

Air Pollution- Road Traffic in India

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Abstract— Traffic congestion is a common problem in India in almost every city and towns as they are rapidly expanding. Reasons for this are several, like, increasing number of all varieties of vehicles, poor road infrastructure and irregular maintenance, inefficient enforcement of traffic laws. Automobile production is rising every year, more than 21 million automobiles were produced in India, 2013-14. Traffic congestion slows down the average speed of traffic, which causes inefficient burning of fuel and ultimately leads to more pollution. Air pollution has been associated with many cardiovascular and respiratory diseases, eventually resulting in premature morbidities and mortalities. Certain greenhouse gases emitted through the automobiles is a major source for global warming. Therefore, it is essential to implement ways to improve the air quality, that gets immediately into action and be followed across the entire country.

Index Terms— Air Pollution, Bharat Stage Emission Standards, CNG Fuel, Global Warming Potention (GWP), Particulate Matter (PM_{2.5}), Respiratory Disorders, Road Traffic Accidents.

1 INTRODUCTION

Traffic congestion is a common problem in India in almost every city and towns as they are rapidly expanding. Reasons for this are several, like, increasing number of all varieties of vehicles, poor road infrastructure and irregular maintenance, inefficient enforcement of traffic laws. Automobile production is rising every year, more than 21 million automobiles were produced in India, 2013-14.(data.gov.in, January 5, 2016)

Several problems occur due to such road traffic conditions. The number of deaths due to traffic collision are one of the highest in India in the world. Noise pollution is another big issue which has many physical, medical, and mental impacts on humans in both long and short term aspects. The major issue that affects human health as well as environmental health is air pollution. Traffic congestion slows down the average speed of traffic, which causes inefficient burning of fuel and ultimately leads to more pollution. Air pollution has been associated with many cardiovascular and respiratory diseases, eventually resulting in premature morbidities and mortalities. Certain greenhouse gases emitted through the automobiles is a major source for global warming.

Looking at the continuous increase in the rate of vehicle demand in India, the risk of increasing pollution along with it also comes in the sight. Therefore, it is essential to implement ways to improve the air quality, that gets immediately into action and be followed across the entire country. Designs for expansion and formation of new metro zones, roads, and flyovers have been proposed in most bigger cities. In concern of reducing the pollutant emission rates, newer emission norms will be incorporated into motor engines and fuels in the next few years. Further researches are required for the smaller cities and other rural and urban regions where certain strategies to improve the traffic are not feasible, like metros and flyovers. (Tiwari, 2002)

2 LITERATURE

2.A Current traffic conditions in India

2.A1 Flyovers

Overcrowded traffic is a chief source of pollution in every city in India. Megacities like Delhi, Mumbai, Bengaluru, Kolkata, and Chennai are most impacted of all. Limited infrastructure and high density of activities makes the traffic highly congested and affects day to day life. The situation gets worse due to faulty exhaust control measures. Construction of flyover bridges had some positive results in several cities in bringing down the level of congestion, however, the ascending number of new cars and other vehicles have limited the effectiveness of the flyovers. Moreover, flyover constructions are not possible in certain area. (Kumar et al., 2015)

2.A2 Quality of Fuel

There are certain emission control strategies that are under implementation in the metro cities in the country, for example, using clean CNG fuel in the public transportations. Despite these measures, the pollutants did not go down significantly because there are many vehicles from different towns that enter and exit through the city, causing more congestion and pollution while in the city. Those vehicles run on fuel that are of inferior quality, having higher Sulphur content, as a uniform quality standard of fuel is not present across the country. (Kumar et al., 2015)

2.A3 Deaths due to Pollution

Per WHO, an estimated 1.5 million deaths in India occurred due to effects of air pollution, 2012.(Chatterjee)

2.A4 Bharat Stage Emission Standards

In 2005, India adopted stage IV of Bharat stage emission standards. It was adopted with the aim to decrease the output of air pollutants through internal combustion engines, like motor vehicles. Bharat Stage IV is equivalent to European standard Euro IV for emissions by vehicles. However, older vehicles that are pre-2005 and even more older motor vehicles are still on the streets of India. (Guttikunda and Mohan, 2014)

