Impingement of Transportation on the Ambient Air Quality of Lucknow

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PROJECT REPORT

IMPINGEMENT OF TRANSPORTATION AN AMBIENT AIR QUALITY OF LUCKNOW

Submitted For Partial Fulfillment Of Award For The Degree Of
Bachelor of Technology
In
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CERTIFICATE

Certified that the project entitled **"IMPINGEMENT OF AMBIENT AIR QUALITY DUE TO TRANSPORTATION IN LUCKNOW"** submitted by Shweta Gaurav (1712200053) in partial fulfillment of the requirements of award of the degree of Bachelor of Technology (Civil Engineering) of DR. A.P.J. Abdul Kalam Technical University, is a record of student's own work carried under our supervision and guidance. The project report embodies results of original work and studies carried out by students and the contents do not form the basis for the award of any other degree to the candidate or to anybody else.

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DECLARATION

I hereby declare that the project entitled **"IMPINGEMENT OF AMBIENT AIR QUALITY DUE TO TRANSPORTATION IN LUCKNOW"** submitted by me in the partial fulfillment of the requirements of award of the degree of Bachelor of Technology (Civil Engineering) of DR. A.P.J. Abdul Kalam Technical University, is a record of my own work carried under the supervision and guidance of **Mr. ABHAY SRIVASTAVA.**

To the best of my knowledge this project has not been submitted to DR. A.P.J. Abdul Kalam Technical University or any other institute for the award of any degree.

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In the sense of great pleasure and satisfaction I present this project entitled **"IMPINGEMENT OF AMBIENT AIR QUALITY DUE TO TRANSPORTATION IN LUCKNOW"**. The completion of this project is no doubt a product of invaluable support and contribution of number of people.

I would like to express my sincere thanks to our guide **Mr. Abhay Srivastava** (Asst. Professor, Department of Civil Engineering) for his continuous help and valuable suggestions and also providing encouraging environment, without which our project and its documentation would not have been possible. I am also grateful to our Head of Department **Mr. Neelesh Singh** for his valuable help, encouragement and inspiration.

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PREFACE

This project report basically is based on impigement of ambient air quality due to transportation in lucknow. Transportation is one of the most important sources of air pollution. The pollution from automobiles may be highly significant particularly in congested and poorly ventilated roads. Congestion intensifies air pollution problems, increase commuting times and raises vehicle operating cost, a major factor responsible for poor maintenance of vehicles.

This project report is divided into different chapters each of which covers different aspects of implementation of our project work.

Chapter 1 is introduction which shows studies about air pollution and vehicular related information.

Chapter 2 is Literature Review, in which we represent the past study related to our project work.

Chapter 3 is Methodology, which gives the methodology which we use in our project work.

Chapter 4 is Result and Conclusion. In this chapter we provide the results and conclusion of our project.

Chapter 5 is Applications and Limitations. In this chapter we provide the applications and limitations of our project.

Chapter 6 is Mitigation measures. In this chapter we provide remedial measures for air pollution.

ABSTRACT

In this project main objective is to analyze the impact of transportation on air quality. Since congestion intensifies air pollution problems so it is necessary to check the traffic density. So the main objective of our study is to provide remedial measures to overcome air pollution related problems. In our project work we will provide traffic data, vehicular emission data and ambient air quality data. In our study we will compare the traffic census with the vehicular emission data. We will provide mitigation measures to control the air pollution.

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CHAPTER 1 –INTRODUCTION

1.1 Overview

Transportation contributes to the economic, industrial, social and cultural development of any city. Transportation is vital for the economic development of any region since every commodity produced whether it is food, clothing, industrial products or medicine needs transport at all stages from production to distribution. The adequacy of transportation system of a country indicates its economic and social development but evolution of transportation system has lead to several adverse effects on environment.

Transportation is one of the most important sources of air pollution. The pollution from automobiles may be highly significant particularly in congested and poorly ventilated roads. **Congestion intensifies air pollution problems**, increase commuting times and raises vehicle operating cost, a major factor responsible for poor maintenance of vehicles. The major pollutants generated by the automobiles are hydrocarbon (HC), oxides o nitrogen (NO_X), carbon monoxide (CO), smoke and lead.

On average basis, the transportation contributes more than 50% of total pollutants emitted into the atmosphere. The first gasoline powered automobiles appeared in 1886, by 1990 the world production was only 20000 vehicles per year compared to about 30 million in 1999. The personal motor car has given its owners personal mobility and freedom what would have been incompressible two centuries ago. Alas, although any one car consumes little fuel and emits small amount of pollutants, together the roughly 500 million of them in the world consumes large amount of fuel and emit large amount of pollutants.

A report, on the basis of the study carried out by Jawaharlal University, New Delhi, says that nearly 400 tons of pollutants every day from 200000 different kinds of vehicles in New Delhi. Total numbers of vehicles in India have gone considerably higher from 306313 in

1951 to 1234700 in 1987 and growing presently at much higher rate than this. Motor cars are most preferred mode transport in various countries over the rail and buses. Similarly there are about 123 million autos used in United States and about 70 million trucks.

A survey was carried out in India in 1980 which represents amount of gases emitted by several vehicles.

CATEGORY	**CO**	**HC**	**NO_X**	**SPM**	**SO_2**
CARS	0.380	0.036	0.031	0.003	Negligible
BUSES	0.209	0.034	0.030	0.012	0.025
TWO WHEELER	0.050	0.030	Negligible	Negligible	Negligible
THREE WHEELER	0.090	0.050	Negligible	Negligible	Negligible
OTHERS	0.100	0.020	0.170	Negligible	Negligible

Table 1.1 Auto Exhaust emission in India

This table shows that motor vehicles are the source of three-fourth of their national emissions of CO, and 40 to 50 percent of their emissions of HC and NO_x. Motor vehicles also emit particles and SO_2 but their percent contribution to those problems is much less than other gases.

In India, pollution has become a great topic of debate at all levels and specially the air pollution because of the enhanced anthropogenic activities such as burning fossil fuels, i.e. natural gas, coal and oil-to power industrial processes and motor vehicles. Among the harmful chemical compounds, this burning puts into the atmosphere, are carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO_2) and tiny solid particles including lead from gasoline additives called particulates.

In India outdoor air pollution is restricted mostly to urban areas, where automobiles are the major contributors, and to a few other areas with a concentration of industries and thermal power plants. Apart from rapid industrialization, urbanization has resulted in the emergence industrial centers without a corresponding growth in civic amenities and pollution control mechanisms. In most of the 23 Indian cities with a million plus population, air pollution levels exceed World Health Organization's (WHO) standards. In everycity, the levels are getting worse because of rapid industrialization, growing number of vehicles, energy consumption, and burning of wastes. A study conducted by the World Bank indicates premature deaths of people in Delhi owing to high levels of air pollution (Review of air quality management system in India).

Today, adverse health effect of air pollution is a serious issue I urban areas particularly in developing countries like India. In general, some criteria pollutants like particulate matter, SO_2 , NO_x are quantified for assessment of ambient air quality and major source of these pollutants are burning of fossil fuels. In urban areas, mainly gasoline, diesel and CNG are used by vehicles which are the major source of pollutants. Epidemiological studies suggest that air pollutants like Particulate matter, SO_2 and NO_x are significantly co related with cardiovascular morbidity and mortality. The effect of air pollutants depends on the concentration, chemical and physical characters of pollutants. The particulate matter (PM) is a carrier of number of pollutants like trace elements, Poly aromatic hydrocarbons etc. Inhalation of these pollutants with particulate matter is a matter of serious concern as most of the big cities particularly in India including Lucknow reported higher than permissible limit of PM specified by Ministry of Environment & Forest. Govt. India.

1.2 Fuel Efficiency

Fuel efficiency or fuel economy is the energy efficiency of a vehicle, expressed as the ratio of distance traveled per unit of fuel consumed in km/litre. Fuel efficiency depends on many parameters of a vehicle, including its engine parameters, aerodynamics drag, weight, and rolling resistance. Higher the value of fuel economy, the more economical a vehicle is. Fuel economy else affects the emissions from the vehicles.

1.3 Fuel Consumption

Fuel consumption is the reciprocal of fuel efficiency. Hence, it may be defined as the amount of fuel used per unit distance, expressed in liters/100km. Lower is the value of fuel consumption, more economical is the vehicle. That is less amount of fuel will be used to travel a certain distance.

1.4 Air Pollution

Air pollution may be defined as “the disruption caused due to the natural atmospheric environment by the introduction of certain chemical substances, gases or particulate matter, which cause discomfort and harm to structures and living organisms including plants, animals and humans.”

Air pollution has become a major concern in most of the countries of the world. It is responsible for causing respiratory diseases, cancers and serious other ailments. Besides the health effects, air pollution also contributes to high economic losses. Poor ambient air quality is a major concern, mostly in urban areas. Air pollution is also responsible for serious phenomenon such as acid rain and global warming.

The substances causing air pollution are collectively known as air pollutants. They may be solid, liquid or gaseous in nature. Pollutants are classified as primary and secondary air pollutants. Primary pollutants are those which are emitted directly to atmosphere, whereas, secondary pollutants are formed through chemical reactions and various combinations of the primary pollutants. Some of the major primary and secondary air pollutants are given below.

PRIMARY POLLUTANTS	SECONDARY POLLUTANTS
Carbon monoxide (CO)	Photochemical Smog
Volatile organic compounds (VOCs)	Peroxy acetyl Nitrate (PAN)
Nitrogen Oxides (NO_{x})	Ozone ($O_{.3}$)
Hydrocarbons (HCs)	
Sulphur Oxides (SOx)	

Table 1.2 Primary & Secondary Pollutants

The pollutants which are emitted from the exhaust pipe of the automobiles are known as exhaust pollutants. They are formed as a result of combustion of the fuel in the engine. These pollutant are harmful to the atmosphere and living things in particular.

1.5 Automobile Pollution

The pollution caused due to the emissions from vehicles is generally referred to as automobile pollution. The transportation sector is the major contributor to air pollution. Vehicular emissions are of particular concerns, since these are ground level sources and hence have the maximum impact on the general population. The rapid increase in urban population have resulted in unplanned development, increase in consumption patterns and higher demands for transport and energy resources, which all lead to automobile pollution. The automobile pollution will be higher in congested urban areas. The vehicle obtains its power by burning the fuel. The automobile pollution is majorly caused due to this combustion, which form the exhaust emissions, as well as, due to evaporation of the fuel itself.

1.6 Types Of Vehicular Emisssions

- **Exhaust Emissions:** Exhaust emissions are those which are emitted through the exhaust pipe when the vehicle is running or is started. Hence the exhaust emissions are of two types-

Startup emissions: Emissions when the vehicle is started initially. Based on how long vehicle had been turned off after the use, they may be cold start and hot start. Cold start refers to when the vehicle is started suddenly after a long gap of use, whereas, hot start refers to when the vehicle is started without the vehicle getting enough time to cool off after its previous use.

Running emissions: Emissions during normal running of the vehicle, i.e., when the vehicle is in a hot stabilized mode.

- **Evaporative Emissions:** These include running losses and hot soak emissions produced from fuel evaporation when an engine is still hot at the end of a trip, and diurnal emissions (daily temperature variations).

1.7 Factors Affecting Emission Rates

The vehicular emissions are due to a variety of factors. The emissions vary according to the environment, fuel quality, vehicle, etc. emissions are higher in congested and urban areas. Fuel adulteration and overloading also cause higher amount of emissions. The emissions from vehicles depend on following factors:

1.7.1 Travel Related Factors

1emissions. As the number of trip increases, the amount of emissions also increases. Emissions increase with the distance travelled by the vehicle. The vehicular emissions also depend on the driving mode. The driving modes may be idling, cruising, acceleration and deceleration. These modes complete one driving cycle. Other factors affecting the emission rates are the speed and engine load of the vehicle. Low speeds, congested driving conditions, sharp acceleration, deceleration, etc. results in higher emissions.

1.7.2 Highway Network Related Factors

These include the geometric design features of the highway such as grade. The emission rate is high at steep gradients, as the vehicle needs to put in more effort to maintain its speed. The highway network facilities such as signalized intersections, freeway ramps, toll booths, weaving sections, etc. also influences the vehicular emission rates.

1.7.3 Vehicle Related Factors

Vehicle related factors include the engine sizes, horsepower and weight of the vehicle. Vehicles with large engine sizes emit more pollutants. Since larger sized engines are seen in vehicles with more horsepower and more weight, these factors also contribute to the emission rates. Another important factor is the age of" the vehicle. Older vehicles have higher emission rates**.**

1.8 Why Lucknow ?

l) Lucknow is the capital city of Uttar Pradesh, the most populous state of India. Lucknow had a population of 4,815,601 according to population census 2011. Lucknow is a second largest city after Delhi within the states of north, central and eastern India. Lucknow is also the administrative headquarters of Lucknow District and Lucknow Division.

2) As a Capital City, Lucknow offers better social and physical infrastructure and amenities compared to other cities in the state.
3) According to Master Plan 2021, the population growth projected varies between 3.51 to 4.37 per cent per year over different S-year periods until 2021 which will necessitate new Public Transport Support thereby increasing the transport network which results increament in air pollution.
4) The total no. of registered motor vehicles are increasing continuously in city. In 2002, there Were 556000 vehicles in city but in 2011, this no was increased to 1211000 vehicles.

1.9 Selected Sites For Data Collection

- **Hazratganj:** Hazratganj is the commercial area. In hazratganj our site is near saharaganj mall.
- **Talkatora:** Talkatora is Industrial area. In Talkatora our site was near Every Ready Chauraha, which is T-intersection
- **Aliganj:-** Aliganj is residential area. In Aliganj our site is near Kapoorathala square.

CHAPTER 2 - LITERATURE REVIEW

2.1 By Srivastava R.K., Saxena Neeta and Gautam Geeta

AIR POLLUTION DUE TO ROAD TRANSPORTATION IN INDIA: A REVIEW ON ASSESSMENT AND REDUCTION STRATEGIES.

Received May 07, 2013 Accepted September 15, 2013. Rapid urbanization and growth of motor vehicles impose a serious effect on human life and its environment in recent years. Most of the cities of India are being suffered by extremely high level of urban air pollution particularly in the form of CO, SO2, NO2, PM (Particulate Matter) and RSPM (Respirable Suspended Particulate Matter). Transport sectors contribute a major share to environmental pollution (around 70%). A among these pollutants CO is the major pollutant coming from the transport sector, contributing 90% of total emission. Hydrocarbons are next to CO. It is indeed interesting to observe that the contribution of transport sector to the particulate pollution is as less as 3-5%, most of the SPM (Suspended Particulate Matter) are generated due to re-suspension of dust out of which PM10 is the most prominent air pollutant. NOx is another important air quality indicator. 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 level of research around the world. The present study is a review of an assessment model for emitted pollutants and effective strategies to reduce air pollution due to road transport.

Air pollution is one of the serious environmental concerns of the urban Asian cities including India, where majority of the population is exposed to poor air quality. It causes health related problems such as respiratory disease, risk of developing cancer and other serious ailment etc. and also contributes to tremendous economic loss especially in the sense of financial resources that are required for giving medical assistance to the affected people. Most of the Indian cities are also experiencing rapid urbanization and the majority of the country's population is expected to be living in cities within a span of next two decades. It has also resulted in a tremendous increase in the number of motor vehicles.

The vehicle fleets have even doubled in some cities in the last one decade. This increased mobility, however come with a high price. Vehicles are now becoming the main source of air pollution in urban India. The growth rate of vehicles is the backbone of economic development an the Indian automotive industry (the second faster growing in the world). About 7-8 million vehicles are produced annually in the country today. In 2011 country reported 141.8 million registered motor vehicles (Table 1 and Fig.1). A motorization rate in India is 26 vehicles per 1000 population, and this is lower than many developing countries throughout the world (Brazil-222/1000 population in 2012, South Africa 153/1000 population.), but over the last three decades number of motor vehicles has been doubling against a 2-5% annual growth rate in Canada, the US, the UK and Japan.1 Automobiles are the primary source of air pollution in India's major cities. In India transport sector emits an estimated 261 tones of CO_2, of which 94.5% is contributed by road transport. According to data out of total 3,000 metric tones of pollutants belched out every day, close to two-third (66%) is from vehicles in Delhi. Similarly, the contribution of vehicles to urban air pollution is 52% in Bombay and close to one-third (33%) in Calcutta.2 The transport sector in India consumes about 17% of total energy and responsible for 60% production of the GHG 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 tail pipes.

