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Review Article

A review of vehicular pollution in urban India and its effects on human health

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Abstract: The rapid development in urban India has resulted in a tremendous increase in the number of motor vehicles. In some cities, this has doubled in the last decade. Rapid urbanization and growth of motor vehicles impose a serious effect on human life and the environment in recent years. Motor vehicles are a significant source of urban air pollution and are increasingly important contributors of anthropogenic carbon dioxide and other greenhouse gases. Transport sector contributes a major sector, contributing 90% of total emissions. Air pollution is a serious environmental health threat to humans. Adverse effects range from nausea, difficulty in breathing and skin irritations, birth defects, immunosuppression and cancer. All these situations indicate that air pollution becoming a major problem in Indian context and there is an essential need to build up healthy environment and increase the level of research around the world. The present study is a review of an increase in vehicular pollution in India and its effect on human due to increasing road transport.

Keywords: Air pollution, Vehicular emission, Carcinogenicity, Mutagenicity, Cardiovascular mortality.

1. Introduction

The growing cities, increasing traffic, trajectory growth, rapid economic development and industrialization with higher levels of energy consumption have resulted in an increase in pollution load in an urban environment (CPCB, 2010). Air pollution is the major environmental risk to health and is estimated to cause approximately 2 million premature deaths worldwide per year (WHO, 2005). Besides health effect, air pollution also contributes to tremendous economic losses, especially in the sense of financial resources that are required for giving medical assistance to the affected people.

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% (Census of India, 2011). In 1991, there were 18 cities with a population of over 1 million in 2012; this is estimated to extend to 46 cities. 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 (Sood, 2012).

2.2 Vehicular Population in India

In India, the vehicle population is growing at the rate of over 5% per annum and today the vehicle population is approximately 40 million. The vehicle mix is also unique to India in that there is a very high proportion of two-wheelers are 76% (SIAM, 2011). The growth rate of vehicles is the backbone of economic development and the Indian automotive industry (the second fastest growing in the world). Today, in the country about 7-8 million vehicles are produced annually. In 2011, the country reported 141.8 million registered motor vehicles (Fig. 1).

The Road transport sector accounts for a share of 4.8% in India's GDP (MORTH, 2011). In India, the number of motor vehicles has grown from 72.7 million in 2004 to approximately 141.8 million in 2011, of which two-wheelers (mainly driven by two-stroke engines) accounts for approximately 72% of the total vehicular population (Table 1). There is a direct relationship between road transport system and air pollution in a city. Vehicular emissions depend on vehicle speed, age of vehicle and emission rate. In general, the average peak hour speed in Indian cities is

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far less than the optimal one. Growing traffic and limited road space have reduced peak-hour speeds to 5-10 Km/h in the central areas of many major cities. We must retain that the estimation of road transport pollutant emission should allow significant disaggregation of the result by fuel type and composition, by vehicle type, by emission standard. In general, one differentiates also emission produces in and out of the city, and also time scale can be necessary, depending on the objectives of the environmental assessment (Shrivastav *et al*., 2013).

Numbers of vehicles sold in India are increasing at a rapid rate. In 2005-06, there were 8.9 million vehicles sold and in five years this number has scaled to 15 million (in 2010-11). While accelerated growth in the 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% of these vehicles are plying in metropolitan cities alone, which constitute about 11% of the total population. Delhi, which contains 1.4% of the Indian population, accounts for nearly 7% of all motor vehicles in India. Two-wheelers and cars account for more than 80% of the vehicle population in most large cities. Analysis of data presented in Table 2 reveals that, during the year 2000, personalized vehicle population share was more than 90% of the total vehicle population in 6 out of 13 sample sites. 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% of vehicles in Kanpur and 90% in both Hyderabad and Nagpur, whereas in these city buses constitute 0.1, 0.3, and 0.8% respectively (Sood, 2012).

