

Vehicular Emissions and their Contribution to Urban Air Pollution

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ABSTRACT

One of the biggest environmental problems facing contemporary cities is urban air pollution. Pollutant emissions from the transportation industry have dramatically increased due to rapid urbanization, population growth, and rising car ownership. Nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM), and volatile organic compounds (VOCs) are among the dangerous pollutants released by vehicle emissions that worsen air quality and have a negative impact on both human health and the environment. The sources, makeup, and effects of vehicle emissions in cities are reviewed in this study, along with how they contribute to air pollution. In order to lower emissions from transportation networks, the study also addresses policy interventions and mitigation techniques.

Keywords- urban air pollution, pollutants, motor vehicles, photochemical oxidants, emissions, health effects, Central Pollution Control Board (CPCB), Central Road Research Institute (CRRI).

I. INTRODUCTION

In urban locations around the world, air pollution is a serious environmental and public health issue. The number of motor vehicles has increased due to rapid urban expansion, making transportation one of the main causes of urban air pollution. According to studies, vehicle pollution. emissions are a major source of pollutants in metropolitan areas, including carbon monoxide, nitrogen oxides, hydrocarbons, and particulate matter. Due to urbanization and economic expansion, car ownership has increased dramatically in developing nations, especially India. Nowadays, one of the main anthropogenic sources of greenhouse gases and urban air pollutants is motor vehicles. Due to heavy traffic and restricted emission dispersion, urban dwellers are exposed to elevated levels of these pollutants. Therefore, creating efficient mitigation methods requires an understanding of how vehicle emissions contribute to urban air.

Vehicle emissions are a significant contributor to urban air pollution in India due to the country's fast urbanization and economic expansion(1). According to urban-scale simulations, 25–50% of PM_{2.5} pollution

comes from vehicle exhaust and on-road resuspended dust, with hotspots concentrated along major road corridors in Indian cities(2). There is growing evidence that atmospheric pollution, which is influenced by the particle size and chemical composition of carbonaceous aerosols, is linked to major health risks and climate impacts. According to a recent study, ambient air pollution in India causes 2.18 million fatalities annually(3). Carbonaceous aerosols comprise elemental carbon (EC), inorganic carbon compounds, mostly carbonates, and organic carbon (OC), including polycyclic aromatic hydrocarbons (PAHs) and other hydrocarbons (4). Total carbonaceous aerosol is estimated to provide between 20 and 85 percent of ambient PM_{2.5} mass in India, depending on the season (5). PAHs from on-road vehicles come from both exhaust and non-exhaust sources, including resuspended dust, brake wear, tire wear, and asphalt(6). Vehicle mileage, fuel composition, engine type, operating conditions, and the presence of catalytic converters all have a substantial impact on the properties and emission factors of PAHs released by automobiles(7). On-road exhaust emissions are a major source of PAHs in urban settings, according to numerous recent studies conducted

in India (8.9). Due to the high population density and variety of emission sources with intricate chemical patterns, metropolitan areas are particularly vulnerable to air pollution exposure. Chronic obstructive pulmonary disease (COPD), acute lower respiratory illness (ALRI), cerebrovascular disease (CEV), ischemic heart disease (IDD), lung cancer (LC), respiratory tuberculosis, and diabetes mellitus are just a few of the negative health effects linked to air pollution (10,11). The use of health impact assessments (HIA) of air pollution has been supported in recent decades by toxicological and epidemiological research (12).

II. CAUSES OF VEHICULAR POLLUTION

Urban Pollution:

The number of people living in cities has expanded fourfold between 1951 and 2011, from 62.4 million to 377.1 million, and its percentage has risen from 17.3% to 31.16% (13). There were 18 cities having a population of one million or more in 1991; by 2012, that number is expected to rise to 46. The pollution issue has been exacerbated by the unplanned urban population growth, which has led to a rise in consumption habits and a greater need for transportation, electricity, and other infrastructure(14).

