Mitigating Air Pollution Caused by Vehicle Traffic: A case of Visakhapatnam, Andhra Pradesh.

Thesis submitted in partial fulfilment of the requirements
for the award of the degree of

BACHELOR OF PLANNING

By

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Declaration

I, Dheeraj Balabadra, Scholar no. 2018BPLN026, hereby declare that the thesis titled 'Mitigating air pollution caused by vehicle traffic: A case study of Visakhapatnam' submitted by me in partial fulfilment for the award of Bachelors of Planning, at School of Planning and Architecture, Bhopal, India, is a record of bona fide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

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Signature of the Student

Date: 30rth June 2022

Certificate

This is to certify that the declaration of Dheeraj Balabadra is true to the best of my knowledge and that the student has worked under my guidance in preparing this thesis.

RECOMMENDED

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Signature of the Guide

(Proff. Paulose N.Kuriakose)

ACCEPTED

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Head, Department of Urban and Regional Planning

June, 2022, Bhopal

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Abstract

Air quality has become a significant issue of concern in recent years, especially in developing countries such as India. Some of our tier-I cities, like Delhi, Mumbai, Chennai, Vijayawada, Vizag, Hyderabad, and Bangalore, are already dealing with the effects. According to various literature reviews, the primary reasons for degrading air quality are the city's spatial structure and function (socioeconomic activities). Rapid urbanization, industrialization, increased congestion, vehicle ownership, reduced transit capacity, and a lack of effective pollution control policies all contribute. Second, as these cities rise in size, commute distances increase, causing increased road congestion. As a result, the city significantly contributes to the degradation of air quality. This is commonly referred to as city-centric pollution

To conclude, a city's spatial structure impacts anthropogenic activities and, therefore, a significant source of urban air pollution, which defines cities as the central focus. Present programs in India include the “National Clean Air Program (NCAP),” “Forty-Two Action Points,” the “National Air Quality Monitoring Program (NAMP),” and others.

Several studies have shown that most of urban areas exceeds the specified standard limits of Air pollution. Central Pollution Control Board has installed ambient air monitoring stations in several metro cities like Delhi, Mumbai, Hyderabad, Vizag etc. The urban planning plays a very important role in reducing the impact of air pollution on human health or to reduce the generation of air pollution. Despite the proven results about the air pollution interference in general well-being of people there is a need of a systemic approach to reduce its effects in an urban area.

With a population of around 1.73 million, Visakhapatnam is Andhra Pradesh's second-largest urban agglomeration (Census, 2011). It's been and remains to be a centre of economic activities in the region, attracting an increasing population to the city. Travel is a result of this population's need for activities such as work, education, recreation, and health, for the aim of bettering their socioeconomic situation However, more transportation activity may result in more pollutants, traffic, and casualties in the city. Hills, forests, the harbour, and industries cover huge swaths of area in the city. Besides these places, the city's urban built-up area is localized in 166km2 throughout 534km2 of total city area.

Only 31% of the overall planning area is currently developed, with the remaining covered by farms, woods, and hills.

As a result, population concentrations in the inner city exceed 27,000 persons per hectare, while the outskirts are sparsely populated. In addition, this area has 686 slums, that also account for 44% of the city's total population.

For tourism and other factors in the city, descriptive and inferential analysis was collected, the findings from which summarise the main status and main challenges with in city.

सार

हाल के वर्षों में, विशेष रूप से भारत जैसे विकासशील देशों में वायु गुणवत्ता चिंता का एक महत्वपूर्ण मुद्दा बन गया है। हमारे कुछ टियर- । शहर, जैसे दिल्ली, मुंबई, चेन्नई, विजयवाड़ा, विजाग, हैदराबाद और बैंगलोर, पहले से ही प्रभावों से निपट रहे हैं। विभिन्न साहित्य समीक्षाओं के अनुसार, वायु गुणवत्ता में गिरावट के प्राथमिक कारण शहर की स्थानिक संरचना और कार्य (सामाजिक आर्थिक गतिविधियां) हैं। तेजी से शहरीकरण, औद्योगीकरण, बढ़ी हुई भीड़भाड़, वाहन स्वामित्व, कम पारगमन क्षमता, और प्रभावी प्रदूषण नियंत्रण नीतियों की कमी सभी योगदान करते हैं। दूसरा, जैसे-जैसे ये शहर आकार में बढ़ते हैं, आवागमन की दूरी बढ़ती जाती है, जिससे सड़कों पर भीड़भाड़ बढ़ जाती है। नतीजतन, शहर हवा की गुणवत्ता में गिरावट में महत्वपूर्ण योगदान देता है। इसे आमतौर पर शहर केंद्रित प्रदूषण के रूप में जाना जाता है

निष्कर्ष निकालने के लिए, एक शहर की स्थानिक संरचना मानवजनित गतिविधियों को प्रभावित करती है और इसलिए, शहरी वायु प्रदूषण का एक महत्वपूर्ण स्रोत है, जो शहरों को केंद्रीय फोकस के रूप में परिभाषित करता है। भारत में वर्तमान कार्यक्रमों में "राष्ट्रीय स्वच्छ वायु कार्यक्रम (एनसीएपी),", "बयालीस कार्रवाई बिंदु", "राष्ट्रीय वायु गुणवत्ता निगरानी कार्यक्रम (एनएएमपी)" और अन्य शामिल हैं।