Registered motor vehicles in India

Year	No. of motor vehicles (in millions)
2004	72.7
2005	81.5
2006	89.6
2007	96.7
2008	105.3

2009	115.0
2010	127.7
2011	141.8

Source: Road Transport Year Book 2012

Estimated pollution load in Indian cities (Source: Auto Fuel Policy Report)

City	**Pollution load in metric tons 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	952.64	7.29
Hyderabad	163.95	36.89	90.09	8.00
Bangalore	207.04	29.72	117.37	8.11
Kanpur	28.73	7.25	11.70	1.91
Agra	17.93	3.30	10.28	.91

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 . There is a direct relationship between road transport system and air pollution in a city. Vehicular emissions depend on vehicle speed, vehicle-km, age of vehicle, and emission rate. In general, the average peak hour speed in Indian cities are far less than the optimum 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 city, and also time scale can be necessary, depending on the objectives of the environmental assessment

2.2 By Mahadevappa Harish

A STUDY ON AIR POLLUTION BY AUTOMOBILES IN BANGALORE CITY

The sources of pollutants includes emissions from the combustion of fossil fuels in motor vehicles and for industrial processes, energy production, domestic cooking and heating, and high dust levels due to local construction, smoking, unpaved roads, sweeping, hotels, restaurants and long-range transport. By this the quality of air has become so poor that, Bangalore is the result of both high emissions from the vehicles and unfavorable conditions. The rapid growth in motor vehicle activity is the challenges to overcome in urban areas in Bangalore during the last and this decade. This has brought a serious range of socio-economic, environmental, health, and welfare impacts on environmental degradation. The rapid growth in motor vehicles in Bangalore is important not only because of their locally harmful air pollution effects, but also because of their regional and global impacts So the paper deals with the study of air pollution caused by the automobiles in the city of Bangalore.

One of the main problems that is overlooked across the globe is pollution. The Pollution is evident in many different forms, such as, water, sound, light, radioactive, land, and air. The only way is to reduce the problem of air pollution is the elimination or reduction of fossil fuels used by vehicles. Thus, the increases in population, migration, uncontrolled urban expansion, income, economic growth, energy consumption and mobility have created a serious for air pollution problems, in cities throughout the world. The study is to find the emissions from the vehicles and their impact on the environment. This deals with the present scenario of air pollution and the effects on environment in Bangalore city. The worst thing about vehicular pollution is that it cannot be avoided as the vehicular emissions are emitted at the nearground level where we breathe. The problem of vehicular air pollution especially relates to Bangalore. This paper depends on the data of registered vehicles and the emission factors of vehicles.

1. To identify the number of vehicles in Bangalore city.

2. To identify the types of pollutants released from vehicles in Bangalore city.

3. To forecast and suggestion for controlling measures of air pollution in Bangalore.

Bangalore is a rapid development in urban area either in demography, migration, transportation, or industrial sector since last two decades. The Bangalore has the highest demography and the only metropolitan city, of Karnataka, which it has 94 lacks of population as per the 2011 census. The intensity, quantity, and frequency of both urban, suburban and movement with other cities are same factor of increasing transportation problem in the Bangalore area; particularly in transportation utility development could not comply with the demand. The dependency of urban population on transportation systems on fossil fuels is quite high. The Bangalore is one of the cities having 41 lacks registered vehicles apart from other vehicles of neighboring city and towns. The vehicle with poor environmental quality continues to grow in multiple ratios.. There is an urgent need to address the interrelated problems and obstacles experienced by the people of Bangalore regarding air pollution through the vehicles. The traffic congestion resulting from transportation changes contributes even greater to deteriorating environment in urban communities. In the last few years, about 70% of ambient-air quality degradation in Bangalore is affected by transportation activities.

AIR POLLUTION FROM TRANSPORT SOURCES

Air pollution is addition of any harmful gaseous, liquid or solid particles or substances to the atmosphere, which causes the damaging of the environment, human health on quality of life in urban area that can endanger the health of human beings, plants animals, or damage materials reduce visibility or release undesirable odors. By this one of the great problems faced in urban areas throughout the world is the increase in vehicles due to imbalance between the public transport and the increase in population, mobility and last mile connectivity. This increase in the number of vehicles has lead to increase in congestion and the increase in pollution by the private vehicles Polluting such a natural resource by various human activities will substantially change the composition of air. This may lead to many short term and long term implications on the life of plants and animals. Besides the change in composition, the pollution may directly add some poisonous and harmful gases - which may cause series of health complications. Transportation is one of the important of economic activity and beneficial social interactions. While the transportation sector is also a major source of air pollution in Bangalore, estimated to account for nearly all of carbon monoxide (CO), more than 80% of nitrogen oxides (NOx), 40% of volatile organic compounds (VOC), 20% of sulfur dioxide (SO2), and 35% of PM10 in 1998. The growing problems related to traffic are congestion, accidents, pollution and lacks of security are also very worrisome. The key question is how to reduce the adverse environmental impacts and other negative effects of transportation without giving up the benefits of transportation. This is due to increase in the automobiles and the mobility of people, rapid urban growth, which is likely to increase travel demand significantly in Bangalore city. Given current trends, by 2020 the Bangalore city will have a 1.3 crore population will reach 2 largest city including the nearby cities of other states capital such as, Hyderabad, Chennai, Tiruvananthapuram in south India by 2030. The increase in the number of vehicles from transportation sector presents a wide range of issues viz. air pollution, noise, congestion, accidents and increased travel time and delays. It was evident from the existing information that air pollution controls are not only important and a current priority in the local context, but also can present a significant potential to control greenhouse gas emissions. Thus, with an ultimate goal of greenhouse gas reduction, the present study has chosen air pollution control as a strategic target from the transport sector due to its high greenhouse gas co-benefits.

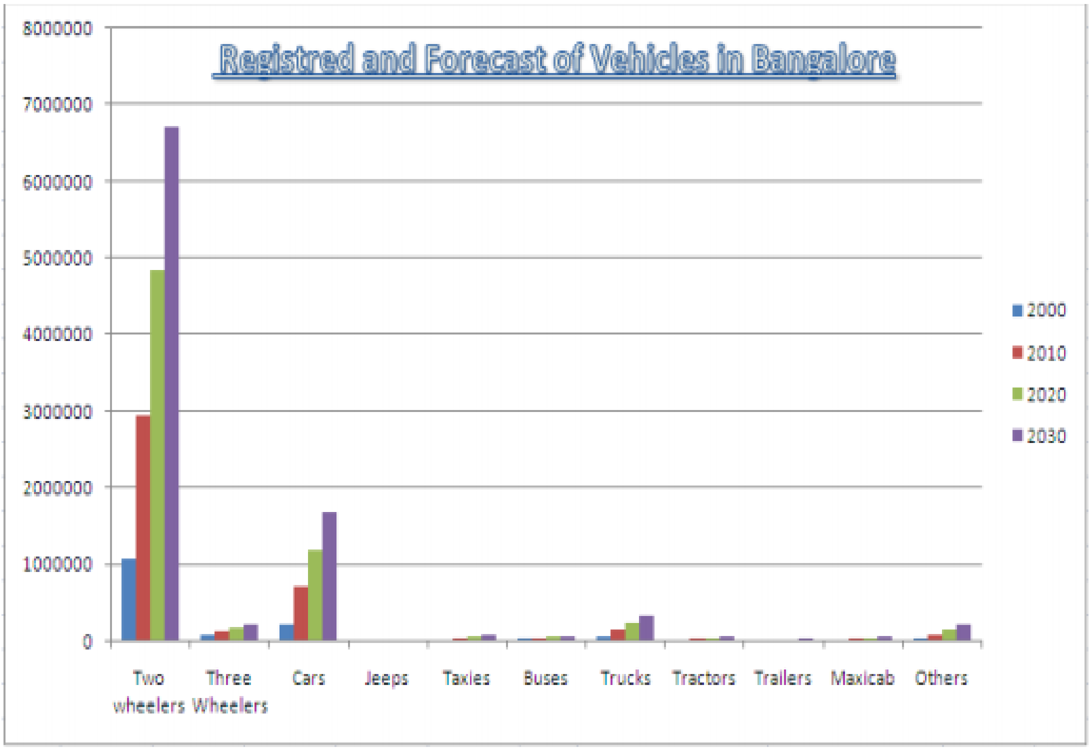

FIGURE 1 - SHOWS THE DATA OF REGISTERED VEHICLES IN BANGALORE IN 2010.

MOBILITY AND AIR POLLUTION

In recent years due to increase in the number of vehicles has shown drastically in, levels of air, noise, and sight pollution were much higher in all urban centers today. Due to increase in automobiles on the road today we experience higher levels of pollution than before. The automobile is one of the major sources, probably the leading contributor pollution in the cities. The transportation is of the major source for the economic activity and redistribution of resources among people. But transportation sector is a major source of air pollution in Bangalore, it is estimated that the account for nearly all of carbon monoxide (CO), more than 80% of nitrogen oxides (NOx), 40% of volatile organic compounds (VOC), 20% of sulfur dioxide (SO2), and 35% of PM10 in 1998. The growing automobiles have lead to problems of congestion, accidents, and lack of security due to automobiles are worrisome. Therefore to reduce adverse environmental impacts and other negative effects of transportation without giving up the benefits of mobility. As the increasing geographic dispersion of Bangalore population is also likely to increase aggregate transportation demand, since the greater number of trips will also be longer and public transport will be less efficient and universal. As the population increased in residential areas where decentralized, patterns of passenger trip mode choice in Bangalore have also shifted dramatically by using private vehicles: The number of private vehicles increased drastically, due to decentralization, globalization, economic development, standardization by most estimates at a rate of 18 percent annually in recent years. This could mean a higher number of vehicles in Bangalore, a higher ratio of vehicles per persons, possibility of trips and the distances traveled will increase even more for coming years.

SOURCES OF POLLUTION

Pollution from 2-wheelers: Two-wheelers account for about 72 percent of the total vehicular population in Bangalore. Because of inherent drawbacks in the design of 2-stroke engines, 2-wheelers emit about 20-40% of the fuel un-burnt/partially burnt. Presently, two-wheelers account for more than 65% of the hydrocarbons and nearly 50% of the carbon monoxide in Bangalore. As these emissions are less visible, the general public is not aware of the role of 2-wheelers in the deteriorating air quality in the city. The 2-stroke engine, in spite of R&D efforts towards improving its design, will continue to be a high emitter of hydrocarbons and carbon monoxide. While the absence of a technological breakthrough on the conventional 2-stroke engine and its high pollution potential, it is for consideration that Government considers the phasing out of two-stroke two and three wheelers. Pollution from 3-wheelers: Of the 1, 15,401 three-wheelers in Bangalore nearly 3 percent of the total population of vehicles, they are petrol-driven, powered by 2-stroke engines. These vehicles are also high emitters of carbon monoxide and hydrocarbons. A pollution check conducted by Regional Transport Department has revealed that in some instances the levels are so high that they go beyond the measurable scale of test instruments. In addition, it is widely believed that petrol is adulterated with kerosene which results in emissions of thick black smoke. Pollution from 4-wheelers: The Bangalore city is having 7, 39,667 vehicles on the roads (Jeep-9104, Taxi32818 and Cars-697745) as it consist of both petrol and diesel driven vehicles. It excludes the floating vehicles in the city area. These vehicles are also high emitters of carbon monoxide and hydrocarbons which pollutes the air. These consist of old as well as new vehicles in the city. The city is having 18 percent of 4 wheelers which occupies maximum space on the road, it is one of the air pollutants in the city. it is widely believed that petrol is adulterated with kerosene which results in emissions of thick black smoke. Pollution from BMTC and other privately operated buses: There are about 3,500 privately operated BMTC buses of about 6077 buses in Bangalore Metropolitan transport Corporation consists of 1 percent of the total population. About two thirds of the BMTC fleet is beyond the recommended age of 4-5 years, some even beyond 8-10 years. Most of these buses require phasing out as their condition is beyond normal maintenance measures. Their continued use has resulted in emissions of very high levels of smoke and particulates from this the KSRTC, NWKSRTC, other State owned buses, and the private and industrial busses. If such vehicles continue to function beyond the recommended age and carry more than the permitted load of passengers. Overloading at peak hours: The buses, particularly during peak hours, carry more than recommended load of passengers. These buses will stops near the junctions and signal lights due to congestion of vehicles. This results in higher smoke emissions during the peak hours. While high capacity buses require to be inducted for carrying more passengers. The worst polluters should be taken off the heavy traffic corridors and high density areas. Similarly, for trucks, enforcement of laws related to overloading requires to be enforced vigorously to BMTC and other state owned buses etc. Pollution from diesel trucks: The diesel trucks consists of 3 percent in population, similar to buses, emit high levels of smoke and particulate matter. An age limit needs to be specified for all commercial diesel trucks 15 years but still it had remained in the paper. But still so many BBMP, BESCOM and other Government vehicles is running on the streets. Renewal of permits must be done only if the vehicle conforms to satisfactory inspection and maintenance measures for pollution control for the state owned and private buses. Impact of air Pollution on Health Human health is the major concern over air pollution in the urban areas. However, the Bangalore City Study considers effects of air pollution in and its impact on ecosystems, and with the linkage with global warming. The Bangalore city like other countries in the world, contributes to global warming and is likely to be affected by it. In this paper, we will discuss only the impact on health. Air pollution caused by the automobiles has impacts on health and imposes potentially substantial economic costs to society. Most of the health effects from air pollution come from respiratory symptoms in the levels of pollution in Bangalore City and other cities throughout the world. The time-series have revealed the effects of various pollutants (generally PM10= particulate matter smaller than 10 µm in diameter, ozone, CO=Carbon Monoxide, NO2=Nitrogen dioxide, and SO2=Sulpher dioxide.).The Harvard school of public health has assessed health risks found in current and anticipated levels of air pollution Mexico city Metropolitan Area implications of air quality focused on pollutants, mainly by PM10 (particulate matter smaller than 10 µm in diameter) and ozone. The Studies in various cities around the world, including Bangalore City, shows that there is a daily fluctuations in air pollution levels in different parts of the world. It is estimated that for each 10 µg/m3 increase in daily levels 4 of PM10. So, due to increase in particulate matter of air cardiovascular, coronary heart diseases and even premature deaths among the infants will take place. This can be done by reducing 10 percent reduction in PM10 may reduce the death of infants. Several studies revealed that the effect could be several times larger if one considers longer-term responses to particulate matter exposure PM10 concentrations have also been associated with health outcomes including increased cases of chronic bronchitis, respiratory or cardiovascular problems, asthma attacks, symptoms etc. The ozone has significant effects on respiratory function and on respiratory conditions such as asthma. So for this recent research suggests that important factor for human health involves the presence of fine particles (PM2.5). So for the monitoring PM2.5 and to develop an emission in inventory should be given more importance. So for this the government or the pollution control board has to set up 8 to 10 air pollution monitoring centers in and around the Bangalore. The collected data will be useful for control of pollutant in a spatial manner. The corporation or Karnataka Government and other agencies has to contribute to the understanding of the air quality problem in Bangalore by conducting measurements and modeling studies of atmospheric pollutants within the city. Such an understanding will helps to provide a scientific base for devising effective emissions control strategies to reduce exposure to harmful pollutants in Bangalore and also provide insights to air pollution science in other cities in Karnataka.

MEASURES FOR EMISSION CONTROL

1. Use of Remote Sensing Technology: Remote sensing technology measures the pollutant level during the vehicle's exhaust while vehicle is traveling down the road. Unlike the conventional methods, the remote sensing devices are not physically connected to the vehicle. The paper highlights how to achieve almost zero percent pollution and prevent the

environment from vehicle emission.