Vehicular Pollution in India:

The number of vehicles in India is currently at 40 million, and it is increasing at a rate of more than 5% annually. Another distinctive feature of India's vehicle mix is the extremely high percentage of two-wheelers—76% (15). The Indian automotive sector, which is

expanding at the second-fastest rate in the world, depends on the growth rate of automobiles. Currently, the nation produces between 7 and 8 million cars a year. There were 141.8 million registered cars in the nation in 2011 (Fig. 1)(15).

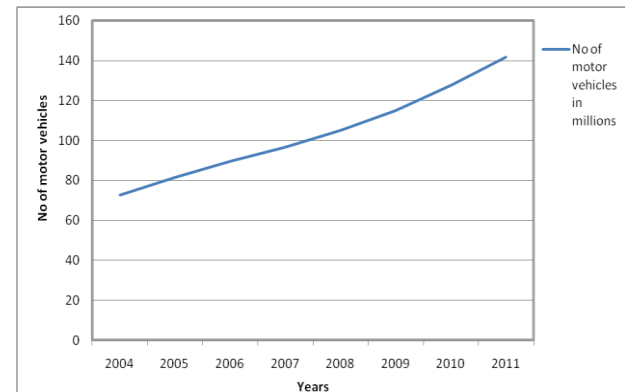


Figure 1: Registered motor vehicles in India (15)

The road transport industry contributes 4.8% of India's GDP. The number of motor vehicles in India increased from 72.7 million in 2004 to over 141.8 million in 2011. Approximately 72% of all vehicles are two-wheelers, which are mostly powered by two-stroke engines (Table 1)(16). Air pollution in a city is directly correlated with the road transportation system. Vehicle age, speed, and emission rate all affect vehicle emissions. In Indian cities, the average peak-hour speed is typically far lower than the ideal one. In the heart of many large cities, peak-hour speeds have dropped to 5–10 km/h due to growing traffic and a lack of road space.

Table 1. composition of vehicle population (%of total) (16)

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	111.5
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)

We must maintain that the estimation of road transportation pollutant emissions should enable substantial disaggregation of the results by vehicle type, fuel type and composition, and emission standard. Depending on the goals of the environmental assessment, it is generally important to distinguish between emissions produced inside and outside of cities, as well as time scales (17). In India, the number of automobiles sold is rising quickly. In just five years, the number of vehicles sold has increased from 8.9 million in 2005–06 to 15 million in 2010–11. The issue arises from the concentration of vehicles in a small number of

chosen cities, even though faster expansion in the number of vehicles promotes growth and development. The fact that 32% of these cars are operating in metropolitan areas alone—which account for roughly 11% of the population—is concerning. Nearly 7% of all motor cars in India are found in Delhi, which is home to 1.4% of the country's population. In most metropolitan cities, autos and two-wheelers make up over 80% of all vehicles. According to an analysis of the data in Table 2(18), six out of the thirteen study sites had a personalized vehicle population share of more than 90% of all vehicles in 2000. When compared to customized

vehicles, buses make up a very small portion of most Indian cities. For instance, cars and two-wheelers account for almost 95% of all vehicles in Kanpur and

90% in Hyderabad and Nagpur, whereas buses make up 0.1, 0.3, and 0.8% of all vehicles in these cities, respectively (14).

Table 2. Private and public vehicles in metropolitan cities in india (18)

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)

India's motorization rate is 26 automobiles per 1000 people, which is lower than many developing nations worldwide. However, over the past three decades, the number of motor vehicles has doubled, compared to the 2-5% annual growth rate in Canada, the US, the UK, and Japan (16).