कई अध्ययनों से पता चला है कि अधिकांश शहरी क्षेत्र वायु प्रदूषण की निर्दिष्ट मानक सीमा से अधिक हैं। केंद्रीय प्रदूषण नियंत्रण बोर्ड ने दिल्ली, मुंबई, बैंगलोर, चेन्नई, हैदराबाद, कोलकाता, विजयवाड़ा, विजाग आदि जैसे कई मेट्रो शहरों में परिवेशी वायु निगरानी स्टेशन स्थापित किए हैं। शहरी नियोजन मानव स्वास्थ्य पर वायु प्रदूषण के प्रभाव को कम करने में बहुत महत्वपूर्ण भूमिका निभाता है। या वायु प्रदूषण की पीढ़ी को कम करने के लिए। लोगों की सामान्य भलाई में वायु प्रदूषण के हस्तक्षेप के सिद्ध परिणामों के बावजूद शहरी क्षेत्र में इसके प्रभावों को कम करने के लिए एक व्यवस्थित दृष्टिकोण की आवश्यकता है।

लगभग 1.73 मिलियन (जनगणना, 2011) की आबादी के साथ विशाखापत्तनम आंध्र प्रदेश में दूसरा सबसे बड़ा शहरी समूह है। यह क्षेत्र में आर्थिक गतिविधियों का केंद्र रहा है और बना हुआ है, जिससे अधिक से अधिक लोग शहर की ओर पलायन कर रहे हैं। यात्रा इस आबादी की व्युत्पन्न मांग है, जो अपने बेहतर सामाजिक-आर्थिक कल्याण के लिए काम, शिक्षा, मनोरंजन, स्वास्थ्य आदि जैसी गतिविधियों में संलग्न है। हालांकि परिवहन गतिविधि में वृद्धि से शहर में प्रदूषण, भीड़भाड़ और दुर्घटनाओं में वृद्धि हो सकती है। शहर में पहाड़ियों, जंगलों, बंदरगाह और उद्योगों से आच्छादित भूमि

के बड़े हिस्से हैं। इन क्षेत्रों को छोड़कर, शहर का शहरी निर्मित क्षेत्र कुल शहर क्षेत्र के 534km2 में फैले 166km2 में केंद्रित है

कुल नियोजन क्षेत्र में से केवल 31 प्रतिशत ही वर्तमान में निर्मित है और शेष कृषि, वन और पहाड़ियों से आच्छादित है। नतीजतन, जनसंख्या घनत्व कोर शहर में प्रति हेक्टेयर 27,000 लोगों से अधिक है, और बाहरी इलाके बहुत कम आबादी वाले हैं। इसके अलावा, शहर में 686 मलिन बस्तियां हैं, जो कुल घरों का 44 प्रतिशत हैं।

शहर में यात्रा व्यवहार और अन्य मापदंडों के लिए माध्यमिक और प्राथमिक डेटा एकत्र किया गया था, जिसके परिणाम वर्तमान स्थिति और शहर की प्रमुख चुनौतियों को संक्षेप में प्रस्तुत करते हैं।

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CHAPTER 1. INTRODUCTION

1.1 Background

The (WHO) World Health Organisation describes air high-quality as "the contaminating of the indoors or outer location via any physical, chemical, or biological factor that changes the inherent features of the atmosphere." The main effects of air pollution are smog and soot, harmful emissions, greenhouse gases, pollen, and mould, according to JohnWalke, Clean Air Project, NRDC. The main air pollution effects are soot and smog, harmful air impurities, pollen, greenhouse gases, and mould. The presence of hazardous substances or contaminants in the air at concentrations that put one's health at jeopardy. In a larger sense, the discharge of contaminants or substances into the atmosphere is what is referred to as air pollution that aren't ordinarily there, reducing air quality, or producing negative impacts in life quality (environmental pollution centres).

In India, this problem's consciousness emerged long ago, in 1972, soon after the Stockholm conference. The "Air (Prevention and law of pollution) bill of 1981" turned into designed to save you air pollutants. The "Environmental (Protection) Act, 1986" addresses the Act's additional responsibilities (MOEFCC, 2020). Therefore, the “National air quality monitoring Program (NAMP)” is responsible for reporting air quality data in real-time to control further contamination in air quality. Initially, monitoring stations were installed at various locations in metro cities, but today we have them for small and medium-scale cities (non-attainment cities). Under NAMP So_2, No_2, Particulate matter is the most common traced contaminants. The"countrywide Environmentalair quality standards (NAAQS)" provide standards for evalua ting air great decline. The “National Air Quality Index” is a tool to translate this complicated structure into a single number, defining each value's colour, communicating the air quality laymen's terms (MOEFCC, 2019). Initially, these programs' focus was the metro cities, and recently they considered small and medium cities called non-attainment cities.

The "National Clean Air Program 2019" describes the pollution as urban-centric, and while assessing, priority is to be given to all the urban areas. The “Air pollution knowledge assessment city program” (non-attainment towns) is meant to provide a framework for an understanding of “air quality” in urban areas since there is limited information available for

cities (other than metropolitan) on atmospheric monitoring and source impact (Urban Emissions, 2019). It also notes that reliable data is needed to develop successful air quality control for a city. Concluding that, the “Air pollution knowledge assessment city program” is attempting to estimate the scope of the issue in each city. Cities are evaluated based on population size and the development of airsheds (Sarath K. Guttikundaa, 2019).