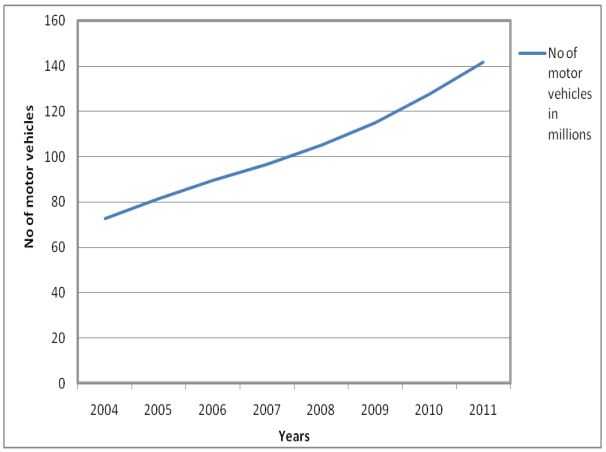

Fig. 1. Registered motor vehicles in India.

A motorization rate in India is 26 vehicles per 1000 population and this is lower than many developing countries through the world, but over the last three decade's number of motor vehicles has been doubling against a 2-5% annual growth rate in Canada, the US, the UK and Japan (MoRTH, 2012).

Table 1. Composition of vehicle population (% of total).

As of 31 March	2 Wheeler	4 Wheeler	Buses	Goods vehicles	Other vehicles	Total (in millions)
			As % of total vehicle population			
2004	71.4	13	1.1	5.2	9.4	72.7
2005	72.1	12.7	1.1	4.9	9.1	81.5
2006	72.2	12.9	1.1	4.9	8.8	89.6
2007	71.5	13.1	1.4	5.3	8.7	96.7
2008	71.5	13.2	1.4	5.3	8.6	105.3
2009	71.7	13.3	1.3	5.3	8.4	1115
2020	71.7	13.5	1.2	5.0	8.6	127.7
2011	71.8	13.6	1.1	5.0	8.5	141.8

(Source: Road Transport Year Book, 2012)

Table 2. Private and public vehicles in metropolitan cities in India (as of March 31, 2000).

Metropolitan Cities	Two Wheelers	Cars & Jeeps	Taxis & 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)

3. Vehicle Fuel pollutants

Automotive vehicles emit several pollutants depending upon the type of quality of fuel consumed by them. The release of pollutants from vehicles also includes fugitive emissions of the fuel, the source and level of these emissions depending upon the vehicle type, its maintenance, etc. The majority pollutants released as a vehicle/fuel emissions are carbon monoxide, nitrogen oxides, photochemical oxidants, air toxics namely benzene, aldehydes, 1,3-butadiene, lead, particulate matter, hydrocarbon, oxides of sulphur and polycyclic aromatic hydrocarbon (CPCB, 2010).

Automobiles are the primary source of air pollution in India's major cities. In India, transportation sector emits an estimated 261 tonnes of CO_2, of which 94.5% is contributed by road transport. The transport sector in India consumes about 17% of total energy and responsible for a 60% production of the greenhouse gases from various activities. The pollution from vehicles is due to discharge like CO, unburnt HC, Pb, NO_2 and SO_2 and SPM mainly from tailpipes (Dayal, 2011).

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 SO_2 of the total pollution load of these cities, of which two-thirds is contributed by two-wheelers alone. These high levels of pollutants are mainly responsible for respiratory and other air pollution-related ailments including lung cancer, asthma, etc., which is significantly higher than the national average (CSE, 2001; CPCB, 2002).

4. Country's status

Total Indian transport emission of CO_2, CO, NOx, CH_4, SO_2, PM, HC, N_2O and NMVOC are summarized in Table 3. During 2003–2004, total transport emission of CO_2 was 258.10 Tg. The CO_2 contribution of road sector, aviation, railways and shipping was 243.82 Tg (94.5%), 7.60 Tg (2.9%), 5.22 Tg (2%) and 1.45 Tg (0.6%) respectively. Road sector and aviation mainly contribute 3.03 Tg (53.3%) and 2.57 Tg (45.1%) of CO. Among all types (road, shipping, railways and aviation) of transport, road and aviation are the major contributors to air pollution (CPCB, 2010).