Vehicle Fuel Pollutants:

Depending on the kind of gasoline they use, automobiles release a variety of pollutants. Fuel fugitive emissions are another sort of pollution released by automobiles. The source and intensity of these emissions vary depending on the type of vehicle, how it is maintained, etc. Carbon monoxide, nitrogen oxides, photochemical oxidants, air toxics such as benzene, aldehydes, 1,3-butadiene, lead, particulate matter, hydrocarbons, oxides of sulfur, and polycyclic aromatic hydrocarbons are the main pollutants emitted as vehicle/fuel emissions (19). In India's largest cities, cars are the main cause of air pollution. Road transport contributes 94.5% of India's transportation sector's estimated 261 tons of CO₂ emissions. About 17% of India's overall energy consumption and 60% of the country's greenhouse gas emissions are caused by the

transportation sector. Vehicle emissions such as CO, unburned HC, Pb, NO₂, SO₂, and SPM are mostly caused by tailpipes. In large cities, vehicles are thought to be responsible for 70% of CO, 50% of HC, 30–40% of NO_x, 30% of SPM, and 10% of SO₂, with two-wheelers accounting for two-thirds of this total. These high pollution levels, which are far higher than the national average, are mostly to blame for respiratory and other air pollution-related illnesses like lung cancer, asthma, etc. (20).

Emissions From Different Vehicle Type in India:

Table 3(19) summarizes the total transport emissions of CO₂, CO, NO_x, CH₄, SO₂, PM, HC, N₂O, and NMVOC in India. Transport-related CO₂ emissions totaled 258.10 Tg in 2003–2004. Road construction, aircraft, railroads, and shipping each contributed 243.82 Tg (94.5%), 7.60 Tg (2.9%), 5.22 Tg (2%), and 1.45 Tg (0.6%) of CO₂. 3.03 Tg (53.3%) and 2.57 Tg (45.1%) of CO are primarily contributed by the road sector and aviation. Road and aircraft are the main sources of air pollution among all forms of transportation, including shipping, railroads, and airplanes (19).

Table 3. Total emissions from Indian transport for(19)

	Transport Mode	CO ₂	CO	NO _x	CH ₄	SO ₂	PM	HC	N ₂ O	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
	Coal	5.280	0.015	0.012	-	0.0421	-	-	-	-
Railways	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
	Coal	85.860	1.17	0.9359	0.0058	-	-	-	0.0007	0.2340
Aviation	High Speed, Diesel	6.360	0.086	0.069	0.004	-	-	-	0.0001	0.0173
	Light Diesel Oil	222.23	2.835	2.2828	0.0143	-	-	-	0.0017	0.5707
	Fuel oil	7294.14	2565.35	8.733	6.549	-	-	-	-	-
	Aviation turbine fuel	243816.6	3032.10	2213.85	126.78	709.09	153.127	723.4	-	-
Road Transport		258103.1	5692.16	2298.29	133.80	709.13	153.12	723.4	0.0568	18.9219
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 (19) summarizes the emissions calculated for several types of road transport vehicles.

Trucks and lorries account for 25% of India's total vehicular emissions, including 28.8% CO₂ (70.29 Tg),

39% NO_x (0.86 Tg), 27.3% SO₂ (0.19 Tg), and 25% PM (0.03 Tg).

Similarly, buses release NO_x (0.68 Tg; 30.7%) and PM (0.03 Tg; 20.5%), while two-wheelers are a significant source of CO (0.72 Tg; 23.7%), CH₄ (0.06 Tg; 46.4%), and HC (0.46 Tg; 64.2%). The kind, economy, and fuel type of a vehicle all affect its emissions.

Buses and Omnibuses generate more CO₂ (CO₂: 96.5%, NO_x: 2.28%) than two-wheelers (CO₂:

86.8%, CO: 7.18%, HC: 4.6%), according to emission analysis depending on vehicle type. There are differences between passenger light motor vehicles (CO₂: 86.8%, CO: 7.6%, NO_x: 1.9%), cars and jeeps (CO₂: 98.8%), taxis (CO₂: 94.6%, SO₂: 4.68%), trucks and lorries (CO₂: 97.6%, NO_x: 1.2%), goods light motor vehicles (CO₂: 98.4%), and trailers and tractors (CO₂: 98.4%) (19).

Table 4. Emissions from different vehicle type of India (19)

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).