The NCAP approached these non-attainment cities by a systematic science-based approach in which the "source allocation" analysis is carried out. According to the survey, the Indo-Gangetic Plain is the most affected by particulate matter than the southern states. The reason for this is the topography (hilly) and meteorological features that create a landlock or "valley effect" that stops air pollution from dispersing (MOEFCC, 2019). The city-scale analysis of Indo-Gangetic plains was performed during the summer season with fewer relative humidity effects. It has been noted that the levels of particulates in smaller metropolitan regions are higher than those concentrations seen in big metropolitan centers. (Ningombam, Linthoingambi, Devia, 2020).

The Sustainable Development Scenario (S.D.S.) draws on the chosen U.N. S.D.G.s. It seeks to include a roadmap that combines various tightly related but separate policy objectives: securing universal coverage, economical, and sustainable sources before 2030 "(SDG 7.1)"; severely reducing "air quality" that causes death and illness "(SDG 3.9)"power production, industry, and transportation are major sources to air emissions Cities' negative per capita environmental consequences should be decreased by 2030, with specific attention on "air quality, “urban waste systems," and other waste management" (SDG 11.6). Eventually, the use of fossil fuels is a significant contributor to climate change, putting at risk not just the environment but also human health, air quality, and water supplies. “(S.D.G. 13)” (Peter Rafaja, 2018).

India has been welcomed into the "climate & clean Air Coalition" through the Ministry of surroundings, Forests, and climate alternate (MOEFCC) (CCAC). In the context of which India initiated the National Clean Air Action Plan (NCAP) in January 2019, it included detailed policies to deter, regulate and mitigate air pollution and enhance air quality monitoring throughout the country (UNEP, 2019).

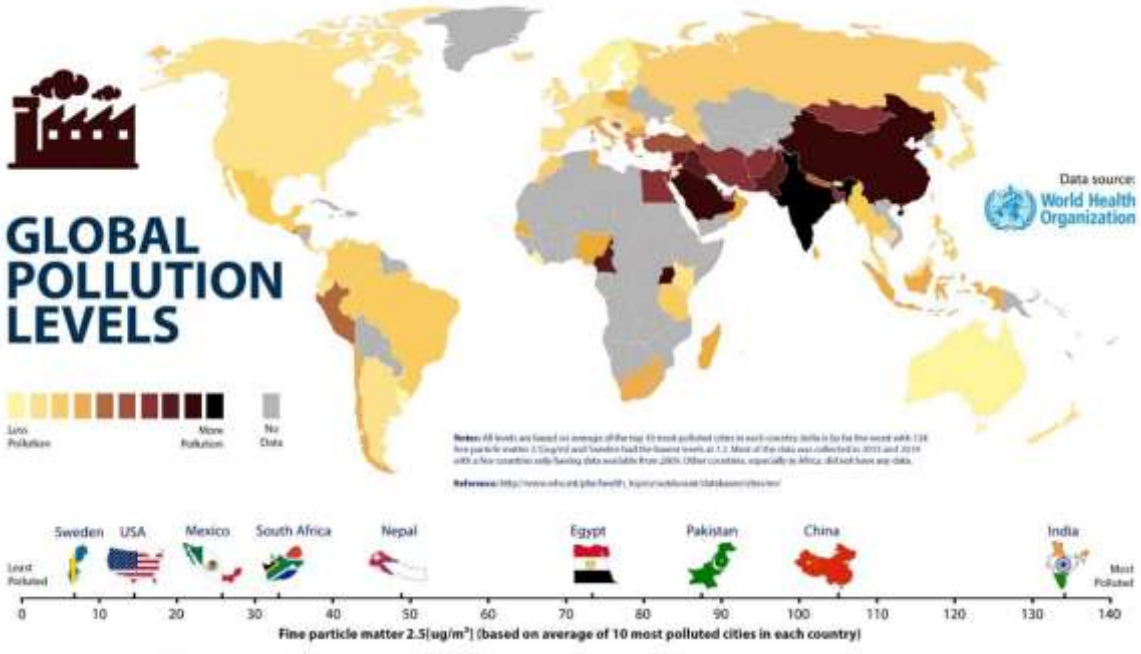


Figure 1-1 Annual average PM2.5 concentrations in 2017 *Source: World Health Organization" (WHO, 2020)*

Polluted air was involved for 6.7 percent among all deaths worldwide in 2012. (WHO) In accordance with the "2019 State of the Global Air Report", The fifth main cause of demise global is air pollutants that reasons 5 million deaths in 12 months. China and India are the primary perpetrators as well as the primary victims of the situation (HEI, 2019).