2. Modification on cost effective: Due to today's strict emissions and fuel economy standards to which manufacturers have to conform, most new cars bought these days are actually capable of performing far better than they are advertised. Cost effective depends on these factors

a. Turbo Charger: The turbo Charger works as compresses air which is driven through the exhaust system,

b. Nitrous helps in cooling effect as it rapidly changes from a liquid to a Gas.

c. Sway bars and control arms: It works components of car suspensions that work to counteract body roll and keep the car firmly planted in turns. Adding stronger sway bars and control arms to a car stiffens the suspension, minimizing body roll and allowing it to take corners at higher speeds.

d. Ceramic brakes: is used instead of mottled brakes as they get very hot and when brakes get hot, they lose a lot of their stopping power. One way around this is to switch to ceramic disc brakes.

e. Spoiler: is the addition of air rushing overhead to push down on the car, stabilizing it and making sure that more of the engine's power hits the road. And for even more grip a splitter can be added which has much the same effect but at the front of the vehicle,

f. Chipping and ECU remapping: Chipping is basically the same as ECU remapping but instead of re-programming the unit you're bypassing it completely. This is often less effective than remapping because every engine runs slightly differently, and mass produced pre-programmed chips don't take into account an engines subtle differences.,

g. Reboring the engine: it's important to check that you can get a gasket, piston with rings and other components to match your chosen bore capacity. A rebore is irreversible and you'll certainly not want to have to do it again. Another thing to consider is that after reboring your engine, it will be necessary to run the engine in again.

h. Additional cylinder heads: A good way to get more power out of your car is to upgrade your cylinder heads to a set that has four valves per cylinder. The additional intake valve allows more air to enter the cylinder, resulting in stronger combustion, while the extra exhaust valve clears out the engine's waste faster.

i. Exhaust: A good way to get more power out of your car is to let more air into the engine which results in stronger combustion. An often-overlooked way to improve performance is to help the exhaust gasses get out of the engine. The exhaust is an engine's way of exhaling.

3. Curtile use of private Vehicles: Reducing vehicles use across the globe can cut carbon dioxide emissions by thousands of tones. As mention before, efficiency is unquestionably the largest, cheapest, and cleanest wedge among the many we need to rid carbon from our energy economy. Avoiding unnecessary driving is the most effective way to reduce vehicle emissions; however, traffic trends indicate more vehicles are being driven more frequently due to urban sprawl. The options we have available to reduce the number of vehicles being driven on our roads.

4. Day without car/ 2 wheeler: This is a new idea which has been accepted in different countries and to accept and implement ideas such as a car-free day in order to ensure less traffic congestion, stem pollution and contribute our small bit in solving the environmental problems that confront us today.

5. Car Pooling: The employers, or groups of employers, find it convenient to have one or more cars or vans that are readily available for business use by a number of employees. The cars or vans are not allocated to any one employee and are only available for genuine business use. Such cars and vans are usually known as pooled cars and vans. As it has to be started in the corporations ex: BEML, Vikrant, Universities, Institutions and corporate sectors such as Infosys, L&T etc.

6. Staged Working Scheme: will be different times for the people employed state Government, Central Government, Corporate, Banks and Financial institutions, Educational institutions, and Public sector etc. This should be introduced in the developed and developing countries based on the congestion and the level of pollution. This will help the citizens or employer will be healthy and can drive his vehicle during their office timings within the city based on their convenience as per the city.

7. Commitment: The citizens should have commitment for the society as it helps in solving the problems related to pollution and the human health in Mysore. The people has to think in a manner that, the pollution is a problem of our house rather than the society which effects mankind and poisoning the environment by unwanted emissions from vehicles and make them unhealthy.

8. Traffic Management side: The present day traffic has to be maintained and planned in such as way that the junctions, intersections, should be made as a traffic free corridor as it emits smoke in these places which will effects the human health and harms the environment.

9. Emission test by RTO: To mitigate transport emissions, stringent emission norms are being introduced for new vehicles. However, this effort would be futile without an improvement in the emissions performance of the large number of in use vehicles. Hence, an effective inspection and maintenance program for in use vehicles is essential for mitigating transport emissions the Regional Transport offices with environment experts.

10. Ban of 2 stroke vehicles: Emissions from 2-stroke engines can be reduced by rigorous inspection and maintenance programs and used of lubricating oil of correct quality and quantity. But the best option is to ban the use of 2-stroke engines in new motorcycles in favour of 4-stroke engines. The 4- stroke engines may be slightly more expensive, but are cheaper to run as they are more fuel efficient and last longer

11. Ban of vehicles more than 15 years of age: The Supreme court has banned the Commercial vehicles of 15 years of age, but we should think of banning all the vehicles of same age .The law should be made that imports of heavy vehicles (Trucks etc) older than seven years from the date of manufacture and light vehicles (Cars, Pickups) older than five years from the date of manufacture should also be banned. While the transfer of ownership of a vehicle over 10 years old should also be illegal, in other words you cannot sell the vehicle on. This leaves two options scrap the vehicle or export it to another, more lenient, country.

12. Celebration of Bus Day: This has been introduced BMTC on 4th of every month should use public transport. As an individual we should not use our cars for the day, and only use public transport as it reduces the traffic. The Bus Day will be success if the roads are not congested, polluted. If we can see a change in the traffic around us like smoke rings or fog around street lights in the night, winter fog instead of pollution fog, in the night sky. Urban Planning: Studies of advanced urban-engineering concepts for cities to evaluate alternatives to urban sprawl. Such engineering analysis would consider the co-location of activities with complementary needs for energy, water, and other resources and would enable evaluation of alternative configurations that could significantly reduce vehicle-

miles travelled and GHG emissions. The city transport systems has to provide faster and cheaper movement of passengers than the urban automobile such as (ELRTS) elevated rail system, Bus route priority system, (BRTS) Metro rail, Mono rail, commuter rail, Sky Bus etc. for the public transport modes. Freight Transport: Strategies and technologies are needed to address congestion in urban areas and freight gateways by increasing freight transfer and movement efficiency among ships, trucks, rail and ports.

CONCLUDING REMARKS

The rapid population growth of vehicles in multiple ratios continues to be a matter of concern for the Bangalore city as it has manifold effects since the last decade, one of the most important being environment degradation. The unprecedented speed of urbanization of Bangalore has resulted in enormous pressure on the environment with severe adverse impacts in terms of pollution, and today city is considered as one of the most polluted city in the country. While the projected rate of population increase may be reduced, even moderate population growth is likely to lead to substantial increases due to passenger and freight travel demand in the city, due to introduction of Metro, Monorail, BRTS, fuel price etc. The increasing geographic dispersion of metropolitan population is also likely to increase aggregate transportation demand, since the greater number of trips will also be longer and public transport will be less efficient and universal. So to improve the quality of air and water there is a need of strict enforcement and monitoring program by the Karnataka Pollution Control Board. There is also a need traffic regulations; efficient public transportation system in the city and heavy penalties and seizure of vehicles during violation of rules should be imposed on public. For the protection of environment more emphasis should be laid on compulsory environmental education at school level for the awareness to people know about how and why we need to save environment.

2.3 By Kai Zhang and Stuart Batterman

AIR POLLUTION AND HEALTH RISKS DUE TO VEHICLE TRAFFIC

Traffic on roads has significantly increased in the U.S. and elsewhere over the past 20 years (Schrank and Lomax, 2007). In many areas, vehicle emissions have become the dominant source of air pollutants, including carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOCs) or hydrocarbons (HCs), nitrogen oxides (NO_x), and particulate matter (PM) (Transportation Research Board (TRB), 2002). The increasing severity and duration of traffic congestion have the potential to greatly increase pollutant emissions and to degrade air quality, particularly near large roadways. These emissions contribute to risks of morbidity and mortality for drivers, commuters and individuals living near roadways, as shown by epidemiological studies, evaluations of proposed vehicle emission standards, and environmental impact assessments for specific road projects (World Health Organization (WHO), 2005; Health Effects Institute (HEI), 2010).

It is useful to separate traffic-associated pollutant impacts and risks into two categories. First, “congestion-free” impacts refer to impacts of traffic at volumes below the level that produces significant congestion. In this case, each additional vehicle added to the road does not substantially alter traffic patterns, e.g., the speed and travel time of other vehicles are unaffected, and thus vehicle emission factors do not depend on traffic volume. As a result, the marginal impact of an additional vehicle is equal to the average impact of the vehicle fleet. This is not necessarily true during congestion, the second category considered. While there are many definitions, congestion is often defined as periods when traffic volume exceeds road capacity. (Other definitions use a speed threshold, a percentage of free-flow speed of a roadway, or other indicator.) The present study focuses on what might be called “recurring congestion,” specifically, congestion caused by high traffic volumes during weekday peak “rush hour” periods. However, traffic volume is treated as a continuous variable, and strict definitions of congestion are not needed.

In the present analysis, “congestion-related” impacts incorporate multiple interactions that occur with congestion. First, congestion lowers the average speed, which increases travel time and exposure on a per vehicle basis. This effect can be considerable, e.g., the average annual travel delay for a traveler making rush hour trips in the U.S. was 38 h in 2005, based on 437 urban areas (Schrank and Lomax, 2007). Second, congestion diminishes dispersion of vehicle-related pollutants since vehicle-induced turbulence depends on vehicle speed

(Benson, 1989). Thus, lower vehicle speeds can increase pollutant concentrations from roadway sources. Third, congestion can change driving patterns, resulting in an increased number of speedups, slowdowns, stops and starts, which increase emissions compared to "cruise" conditions, especially with high power acceleration. For example, Sjodin et al. (1998) showed up to 4-, 3- and 2-fold increases in CO, HC and NO_x emissions, respectively, with congestion (average speed of 13 miles per hour, mph; 1 mph=1.61 km per hour) compared to uncongested conditions (average speed, 38–44 mph). Thus, it is important to separate congestion-free and congestion-related impacts since emissions, impacts and risks can differ greatly, and because such analyses can better inform decisions related to traffic and air quality management, as well as impact and risk assessments.

Few evaluations of congestion-related impacts have been undertaken, and available studies have essentially combined congestion and non-congestion related impacts. Tonne et al. (2008) predicted that the congestion charging zone in London, where drivers must pay fees when their vehicles enter this area, would gain 183 years-of-life per 100,000 population in the congestion charging zone itself and a total of 1,888 years-of-life in the greater London area. Eliasson et al. (2009) estimated that a similar zone in Stockholm would avoid 20–25 deaths annually due to traffic-related air pollution in the inner city, and 25–30 deaths annually in the metropolitan area, which contains 1.4 million inhabitants. Both studies indicate that congestion pricing is beneficial in reducing traffic-related health impacts, but congestion-free and congestion-related impacts were not separated. These European studies focused on congestion charging zones, which are uncommon in the U.S., and the vehicle mix and fleet emission characteristics may differ substantially from those in the U.S. Using a different approach that examined shifts in time activity patterns (TAPs: the amount of time spent at various locations and related activities) due to travel delays along with literature values of exposure concentrations in relevant microenvironments, we estimated that a 30 min day^{-1} travel delay accounted for 21±12% of the exposure to benzene and 14±8% of $PM_{2.5}$ for a typical working adult on weekdays (Zhang and Batterman, 2009). Levy et al. (2010) estimated that the estimated public health cost of mortality attributable to congestion in 83 U.S. cities in 2000 was $31 billion (2007 dollars). This study used a macro-level approach to estimate traffic volume, which was then linked to the Motor Vehicle Emissions Factor Model 6.2 (MOBILE6.2) (EPA, 2003), thus providing a snapshot of congestion. However, congestion is dynamic and varies with time, space, weather and other factors (Downs, 2004). Overall, these studies suggest that congestion represents a substantial share of exposure to drivers and commuters, with potentially significant risks and impacts on health.

This study investigates the magnitude of air pollution impacts and health risks to on- and near-road populations that might occur due to recurring congestion, such as Monday through Friday rush hour traffic. Recurring congestion can result in repeated and chronic exposures, and an increase in long term health risks. "Incident congestion," such as that caused by an accident or disabled vehicle, is not addressed, although such events may also be important for certain acute health outcomes, e.g., asthma exacerbation. This study utilizes predictive risk assessment techniques, namely, simulation models for traffic, emissions, pollutant dispersion and risk, and an incremental analysis that evaluates congestion-free and congestion-related impacts. After describing the approach, two case studies are used to analyze air pollution impacts and risks. A limited sensitivity analysis is conducted to examine impacts of key parameters on the estimated incremental risk. The merits of the various approaches that might be used to estimate congestion impacts conclude the analysis.

APPROACH

Risk assessment methods, depicted in Fig. 1, are used to estimate health risks due to traffic for two scenarios. In brief, vehicle emissions are used as an input to a dispersion model to estimate concentrations, which are then multiplied by exposure time and a risk factor representing the concentration–response relationship. While some exposure and risk assessments utilize time activity patterns (TAPs) or human activity patterns, for simplicity we consider only exposure durations in traffic micro-environments, which include the delays due to traffic congestion. An incremental analysis is used to estimate the marginal impacts of increases in traffic volume. Such analyses are widely used in economic models to examine effects of small changes of an input on outcomes of interest; they also represent one of the classical "sensitivity analysis" techniques used to identify key variables in modeling systems (Trueman, 2007). One difference here, however, is that a wide range of traffic flows is examined over which relationships are expected to vary considerably.

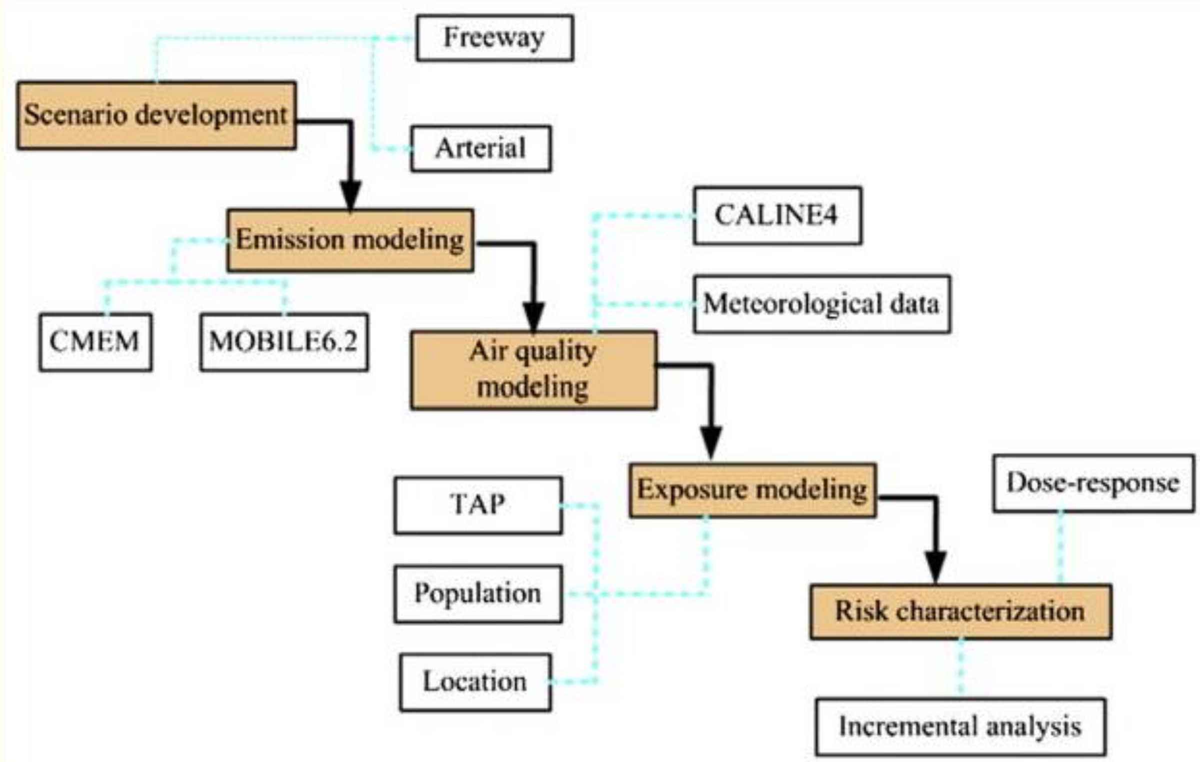

Fig. 1

Diagram for modeling health risks due to traffic and congestion (CALINE4, the California Line Source Dispersion Model version 4 CMEM, the Comprehensive Modal Emissions Model; MOBILE6.2, the Motor Vehicle Emissions Factor Model version 6.2; TAP, time activity pattern).