4.1 Emissions from different vehicle type of India

The emissions calculated for different type of road transport vehicles are summarized in Table 4. Among different types of vehicles, Trucks and Lorries contribute 28.8% CO_2 (70.29 Tg), 39% NOx (0.86 Tg), 27.3% SO_2 (0.19 Tg) and 25% PM (0.03 Tg), which constitute 25% of the total vehicular emission of India. Similarly, two-wheelers are a major source of CO (0.72 Tg; 23.7%), CH_4 (0.06 Tg; 46.4%), and HC (0.46 Tg; 64.2%) and buses are emitting NOx (0.68 Tg; 30.7%) and PM (0.03 Tg; 20.5%). Vehicular emissions vary with type, efficiency and the type of fuel used. Emission analysis based on the vehicle type reveals that bus and Omnibuses contribute higher CO_2 (CO_2: 96.5%, NOx: 2.28%) compared to two-wheelers (CO_2: 86.8%, CO: 7.18%, HC: 4.6%).

Passenger light motor vehicles (CO_2: 86.8%, CO: 7.6%, NOx: 1.9%), cars and jeeps (CO_2: 98.8%), taxi (CO_2: 94.6%, SO_2: 4.68%), Trucks and Lorries (CO_2: 97.6%, NOx: 1.2%), goods light motor vehicles (CO_2: 98.4%), and trailers and tractors (CO_2: 98.4%) is different (CPCB, 2010).

4.2 Pollution Load from road traffic in various megacities

The vehicle pollution load as estimated through a joint study conducted by Central Road Research Institute (CRRI), National Environmental Engineering Research Institute (NEERI) and Indian Institute of Petroleum (IIP) in the year 2002 for four key pollutants (i.e. CO, NOx, HC and PM) in eight megacities, namely Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Kanpur and Agra are given in Table 5. This is attributable to the highest number of automobiles operating in Delhi. From the Table, it can be seen that Delhi has the maximum vehicle pollution load compared to any other city in the country.

Table 3. Total emissions from Indian transport for 2003/04 (Gg).

	Transport Mode	CO_2	CO	NOx	CH_4	SO_2	PM	HC	N_2O	NMVOC
Shipping	High Speed, Diesel	782.28	10.66	8.527	0.533	-	-	-	0.0064	2.13
	Light Diesel Oil	162.18	2.21	1.767	0.011	-	-	-	0.0013	0.442
	Fuel oil	510.19	6.55	5.24	0.033	-	-	-	0.0039	1.31
Railways	Coal	5.280	0.015	0.012		0.0421	-	-		
	High Speed, Diesel	5186.58	70.67	56.64	0.353	-	-	-	0.0424	14.13
	Light Diesel Oil	6.360	0.086	0.069	0.004	-	-	-	0.0001	0.0173
	Fuel oil	25.04	0.321	0.257	0.0016	-	-	-	0.002	0.0643
Aviation	High Speed, Diesel	85.860	1.17	0.9359	0.0058	-	-	-	0.0007	0.2340
	Light Diesel Oil	6.360	0.086	0.693	0.004	-	-	-	0.0001	0.0173
	Fuel oil	222.23	2.835	2.2828	0.0143	-	-	-	0.0017	0.5707
	Aviation turbine fuel	7294.14	2565.35	8.733	6.549	-	-	-	-	-
	Road Transport	243816.6	3032.10	2213.85	126.78	709.09	153.127	723.4	-	-
	Total	258103.1	5692.16	2298.29	133.80	709.13	153.12	723.4	0.0568	18.9219

(Source: Central Pollution Control Board Status of the vehicular pollution control program in India (2010), program objective series PROBES/136/2010)

Table 4. Emissions from different vehicle type of India (Gg).