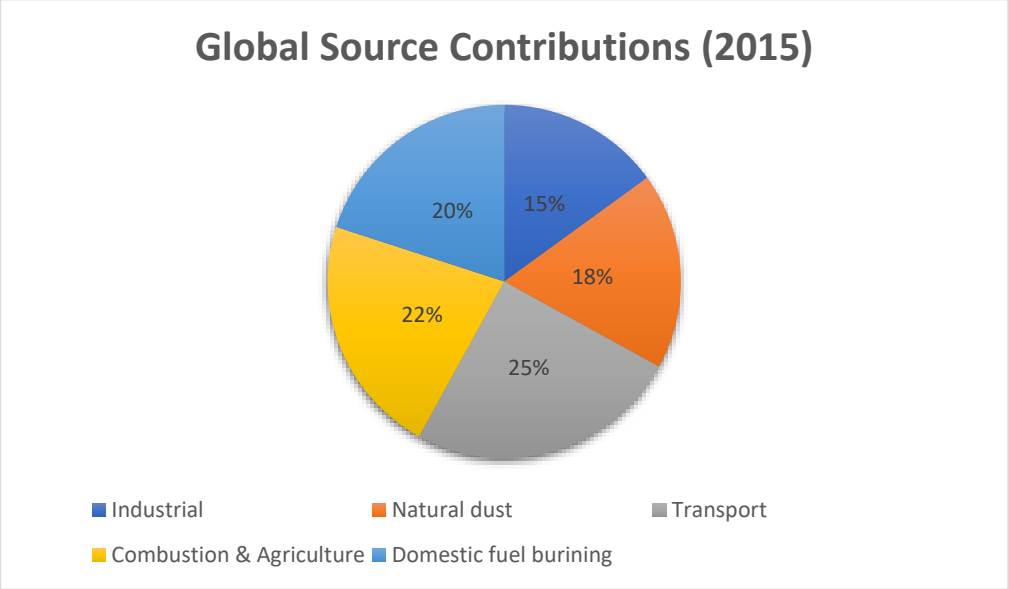


Figure 1-2 Global Source Contributions (2015) of Air Pollution

1.2 Need of the Study

As per India's commitment to a clean climate and pollution-free atmosphere and meeting sustainable development goals, measures are needed to increase air emissions. Over the past few decades, India's economic development and rapid urbanization have resulted in many Environmental issues, including degradation in “air quality,” which are prevalent, especially in many cities. It implies that air pollution is majorly urban-centric and is a result of anthropogenic activities. These anthropogenic activities are determined by the city's spatial structure, i.e., the urban form. If levels remain unchanged, human exposure to such sites may be harmful from a health perspective (MOEFCC, 2019). For planners and political research, assessment, and characterization of how and to what extent different urban form features influence the developing countries' air quality is crucial (Matthew J. Bechle, 2016). It means that by limiting the unchecked spread of urban territory, greater air quality and lower pollutant concentrations may be achieved through urban design and management measures. Each city has its structure that enables the aggregation and dispersion of air to develop a microclimate that collectively leads to the global climate change scenario. If it is to be resolved, a rigorous urban form management approach is required.

As per a global database of PM 2.5 particulate pollution statistics provided by IQAir, an air filtration company, India was indeed the fifth highly polluted nation in 2019, with Ghaziabad with in NCR ranked as the world's most polluted city.

In India, pollution levels resulted in the deaths of 1.67 million people during 2019, amounting to 17.8percent of the overall of the nation's total deaths. (Puneeta Pandey, Rajveer Kaur 2021)

The main reasons of the study to reduce the air pollution from our lives are pollution present in the air which is creating a health emergency on a very quick and frequent basis which is leading to risk to most of the children all over the area and thus results to a lead in climatic risk. (UNEP)