CASE STUDIES

Two case studies or scenarios were developed to examine associations between traffic volume, exposures and health risks. The first, a freeway scenario, models an 8 km long segment of interstate I-94 in Ann Arbor, MI (Fig. S1), which was selected for a field study in which instantaneous emission rates were modeled. This segment had a permanent traffic recorder (PTR) operated by the Michigan Department of Transportation (MDOT). The portion of the segment west of US-23 had two lanes in each direction; the segment to the east had three lanes in each direction. The annual average daily traffic (AADT) volumes for these segments were 78,300 and 91,300 vehicles day^{-1} in west and east directions, respectively (MDOT, 2008). During the field study described in Zhang et al. (2011), traffic volumes were 3099 and 4040 vehicles per hour (vph) in morning and afternoon rush hour periods, respectively. The vehicle mix (8% heavy duty trucks and 92% light duty vehicles) during rush hour was based on PTR records from October, 2007 (Southeast Michigan Council of Governments (SEMCOG), 2006), and was assumed to be constant. The southeast Michigan vehicle age distribution was assumed to represent the fleet. The traffic volume in the incremental analysis was allowed to vary from 1000 to 10,000 vph. Given that design capacity is 2000 vehicles h^{-1} lane^{-1} for a freeway (SEMCOG, 2004), the upper volume represents about 120% of road capacity. In addition to the freeway scenario with an incremental analysis, a scenario using observed volumes on I-94 during rush hour was modeled to demonstrate the spatial and temporal patterns of predicted pollutant levels.

An arterial scenario was also modeled. This used a segment along Grand River Boulevard (M-5) in Detroit, which is 8.5 km long and includes two lanes per direction and a central turning lane (Fig. S2). The AADT volumes for the segment west of M-39 and east of M-39 were 23,800 and 19,200 vehicles day^{-1}, respectively (MDOT, 2009). The regional vehicle mix and age distribution described above were used. Traffic volumes ranged from 1000 to 4000 vph (about 120% of road capacity; design capacity is 825 vehicles h^{-1} lane^{-1} for an arterial road; SEMCOG, 2004).

Exposures of drivers and commuters were estimated using several assumptions about their behavior, traffic, and in-vehicle concentrations. A driver or commuter was assumed to travel on the segments under a constant traffic volume in both morning and afternoon rush hours every weekday throughout the year. The in-vehicle concentration was assumed to be equal to predicted on-road concentrations.

Exposures of near-road residents were derived as follows. A uniform population density along both sides of the road was assumed. The (non-commuting) residents were assumed to stay at home, which was assumed to be located 100 m from the road, during rush hour every weekday. Obviously, time activity patterns and actual distances can vary considerably, although an estimated 11% of the US households are located within 100 m of a four lane highway (Brugge et al., 2007). The average concentrations at upwind and downwind receptors (each at 100 m distance) were used, given the assumption of a uniform population density. Since indoor NO_2 concentrations (in homes without indoor sources) are about 50% of outdoor concentrations (HEI, 2010), the indoor exposure concentration was assumed to be half that of predicted outdoor concentrations at the 100 m receptors.

EMISSION MODELING

Emission factors for a vehicle fleet traveling at different speeds were estimated using the Comprehensive Modal Emissions Model (CMEM) and MOBILE6.2. In this study, emissions were estimated for NO_x since traffic is its major source, and both models can predict NO_x while adjusting for speed effects. There are other important traffic-related pollutants, e.g., $PM_{2.5}$; however, CMEM does not estimate $PM_{2.5}$, and MOBILE6.2 does not account for vehicle speed effects on $PM_{2.5}$.

CMEM is a power-demand instantaneous model that can predict fuel consumption and emissions of CO, HC, NO_x and CO_2 on a fine time scale, e.g., a second-by-second basis (Scora and Barth, 2006; Zhang and Batterman, 2011). CMEM was used only in the freeway scenario because driving patterns were collected at this frequency only for this freeway segment. The CMEM estimates from Zhang and Batterman (2011), which were based on the east-bound I-94 segment, were assumed to apply to both directions.

MOBILE6.2 is a widely used regulatory emission model (Pierce et al., 2008) that estimates emissions of HC, CO, NO_x, PM and air toxics like benzene on the basis of chassis dynamometer measurements and driving cycles designed for four road types: freeway, arterial, ramp and local road (Environmental Protection Agency (EPA), 2003; Pierce et al., 2008). Emission factors in summer and winter were estimated using MOBILE6.2 and the fleet mix, vehicle age distribution, and typical daily temperatures for different vehicle speeds. Annual average emission factors were approximated as the average of summer and winter predictions.

DISPERSION MODELING

Dispersion model predictions of NO_x concentrations attributable to traffic emissions were given by the California Line Source Dispersion Model version 4 (CALINE4). This model uses a Gaussian-plume model for a line source of finite length, and a mixing zone to characterize thermal and mechanical turbulence (e.g., vehicle wake effects), which is defined as the region over the roadway (traffic lanes, not shoulders) plus 3 m on each side (Benson, 1989). Both emissions and turbulence in the mixing zone are assumed to be uniformly distributed, while the decay of concentrations at more distant locations follows an empirical Gaussian line source equation (Benson, 1989). Because CALINE4 was not designed to process hourly data for a full year, a simplified modeling approach was used (Zhang and Batterman, 2010). In brief, the annual average concentration at a receptor was estimated as the sum of CALINE predictions for 16 wind sectors (each spanning 22.5°) and 15 wind speed classes (1 m s^{-1} for each bin, e.g., 0.5 to 1.5, 1.5 to 2.5, …), weighted by the joint probability of each wind sector/wind speed category during morning and afternoon rush hour periods, based on (hourly) meteorology from 2005. Model inputs included emission factors, traffic flows, receptor locations, and surface meteorological data for morning and afternoon rush hours (7–9 am and 4–6 pm) in 2005, measured at Detroit Metropolitan Airport (located 24 and 18 km from the freeway and arterial segments, respectively). Receptors were placed 0, 25, 50, 75, 100 and 150 m from both sides of a transect perpendicular to the center of the studied road segments.

Predicted NO_x concentrations were converted into NO_2 levels in order to utilize NO_2-based concentration–health response relationships. Nitric oxide (NO) emissions, which usually account for 90–95% of NO_x emissions in traffic (WHO, 2005), are rapidly converted into NO_2 by reaction with ozone and OH^- radicals. Ambient concentrations of NO and NO_2 vary with distance from traffic and other factors, e.g., background ozone and NO_2 concentrations, sunlight and dispersion conditions (HEI, 2010). In this study, NO_2 concentrations were predicted using an empirical model recommended by the UK Department for Environment, Food and Rural Affairs (2003).

RISK CHARACTERIZATION

Health risks were calculated by linking estimated exposures to the relevant concentration–response relationships from the literature. These relationships were assumed to hold for traffic-related air pollutants as indicated by NO_2, and for both congestion and congestion-free conditions, which can be justified if the pollutant mixtures associated with these conditions are similar. Health outcomes of interest and available in the literature include short term morbidity, which represents emergency doctor visits and hospital admissions (EDA), and long term mortality. Both short- and long-term endpoints were selected, based on the strongest concentrations–response relationships in the literature as given by US Environmental Projection Agency (EPA) (2008). Specifically, risks were estimated using exposures and the concentration–response intervals of 0.5–5.3% and 0–14.8% per 10 μg m^{-3} NO_2 concentration increase for EDA and all-cause mortality, respectively. These intervals represent the ranges of the mean estimates from different studies, and not statistical confidence intervals from a meta-analysis. EPA (2008) states that confidence intervals cannot be established since the underlying studies used different models, e.g., single and multi-pollutant models, different covariates, different cohorts, some studies only consider one age group, and other differences.

The incremental risks of increases in traffic volume were derived by dividing the differences of the risks corresponding to nearby traffic volumes by the differences of these traffic volumes. They represent the change (e.g., increase) in risk for an individual per each additional vehicle at a specific traffic volume. Thus, the incremental risk is the marginal risk for an individual given changes in traffic volume. The analysis addressed risks for individuals in traffic-related microenvironments, e.g., in vehicles and near major roads. Incremental risks might also change for populations in other environments due to emissions of primary pollutants, e.g., carbon monoxide and NO_2, as well as the formation of secondary pollutants, e.g., ozone promoted by NO_2 emissions.

2.4 By G.Titos and H.Lyamani etc.

EVALUATION OF THE IMPACT OF TRANSPORTATION CHANGES ON AIR QUALITY

Transport regulation at local level for the abatement of air pollution has gained significant traction in the EU. In this work, we analyze the effect of different transportation changes on air quality in two similarly sized cities: Granada (Spain) and Ljubljana (Slovenia). Several air pollutants were measured at both sites before and after the implementation of the changes. In Ljubljana, a 72% reduction of local black carbon (BC), from 5.6 to 1.6 µg/m3, was observed after the restriction was implemented. In Granada, statistically significant reductions of 1.3 µg/m3 (37%) in BC and of 15 µg/m3 (33%) in PM10 concentrations were observed after the public transportation re-organization. However, the improvement observed in air quality was very local since other areas of the cities did not improve significantly. We show that closing streets to private traffic, renewal of the bus fleet and re-organization of the public transportation significantly benefit air quality.

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Atmospheric pollution represents a risk factor for respiratory and cardiovascular diseases and for cancer (e.g. Pope and Dockery, 2006). Traffic emissions are of particular concern in urban areas and their surroundings, since traffic-related pollutants have been associated with overall mortality increase (e.g. Hoek et al., 2000), lung cancer risk (e.g. Beelen et al., 2008), and worsening of respiratory health (e.g. Brauer et al., 2002).

Among traffic-related pollutants, black carbon (BC) has become a matter of concern during the past years. Aerosolized black carbon is a primary product of incomplete combustion of carbonaceous fuels. In particular, diesel engines in the transportation sector are the major source of black carbon in many European urban areas (e.g. Hamilton and Mansfield, 1991, Pakkanen et al., 2000). The emissions from these engines depend on the efficiency of combustion as well as on the amount and type of the consumed fuels, and on the exhaust treatment (e.g.Wehner et al., 1999). Previous studies have shown a proportional relationship between ambient BC concentrations and amount of traffic emissions (Hamilton and Mansfield, 1991, Watson et al., 1994, Pakkanen et al., 2000, Reche et al., 2011). Reche et al. (2011) showed that variations of particulate matter and particle number concentrations do not always reflect the variation of the impact of road traffic emissions on urban aerosols. However, BC concentrations vary proportionally with those of traffic related gaseous pollutants, such as CO, NO_2 and NO (Reche et al., 2011). Therefore, according to these authors, BC can be considered a suitable proxy to quantify changes in road traffic emissions because it is primary and directly emitted by vehicles. Due to the relatively short atmospheric lifetime of BC particles, controlling their emissions can be a quick way to improve air quality and hence reduce the effect of particulate air pollution on public health (e.g. Jacobson, 2002).

In many large cities of Europe standard air quality limit values of particulate matter (PM) and gaseous pollutants are exceeded. Emissions from road traffic are frequently reported to be the major cause of such exceedances (EEA, 2010). To reduce the number of exceedances, and with the aim of meeting the European regulation (2008/50/EC), a large number of air quality plans, most of them focusing on traffic emissions, have been implemented in the last decade. Despite this implementation, exceedances of the PM concentrations are still observed in many cities. Reche et al. (2011) and Janssen et al. (2011) pointed out that a reason for that could be an inappropriate metric for quantifying the impact of these plans on air quality and suggest that the regulation of BC along with PM_{10} will be appropriate. Current air quality action plans have a strong emphasis on traffic regulation and involve policies such as encouragement of public transportation usage, ring road utilization, traffic flow improvement, speed limit reduction and implementation of low emission zones (LEZs, www.lowemissionzones.eu). However, there is very little evidence of the effectiveness of these local policies in reducing air pollution and ultimately improving public health. From the cost-effective point of view, evaluation of these policies is of interest, as questions arise whether they are worth pursuing. Previous studies have investigated the effect of different air quality action plans in urban areas. Based on a three days campaign, Invernizzi et al. (2011) found that the restricted area in Milan (ECOPASS) has considerably lower BC concentrations than regular traffic areas but concentrations of PM_{10}, $PM_{2.5}$, and PM_1 did not change significantly. Panteliadis et al. (2014) observed a significant decrease in traffic-related pollutants concentrations in a LEZ in Amsterdam, with the larger decrease observed for BC concentrations. Boogaard et al. (2012) investigated the effect of the implementation of LEZs on air quality in various Dutch cities. These authors reported that LEZ policies directed at old heavy duty vehicles (trucks) did not substantially change concentrations of traffic-related pollutants, mainly because old trucks constituted only a small part of the average fleet. Cyrys et al. (2014) observed a 10% decrease in PM_{10} concentrations after the LEZ implementation in Cologne, Berlin, and Munich. Fensterer et al. (2014) also report a 10% reduction in PM_{10} concentrations after the LEZ implementation in Munich. Also in Munich, Qadir et al. (2013) concluded that there was a positive effect of implementation of LEZ on the reduction of organic particles concentrations. Furthermore, Qadir et al. (2013) found a reduction of 60% in the contribution of traffic sources to $PM_{2.5}$ after the LEZ implementation. Gramsch et al. (2013) investigated the extent of which the re-engineered public transportation system in Santiago de Chile affected BC concentrations. The transportation system in Santiago de Chile saw a decrease in total number of buses and a reduced overlap of bus routes. The results of Gramsch et al. (2013) indicated that a more significant reduction in BC concentrations occurred when the total amount of vehicles and not only the number of buses was reduced.

Recently, the municipalities of two similarly sized cities Granada (Spain) and Ljubljana (Slovenia) carried out abatement measures with the aim of reducing particulate and gaseous air pollution from traffic. In Ljubljana, a major street through the city center was closed, allowing only public bus and taxi traffic. In Granada, where a similar restriction was implemented in the past, the public transportation system was significantly reorganized. The new scheme reduces overlap between bus lines in the city center and introduces brand-new buses with higher passenger capacity and lower emissions. The aim of this work is to evaluate to what extent these changes positively impact the air quality of both cities.

METHODOLOGY

CONTEXT FOR THE STUDY

The analysis was conducted in the cities of Granada and Ljubljana. Both are of a similar size and lie in basins.Ljubljana, the capital of Slovenia, is a city with 285,000 inhabitants.

It lies in a well populated basin featuring frequent winter inversions, and PM_{10} concentrations have regularly exceeded the regulated number of days per year (Directive, 2008/50/EC) in the past 5 years in several measurement sites in the city (SEA, 2010, SEA, 2011, SEA, 2012, SEA, 2013, SEA, 2014). In addition to road traffic, biomass burning for heating purposes constitutes an additional source of pollutants during the cold season. The population of the Ljubljana conurbation is estimated to be around 500,000, with 71% of the travel to work being conducted with a car (Pelko et al., 2010). Previous research (Ogrin, 2007) has identified a NO_x air pollution hotspot in the city center, a street-canyon section of Slovenska Street. The Ljubljana municipality has closed a 400 m section of Slovenska Street on 22 September 2013 for all traffic except public buses and taxis as an abatement measure (Fig. 1). Following this date, the street had been reconstructed with works ending on 28 September. There are 15 public bus lines through this section of Slovenska Street. The frequency of the buses varies though the day with up to 6 buses from a single line passing this section each hour. Neither the number of lines nor the number of buses in this section of Slovenska Street had changed with the implementation of the traffic restricted zone.