In metropolitan areas around the world, motor vehicles have been directly linked to rising air pollution levels (21; 22). These cars release large amounts of CO, HC, NO_x, SPM, and other air pollutants into the atmosphere in addition to CO₂, which has detrimental effects on the environment and human health. Similar to many other regions of the world, one of the biggest and fastest-growing issues in India's cities is air pollution from motor vehicles (23,24). In several of India's largest cities, the issue of air pollution and vehicle emissions has grown significantly (25). Despite recent advancements in air. While some cities have reported quality in terms of the criterion pollutants (i.e., NO_x, SO₂, CO, and HC), the majority of cities still have far from adequate air pollution. The concentration of a lot of cars and relatively high motor vehicle to population ratios in certain places have made the issue worse (24).

III. HEALTH EFFECTS OF VEHICULAR POLLUTANTS (SPECIFICALLY)

Both human health and the environment are negatively impacted by automobile emissions. Vehicle emissions of contaminants have a variety of detrimental health impacts. Acute exposure to pollutants, particularly carbon monoxide, can have both direct and indirect effects, ranging from decreased vision to cancer and even death. The respiratory and cardiovascular systems are thought to be directly impacted by these pollutants. Increased mortality, morbidity, and reduced pulmonary function are specifically linked to elevated levels of sulfur dioxide and suspended particulate matter.

- **CARBON MONOXIDE:** When fuels containing carbon are burned partially, carbon monoxide (CO), an odorless, colorless gas, is produced. This poses a major danger to people's health. At high exposure levels, CO is known to be fatal. Because blood hemoglobin has a 200-fold higher affinity for carbon monoxide than for oxygen, CO prevents oxygen from being transported from the blood into the tissues. Even at modest exposure levels, the effects of this gas on humans have been demonstrated. Angina (chest pain) in those with coronary artery disease is accelerated by low levels of exposure. Healthy people are likewise impacted, but only to a greater extent. Visual perception, labor capacity, physical dexterity, learning ability, and the ability to complete complicated tasks are all negatively impacted by exposure to high CO levels.
- **NITROGEN OXIDES:** Higher susceptibility to respiratory infections, higher airway resistance in asthmatics, and worse pulmonary function have all been associated with nitrogen dioxide (NO₂). Research has demonstrated that even brief exposures to NO₂ can cause a variety of respiratory issues in school-age children, with cough, runny nose, and sore throat being among the most prevalent. Additionally, nitrogen oxides cause acid buildup on plants and surface water, which harms aquatic life and trees. By transforming into nitric acid in the atmosphere and creating particle nitrate, NO_x emissions also raise particulate matter levels.
- **PHOTOCHMEICAL OXIDE:** Ozone is created as a result of chemical interactions between volatile compounds and NO_x in the presence of heat and sunlight, rather than being released directly from the

automobiles. Put another way, the emission of pollutants from automobiles also causes chemical reactions that lead to the creation of ozone. The primary component of the smoke, ground level ozone, can lead to respiratory issues such chest discomfort and coughing. Inflammation of the respiratory tract, a decrease in lung function, an increase in asthma, and other lung disorders are all documented effects of ozone gas. Ozone is known to negatively impact the ecosystem in a variety of ways in addition to its effects on human health, such as decreasing yield for commercial forests, crops, fruits, ecosystems, etc. Additionally, it harms trees, shrubs, flowers, and urban grass.