Categories	CO_2	CO	NO_X	CH_4	SO_2	PM	HC
Bus	28748.16	207.26	679.73	5.02	79.24	31.36	51.72
Omnibuses	8508.42	60.94	200.53	1.49	23.45	9.28	15.11
Two wheelers	8701.08	719.64	62.15	58.88	4.25	16.36	464.49
Light Motor Vehicles (Passengers)	4378.10	370.29	92.93	13.07	2.11	14.52	10.16
Cars and Jeeps	23901.22	212.30	22.14	18.17	5.67	3.22	28.01
Taxi	2367.08	10.23	5.68	0.11	117.03	0.80	1.48
Trucks and lorries	70288.92	491.15	859.51	12.28	193.73	38.2	118.69
Light Motor Vehicles (goods)	44654.58	442.04	110.94	7.80	123.04	17.33	12.13
Trailers and tractors	46563.85	460.94	115.69	8.13	128.3	18.08	12.65
Others	5705.22	57.41	64.54	1.83	32.19	3.98	8.96

(Source: Central Pollution Control Board Status of the vehicular pollution control program in India (2010), program objective series PROBES/136/2010).

Table 5. Estimated Pollution Load in the cities (2002).

City	Pollutant load in Metric tonnes per day			
	CO	NOx	HC	PM
Delhi	421.84	110.45	184.37	12.77
Mumbai	189.55	46.37	89.93	10.58
Kolkata	137.50	54.09	47.63	10.80
Chennai	177.00	27.30	95.64	7.29
Bangalore	207.04	29.72	117.37	8.11
Hyderabad	163.95	36.89	90.09	8.00
Kanpur	28.73	7.25	11.70	1.91
Agra	17.93	3.30	10.28	0.91

(Source: Central Pollution Control Board Status of the vehicular pollution control program in India (2010), program objective series PROBES/136/2010).

4.3 Vehicular pollution problems in India

Motor vehicles have been closely identified with increasing air pollution levels in urban centers of the world (Mage *et al*., 1996; Mayer, 1999). Besides substantial CO_2 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. Like many other parts of the world, air pollution from motor vehicles is one of the most serious and rapidly growing problems in urban centers of India (UNEP/WHO, 1992; CSE, 1996; CRRI, 1998). The problem of air pollution has assumed serious proportions in some of the major metropolitan cities of India and vehicular emissions, (CPCB, 1999). Although recently, improvement in air quality with reference to the criteria pollutants (viz. NOx, SO_2, CO and HC) have been reported in some of the cities, the air pollution situation in most of the cities is still far from satisfactory (CPCB, 2000). The problem has further been compounded by the concentration of a large number of vehicles and comparatively high motor vehicles to population ratios in these cities (CRRI, 1998).

5. Health effects of vehicular pollutants

The vehicle emissions have damaging effects on both human health and ecology. There is a wide range of adverse health effects of the pollutants released from vehicles. The effects may be direct as well as indirect covering right from reduced visibility to cancers and death in some cases of acute exposure of pollutants especially carbon monoxide. These pollutants are believed to directly affect the respiratory and cardiovascular systems. In particular, high levels of Sulphur dioxide and Suspended Particulate Matter are associated with increased mortality, morbidity and impaired pulmonary function.

Table 6: Health effects associated with pollutants.

Pollutant	Effects
Carbon monoxide	Affects the cardiovascular system, exacerbating cardiovascular disease symptoms, particularly angina; may also particularly affect fetuses, sick, anemic and young children, affects the nervous system, impairing physical coordination, vision and judgments, creating nausea and headaches, reducing productivity and increasing personal discomfort.
Nitrogen Oxides	Increased susceptibility to infections, pulmonary diseases, impairment of lung function and eye, nose and throat irritations.
Sulphur Dioxide	Affect lung function adversely.
Particulate Matter and Respirable Particulate Matter (SPM & RPM)	Fine particulate matter may be toxic in itself or may carry toxic (including carcinogenic) trace substance, and can alter the immune system. Fine particulates penetrate deep into the respiratory system irritating lung tissue and causing long-term disorders.
Lead	Impairs liver and kidney, causes brain damage in children resulting in lower I.Q., hyperactivity and reduced ability to concentrate.
Benzene	Both toxic and carcinogenic. Excessive incidence of leukemia (blood cancer) in high exposure areas.
Hydrocarbons	Potential to cause cancer

(Source: Central Pollution Control Board Status of the vehicular pollution control program in India (2010), program objective series PROBES/136/2010).

