollution

2.1. Urban Population

Between 1951 and 2011, the urban population has quadrupled, from 62.4 million to 377.1 million, and its proportion has increased from 17.3% to 31.16% (1). In 1991, there were 18 cities with a population of over 1 million, in 2012 this is estimated to extend to 46 cities (2). This rapid increase in unplanned urban population has resulted in an increase in consumption patterns and a higher demand for transport, energy and other infrastructure, thereby putting a load on the pollution problem.

2.2. Vehicular Population

Number of vehicles sold in India is increasing at a rapid pace. In 2005-06 there were 8.9M vehicles sold and in five years this number has scaled to 15M (in 2010-11) (3). While accelerated growth in number of vehicles aids growth and development, the problem stems from their concentration in a few selected cities. It is alarming to note that 32 percent of these vehicles are plying in metropolitan cities alone which constitute about 11 percent of the total population. Delhi, which contains 1.4 percent of the Indian population, accounts for nearly 7 percent of all motor vehicles in India. Two-wheelers and cars account for more than 80 percent of the vehicle population in most large cities (3). Analysis of data presented in Table 1 reveals that, during the year 2000, personalized vehicle population share was more than 90 percent of the total vehicle population

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in 6 out of 13 sample cities. The share of buses is negligible in most Indian cities as compared to personalized vehicles. For example, two-wheelers and cars together constitute more than 95 percent of vehicles in Kanpur and 90 percent in both Hyderabad and Nagpur, whereas in these cities buses constitute 0.1, 0.3, and 0.8 percent respectively (4).

Table 1: Private and Public Vehicles in Selected Metropolitan Cities in India (as of March 31, 2000)

| Metropolitan Cities | Two Wheelers | Cars (incl'd Jeeps) | Taxis (incl'd Auto Rickshaws) | Buses | Others | Total |
|---------------------|--------------|---------------------|-------------------------------|--------|----------|-----------|
| Ahmedabad | 6,16,738 | 1,04,179 | 43,865 | 14,993 | 19,316 | 7,99,091 |
| Bangalore | 11,64,204 | 2,38,374 | 77,375 | 6,380 | 63,362 | 15,49,695 |
| Chennai | 8,48,118 | 2,07,860 | 45,016 | 4,409 | 44,223 | 11,49,626 |
| Delhi | 21,84,581 | 8,69,820 | 1,04,747 | 37,733 | 2,26,593 | 34,23,474 |
| Hyderabad | 7,57,684 | 99,314 | 48,898 | 2,539 | 42,189 | 9,50,624 |
| Jaipur | 4,44,889 | 76,133 | 12,513 | 14,362 | 49,760 | 5,97,657 |
| Kanpur | 2,73,208 | 3,23,212 | 5,252 | 882 | 23,556 | 6,26,110 |
| Kolkata | 2,98,959 | 2,38,560 | 41,946 | 8,586 | 75,995 | 6,64,046 |
| Lucknow | 3,44,268 | 53,069 | 15,454 | 2,816 | 26,779 | 4,42,386 |
| Mumbai | 4,07,306 | 3,25,473 | 1,56,261 | 15,414 | 65,226 | 9,69,680 |
| Nagpur | 2,72,734 | 27,573 | 10,666 | 2,788 | 17,478 | 3,31,239 |
| Patna | 1,84,585 | 40,357 | 16,302 | 3,785 | 30,989 | 2,76,018 |
| Pune | 4,43,266 | 62,885 | 44,590 | 7,827 | 34,046 | 5,92,614 |

Source: Transport Research Wing, Ministry of Road Transport & Highways, Government of India, New Delhi. Motor Transport Statistics of India. Various issues.

Note: Others include goods vehicles, tractors, trailers, and other miscellaneous vehicles that are not separately classified; figures for Hyderabad and Kolkata are for 1999 and 1998, respectively.

It is interesting to note that among various modes of road based passenger transport, buses occupy less road space and causes less pollution per passenger-km than personalized modes of transport (Table 2) (5).

Table 2: Pollution Rate and Congestion Effect of Private and Public Transport Vehicles

| Type of Vehicle | Average Passenger per vehicle | Pollution load in gm/pass.-km | Congestion effect in PCU/Pass. |
|--|-------------------------------|-------------------------------|--------------------------------|
| Two-stroke two-wheeler petrol engine | 2 | 7.13 | 0.375 |
| Four-stroke two-wheeler petrol engine | 2 | 4.76 | 0.375 |
| Car with catalytic converter petrol engine | 4 | 0.93 | 0.25 |
| Bus with diesel engine | 40 | 1 | 0.075 |

Note: PCU = Passenger Car Unit where 1 car = 1 PCU, 1 bus = 2.5 PCU, 1 scooter = 0.75 PCU, etc.