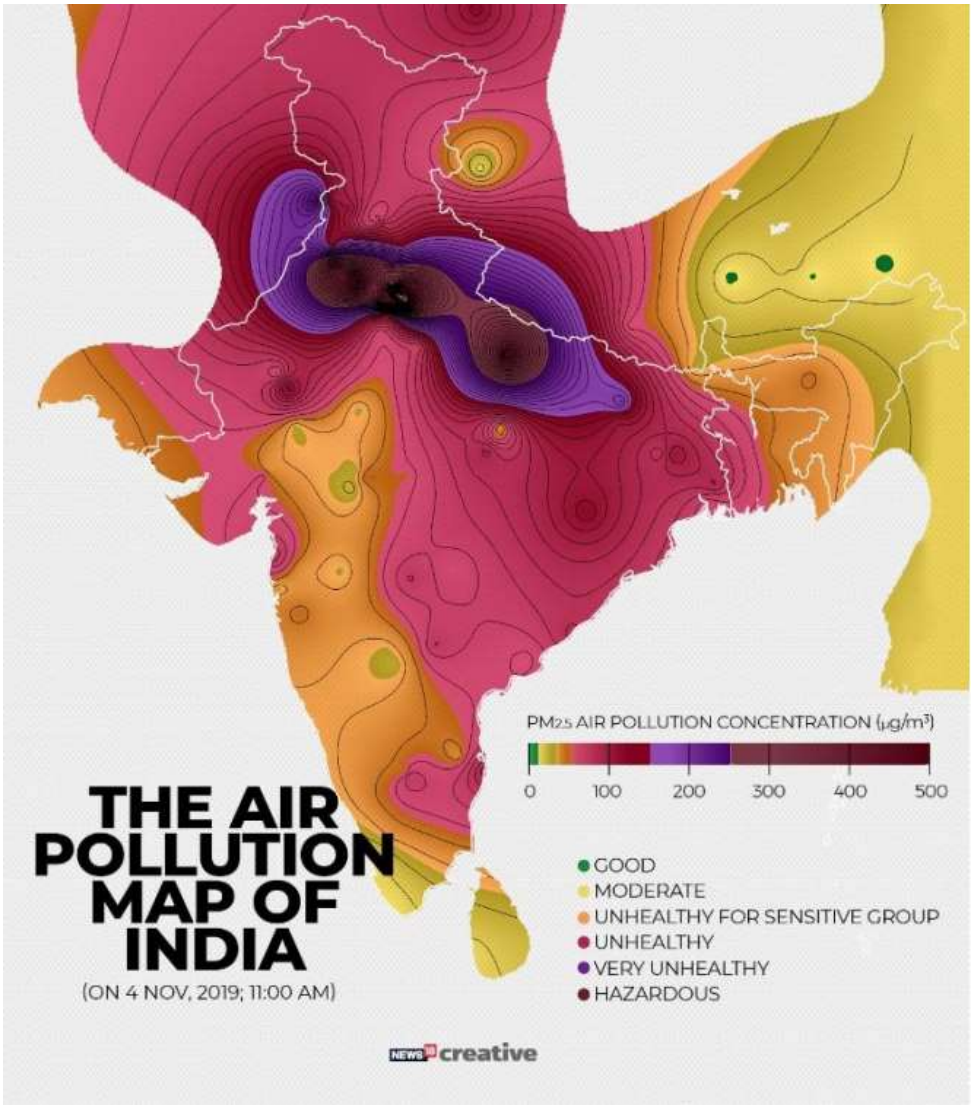


Figure 1-3 Pollution Levels in India *Source: (News18, Nov 4, 2019)*

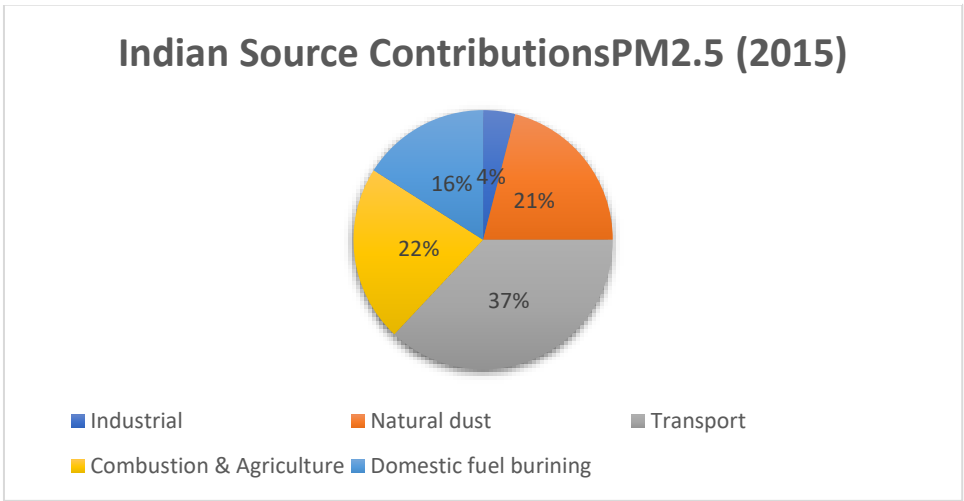


Figure 1-4 Indian Source Contributions PM2.5(2015) of Air Pollution

1.3 Site Selection

Visakhapatnam, Vijayawada, Guntur, Nellore, and Kurnool are all suffering from the state's alarmingly high levels of air pollution, which are disrupting the delicate ecological balance of these cities, Centre for Science and Environment (CSE).

At Amaravati, Tirumala, Rajahmundry, and Visakhapatnam, the APPCB has real-time air pollution monitoring equipment. In comparison to prior years, air pollution in Amaravati, Tirumala, and Rajahmundry decreased, but Visakhapatnam city saw a minor increase. (From the New Indian Express)

This year, Visakhapatnam's PM10 (particulate matter) level jumped to 141 micrograms per cubic metre, up from 124 previous year.

Vishakhapatnam stand first in most polluted city in Andhra Pradesh (iQair) As per a study report released by Greenpeace India, Vizag is perhaps the most polluting country in the south India. Annual PM10 levels in Visakhapatnam were seven times higher than WHO standards, while PM2.5 levels were seven to eight times higher.