Granada is medium-sized city located in south-eastern Spain whose population is between 240,000 and 350,000 inhabitants (depending on whether the entire metropolitan area is considered). The city is surrounded by mountains with elevations varying from 1000 to 3500 m.a.s.l. The bowl-like topography of Granada basin favors temperature inversions and dominance of weak wind speeds. This, in combination with pollutant emissions can lead to a large accumulation of particles near the surface (e.g. Lyamani et al., 2012). There are no large industries in the surroundings and the main aerosol local source is road traffic (Titos et al., 2014). According to information from Spanish authorities (www.dgt.es), the total vehicle fleet at Granada was 628,244 in 2013 and about 57% of them were vehicles with diesel engines. Traffic related sources contribute around 60% to the fine fraction (PM_1) mass concentration in Granada and their contribution to PM is higher in winter than in summer (Titos et al., 2014). From October to March, domestic heating (based on fuel oil combustion) represents an additional important source of aerosols. As many European cities, Granada failed to comply with the air quality European limits for particulate matter and nitrogen dioxide, especially in traffic influenced monitoring stations (e.g. Vida-Manzano et al., 2008, Bravo-Aranda et al., 2010). In an effort to decrease air pollution, the municipality of Granada implemented a new bus transportation system on 29 June 2014. The new scheme has reduced the overlap between bus lines in downtown and introduced brand-new buses with higher passenger capacity and lower emissions. The overlap between bus lines was reduced by replacing around 10 bus lines with identical routes when crossing the Granada downtown (from Caleta to Palacio de Congresos) by a single bus line (named Linea de Alta Capacidad, LAC). Fig. 2a shows that there were originally around 10 bus lines going through Gran Vía (shown in a box in Fig. 2) which were replaced on 29 June 2014 by a single line, LAC, as can be seen in Fig. 2b. Only two old bus lines (C1 and C2) still transit Gran Vía together with LAC (Fig. 2b), because these lines use small buses that are able to traverse the narrow streets of the historical center. New buses in the LAC line are very frequent, about a 3–5 min wait for passengers at any given moment in contrast to the passage frequency of 15 min of the old buses. With this new all-purpose central line, two new bus hubs have been placed at Palacio de Congresos and Caleta (marked as black stars in Fig. 2). The new fleet in the LAC line consists of 15 Mercedes-Benz CapaCity buses (model C628.486) that use diesel fuel and comply with the EURO V regulation. These new buses only operate in the LAC line which goes from Caleta to Palacio de Congresos (Fig. 2b). The other lines still operated by old buses of varying ages (6 years old in average). Most of these old buses use diesel fuel and only few ones use biodiesel fuel. Unfortunately, traffic data are not available. However, taking into account the number of buses in each line and their frequency we have estimated a 50% reduction in the number of buses passing through Gran Vía. This reduction in the number of buses results in significant reduction in traffic congestion in downtown, especially in Gran Vía Street. In this study, we analyze ambient pollutant concentrations measured at three sites in Granada (marked as red squares in Fig. 2b) and three sites in Ljubljana (marked as red circles in Fig. 1) before and after the implementation of the new transportation scheme to determine whether these measures have had any effect on air quality and to what extent. The measurement sites and the instrumentation used are described in the following sections.

DISCUSSION AND CONCLUSIONS

The traffic restriction implemented in Slovenska Street in Ljubljana is similar to the restriction implemented in Gran Via, Granada, several years ago when the traffic to private cars was limited. The effect of traffic restriction on air quality in the center of Ljubljana was evaluated using black carbon measurements. The local contribution to BC was determined in Ljubljana by subtracting the urban background concentration from the measurements at restriction zone and bypass road. The results show a 72% reduction of the local BC pollution at the restriction site and almost no change at the bypass road. The traffic restriction is limited in its scope as only a 400 m long section of Slovenska Street has been closed to cars. The effect of the restriction is therefore larger than one might expect from its length. In Granada, a new transportation scheme was implemented in the city center, which involves a reduction in the number of buses transiting Gran Via and a completely re-engineered bus fleet in this street. A statistically significant decrease in air pollutants concentrations (BC and PM_{10}) was observed at Gran Vía after the implementation of the new public transportation system. The change in the public transportation system resulted in a 37% (1.3 $\mu g/m^3$) and 33% (15 $\mu g/m^3$) decrease in BC and PM_{10} concentrations at Gran Via, respectively. In addition, measurements of PM_{10}, BC and gaseous pollutants close to one of the new bus interchange stations showed no changes in PM_{10}, SO_2 and NO_2 mass concentrations and a slight increase of 2.2% on CO concentrations after the implementation of new public transportation system. At the background station, CEAMA, which was not directly affected by the changes in the public transportation, BC mass concentrations did not change significantly.

Since the change in the public transportation occurred in a period that could be influenced by a decrease in the number of private cars due to summer vacation we have investigated the BC concentrations measured at CEAMA for the same time period of the three previous years (2011, 2012 and 2013). Over these past years, BC concentrations did not change significantly during the transition from June to July. With this in mind and taking into account that GV station is located in an area where private transportation is restricted except during the evening, the decrease observed in BC and PM_{10} concentrations at Gran Vía street can be attributed to the change in the public transportation system. Since the new buses as old ones run on diesel fuel, the improvement observed on air quality in Gran Vía might be due to the reduction in the number of buses passing by this street and/or to the new technology implemented in the LAC buses with lower emissions. A similar modification in the public transportation system was implemented in Santiago de Chile (Transantiago) in July 2006. Gramsch et al. (2013) studied the effect of this change on BC concentrations along four roads directly affected by the modification of the transport system by analyzing the BC concentrations during July 2005 and July 2007. Gramsch et al. (2013) reported a statistical significant BC reduction in one of the streets, an increase in other one and no changes in the other two streets. These authors concluded that the decrease observed was more likely due to a decrease in the total number of cars, but not to changes in the public transportation system. In our study, since Gran Vía was already a street restricted to private cars, the decrease observed in BC and PM_{10} was likely due to the re-engineered bus fleet and the reduction in the number of buses passing through Gran Vía.

Other measures to improve air quality have been implemented over the last decade at many European cities. These actions are often unpopular and debatable and their effectiveness is still somewhat unquantified. Low Emission Zones (LEZs) have become a very common measure to reduce air quality degradation in Europe. Panteliadis et al. (2014) reported a 13% and 7.7% reduction in elemental carbon, EC, concentrations after the implementation of a LEZ in Amsterdam. Rapaport (2002) and Carslaw and Beevers (2002) reported that the implementation of the LEZ in Stockholm and London, respectively, did not resulted in any improvement in NO_2 concentrations. On the other hand, Invernizzi et al. (2011) reported a decrease of black carbon (47%) and no changes in PM_{10} in the Ecopass Zone in Milan in comparison to a non-restricted area during a three days campaign. Davis (2008) investigated the LEZ in Mexico City and showed no evidence of air quality improvement, mostly because inhabitants circumvented the restrictions. Our study shows an overwhelming 72% reduction in BC due to limiting traffic allowing only public transport and taxis in Ljubljana and a decrease above 30% in BC and PM_{10} in the street directly affected by the modification of the public transportation in Granada. Thus, appropriate transportation policies can importantly improve the air quality of the city. Limiting traffic to public transport only and reducing overlap between public transport lines with a concurrent renewal of the fleet can reduce the primary air pollution by up to 80%.

2.5 By Pieter Jan Kole, Ansje J. Löhr, Frank G. A. J. Van Belleghem and Ad M. J. Ragas

WEAR AND TEAR OF TYRES: A STEALTHY SOURCE OF MICROPLASTICS IN THE ENVIRONMENT

Wear and tear from tyres significantly contributes to the flow of (micro-)plastics into the environment. This paper compiles the fragmented knowledge on tyre wear and tear characteristics, amounts of particles emitted, pathways in the environment, and the possible effects on humans. The estimated per capita emission ranges from 0.23 to 4.7 kg/year, with a global average of 0.81 kg/year. The emissions from car tyres (100%) are substantially higher than those of other sources of microplastics, e.g., airplane tyres (2%), artificial turf (12–50%), brake wear (8%) and road markings (5%). Emissions and pathways depend on local factors like road type or sewage systems. The relative contribution of tyre wear and tear to the total global amount of plastics ending up in our oceans is estimated to be 5–10%. In air, 3–7% of the particulate matter ($PM_{2.5}$) is estimated to consist of tyre wear and tear, indicating that it may contribute to the global health burden of air pollution which has been projected by the World Health Organization (WHO) at 3 million deaths in 2012. The wear and tear also enters our food chain, but further research is needed to assess human health risks. It is concluded here that tyre wear and tear is a stealthy source of microplastics in our environment, which can only be addressed effectively if awareness increases, knowledge gaps on quantities and effects are being closed, and creative technical solutions are being sought. This requires a global effort from all stakeholders; consumers, regulators, industry and researchers alike.

The global production of thermoplastics has grown rapidly since the start of its large-scale production around the 1950s, reaching 322 million tonnes/year in 2015 . The different varieties of polymers produced have unique characteristics when compared to traditional materials, in particular in terms of durability, production costs, weight, strength, flexibility and limited electric conductivity. As a result, plastics are used increasingly in many sectors such as construction, transportation, household goods and packaging. Nowadays, the market of thermoplastics is dominated by four main classes of plastics, being polyethylene (PE; 73 million tonnes in 2010), polyethylene terephthalate (PET; 53 million tonnes in 2010), polypropylene (PP; 50 million tonnes in 2010) and polyvinyl chloride (PVC; 35 million tonnes in 2010). Besides thermoplastics, rubber is also considered a class of plastic. The 26.9 million tonnes rubber market sells two main classes: natural rubber (12.3 million tonnes in 2016) and synthetic rubber (14.6 million tonnes in 2016).

As a result of the growing production of plastics, their widespread use and the mismanagement of waste, the amount of plastics in the environment is increasing rapidly. It has been estimated that between 4.8 and 12.7 million metric tonnes of plastic ended up in the ocean in the year 2010. Even on the beaches of remote areas such as Henderson Island, an uninhabited island in the South Pacific, large amounts of plastics have been detected .Pollution of the environment with plastics is recognized as a serious global threat because it can negatively affect human health, aquatic organisms, as well as the economy. Plastics end up in the ocean either as large pieces, macro plastics, micro plastics ($\leq$5 mm) or nanoplastics ($\leq$100 nm) [9]. The sources of both macro plastics and micro plastics are many and diverse. However, the implications for ecological and human health and the impact on our economy are still unknown. More research is needed to pinpoint these sources in order to enable the identification and implementation of cost-effective measures to reduce plastic pollution sources.

In this paper, the whole family of synthetic polymers, including modified natural bio-polymers, is considered to be a potential source of pollution. From an environmental point of view, thermoplastics, thermosets and elastomers all are potential sources of micro plastics.

Car tyres release wear particles through mechanical abrasion. Several studies have suggested that wear and tear from car tyres is an important source of micro plastics in the environment. However, many questions remain. Which factors determine the release of wear and tear from car tyres, and how much is actually being released? What is the fate of these particles, once released into the environment? What impacts do the particles have on human health and on aquatic ecosystems? And, how can the emission of wear and tear from car tyres be reduced effectively? Although some of these issues have been addressed in specific scientific studies, the available knowledge is largely fragmented and often localized.

The aim of the present review is to bring together the fragmented knowledge on wear and tear of car tyres emitted into the environment and provide a global assessment of the implications for human health of this emerging source of micro plastics. The review:

(1) describes the characteristics of the tyre and its wear and tear;

(2) Summaries the amount released into the environment in different countries;

(3) Describes the different pathways of the wear and tear into the environment;

(4) Presents an estimate of the total amount of tyre wear and tear to total emissions of micro plastics to the oceans;

(5) Discusses possible effects on humans, and

(6) Evaluates mitigation options. The numbers calculated in the present paper are rough estimates and should be considered as such. These numbers have been produced in a first attempt to explore the extent of the problem.

EMISSIONS

1. Tyres

When driving a vehicle, particles are being released into the environment from its tyres. These section summaries the available knowledge on the composition of tyres, the particle generation process and the sizes of the particles generated.

2. Tyre Composition

Tyres were initially only made of natural rubber, often derived from the Brazilian rubber tree (Hevea brasiliensis). Nowadays, a mixture of natural and synthetic rubbers is being used. Synthetic rubbers are polymers made from petroleum. About 1–4% of sulphur is added in order to vulcanise the rubber compounds, transforming them into highly elastic material, in which 1% zinc oxide serves as a catalyst. Furthermore, 22–40% carbon black is added as filler and to make the tyre UV-resistant. In recent years, carbon is sometimes partially replaced by silica (nanoscale glass balls) [14]. Silica reduces the road resistance but it's more difficult to form a proper bond to the rubber. In a final stage, oil is added to make the tyre less stiff and to improve its wet grip performance. Traditionally, the oil used is aromatic because of its low price and its compatibility with rubber.

The specific gravity of a micro plastic influences the floating ability of the particle in water. According to the United States (US) Federal Highway Administration, the specific gravity of tyre rubber is approximately 1.15. Banerjee and colleagues mention a specific gravity of 1.17, while Dumne mentions a specific gravity of 1.18. The average density of ocean waters at the surface is 1.025.

3. Particle Generation

The release of wear and tear from tyres results from the contact between the road surface and the tyre. The amount and size of the particles released depend on factors such as climate (temperature), composition and structure of the tyre, the road surface, driving speed and style and the nature of the contact (e.g., rolling versus slipping)

The contact between tyre and road surface causes shear and heat in the tyre; both of these processes result in the generation of wear particles. Shear forces result in the emission of comparatively large tyre particles. Heat accumulates, creating hot spots on the tyre's surface, reaching temperatures that cause the volatile content to evaporate, which results in the subsequent release of relatively small, submicrometer, particles. Additional to the tyre wear and tear, the shear forces and the heat in the rubber also cause road wear particles to stick to the rubber wear and tear. Some researchers report that most tyre wear and tear is conglomerates with road wear.

4. Size of Wear and Tear

The tyre wear and tear particle size (distribution) is dependent on many factors such as type of pavement, temperature, speed, age and composition of the tyre. However, the particles sizes reported in any particular experimental study also depend on the experimental setup. Particles can be collected while driving a car on the road or in laboratory tests with road simulators. The samples collected typically consist of a mixture of tyre particles and particles from the road or simulator surface. Airborne particles are typically drawn by suction and measured real-time, while the coarser particles are typically collected after the test run, e.g., from the contact surface or from its direct environment like the road run off. By adjusting the suction flow, a range of particle sizes can be collected. The size ranges reported in any particular study also depend on the technical specifications of the equipment and analytical techniques used.

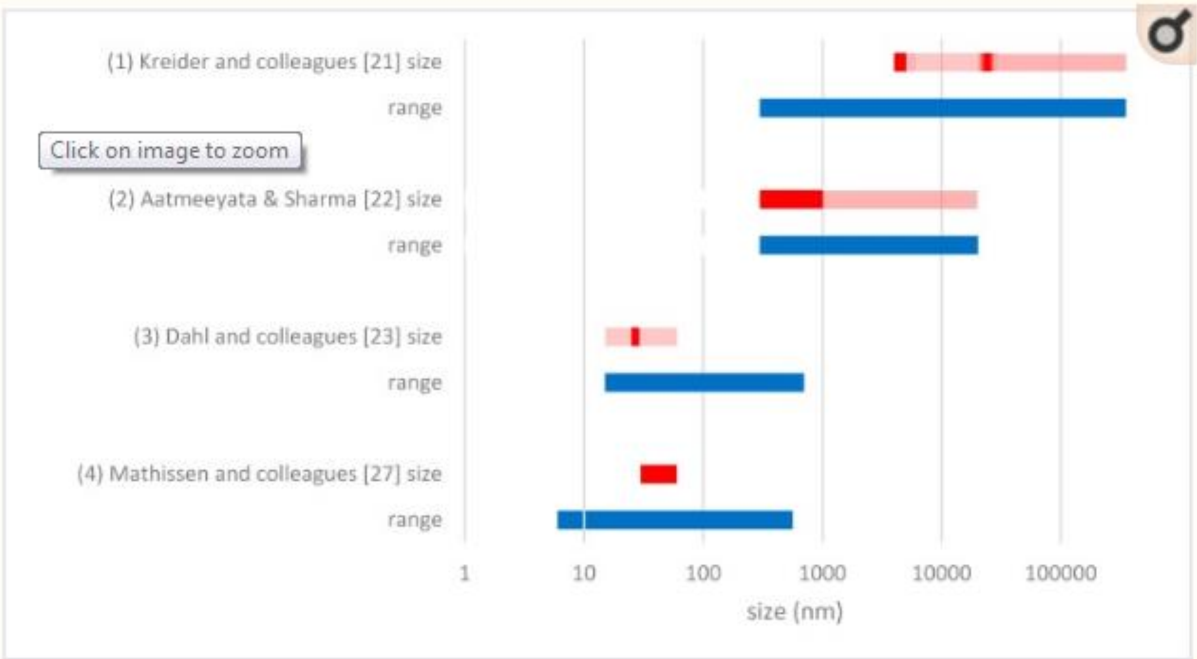


Figure 1

Size ranges of tyre wear and tear covered (blue bars) and detected (red bars) in four different studies (see text). Dark red suggests the size of the major number of particles [21,22,23,27].