This clearly points to a tremendous increase in the share of personal transport vehicles and shows a rapid increase in the load on air pollution.

2.3. Road Growth

The growth of vehicular traffic on roads has been far greater than the growth in road network; as a result the main arteries face capacity saturation. Between 1951 and 2004, motor vehicle population grew at a compound annual growth rate (CAGR) of close to 11% (10.9 %) compared to CAGR of 3.6% in the total road length, with National Highway segment increasing by a mere 2.3%. There has been a step-up in the growth of the National Highway network in recent years which has grown at CAGR of about 4.5 per cent with total vehicle population growing at 10% CAGR (1991-2006). The average modal shares of road in the country as per data collected by the MoRTH (Ministry of Road Transport & Highways) at sample stations on national highways in different states during 2006 was as follows: 33% for cars and three wheeled vehicles, 29% for motorized two-wheelers, 29% for trucks, 7% for buses, and 2% for tractors (6). The slow growth of road infrastructure and high growth of vehicles imply that Indian roads are reaching a saturation point in utilising the existing capacities, hence, leading to congestion and further contributing to air pollution load.

2.4. Fuel Load

Since the birth of automobiles in the 19th century, diesel and gasoline are used as primary sources of energy for vehicles. As per information available from CIA's World Fact, 2008 (7) with an oil consumption of 2,438,000 barrels per day, India stands 6th amongst top ten oil consuming countries of the world. Further, as per PCRA (Pollution Conservation Research Association), the transport sector alone consumes more than 50% of the total oil consumption in the country.

Delhi and Mumbai have more than 100,000 commercial vehicles running on CNG. Delhi has the largest number of CNG commercial vehicles in the World. All buses in Delhi along with a majority of on-road taxis and three wheelers switched over to CNG. CNG powered vehicles emit 85% less Nox, 70% less reactive HCs and 74% less CO than similar gasoline powered vehicles (8). CNG has also been introduced as an automotive fuel in cities like Mumbai, Ahmedabad, Surat and Vadodra (9,10).

3. Vehicular Emissions

A drastic increase in the number of vehicles has resulted in a significant increase in the emission load of various pollutants. Vehicles in major metropolitan cities are estimated to account for 70% of CO, 50% of HC, 30-40% of NOx, 30% of SPM and 10% of SO₂ of the total pollution load of these cities, of which two-thirds is contributed by two wheelers alone (11,12).

4. Measures to Control Vehicular Pollution

Motor vehicles have been closely identified with increasing air pollution levels in urban centres of the world (13, 14). Besides substantial CO₂ emissions, significant quantities of CO, HC, NOx, SPM and other air toxins are emitted from these motor vehicles in the atmosphere, causing serious environmental and health impacts (UNEP/WHO, 1992) (13). Apart from concentration of vehicles in urban areas, other reasons for increasing vehicular pollution are the types of engines used, age of vehicles, predominance of private vehicles especially cars and two wheelers (owing to unsatisfactory public transport systems), thereby causing higher idling emissions and congested traffic, poor road conditions. This leads to increased vehicle travel and fuel consumption, adulteration of fuel and fuel products, absence of mass rapid transport systems. An increase in the number of high-rise buildings in urban areas causes stagnation of the vehicular emissions to the ground level. There are various measures taken by government to mitigate emissions from transport sector.

4.1. Stringent Emission Norms

The Government of India has been instrumental in laying down norms to control vehicular emission. Indian emission standards for 4-wheel vehicles are given in table 3 (15).

Table 3: Indian Emission Standards (4-Wheel Vehicles)

| Standard | Reference | Date | Region |
|------------------|-----------|---------|--------------------------------|
| India 2000 | Euro 1 | 2000 | Nationwide |
| Bharat Stage II | Euro 2 | 2001 | NCR*, Mumbai, Kolkata, Chennai |
| | | 2003.04 | NCR*, 13 Cities† |
| | | 2005.04 | Nationwide |
| Bharat Stage III | Euro 3 | 2005.04 | NCR*, 13 Cities† |
| | | 2010.04 | Nationwide |
| Bharat Stage IV | Euro 4 | 2010.04 | NCR*, 13 Cities† |

* National Capital Region (Delhi)

† Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Sholapur, Jamshedpur and Agra

For 2-and 3-wheelers, Bharat Stage II (Euro 2) was applicable from April 1, 2005 and Stage III (Euro 3) standards would come into force on April 1, 2010.