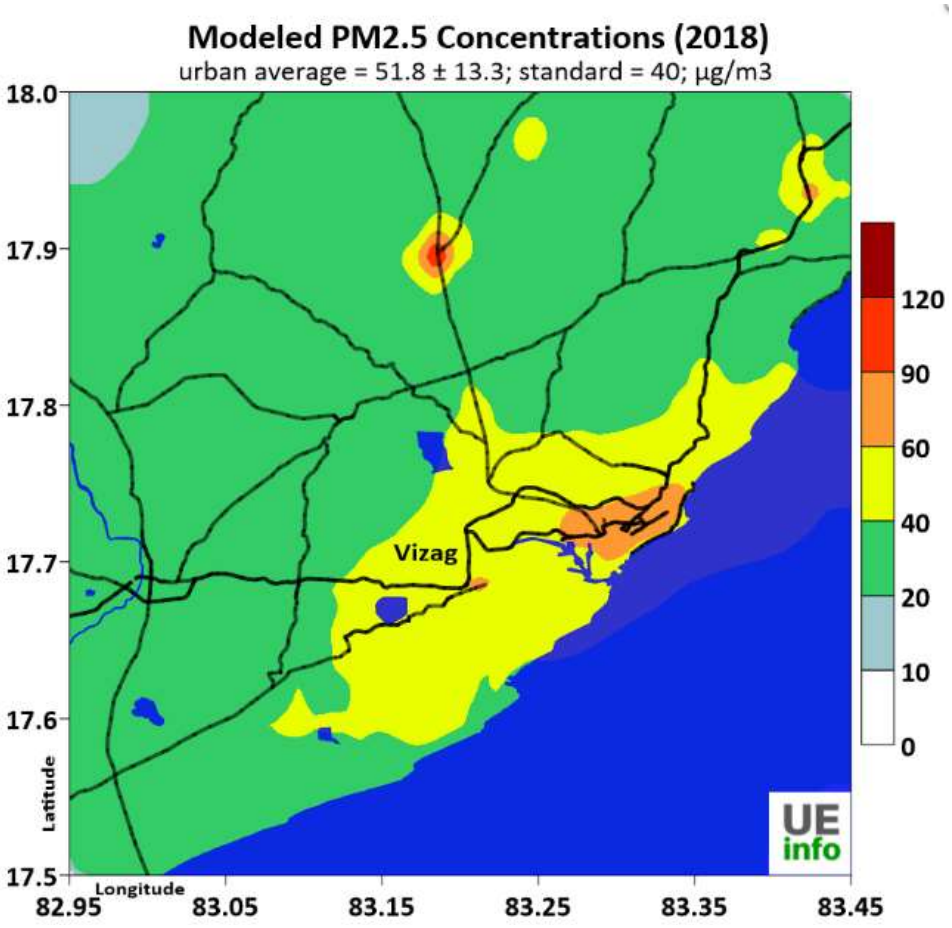


Figure 1-5 Inventory for PM2.5 emissions for the Metropolitan Vishakhapatnam Municipal Corporation

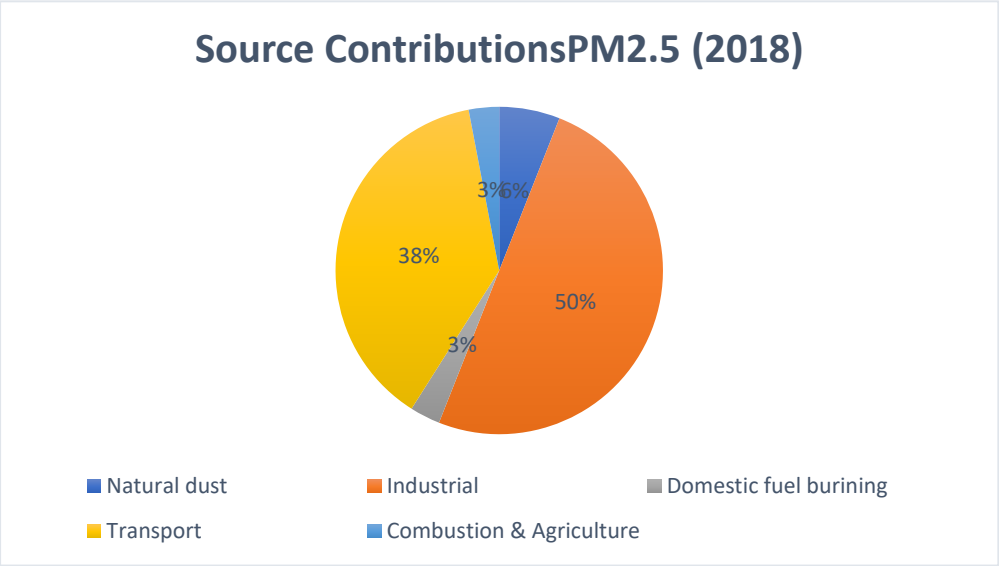


Figure 1-6 City Source Contributions PM2.5(2018) of Air Pollution

1.4 Aim of the Study

To understand the sources of pollutants in different urban locations and to come up with suitable recommendation of policy & Interventions to reduce local air pollution cause due to road transportation.

1.5 Objectives

a) Objective I: To understand the city travel behavior

b) Objective II: To discover and analyses the most particular sites for air pollution.

c) Objective III: To recommend suitable planning interventions & policy to mitigate the causes and local air pollution due to road transport

1.6 Expected Outcomes of the Study

The outcome of the study will be recommending suitable interventions to reduce air pollution due to road transport

1.7 Scope of Work

- To study about how people use transport
- To identify the TVC data of the selected locations with regard to model split
- To analysis the transport emission data to identify the AQI of the study area
- To identify the measures and suitable approaches that can be recommend to reduce the degree of poor air quality in the most affected areas seems to have resulted from city transportation.