5.1 Pollutants specific health effects (CPCB, 2010)

Pollutant specific health effects of vehicular emissions are as below:

a. **Carbon monoxide**: Carbon monoxide (CO) is an odorless, invisible gas created when fuels containing carbon are burned incompletely—poses a serious threat to human health. CO is known to cause death at high levels of exposure. The affinity of blood hemoglobin is 200 times greater for carbon monoxide than for oxygen, CO hinders oxygen transport from the blood into the tissues. The effects of this gas on human have been shown even at low levels of exposure. The low level of exposure accelerates and angina (chest pain) in people having coronary artery diseases. Healthy individuals are also affected, but only at higher levels. Exposure to elevated CO levels is associated with the impairment of visual perception, work capacity, manual dexterity, learning ability and the performance of complex tasks.

b. **Nitrogen Oxides**: Nitrogen dioxide (NO_2) has been linked to increased susceptibility to respiratory infection, increased airway resistance in asthmatics, and decreased pulmonary function. It has been shown that even short-term NO_2 exposures have resulted in a wide range of respiratory problems in school children; cough, runny nose and sore throat are among the most common. The oxides of nitrogen also contribute to acid deposition on plants and surface water resulting in damages of trees and aquatic life. NOx emissions also increase the levels of particulate matter by changing into nitric acid in the atmosphere and forming particulate nitrate.

c. **Photochemical Oxides (Ozone)**: There is no release of ozone as such from the vehicles, but it is formed as a result of chemical reactions of volatile compound and NOx in the presence of heat and sunlight. In other words, the pollutant release from vehicles also results in the formation of ozone through chemical reactions. The ground level ozone, which is the main part of the smoke, can cause respiratory problems such as chest pain, cuffing etc. The ozone gas is known to cause inflammation respiratory tracks, reduction in the ability to breath (lung function), increase in asthma and other lung diseases. In addition to, effects on human health, ozone is also known to adversely affect the environment in many ways, including reducing yield for crops, fruits, commercial forests, eco-system etc. It also damages urban grass, flowers, shrubs and trees etc.

d. **Oxides of Sulphur**: High concentrations of sulfur dioxide (SO_2) can result in temporary breathing impairment in asthmatic children and adults who are active outdoors. Short-term exposures of asthmatic individuals to elevated SO_2 levels while on moderate exertion may result in reduced lung function that may be accompanied by such symptoms as wheezing, chest tightness, or shortness of breath. Other effects that have been associated with longer-term exposures to high concentrations of SO_2, in conjunction with high levels of PM, include respiratory illness, alterations in the lungs' defenses, and aggravation of existing cardiovascular disease

e. **Gaseous Air Toxic**: The hydrocarbon emissions release from vehicles also contained toxic air pollutants that may have a significant effect on public health.

f. **Benzene**: Benzene is a known human carcinogen by all routes of exposure. Low term respiratory exposure to high level of ambient benzene has been shown to cause cancer all the tissues that formed white blood cells. Exposure to benzene or its metabolites have also been linked with genetic changes in human and animals. The occurrence of certain chromosomal changes in individuals with known exposure to benzene may serve as a marker for those at risk of contracting leukemia.

g. **Formaldehyde**: Formaldehyde has been classified as a probable human. Epidemiological studies suggest that long-term inhalation of formaldehyde may be associated with tumors of the nasopharyngeal cavity (generally the area at the back of the mouth near the nose), nasal cavity and sinuses. Formaldehyde is also known to produce mutagenic activity.

h. **1,3-Butadiene**: 1,3-Butadiene has also been classified as a Group B2 (probable human) carcinogen based on evidence from two species of rodents and epidemiologic data (CPCB, 2010).