Emission standards with reference to only gasoline vehicles (GVW ≤ 3,500 kg) are summarized in Table 4. Ranges of emission limits refer to different classes of light commercial vehicles.

Table 4: Emission Standards for Gasoline Vehicles (GVW ≤ 3,500 kg), g/km

| Year | Reference | CO | HC | HC+NOx | NOx |
|-------|-----------|-----------|---------|-----------|------|
| 1991 | - | 14.3-27.1 | 2.0-2.9 | - | |
| 1996 | - | 8.68-12.4 | - | 3.00-4.36 | |
| 1998* | - | 4.34-6.20 | - | 1.50-2.18 | |
| 2000 | Euro 1 | 2.72-6.90 | - | 0.97-1.70 | |
| 2005† | Euro 2 | 2.2-5.0 | - | 0.5-0.7 | |
| 2010† | Euro 3 | 2.3 | 0.20 | | 0.15 |
| | | 4.17 | 0.25 | | 0.18 |
| | | 5.22 | 0.29 | - | 0.21 |
| 2010‡ | Euro 4 | 1.0 | 0.1 | | 0.08 |
| | | 1.81 | 0.13 | | 0.10 |
| | | 2.27 | 0.16 | - | 0.11 |

* For Catalytic Converter fitted vehicles †, ‡ In selected cities

In respect of 2 and 3 wheeler norms, India is ahead of most advanced countries. Vehicular emission norms Bharat Stage II, III is given in the table 5 with reference to gasoline vehicles only (16).

Table 5: Emission standards for 3- and 2-wheeler gasoline vehicles, g/km

| Year | 3 Wheeler Gasoline Vehicles | | | 2 Wheeler Gasoline Vehicles | | |
|------------------|-----------------------------|--------|--------|-----------------------------|--------|--------|
| | CO | HC | HC+NOx | CO | HC | HC+NOx |
| 1991 | 12 – 30 | 8 – 12 | - | 12 – 30 | 8 – 12 | - |
| 1996 | 6.75 | - | 5.4 | 5.5 | - | 3.6 |
| 2000 | 4 | - | 2 | 2 | - | 2 |
| 2005 (BS II) | 2.25 | - | 2 | 1.5 | - | 1.5 |
| 2010.04 (BS III) | 1.25 | - | 1.25 | 1 | - | 1 |

4.2. Cleaner Fuel Quality

To adhere 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 (16, 17). Given the increased usage of diesel in our country, it becomes necessary to reduce its sulphur content, which for Bharat IV has been reduced to 50 ppm. For gasoline, lead was phased out in the entire country w.e.f. 1 February 2000.

4.3. Alternate Fuel

The use of alternative fuels has been promoted in India both for energy security and emission reduction. India is planning to introduce Biodiesel, Ethanol Gasoline blends in a phased manner and has drawn up a road map for the same. The Indian auto Industry is working with the authorities to facilitate for introduction of the alternate fuels. India has also setup a task force for preparing the Hydrogen road map. LPG has been introduced as an auto fuel and the oil industry has drawn up plans for setting up Auto LPG dispensing stations in major cities (17).

4.4. 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 (18). 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.

4.5. Other Measures

- Ban on commercial vehicles, which are more than 15 years old.
- Ban on the registration of new auto-rickshaws with front engines.
- Replacement of all pre-1990 autos and taxis with new vehicles, which use clean fuels.
- Removal of 8 year old buses from the roads unless they use CNG or some other clean fuel (19).

- Emission testing for all vehicles at regular intervals should be made mandatory (PUC certificate).
- Improve Traffic management / flow of traffic on the roads, reducing emissions per vehicle kilometer traveled and enhancing urban mobility.
- Availability of improved and efficient Public Transport facilities. Most cities have improved the availability of buses; few have started building Metro networks.

4.6. Citizen Charter

For making India a cleaner and greener place to live, it is the responsibility of every citizen of the country, irrespective of age or socio economic status, to render their efforts and make this mission possible.

- Adopt and popularize car-pooling.
- Use Public transport where available.
- Avoid congested roads and rush hours to the extent possible.
- Clean fuel filters, air filters and oil filters regularly.
- Clean carbon deposits from silencers.
- Maintain recommended tyre pressure.
- Awareness campaigns to help build public awareness and consciousness right from the school level.

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