2.A5 Air Pollutants

The number of vehicles in the megacities of India is on a continuous rise due to increase in demand, supply and mainly population. Therefore, the pollution load in India increased by more than 70 times in five decades, just from the transportation sector, 1947-1997. During that period, carbon monoxide (CO) had the largest share of the total air pollutants, which was almost 43%. It was followed by Nitrogen oxides and hydrocarbons in huge percentages. While Sulphur Dioxide (SO₂) has decreased due to lesser sulphur content used in coal and diesel, NO had only increased due to higher number of automobiles. (Gurjar et al., 2016)

2.A6 Particulate Matter (PM₁₀)

Global Burden of Disease (GBD) reported deaths due to air pollution to be the 5th leading cause of deaths in India. Organization for Economic Co-operation and Development (OECD) recently reported that the projected PM₁₀ (particulate matter) levels in India would get seven times higher by year 2050 than the existing WHO air quality guidelines. (Ravindra, 2015)

Table 1: Particulate Matter and CO₂ emission of India compared to neighboring countries

Country	PM _{2.5} (µg/m ³)	CO ₂ emission from liquid fuel consumption (kT)
India	73	461,173
Pakistan	63	65,588
China	57	1,235,632
Bangladesh	87	14,305
Afghanistan	46	17,011
Japan	13	511,653

(Bank, 2015)

- From the Table 1, it is seen that Particulate matter and Carbon dioxide emission is high in India, when compared to its neighboring countries.

2.A7 Pollution in Delhi

Cities that are situated close to the coastlines, level of pollution in the air is much lesser when compared to the non-coastal places. These cities benefit through a diurnal cycle exchange pattern that exists between urban air and sea breezes. On the contrary, land-locked megacities suffer from major air pollution problem as the routes for cleansing out of the polluted air are limited. Especially in developing countries where the core of these megacities is already saturated with older houses, industries, and commercial buildings; urban growth is often unplanned, heterogenous, and occurs in the peripheral locations around those cities. Therefore, the atmospheric transport from every direction is more likely to increase the already existing inner-city pollution. The capital city of India, Delhi, is one such similar land-locked region, which so far being at disadvantage in matters of air pollution, irregular transport management and unregulated emission sources makes the situation worse. (Kumar et al., 2015) PM_{2.5} (particulate matter) pollution in Delhi from 2012 to 2014 averaged about 150 µg/m³. This value was almost 15 times higher than the annual-average guideline set by the World Health organization. (Goel et al., 2015)

Table 2: Sources of pollution in Delhi

Source	1970-71	1980-81	1990-91	2000-01
Industrial	56	40	29	20
Vehicular	23	42	64	72
Domestic	21	18	7	8

(Foster and Kumar, 2011)

2.A8 Limited Infrastructure and Funding

Public sector generally has a finite funding for the construction and improvement of the poor road conditions. The infrastructures are old and limited, and since the urban growth has taken place at a faster pace, the existing infrastructure are used beyond their capacity. There are no facilities for the pedestrians and cyclists. A separate lane is missing in the older foundations, and some of the recently upgraded road designs also have not incorporated any side paths for them. In most smaller cities, footpaths are virtually absent and a possibility for change is less due to pre-existing buildings on the sides. (Pucher et al., 2005) (Tiwari, 2002)

2.B Effects on environment and health

2.B1 Cardiovascular

WHO estimates that air pollution causes more than a million premature mortality worldwide every year. Short duration exposures has also been associated with higher number of cardiovascular deaths. (Shah et al.) Carbon monoxide (CO) binds to hemoglobin and modifies its

structure which reduced the oxygen carrying capacity of hemoglobin. This would affect several organs in the body. Brain and heart are high oxygen-consuming organs and hence, they are the most affected ones due to this phenomenon. Moreover, systemic inflammatory changes get induced that affects the blood coagulation mechanism, forming blood clots that can obstruct the cardiac blood vessels, leading to angina, or myocardial infarction. (Kampa and Castanas, 2008)