i. **Lead**: Lead affects many organs and organ systems in the human body, with subcellular changes and Neurodevelopmental effects appearing to be the most sensitive. Lead also causes impaired sensory motor function and renal functions. A small increase in blood pressure has also been associated with lead exposure. Airborne lead can be deposited on soil and water, thus reaching humans through the food chain and drinking water (CPCB, 2010). Atmospheric lead is also a major source of lead in household dust. Ingested, inhaled or absorbed through skin. 86% of atmospheric lead – auto exhaust, leaded petrol, water pipes, paint, battery storage, crystal glass, ceramic glaze, enamel jewelry, etc. Lead concentration in dust is directly proportional to the volume of traffic. Children absorb 50% and adults 10-20% of ingested lead. Lead in tissue, cord blood correlates with air levels. The effect of lead is on GIT, peripheral nerve,

central nervous system, decreased IQ, convulsions, coma, death (H. Paramesh, 2003).

j. **Particulate Matter**: represents a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. Particles may be emitted directly to the atmosphere or may be formed by transformations of gaseous emissions such as sulfur dioxide or nitrogen oxides. The key health effects associated with PM include premature death, aggravation of respiratory and cardiovascular disease, as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days; changes in lung function and increased respiratory symptoms; changes in lung tissues and structure; and altered respiratory defense mechanisms. Exposure to coarse fraction particles is primarily associated with the aggravation of respiratory conditions such as asthma. Fine particles are most closely associated with health effects such as premature death by cardiopulmonary diseases.

k. **Suspended particulate matter (SPM)**: In particular, high levels of sulphur dioxide and suspended particulate matter (SPM) are associated with increased mortality, morbidity and impaired pulmonary function. Environmentalists claim that living in an Indian metropolitan city is like smoking 10-20 cigarettes every day. More than 40,000 people die prematurely every year because of air pollution, says a World Bank report, of which Delhi's share is the highest i.e. 19% (Tahir *et al*., 2012). Table 7 presents total deaths by cause. Out of all causes of death, 16% and 27% deaths are due to respiratory infections and respiratory diseases and cardiovascular problems in India respectively. Table 8 shows age specific death by cause. It reports which age groups affect more due to pollution led diseases and how acute the diseases related to pollution are. The table shows that population belonging to the age group of 60+ are suffering more from Asthma and Bronchitis (82.9%), heart attack (60.7%) and Tuberculosis of lungs (32.4%) while children under 1 year are from pneumonia (54%). If we compare the past data of 1984, 1988 and 1998 it is seen that the respiratory problem and related diseases like asthma and bronchitis among the different age groups are increasing; especially the senior citizens are most affected (Mukhopadhyay, 2009).

Table 7. Estimated total deaths ('000), by all causes in India, 2002.

Cause	Deaths ('000)
All causes	10,378.50
1. Respiratory infections	1,123.10
Lower respiratory infections	1,107.90
Upper respiratory infections	14.7
Otitis media	0.5
2. Prenatal Conditions	762.1
Low birth weight	542.5
Birth asphyxia and birth trauma	129.3
3. Cardiovascular diseases	2810.00
Rheumatic heart disease	103.9
Hypertensive disease	49.7
Ischemic disease	1531.50
Cerebrovascular disease	771.1
Inflammatory heart diseases	57.8
4. Respiratory diseases	609.5
Chronic obstructive pulmonary disease	485.8
Asthma	57.1

(Source: Kakali Mukhopadhyay (2009). Air Pollution in India and its impact on the health of different Income Groups, Nova Science Publishers, Inc. New York).

6. Conclusion

Various studies revealed that motor vehicle emissions are the combination of various pollutants which have the potential to result in adverse health effects, including carcinogenicity, mutagenicity, cardiovascular mortality and the aggravation of the health of the vulnerable group such as people with compromised health conditions like the asthmatics, children and elders. The acute exposures have resulted in hospitalization due to respiratory conditions while health effects such as carcinogenicity, mutagenicity, cardiovascular health conditions lead to chronic exposures.