Study 1 by Kreider and colleagues was on the size of wear and tear of car tyres and the interaction with pavement in a road simulator using asphalt concrete pavement, i.e., a mixture of sand, gravel, crushed stone and recycled concrete bound together with asphalt. Their sampling device, consisting of a suction system located close to the tyre's contact surface, only collected particles >0.3 µm; an upper size limit was not specified. They found particles sizes ranging from 4 to 350 µm with most particles having a size around 5 µm and 25 µm.

Study 2 by Aatmeeyata and colleagues as on wear and tear on a specially constructed road simulator using concrete pavement, i.e., a mixture of sand and granite stone bound together with cement. The air was withdrawn by suction and continuously analysed by a particle size analyser on particle number and size within a 0.3 to 20 μm range. Samples were also taken from the walls and the equipment afterwards, which were considered to represent run-off material. The emission of particulate matter with particles of 10 μm or less (PM_{10}) to ambient air was compared to the total weight of the run-off of particles, and was found to be less than 0.1% by weight. Almost 50% of the PM_{10} mass had a size between 0.3 and 1 μm. No size distribution was given on the course particles, i.e., particles $>PM_{10}$.

In study 3 Dahl and colleagues tested tyres in a road simulator of the Swedish National Road and Transport Research Institute. They focused on fine air particles in the size range of 15–700 nm from both road and tyre wear and tear. The measured wear and tear was between 15 nm and 50 nm and had a distinct mean particle diameter of 27 nm. Based on transmission electron microscopy studies of the collected ultrafine wear and tear particles and on-line thermal treatment using a thermodesorber, they concluded that the particles consisted most likely of mineral oils from the softening filler and fragments of carbon black. Carbon black, which is added to tyres as a filler material and to make them UV resistant, is thought to form aggregates of 1–100 μm held together by Van der Waals bonds. The particles detected by Dahl and colleagues fall in the size ranges of the carbon black that is added to the tyres during the production process. For example, Continental Carbon produces carbon black grade N120 with a primary particle size of 1–10 nm, grade N234 of 20–25 nm and grades N330, N339 and N351 of 26–30 nm.

In study 4 Mathissen and colleagues measured air borne particle concentrations inside the car's wheel housing while driving on an existing road. The car drove on asphalt concrete roads and the instrument was capable of measuring particles from 6 to 562 nm. When braking, accelerating and cornering, particles were measured with sizes between 30 and 60 nm. Normal driving did not result in an increase in particle number concentration.

Based on these four studies, it can be concluded that literature data show a considerable variation in the size distribution of tyre wear and tear particles. Interpretation of the experimental results is furthermore complicated by the use of different metrics (e.g., particle mass versus particle numbers), analytical difficulties to separate tyre from road particles, and the enormous variety in experimental conditions and analytical equipment. More research is needed to create a more univocal picture of the numbers and sizes of the particles generated under realistic driving conditions. Nonetheless, all studies show that tyre wear and tear will be a source of micro plastics in the environment not to be ignored, covering the range from 10 nm to several 100 µm.

NATIONAL ESTIMATES ON THE AMOUNT OF WEAR AND TEAR FROM TYRES

Two different approaches are typically used to estimate the amount of wear and tear from tyres. One approach uses emission factors per vehicle-km multiplied by the total mileage, and the other uses the number of tyres multiplied by the weight loss of these tyres during use. Tyres in Europe must be collected after use and processed by the manufacturer or importer. Therefore, almost all used tyres will be handed in and, hence, the numbers are known.

We performed a literature search to collate national estimates on the amount of wear and tear from tyres, resulting in estimates for eight countries. Apart from Japan, the available studies on wear and tear are dominated by Western European countries. In Sweden, Norway, Denmark and Germany both emission estimation approaches have been used. The tyre number weight loss method has been used in the United Kingdom, Italy and Japan. In The Netherlands the emission factor per vehicle-km approach was used. To obtain a global estimate on the amount of wear and tear emitted into the environment, data on mileage and number of vehicles were gathered for countries for which national emission estimates were lacking. These data were found for China, India, Australia, the USA and Brazil. The emission factor method based on data from Japan and a number of European countries was used to estimate the national emission of tyre wear and tear in these countries. In this way, we calculated emissions from countries on all continents, except Africa, covering half the world's population. Here, we first discuss the emissions factor per country, followed by the estimation of the total wear and tear on our planet.

THE NETHERLANDS

Kole and colleagues estimated the emissions of wear and tear from car tyres in The

Netherlands. They used emission factors per vehicle category and mileage data, provided by the institutes Deltares and TNO, The Netherlands Organization for applied scientific research.

Calculation of the amount of tyre wear and tear in The Netherlands by Kole and colleagues [13].

	Wear mg/km	Mileage in 2012 Built-Up Area ($\times 10^6$ km)	Mileage in 2012 Rural Roads ($\times 10^6$ km)	Mileage in 2012 Motorways ($\times 10^6$ km)	Total Wear 2012 tonnes/year	Corrected for 95% Trapped in Motorways
Passenger car	100	20,876	36,472	45,349	10,270	6263
Articulated lorry	495	274	867	3418	2257	762
Lorry	600	406	525	1434	1419	659
Other					1084	1084
Total					15,030	8768

Of the Dutch motorways, 95% is paved with very open asphalt concrete, consisting of rock, sand, filler and bitumen. Contrary to standard asphalt, very open asphalt concrete has 15% to 25% hollow space and is used because of its capabilities to drain rainwater and to reduce noise. Of the wear and tear of tyres, 95% is considered to be captured in the pores of this very open asphalt concrete to remain trapped . To maintain the draining, reducing and trapping capacities of the very open asphalt concrete, its pores have to be cleaned approximately twice per year. The washing water is processed and the dirt disposed properly. If the total amount listed is corrected for the amount trapped in very open asphalt concrete on motorways, still 8768 tonnes will end up in the environment.

Verschoor and colleagues calculated the wear and tear using the specific emission factors per vehicle-km method for urban, rural and highway roads. The capturing of wear and tear in the pores of the very open asphalt concrete was taken into consideration. The total estimated amount of wear and tear for the three road types was 17,300 tonnes/year. If we take the 95% capturing in the very open asphalt concrete into consideration, and subtract this from the amount of 17,300 tonnes/year we end up with 8900 tonnes/year that is released into the environment. The average of the estimated amounts (8768 and 8900 tonnes) is 8834 tonnes/year.

Calculation of the amount of tyre wear and tear for urban, rural and highway roads in The Netherlands by Verschoor and colleagues [31].

	Urban Roads			Rural Roads			Highway Roads		
	Wear mg/km	Total Mileage in 2012 ($\times 10^6$ km)	Total Wear 2012 tonnes/year	Wear mg/km	Total Mileage in 2012 ($\times 10^6$ km)	Total Wear 2012 tonnes/year	Wear (mg/km)	Total Mileage in 2012 ($\times 10^6$ km)	Total Wear 2012 tonnes/year
Moped	13	1608	21	9	690	6	10	0	0
Motorcycle	60	393	24	39	1100	43	47	1089	51
Passenger car	132	20,959	2767	85	36,622	3113	104	45,541	4736
Van	159	2670	425	102	5331	544	125	8649	1081
Lorry	850	412	350	546	533	291	668	1453	971
Truck	658	277	182	423	876	371	517	3455	1786
Bus	415	354	147	267	207	55	326	82	27
Special vehicle light	159	22	3	102	44	4	125	72	9
Special vehicle heavy	850	59	50	546	76	41	668	210	140
Total		26,754	**3969**		45,479	**4468**		60,551	**8801**

SWEDEN

Magnusson and colleagues estimated the wear and tear in Sweden based on emission per vehicle kilometer. In Sweden, a special emission pathway exists; snow is taken from the streets and dumped into the waters. The snow will contain particles already present on the pavement even before precipitation started. Stockholm alone has permission to dump 800,000 m3 of snow annually from the streets into the waters around the city. The Swedish National Chemicals Inspectorate estimated the amount of wear and tear using the total weight of the tyres consumed in Sweden and 17% weight loss during use On average the annual amount is (13,238 + 10,000)/2 = 11,619 tonnes. Here the two approaches, emission factors per vehicle-km multiplied by the total mileage, and number of tyres multiplied by the weight loss of these tyres during use provides similar results.

Calculation of the amount of tyre wear and tear in Sweden [32,33].

	Based on Annual Mileage: Magnusson and Colleagues [32]			Based on Tyres Sold: Swedish National Chemicals Inspectorate [33]		
	Wear mg/km	Total Mileage in 2012 ($\times 10^6$ km)	Total Wear 2012 Tonnes/Year	Mass of Tyres Consumed Annually kg	Weight Loss (17%) kg	Total Wear 2002 tonnes/year
Passenger car	50	62,940	3147			
Bus/lorry	700	14,416	10,091			
Total		77,356	**13,238**	60,000,000	10,000,000	**10,000**

NORWAY

Sundt and colleagues used several methods to calculate the amount of wear and tear in Norway. First, they used data by the United Nations Economic Commission for Europe (UNECE) on tyre wear and tear per km, based on Russian research. UNECE advises to use an emission factor of 0.033 g/tyre km for passenger cars and 0.178 g/tyre km for commercial vehicles. In their calculations, Sundt and colleagues assumed all vehicles to have four wheels Second Sundt and colleagues calculated the wear and tear using the wear/km for passenger cars by Luhana and colleagues , who used an emission factor of 0.1 g/vehicle km.

Third Sundt and colleagues estimated the amount of wear and tear in Norway using figures by Norsk Dekkretur (Norwegian Tyre Recycling) on disposed tyres, assuming tyres will wear 12.5% on average before being disposed. Norsk Dekkretur organizes the collection and recycling of disposed tyres in Norway.

The estimated emissions for Norway vary from 6560 to 9571 tonnes/year, with an average of 7884 tonnes/year from all the studies. As the outcomes calculated by emission/km and by disposed tyre weight loss are relatively tantamount, they are considered to be reliable. As mentioned the differences between the two calculation approaches could be used to improve the figures. Here the disposed tyres approach gives a higher wear and tear number. Contrary to the results the weight loss in Norway was assumed to be 12.5%; in Sweden 17%.

Calculation of the amount of tyre wear and tear in Norway [10].

	Based on Annual Mileage: Sundt and Colleagues [10] Using United Nations Economic Commission for Europe (UNECE) Data			Based on Annual Mileage: Sundt and Colleagues [10] Using Data by Luhana and Colleagues [34]			Based on Disposed Tyres: Sundt and Colleagues [10]			
	Wear mg/km	Total Mileage in 2013 ($\times 10^6$ km)	Total Wear 2013 tonnes/year	Wear mg/km	Total Mileage in 2013 ($\times 10^6$ km)	Total Wear 2013 tonnes/year	Weight of Disposed Tyres	Times Re-Treaded	Weight Loss from New	Total Wear 2013 tonnes/year
Passenger car	132	30,000	3960	100	30,000	3000	42,000	0	12.5%	6000
Heavy transport	712	5000	3560	712	5000	3560	10,000	2.5	12.5%	3571
Total		35,000	**7520**		35,000	**6560**	52,000			**9571**

DENMARK

In Denmark Lassen and colleagues used two different sources of emission factors to estimate the amount of wear and tear. First, they used the emission factors advised by the United Nations Economic Commission for Europe (UNECE); 0.033 g/km per passenger car tyre, 0.051 g/km per light commercial vehicle tyre and 0.178 g/km per other commercial vehicle tyre. Using these emission factors and considering 35,800, 7400 and 2000 million kilometres for passenger, light commercial and other commercial cars, respectively, the total emission of tyre wear and tear was estimated to be 1915 tonnes/year . However, instead of being quoted by car, the UNECE data are given per tyre. After consulting Lassen we recalculated the emissions considering an average of four tyres per vehicle, as done by Sundt and colleagues, the total emission is 7660 tonnes/year Second, Lassen and colleagues also calculated the emission by passenger car using an emission factor of 0.1 g/vehicle km, taken from Luhana and colleagues . In this way the total emission will be 6514 tonnes/year.

Lassen and colleagues also calculated the amount of wear and tear by multiplying the number of tyres sold with the mass difference between new and disposed tyres. The weight loss of new tyres was estimated by several studies to vary between 10% and 15%. Considering the number of tyres completely outworn during the car's life and assuming the car's last set of tyres (i.e., before disposing the car) lost half of what an outworn tyre would lose, their calculations resulted in an estimate of 5400 tonnes/year.

Fauser and colleagues also calculated the wear and tear by the number of consumed tyres multiplied by the average wear per tyre.On average the estimated emissions for Denmark vary from 7660, 6514, 5400 to 7310 tonnes/year, on average 6721 tonnes/year. Here the results of the two emission factors studies provide similar results; but the two studies on sold tyres differ: 5400 and 7310 tonnes/year. In this case further study should provide more insight.

GERMANY

Hillenbrand and colleagues calculated the amount of wear and tear by using an emission per vehicle kilometer. The figures they used are covering mileage for the year 2001 and vehicle numbers for the year 2002. We used the emission per vehicle kilometer data from Hillenbrand and colleagues to estimate the emissions for the year 2013 using data on total mileage from the German Federal Ministry of Transport (Bundesministerium für Verkehr)

In a study commissioned by the German Federal Environment Agency (Umweltbundesamt) on sources of micro plastics, Essel and colleagues discuss two studies, i.e., the calculations by Hillenbrand and colleagues mentioned above and the calculations by the German rubber trade association (Wirtschaftsverband der Deutschen Kautschukindustrie; WDK). The WDK calculated the total annual amount of wear and tear for all vehicle categories to be 60,000 tonnes. Hillenbrand and colleagues calculated 62,570 tonnes for buses, lorries and articulated lorries alone, while the WDK calculated only 17,000 tonnes for these categories. For the category "lorry", Hillenbrand and colleagues [37] used 700 mg of wear per vehicle kilometer, whereas the WDK assumes a wear of 17,000/62,570 × 700 = 190 mg/km. This is about what UNECE advises for calculating a single tyre.

Baumann and Ismeier calculated that the total wear and tear using amounts of wear and tear per tyre kilometre significantly differed from that calculated by UNECE; the wear and tear per tyre for heavy and articulated lorries is assumed to be about the same as for a passenger car Comparing the results by Hillenbrand and colleagues , the WDK and Baumann and Ismeier , the large differences in tyre wear and tear for heavy vehicles are remarkable. WDK and Baumann and Ismeier consider the wear and tear per vehicle km for lorries to be in the same order of magnitude as passenger cars. Considering the fact that experiments in a road simulator have shown a linear relationship between tyre load and tyre wear and tear , the figures by the WDK and Baumann and Ismeier can be considered unconvincing. Considering this, we will only use the 125,188 tonnes/year as calculated by Hillenbrand and colleagues and adapted to 2013 mileage, for further calculations.

UNITED KINGDOM

The United Kingdom (UK) Environment Agency estimated the amount of tyre wear and tear in the year 1996 by the weight of the 37 million tyres disposed that year, to be approximately 380,000 tonnes. The Agency assumed that a car tyre loses approximately 10–20% of its weight during use.