2.B2 Respiratory Disorders

Road traffic pollutant exposure attributed to 15% of all exacerbations of *asthma* in children. As India and many developing countries are getting more urbanized and the population also rising, the rate of outdoor pollution would tend to increase, thus likely to result in an increased global burden of asthma. (Guarnieri and Balmes)

Several studies have reported an association between symptoms of respiratory problems and residing at closer proximity to the traffic. As per the report of a cross-sectional study, stronger association was observed between exposure to traffic air pollutants like NO_x, NO₂ and bronchitis symptoms in children. (Kim et al., 2004)

Around 119,900 premature deaths in India occur due to outdoor air pollution every year (WHO 2009). The age group mainly affected are between 15-45 years. The largest impacts are in the metropolitan cities due to greater population. India's capital territory, Delhi has 12 times incidence of *respiratory disorders* than the national average. Almost 30% of the population in the city suffers from respiratory diseases. (Gurjar et al., 2016)

A short-term exposure at a higher concentration, or a long-term exposure to lower concentration of pollutants, both have been found to be positively affecting the airways. An exposure to Sulphur dioxide causes symptoms such as nose and throat irritation, which is followed by dyspnea and Bronchoconstriction, if the exposure level is high. (Kampa and Castanas, 2008)

2.B3 Road Traffic Accidents

World Health Organization reported more than 137,000 deaths in India in the year 2015 due to road traffic accidents. (WHO, 2015)

As per a study in a dental college of India on patients with maxillofacial fractures, road traffic accidents accounts for the highest number of fractures, predominantly in male. The majority of the injuries included cases that occurred during the night time; under the influence of alcohol; riding motorbikes without wearing helmets. (Bali et al., 2013)

2.B4 Global Warming

Global effects such as *global warming* and *atmospheric brown clouds* are some other consequences of degrading quality of air. Emission of gases like carbon dioxide, carbon monoxide, nitrogen dioxides, Sulphur dioxides, causes atmospheric changes through oxidation, cloud precipitation, and photo-chemical reactions and contribute largely in global warming. (Gurjar et al., 2016)

Table 3: Global Warming Potential (GWP) of Each Pollutant

Pollutant	GWP (100 years)
Carbon Monoxide (CO)	1.9
Carbon Dioxide (CO ₂)	1
Nitrogen Oxides (N ₂ O)	298
Nitrogen Oxide (NO _x) ^a	NA
Methane (CH ₄)	25

(Nesamani, 2010, IPCC, 2007)

2.B5 Noise Pollution

Increased noise levels are considered an inconvenience to human populations in urban and suburban areas. The mitigation of the noise due to traffic must be incorporated as an essential part of the budget of road traffic development. (Coffin, 2007)

A comprehensive study on traffic noise pollution was done in Balasore, a town in the state of Odisha. Half of the respondents expressed annoyance to the traffic noise. Other responses included temporary deafening, headache, sleep disturbance and disruption in studies for students. (Goswami, 2009)

2.B6 Acute and Chronic Morbidity and Mortality

A cohort study was done to find an association of changing fine particulate air pollution with acute and chronic mortality. The relation was observed to be directly proportional, i.e., there was an increase in the overall mortality rate with each 10 µg/m³ increase in PM_{2.5} and the mortality rate improved with the decrease in mean PM_{2.5}. Particulate matter (PM_{2.5}) exposure was found to be associated with cardiovascular and *lung cancer* mortality. (Laden et al., 2006)

Acute exposure to PM: Persons with influenza, asthma and chronic cardiopulmonary disease, children, and elderly, are more susceptible to serious morbidity, hospitalization, and mortality from short-term acutely elevated PM exposures. People having asthma have higher chances of getting respiratory symptoms. Lower lung capacity has been observed in

general adults and children. Heart rate variability and pulmonary inflammation recognized in both health and unhealthy adults. (Pope 3rd, 2000)

Chronic exposure to PM_{2.5}: health effects of chronic exposure includes increased mortality rate, reduced survival rate, chronic cardiopulmonary diseases, and reduced lung function. The observation was a broader group of cohort studies where all chronic exposed were potentially affected. (Pope 3rd, 2000)