- **OXIDES OF SULPHUR:** Children and adults with asthma who are active outside may experience transient breathing difficulties due to high sulfur dioxide (SO₂) concentrations. Asthma sufferers may experience symptoms like wheezing, chest tightness, or shortness of breath if they are exposed to elevated SO₂ levels for a brief period of time while exercising moderately. Longer-term exposure to high SO₂ concentrations combined with high PM levels has also been linked to respiratory sickness, changes in the lungs' defenses, and exacerbation of pre-existing cardiovascular disease.
- **GASEOUS AIR TOXIC:** Toxic air pollutants that could have a major impact on human health were also included in the hydrocarbon emissions released by automobiles.
- **BENZENE:** All forms of exposure to benzene are known to cause cancer in humans. It has been demonstrated that long-term lung exposure to elevated ambient benzene levels causes cancer in every tissue that produces white blood cells. Genetic alterations in humans and animals have also been connected to exposure to benzene or its metabolites. Leukemia risk may be indicated by the presence of specific chromosomal abnormalities in people who have been exposed to benzene.
- **FORMALDEHYDE:** Formaldehyde is categorized as likely human. Long-term formaldehyde inhalation may be linked to cancers of the nasal cavity, sinuses, and nasopharyngeal cavity (usually the region at the back of the mouth near the nose), according to epidemiological research. It is also known that formaldehyde has mutagenic properties.
- **LEAD:** The human body's various organs and organ systems are impacted by lead, with subcellular alterations and neurodevelopmental consequences seeming to be the most vulnerable. Additionally, lead impairs renal and sensory-motor functioning. Lead exposure has also been linked to a slight rise in blood pressure. Lead from the air can end up in soil and water, where it can enter human bodies through drinking water and the food chain (CPCB, 2010). Another significant source of lead in household dust is atmospheric lead. consumed, breathed in, or

absorbed through the skin. Auto exhaust, leaded gasoline, water pipes, paint, battery storage, crystal glass, ceramic glaze, enamel jewellery, and other items account for 86% of the lead in the atmosphere. The amount of traffic directly correlates with the concentration of lead in dust. 50% of ingested lead is absorbed by children and 10–20% by adults. Lead levels in tissue and cord blood are correlated. Lead affects the gastrointestinal tract, peripheral nerves, central nervous system, reduced IQ, convulsions, coma, and death (26).

- **PARTICULATE MATTER:** represents a large class of physically and chemically varied substances that exist in a variety of sizes as distinct particles (solids or liquid droplets). Particles can be released straight into the atmosphere or created by changing gaseous pollutants like nitrogen oxides or sulfur dioxide. Premature death, worsening of respiratory and cardiovascular diseases, as evidenced by an increase in hospital admissions and ER 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 are the main health effects linked to PM. The exacerbation of respiratory disorders like asthma is mostly linked to exposure to coarse fraction particles.
- **SUSPENDED PARTICULATE MATTER:** Increased mortality, morbidity, and compromised pulmonary function are specifically linked to elevated levels of sulfur dioxide and suspended particulate matter (SPM). Living in an Indian metropolis, according to environmentalists, is like smoking ten or twenty cigarettes a day. According to a World Bank assessment, air pollution causes over 40,000 premature deaths annually, with Delhi accounting for the largest percentage at 19% (27). Total deaths In India, respiratory infections account for 16% of all deaths, while respiratory disorders and cardiovascular issues account for 27%. People over 60 are more likely to have asthma and bronchitis (82.9%), heart attacks (60.7%), and lung tuberculosis (32.4%), but children under one year old are more likely to have pneumonia (54%). When comparing historical data from 1984, 1988, and 1998, it is evident that respiratory conditions and associated illnesses like bronchitis and asthma are becoming more common in all age categories, with senior persons being the most impacted (28).

IV. CONCLUSION

Numerous studies have shown that motor vehicle emissions are a mixture of several contaminants that may be harmful to one's health. consequences, such as carcinogenicity, mutagenicity, cardiovascular mortality, and worsening the health of vulnerable

groups, such as children, the elderly, and those with impaired health conditions like asthma. While chronic exposures result in health impacts such as carcinogenicity, mutagenicity, and cardiovascular health issues, acute exposures have caused hospitalization owing to respiratory ailments.

As a result, it is advised that efficient vehicle emission control methods be created and put into practice. To guarantee the efficacy of the vehicle emissions-control systems, a program for vehicle maintenance and inspection should be created. Reducing emissions can be achieved through proper maintenance, inspections, clean cars, and the use of clean fuel.

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