Therefore, it is recommended that effective vehicle emission control strategies should be developed and implemented. Vehicle maintenance and inspection program should be developed to ensure the effectiveness of the vehicle emissions-control systems. Proper maintenance, inspection, clean car, use of clean fuel is the ways to reduce emissions.

Table 8. Percentage distribution of deaths in age groups due to air pollution, India, 1988.

S. No.	Diseases	Age Groups in Years								Total reported Death (No.)
		Below 1 yr	1-4	5-14	15-24	25-34	35-44	45-59	60+	
1	**Asthma and Bronchitis**	0.8	0.8	0.7	0.8	1.2	2.1	10.7	82.9	5055
2	**Heart attack**	0.1	0.2	0.8	1.9	3.4	7.9	25.1	60.7	3577
3	**Pneumonia**	54	23.7	7.6	2.0	1.2	1.4	2.5	7.6	1282
4	**TB of lungs**	0.6	1.2	1.8	6.2	13.1	18.5	26.2	32.4	1987
5	**Prematurity**	100	-	-	-	-	-	-	-	1762

(Source: Kakali Mukhopadhyay (2009). Air Pollution in India and its impact on the health of different Income Groups, Nova Science Publishers, Inc. New York).

Table 9. Summary of the study is given below.

Study and Year	Variable	Findings
Siddique *et al*., (2011)	Vehicular air pollution	The Ambient PM10 level was positively correlated with ADHD in children (OR=2.07, 95% cl, 1.08-3.99).
Rajarathnam *et al*., (2011)	Outdoor air	It was found that every 10ug/m^3 change in pm 10 was associated with a 0.15% increase in total all natural cause mortality.
S.A. Rizwan *et al*., (2013)	Vehicular emissions and industrial effects on health	Delhi has exceeded the maximum PM10 limit by almost 10-times at 198μg/m^3.
Mukhopadhyay and Forssell, (2005)	Fossil fuel combustion	Mukhopadhyay and Forssell (2005) have estimated air pollution (CO_2, SO_2, and NOx) from fossil fuel combustion in India. They also estimate the emissions of CO_2, SO_2 and NOx for the year 2001–2002 and 2006–2007. A link between the emission of pollutants and their impact on human health is also analyzed. The main factors for emission changes are the pollution intensity, technology, and the volume of final demand. These results are quite different from those observed in some other studies. They conclude that a large number of people are affected by respiratory infection especially lower respiratory infections. The pollutants like SO_2 and NOx have caused these respiratory infections.
Stieb *et al*., (2012)	Outdoor air	Studies reported reduced birth weight and increased odds of low birth weight in relation to exposure to carbon monoxide (CO), nitrogen dioxide (NO_2) and particulate matter less than 10 and 2.5 microns (PM10 and PM2.5).
Perera *et al*., (2012)	Fossil fuel burning and other combustion sources	The results suggest an adverse impact of prenatal PAH exposure on child behavior that could impact cognitive development and ability to learn. Anxiety, depression, and attention problems, which were associated with PAH exposure.
Hai-Ying Liu *et al*., (2013)	Outdoor air	There is clear evidence that outdoor air pollution is associated with cardiopulmonary diseases. We did not investigate the effects on cardiovascular disease in this study, but we have shown that people living in the most polluted regions had a higher risk of hospital visits related to respiratory diseases than those living in the least polluted areas. This phenomenon is in accordance with other study results. 38, 40–45 (2013).
Miyake, Y. *et al*., (2010)	Vehicular air pollution	756 pregnant mothers and babies followed for 2 years after birth <50 mts versus >200 mts. Doctor diagnosed asthma: 4.0 (1.4-11.2%). Doctor diagnosed asthma: 4.0 (1.4-11.2%). Doctor diagnosed eczema: 2.3 (1.1-4.6%). Maternal exposure to vehicular pollutants during pregnancy is strongly associated with early childhood asthma. Air Pollution increases the risk of premature birth by 30%.

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