2.B7 Effects on Wildlife

Some studies done on the wildlife has shown the road noise has variable effects on animals at disproportionate levels. Some birds were found to have incorporated the sound into their basic behavior. Road noises apparently create confusion interfering with the frequency of their calls. (Coffin, 2007)

Animals like dogs, cows, and goats, are often found on the streets of Indian towns and cities and road traffic accidents are no escape for these animals. Slow moving animals, and animals crossing roads often suffer from mortality due to vehicle collisions.(Coffin, 2007)

2.C Measures and Requirements to Control the Pollution

2.C1 Implementing Bharat Stage-VI Emission Standard Norms

Since 2005, India implemented Bharat stage IV emission standards with a motive to curb the pollution level in the air. But the speed with which the number and demand of vehicles have been on a rise, the need for adopting to the next level of norms has been planned by the Indian government. Initially, a statement was made by the government, according to which, India would be enforcing Bharat Stage V emission standard norms across the nation by the year 2019 and further moving to BS VI, which will be implemented from 2023. (Bureau, 2015) However, the plan was under intense debate as switching from one norm to another at such short period seemed difficult for both oil refineries and automobile companies. The debate for the expedite plan ended afterwards when the Union transport minister announced to directly move from Euro IV standards to Euro VI emission norms for diesel and petrol from April 2020, in all 13 major cities of India, skipping the BS stage V norms altogether. This plan was opposed by the automobile industry as it would have put additional pressure on the automobile manufacturers to produce the compliant vehicles, and would require a huge amount of investment for the oil refineries to upgrade to the standards. But seeing both the rate in rise of pollution and the risks associated with it going high, and having no technical difference between the BS-V and BS-VI, the decision for investment finally went into the favor

of direct switching to BS-VI norms. (IndiaToday.in, 2016) (FirstPost.com, 2016)

2.C2 Improving Traffic Management

Many small and large cities in India lack a proper traffic management system. While the focus of action to improve the condition of the road traffic condition stays mainly towards the megacities of the country, the smaller and medium-sized towns and cities often goes unnoticed. As the population and number of automobiles are on continuous raise in these small cities as well, the traffic situation tends to get complicated. Road congestion is a regular problem, occurring multiple times on a daily basis. Modest improvements have appeared in the bigger cities with enforcement of strict traffic regulations and advanced technologies getting installed, and in contrast, many small Indian cities lack even the basic provisions such as traffic signals, sign boards displaying speed and directions, and other important regular structures. As the traffic rules and regulations in many places are not accompanied by strict enforcement by the traffic-responsible officers, people tend to become more reckless. (Pucher et al., 2005) More than 75% of the people getting head injury due to road traffic accidents, were either under the influence of alcohol or did not wear helmets or both. (Bali et al., 2013) There is a clear need of sound traffic system coupled with modern technology in every city and town, that needs to be implemented with strict watch over for the strategies to for an improved traffic flow. (Pucher et al., 2005)

2.C3 Improving Public Transport Services

An improvement in the public transport services is an extreme necessity for the overall enhancement of the Indian traffic system. Public buses, suburban railways, and metro systems have thus far made a considerable amount of progress, nevertheless, further expansion of the intercity rails and metro trains in the megacities of India is much needed. The lack of adequate availability of these public transport systems, and often the inferior quality of the same, forces the vehicle-dependend people to go for private mode of transportation, which is one of the root causes behind the increasing jamming of streets. Many of the old buses running across various routes needs to be replaced with the new buses designed as per the new emission standard norms. The old buses are not only a source to increasing pollution, but also inconvenient and dangerous, putting lives at risk. (Pucher et al., 2005) The Chennai Mass Rapid System (MRTS), is a state-owned subsidiary of the Indian Railway System, that has more than 90,000 riders every day. The actual capacity is considered to be more than 4 lakhs. The extensions that MRTS covers presently are known as phase one and phase two extensions, covering around 17 railway stations within the city. The future plans for the train proposed by the state government was to further ex-

tend the coverage to phase three and four, and improve facilities, however, the date for beginning the extension project has not been finalized as the Chennai metro had slated a similar alignment. The success of the project would help in reducing the total vehicle kilometer travelled (VKT) to a large extent. (Nesamani, 2010)