Calculating the amount of wear and tear this way in the year 1996 results in 38,000–76,000 tonnes/year. The tyres from 1996 were probably different from current ones because of technological progress, technological changes and the impact of European Union (EU) legislation. Also, mileage will be different now. In 1996, the UK population was 58 million in 2016 the UK population was 64 million . Assuming the mileage per capita/year did not change, the emission would have grown to approximately 42,000–84,000 tonnes/year, or on average 63,000 tonnes/year.

ITALY

Milani and colleagues considered a 10 kg passenger car tyre to lose about 1.5 kg before being abandoned after 50,000 km; this equals approximately 0.03 g/km. They calculated the total amount of wear in Italy to be 50,000 tonnes/year without providing their calculation on mileage and number of cars.

JAPAN

Yamashita and Yamanaka calculated the wear and tear from tyres in Japan. In 2012 there were 79,882,112 vehicles on the roads in Japan. They considered the mean life expectancy of tyres to be five years. The wear in these 5 years was calculated by considering new tyres to have an 8 mm tread depth and 1.6 mm when disposed.

We recalculated the total emissions for the categories “normal vehicle”, “truck/bus” and “trailer”, as the calculated totals by Yamashita and Yamanaka clearly had typos. The calculations of Yamashita and Yamanaka resulted in an unlikely result of 15 kg/year wear and tear per capita/year. The original values reported by Yamashita and Yamanaka.

We recalculated the totals using the “number vehicles”, “tyres/vehicle” and “cm^3/tyre” as provided by the authors.

According to these figures, in five years, a total of 1,042,442 m^3 have been released from the tyres in Japan alone. The specific gravity of tyre rubber is approximately 1.15 . This equates to an annual wear and tear of 239,762 tonnes/year.

CHINA

For China, no estimate on total tyre wear and tear in the literature was found. However, some relevant input data are available, which, combined with some assumptions, we translated to estimates of tyre wear and tear. The World Health Organization (WHO) provides the number of registered vehicles for the year 2013 . Huo and colleagues provided annual mileage for the categories “cars and 4-wheeled light vehicles”, “motorised 2- and 3-wheelers”, “heavy trucks” and “other” for the year 2009. No data was found on the amount of wear and tear per kilometre in China.

Therefore, the amount of wear and tear per kilometre was taken from the UNECE; 0.033 g/km for cars, 0.051 g/km for light commercial vehicles and 0.178 g/km for commercial vehicles . For 2-wheelers Aatmeeyata and colleagues found 0.0035 g/km. These data are per tyre; for cars, we consider 4 wheels, except for heavy trucks where a conservative 6 wheels were assumed. As 2- and 3-wheelers are not differentiated, 2 wheels per vehicle were assumed.

INDIA

For India, no estimate in the literature was found but, like in the case of China, data to calculate it was available. Again, the WHO provides the number of registered vehicles for the year 2011. The data on annual mileage for the year 2013 was taken from Baidya and Borken-Kleefeld who studied mileage in India, published from the year 1999 up to 2006. They published data for

"Megacities" and for "Rest of India" and we used the average of these two figures. The amount of wear and tear was taken from UNECE. For the category "motorised 2- and 3-wheelers", a conservative emission factor of 0.007 g per vehicle km for 2 wheelers as estimated by Aatmeeyata and colleagues

Calculation of the amount of tyre wear and tear in India [22,35,45,47].

	Number Vehicles [45]	Annual Mileage [47]	Wear and Tear g/km [22,35]	Wear and Tear Tonnes
Cars and 4-wheeled light vehicles	38,338,015	10,275	0.132	51,998
Motorised 2- and 3-wheelers	115,419,175	6600	0.007	5332
Heavy trucks	4,056,885	50,075	1.068	216,963
Buses (light duty trucks)	1,676,503	53,745	0.204	18,381
Total	159,490,578			292,674

GLOBAL PER CAPITA TYRE WEAR AND TEAR

In the previous paragraphs, the amount of tyre wear and tear from cars was estimated for different countries. Table 13 lists the estimates of the amount of wear and tear of car tyres per capita per year. The emission per capita is in the same order of magnitude for all countries, i.e., between 0.23 and 1.9 kg/year, but 4.7 kg/year for the USA.

India has the lowest wear and tear estimate, i.e., 0.23 kg/capita/year, while the USA has the highest, i.e., 4.7 kg/capita/year. The 20-fold difference can partly be explained by the fact that the USA has 0.82 cars per capita, while in India there are 0.13 cars per capita. So the car density in India is only 16% of that in the USA. The amount of wear and tear per vehicle in the USA is 6.8 kg/year compared to 1.8 kg/year for India, a 3.8-fold difference. Americans are leading in wear and tear emissions because they have more vehicles while they also travel longer distances per vehicle, especially with their lorries. In India and China the number of vehicles per capita can explain the low emission per capita per year. In The Netherlands, the capturing of wear and tear in the very open asphalt concrete explains the relatively low emission per capita per year. For

The amount of wear and tear of car tyres per capita per year (Number of capita as per July 2016 [42], Number of cars as per 2013 [52]).

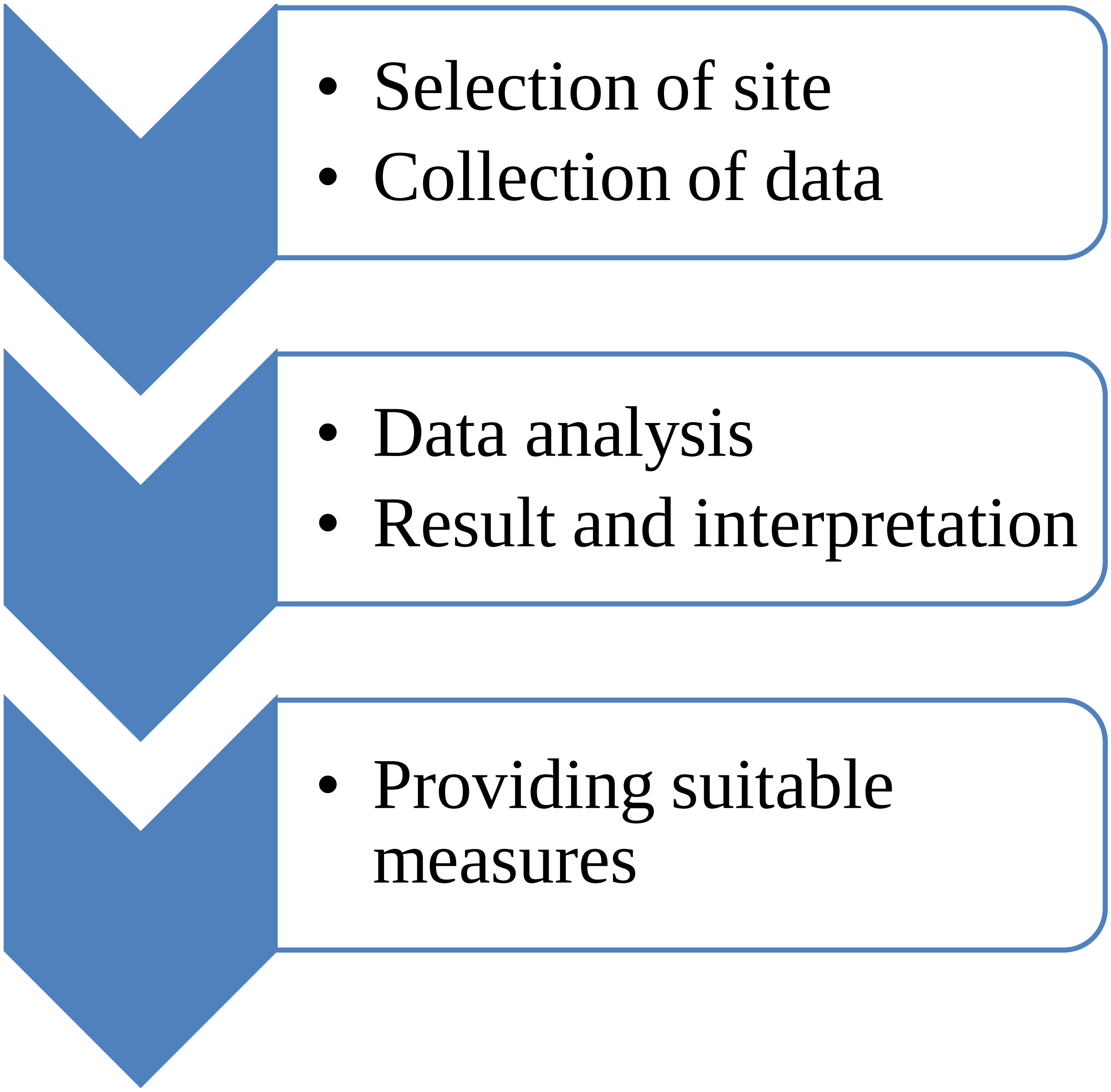
	Number of Capita [42]	Number of Cars [52]	Total Emission from Tyres (tonnes/year)	Emission per Capita/year (kg)
The Netherlands	17,016,967	9,612,273	8834	0.52
Norway	5,265,158	3,671,885	7884	1.5
Sweden	9,880,604	5,755,952	13,238	1.3
Denmark	5,593,785	2,911,147	6721	1.2
Germany	80,722,792	52,391,000	92,594	1.1
United Kingdom	64,430,428	35,582,650	63,000	0.98
Italy	62,007,540	51,269,218	50,000	0.81
Japan	126,702,133	76,763,402	239,762	1.9
China	1,373,541,278	250,138,212	756,240	0.55
India	1,266,883,598	159,490,578	292,674	0.23
Australia	22,992,654	17,180,596	20,000	0.87
USA	323,995,528	265,043,362	1,524,740	4.7
Brazil	205,823,665	81,600,729	294,011	1.4
Total	3,564,856,130	1,011,411,004	3,369,698	0.95

Japan, the assumptions of a five-year tyre lifespan in the calculations, without considering mileage, could be a cause of the high emission per capita per year. For the rest of the countries the estimates are roughly the same; between 0.81 and 1.5 kg/capita/year.

The wear and tear for roughly half of the world's population and 57% of the world's vehicles has been estimated. The total amount of emitted tyre wear and tear from 1,011,411,004 vehicles was estimated to be 3,369,698 tonnes/year. If the mileage from these 1,011,411,004 vehicles is considered representative for all the world's 1,776,136,357 vehicles , the world total amount of emitted tyre wear and tear is

1,776,136,357/1,011,411,004 × 3,369,698 tonnes/year = 5,917,518 tonnes/year. This amount is enough to fill thirty-one of the world's largest container ships, i.e., the 399 m Maersk Triple E with a deadweight tonnage of 194,153 . On a global population of 7,323,187,457 people the amount of emitted tyre dust per person equals 0.81 kg/year.

CHAPTER 3 - METHODOLOGY



3.1 Site Selection

We selected three sites for our project-

- Hazratganj
- Talkatora

- Aliganj

3.1.1 Site Description-

Hazratganj: In hazratganj our site near sahara ganj mall.

Talkatora: It Talkatora our site is Ever ready square.

3.2 Data collection

3.2.1 Vehicular emission data

Note: since it is not possible to accurately calculate the number of vehicles at all sites at same day. so different days are alloted for visiting of different sites. Each site is visited three times by us to calculate average number of vehicles of three days.

Formula for daily traffic=C*F

C= 15 min count

F=multiplier based upon area

36 in urban area; 33 in sub urban area; 27 in rural areas

Average number of vehicles =((data of day 1) + (data of day 2) + (data of day 2))/3

Calculations-

Hazratganj:-

Number of 2 wheelers per day = (19980+20196+20448)/3

= 20208

Number of 4 wheelers per day = (11592+11808+12060)/3

= 11820

Number of 3 wheelers per day = (828+756+936)/3

= 840

Number of truck / buses per day = (180+144+216)/3

= 180

DAY	2 Wheelers	4 Wheelers	3 Wheelers	Trucks / Buses
DAY 1	19980	11592	828	180
DAY 2	20196	11808	756	144
DAY 3	20448	12060	936	216
AVERAGE (decimal neglected)	20208	11820	840	180

Table 3.1 data sheet of Hazratganj

3.2.2 Standard emission factor

It is defined as the quantity of different pollutants emitted by a vehicle on moving particular distance. The vehicle emission factors prescribed for Indian Vehicle from CPCB were considered in this study.

CATEGORY OF VEHICLES	CO gm/Km^3 /vehicle	NO_2 gm/Km^3 /vehicle	SO_2 gm/Km^3 /vehicle
2 WHEELERS	1.36	0.315	0.02
3 WHEELERS	1.59	0.577	0.05
4 WHEELERS	2.41	2.12	0.1
TRUCKS / BUSES	9.02	9.476	0.08

Table 3.3 Emission factors of vehicles

3.2.3 Emission Calculation Methodology

Emission from the vehicles has been calculated using the following expression.

$$Ep=\Sigma(Vehi\ X\ Di\ )\ X\ EF$$

where:

Ep is the pollutant mass emission per day

i is vehicle category

Veh is the number of vehicles

D is the distance travelled in Km in one day

EF is the mass emission factor per Km travel

Here, for calculating vehicular emission the distance travelled will supposed to be one Km.

Calculations-

Hazratganj:-

Quantity of CO emitted-

By 2 wheelers = $1.36*10^{-3}*20208$

= 27.48 $\mu g/m^3$

By 4 wheelers = $2.41*10^{-3}*11820$

= 28.48 $\mu g/m^3$

By 3 wheelers = $1.59*10^{-3}*840$

= 1.33 $\mu g/m^3$

By trucks/buses = $9.02*10^{-3}*180$

= 1.62 $\mu g/m^3$

Net CO emission = 58.91 $\mu g/m^3$

Quantity of NO_2 emitted-

By 2 wheelers = 0.3.15*10^{-3}*20208

= 6.36 μg/m^3

By 4 wheelers = 2.12*10^{-3}*11820

= 25.05 μg/m^3

By 3 wheelers = 0.577*10^{-3}*840

= 0.48 μg/m^3

By trucks/buses = 9.476*10^{-3}*180

= 1.70 μg/m^3

Net NO_2 emission = 33.59 μg/m^3

Quantity of SO_2 emitted-

By 2 wheelers = 0.02*10^{-3}*20208

= 0.40 μg/m^3

By 4 wheelers = 0.1*10^{-3}*11820

= 1.18 μg/m^3

By 3 wheelers = 0.05*10^{-3}*840

= 0.04 μg/m^3

By trucks/buses = 0.08*10^{-3}*180

= 0.01 μg/m^3

Net SO_2 emission = 1.63 μg/m^3

POLLUTANTS	CO μg/m^3	NO_2 μg/m^3	SO_2 μg/m^3

&VEHICLES			
2 WHEELERS	27.48	6.36	0.40
4 WHEELERS	28.48	25.05	1.18
3 WHEELERS	1.33	0.48	0.04
TRUCKS/BUSES	1.62	1.70	0.01
TOTAL	58.91	33.59	1.63

Table 3.4 Vehicular emission data of Hazratganj

3.2.4 AMBIENT AIR QUALITY DATA

The term "ambient air quality" refers to the quality of outdoor air in our surrounding environment. It is typically measured near ground level, away from direct sources of pollution.

Ambient air quality data can be obtained from government agencies such as UPPCB or CPCB. In our study in our project we have use the data given by UPPCB.