1.8 Limitations

The limitations of the study area like, the study is limited to the evaluation of the air pollution on 1 source (road transport) based on 7 pollution indicators and the study will be limited to core area of Vishakhapatnam city. The real air pollution problem due to road transport is in the study area, if we found out the way to eliminate this pollution through core city, so this will automatically bring down the air pollution level of the whole city, also the Study will be carried out within the municipal boundaries of the Vishakhapatnam city and for the survey, time & resource restriction, area coverage of 166 sq. km, Data acquisition from Government Offices & HH Survey

1.8 Research Methodology

The research approach used to conduct this study was divided into three stages:

Stage 1: The Preliminary Stage

Stage 2: Data Collection and Analysis Stage

Stage 3: Final Outcomes Stage

STAGE 1: The preliminary stage is the inception stage which begins with topic identification. Then, a background, need of the study, literature study was conducted to provide a justification to the topic, signifying the importance of reducing air pollution from transport

in the Indian context and stating the current need for the study and its process. Then, an appropriate study area was chosen based on restriction & air pollution level to continue the study further. Setting the need for the study specific to the study area led to the formulation of aim and objectives for the research. To achieve the same, extensive literature has been reviewed to understand the concepts, definitions and the context of air pollution, effects, and its causes. Learnings from the literature review have shaped the overall philosophy of conducting this research

STAGE 2: The learnings from the first objective (literature review study) led to the identification of various sub tasks required in the next three objectives. A comprehensive list of data required to complete the sub-tasks was prepared, which involved both primary as well as secondary data. The secondary data sources were mainly - Research Sources, APPCB, A.Q.I, Visakhapatnam Metropolitan Region Development Authority (VMRDA). Ministry of Rural Urban Government, Census 2011. The General Household Questionnaire is the primary survey; Focused on Travel behaviour. The data collected from the field study will compiled and then compiled data was analysed based on completion and review of respective sub-tasks. Firstly, to identify and analyze the transport emission in the city. Secondly, to identify and analyze most specific locations with regard to air pollution by finding the main junction points in the city which if vehicle emissions are the primary contributor to urban air pollution, then an investigation of the TVC data of those junction to find the which junction emitting more air pollution. The HH information is instead required to determine the trip behavior. Key findings from the overall comprehensive analysis were identified and shortlisted.

STAGE 3: The third and final stage provides the final outcomes stage, which involves combining the outcomes/learnings from each objective and finally leading up to the third and final objective, i.e. To identify the measures and suitable approaches that can be recommend reducing the degree of air pollution caused by transportation in the most affected areas of the city. Based on the key findings, appropriate mechanisms were identified and suggested to address the issues which would help to mitigate local air pollution in the chosen study area.

The research methodology chart as shown in Figure below would help in giving a brief understanding of this topic