In other cities like Hyderabad, Kolkata, and Mumbai, designs for railway and metro extensions have been proposed in which their respective state government and the Indian railway system would invest jointly. In Bengaluru, there are plans to develop the metro system similar to Delhi's metro design. The analysis on the construction of metro stations was done on the basis of several parameters such as the road width, communication channel, population density, condition of traffic place, proximities to workplace and other facilities, and environmental characteristics. Introduction of metros in the bigger cities with a population over millions, offers a preferable mass transit system and help in achieving lower carbon rates. (Sekar and Karuppanan)

2.C4 Designing New Roads

Most of the roadway projects in India have shown focus on private cars, and the target of roads on highways are mostly on the heavy transportation modes such as buses and trucks. Unfortunately, lesser attention is paid for the population preferring other transit modes. It is essential to design the new roads that accommodate the needs of non-motorists such as cyclists and pedestrians. The absence of a separate lane for the pedestrians and cyclists leads to many road accidents, and to go for a safer and convenient solution, some part of the latter group might end up joining the group preferring private cars, that would ultimately lead to an increased burden of traffic related issues. The National Urban Transport Policy has proposed a 50% Central Government funding of paths for pedestrians and cyclists to be implemented in the new road construction, which can help in bringing in some of the most required changes. (Pucher et al., 2005)

With the help of an application known as Petrinet, a model was prepared in orthogonal structure for the Lucknow city in India. From the overall findings, it was concluded that simplest solution to deal with the traffic congestion was to wider the existing road network. The orthogonal array illustrated that introduction of a few flyovers in the Lucknow city would make a huge difference and make the traffic control highly efficient. (Darbari et al.)

Additionally, some more measures that can help to ameliorate the traffic condition are: (Sood, 2014)

- Regular inspection and management of in-use vehicles.
- Establishing ban on commercial and non-commercial vehicles that are 10 or more years old.

Replacing the old public buses with the newer buses.

Mandating emission tests for every vehicle at regular intervals.

Making an integral approach along with the adjacent peripheral regions, to understand the sources of pollutants and their contributions.

3 CONCLUSION

From the various data reported and studies conducted, the road traffic condition in India can be observed as one of the most serious concern in synopsis. It is quite evident that traffic congestion is a highly potential source for multiple health-related issues and if the congestion is integrated with a poor traffic management, the situation would only get complex. Several other factors like, inferiorly constructed roads, deficient maintenance, the growing economy and unplanned urban development, increasing dependency on automobiles, difference in the public vs private transit mode ratio; all have been observed to be interlinked and incorporating in the increasing burden of air pollution along with the pollutant emissions. Speaking of which, the upgrading plans of Bharat stage emission standard norms to reduce the rate of air pollutants, can only become a success if the older automobiles running across the country for more than a decade are removed and replaced by the newer designed vehicles. Fuels of inferior quality also needs to be inspected and strictly be eliminated entirely. (Guttikunda and Mohan, 2014)

The various harmful particulate pollutants have been associated with increased mortalities and morbidities in all age groups, including both healthy and unhealthy individuals, moreover, these particulates contribute in endangering environment through global warming. (Gurjar et al., 2016) The surveys also indicate that plenty of steps have been taken by the government and stakeholders to incorporate methods to reduce the pollutant content and enhance the traffic system in India. However, the increased production and demand of cars and two-wheelers, with a population over millions in every megacity have made the strategies less effective. More active and immediate steps need to be taken for refining the roads and surpassing every obstacle and introducing flyovers in the cities with requirement and feasibility. Additional funding should be provided by the responsible stakeholders. Strict traffic laws, with advanced technological equipment, and regular inspection of the same, for example, wearing of seatbelts, helmets, and speed check, must be followed. (Annadurai et al., 2015)

Implementation of more and extensive public transportation

medium, especially metros and inter-city trains, as they are highly convenient saving time, money, and also lives by reducing traffic problems. It is also a major responsibility of the citizens to render efforts in making the strategies successful by using public transportation whenever possible, car-pooling, cleaning carbon deposits, air-filters and oil-filters, and maintaining the laws and avoiding congestions. (Sood, 2014)

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