SITES	**CO µg/m^3**	**NO_2 µg/m^3**	**SO_2 µg/m^3**
HAZRATGANJ	NA	30.6	8.2

Table 3.6 Ambient Air Quality Data

CHAPTER 4- RESULT AND DISCUSSION

4.1 Traffic survey data

4.1.1 Traffic survey data of various vehicles at Hazratganj -

The average daily patterns of flow of 2 wheelers (2W), 3 wheelers (3W), 4 wheelers (4W), busses/trucks throught the day are shown in figure below

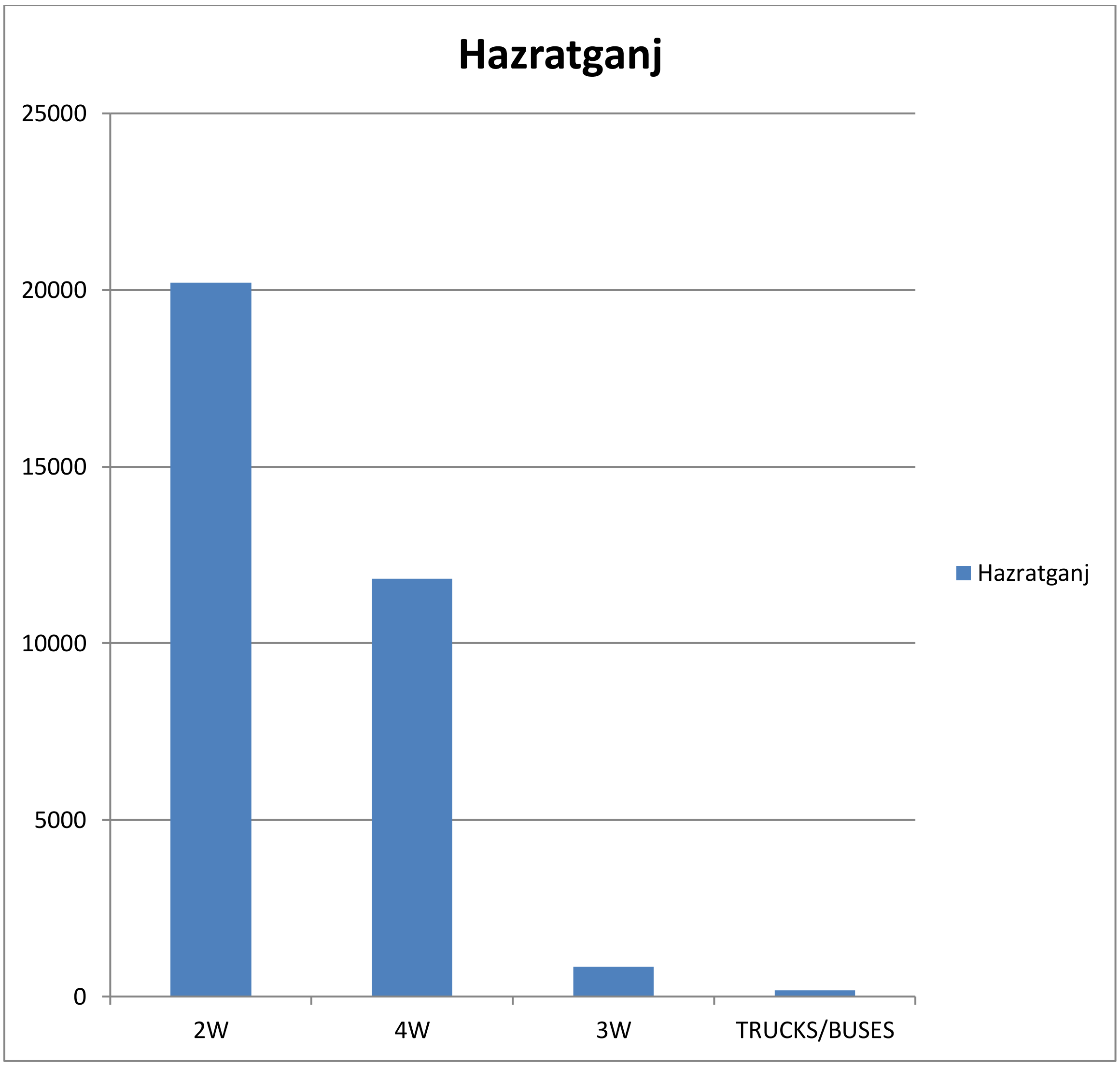


Fig 4.1 Traffic Data Of Hazratganj

.4.2 Vehicular emission data

4.2.1 Vehicular emission data of Hazratganj

POLLUTANTS &VEHICLES	CO µg/m³	NO_2 µg/m³	SO_2 µg/m³
2 WHEELERS	27.48	6.36	0.40
4 WHEELERS	28.48	25.05	1.18
3 WHEELERS	1.33	0.48	0.04
TRUCKS/BUSES	1.62	1.70	0.01
TOTAL	58.91	33.59	1.63

Table 4.1 Vehicular emission data of Hazratganj

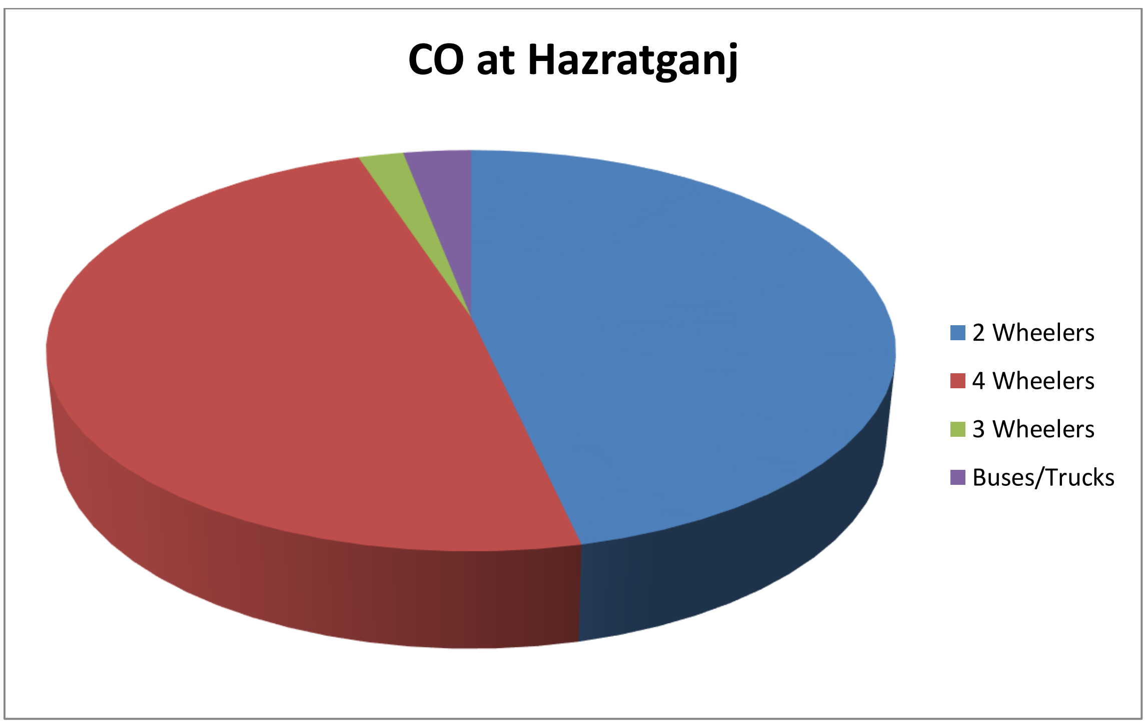


Fig 4.2 CO Percentage Contribution

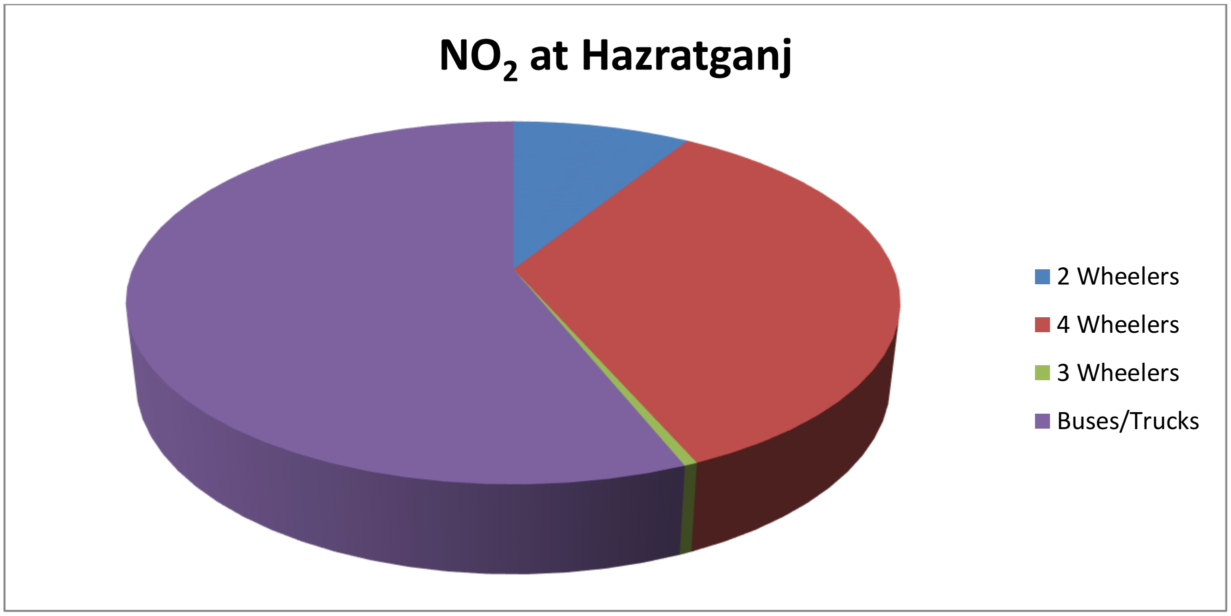


Fig 4.3 NO_2 percentage contribution

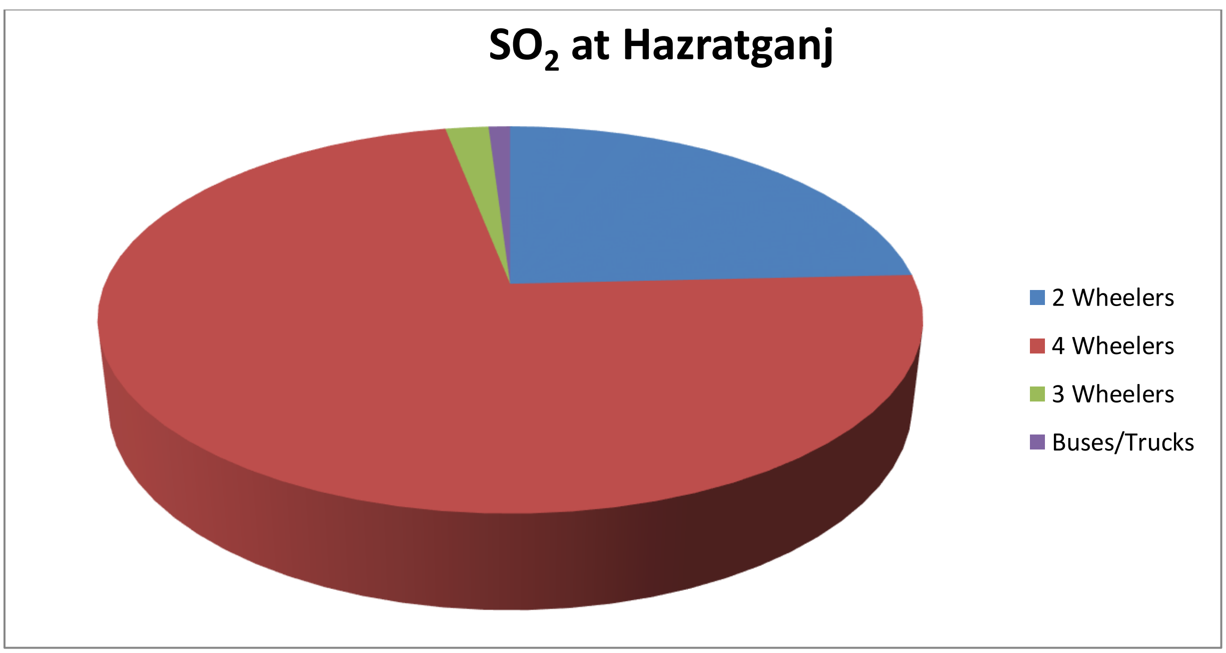


Fig 4.4 SO_2 percentage contribution

4.2.2 Vehicular emission data of Hazaratganj

Conclusion-

• Number of two wheelers are maximum in Hazratganj, number of four wheelers are maximum in Hazratganj.

• Total number of vehicles are maximum in Hazratganj.

• NO2, CO and SO2 concentration due vehicular emission is dominating in Hazratganj which is commercial area.

• There is difference between vehicular emission data and ambient air quality data in our study because vehicular emission is pollution only due transportation facilities while ambient air quality data is due to impact of all the factors on air such as industries, vehicles etc.

CHAPTER– 5 APPLICATIONS AND LIMITATIONS

Applications :

•Determination of Ambient air quality depending on vehicular pollution.

• Types of vehicular pollution dominating in residential area, commercial area, and industrial area.

• Analysis of the recent trends of various unwanted emissions with a comparative approach. • Control strategies for reducing air pollution in selected zones.

• Land use pattern governs the air quality standard of a particular region.

Limitations :

•**Time factor:** Since the available time for project work is about six month only. Thus analysis of each and every place is practically not possible.

•**Secondary Data:** Majorly reliable on data provided by UPPCB. CPCB and other agencies.

• **Instrumentation Factor:** there is unavailability of few instruments for performing our analysis therefore we will be mostly relying on secondary data.

CHAPTER – 6 MITIGATION MEASURES

Mitigation measures are measures taken to control, reduce or prevent pollution due to automobile emissions. Some of the measures that may be adopted to reduce fuel consumption and air pollution are given below.

Control at source using catalytic converters: A catalytic converter is a vehicle emissions control device which converts toxic by-products of combustion in the exhaust of an internal combustion engine to less toxic substances by way of catalyzed chemical reactions. The specific reactions vary with the type of catalyst installed.

Modifications in engine : (Exhaust gas recirculation) A system in the engine of a vehicle that routes a metered amount of exhaust into the intake tract under particular operating conditions. Exhaust neither burns nor supports combustion, so it dilutes the air/fuel charge to reduce peak combustion chamber temperatures. This, in turn, reduces the formation of NOx.

Modification or replacement of fuel: Petroleum and diesel are known as fossil-fuels, during burning the emitted gas is very harmful to living and non-living thing and also to climate. So, modification or replacement of fuels is a way to reduce emission, by curtailing the amount of some particular components of fuel, we can modify it, for e.g. Assulphur is most harmful gas emitted from the vehicles, so we can use low sulphur fuel. Also we can replace the fossil fuels by so many available alternatives, for e.g. bio diesel, methanol,

ethanol battery powered vehicles, LPG, natural gas etc..

Setting of standards: By setting stringent emission standard, the amount of emission from the vehicles can be reduced.

Legislative measures: Under legislative measures the various factors responsible for emission from the vehicle can be put under certain restriction, for e.g overloading of heavy vehicles is a Cause of more fuel consumption and emission, so a standard load or weight can be fixed beyondthat load, the vehicles should be considered overloaded and penalties for the amount of overload can be charged, this measure will discourage the overloading, other legal measures are deciding the type of engine installed in the different category of vehicles.

Vehicle Pollution Monitoring: Vehicles should be monitored regularly at a certain interval of time for their fuel efficiency, their engines condition , rolling power, etc. this step will help in keeping the vehicles in proper condition by the vehicle owners and hence reducing the emission from the vehicle.

Check on adulteration: Adulteration of fuels is one of major causes for excess emission of pollutants from vehicles. To check adulteration, EPCA proposed setting up of two independent fuel Testing Laboratories after consultation with the Ministry of Petroleum and Natural Gas and the Society for Indian Automobile Manufacturers.

Burn less fuel: We should implement the "burn less fuel" strategy. Burning the less fuel will lead to lesser emission and consequent the lesser air pollution and its harmful effect.

Vent Controls: For reducing the evaporative emission vent control is necessary. By controlling the vent we can control the leakage of the vapors.

Vehicle maintenance: As we know the poor vehicle characteristic is one of the factor responsible of higher emission, so proper maintenance of vehicles can be helpful to reducing the emission specially the old vehicles should be checked and examined for amount of emission.

Enhancing dispersion: Once the harmful gases from the vehicles are emitted, they should not be allowed to concentrate surrounding area, they should be immediately dispersed.

Using vegetation: We know that plants and trees are a good sink of harmful gases like CO2 etc. so we should encourage the vegetation on the sides of the roads as much as possible to reduce the amount of pollutants in ambient air.

APPENDIX A

LIST OF TABLES

APPENDIX B

LIST OF FIGURES

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