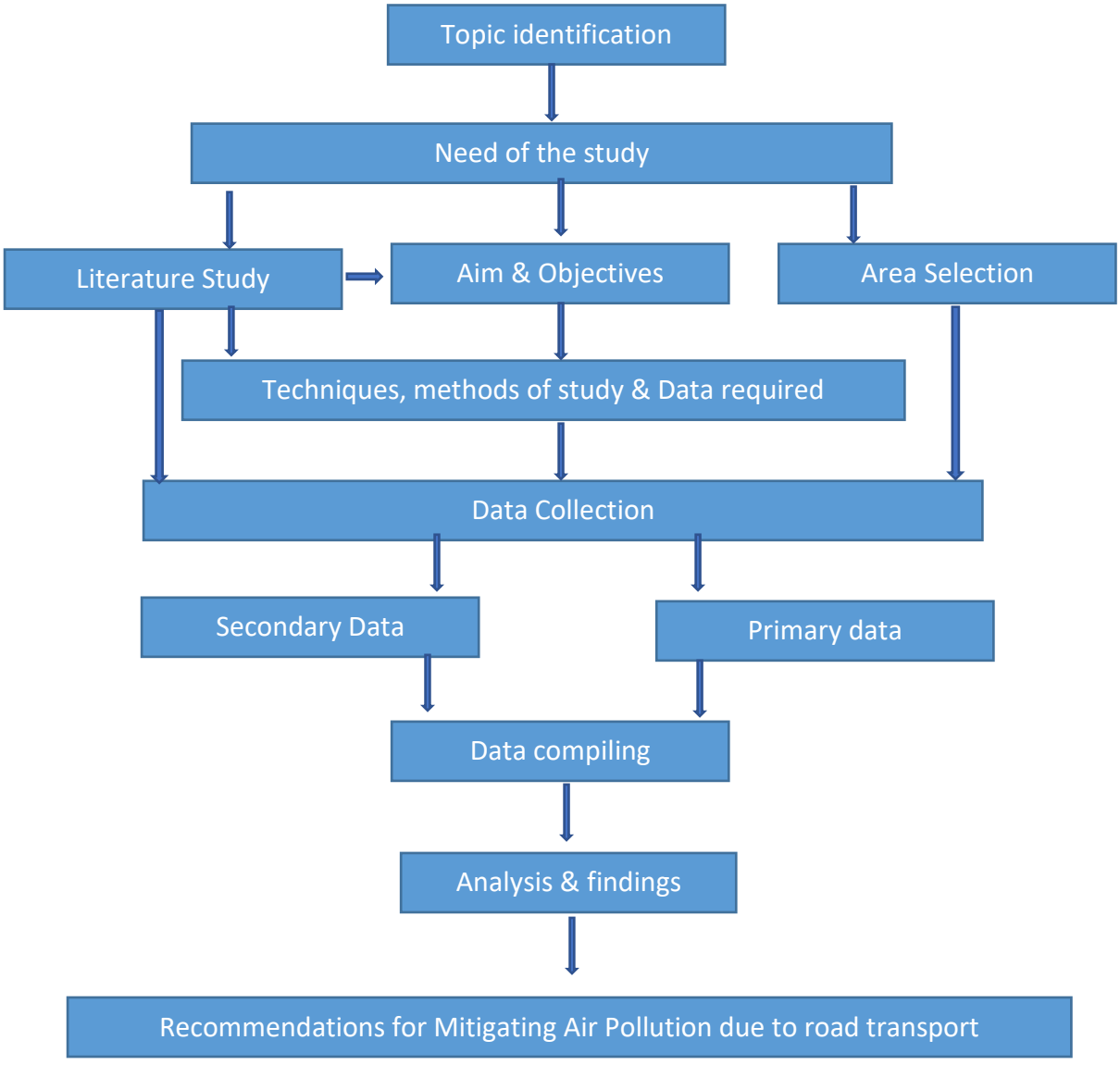


Figure 1-7 Methodology

Objective I: To understand the city travel behavior

HH Data

The City's Trip Purposes

Mode Shares in The City

Trip purpose-wise mode shares

Mode wise Average trip length (in km)

Trip length distribution

Trip Lengths Frequency Distribution

Quality of footpaths

Objective II: To identify and analyze most specific locations regarding air pollution

SIM-air model

Finding equation to find out the emission from vehicle

Emissions (tons/year) = Number of Vehicles * Vehicle km traveled (km/year) * Emission factor (gm/km) * 10-6 (tons/gm)

Emission factor (gm/km)

Vehicle travelled(km/year)

No of vehicles

Identify the main junctions

Analyzing the TVC data of the selected Junctions

Calculation of Mode share

Calculation of Pollution during Peak hours

Calculation of different Air Pollution parameters

Finding AQI of the study area in the city

Objective III: To recommend suitable planning interventions & policy to mitigate the causes and local air pollution

To identify the measures and suitable approaches that can be recommend reducing the level of air pollution in most affected areas

Figure 1-8 Detailed methodology

CHAPTER 2. LITERATURE STUDY

2.1 Air Pollution

Air pollution is any chemical, biological, or organic substance that pollutes the inside or outside atmosphere and hurts the plants that live there. Most air pollution comes from things like cars, homes with fireplaces, businesses, and forest fires. Particles, carbon dioxide, ozone, nitrogen oxides, and sulphur dioxide all pose serious health risks. Polluted interior and exterior air is a major cause of illness and other health problems, and a major cause of illness and death. according to an employer in the fitness industry (WHO).

The existence of toxic components or substances within the atmosphere (including the one and of biomedical groundwork) at quantities that are risky to one's health. Air pollutants, in a bigger feel, makes reference to the existence of chemicals and materials in the atmosphere that aren't present predominantly, reducing the satisfaction level of the atmosphere or starting to cause truly awful modifications in the greatest of ways of life (such as the threat to the ozone layer or the contribution to the acceleration of global warming) (such as the dangerous of the ozone layer or inflicting worldwide warming). in keeping with the findings of the environmental pollutants centre (EPC).

It is estimated that air pollution causes the deaths of seven million people all over the globe each and every single year. According to the World Health Organization (WHO), nearly all of the world's population, or 99 percent, breathes air that is contaminated with excessive levels of pollutants and exceeds the standards set by the WHO. The countries with the lowest and middle incomes are the ones that bear the brunt of the responsibility for this problem. The World Health Organization (WHO) is aiding nations in their fight against air pollution.

one of the maximum big factors affecting our properly-being is the air we breathe. Low air pleasant can motive numerous fitness troubles, reducing one's fine of life. To limit air pollution, it is also important to consider its causes and resources.

In accordance with the “2019 State of the Global Air Report”, The fifth leading cause of death worldwide is air pollution that causes five million deaths a year. China and India are the primary perpetrators as well as the primary victims of the situation (HEI, 2019).

In the last three decades, India has experienced growing economic development, which has contributed to rapid urbanization and industrial output, significantly affecting air quality in urban areas. Nowadays, small, and medium-sized towns also experience air pollution (MOEFCC, 2019).

The quantity of air pollutants at a particular site is determined by a variety of factors, including the number of contaminants that are emitted by the source, the ability of the atmosphere to diffuse these emissions, as well as the climate and terrain of that area (MOEFCC, 2020).

The haze that hangs over cities and people who smoke inside their homes are both big sources of air pollution. There are millions of premature deaths each year as a direct result of the consequences of air pollution caused by both outdoor and interior sources. This is mostly due to more deaths from stroke, heart problems, COPD, lung cancer, and respiratory illnesses (WHO).

2.2 Ambient(outdoor) air pollution

The fog that hangs over cities and the start smoking that fills our homes are both very bad for our health and the environment. It is estimated that 4.2 million individuals pass away annually in the United States as a direct result of air pollution-related illnesses such as cardiovascular disease, lung disease, stroke, and patients with respiratory problems (WHO). Almost everyone on Earth lives in places where the air quality is better than what the WHO recommends. Ambient air pollution affects both developing and industrialized countries, but the WHO says that low- and middle-income nations have to deal with it the most. West Pacific and Southeast Asian regions.

Harmful air emissions have intensified due to rapid urbanization and industrialization, causing environmental, human health, and “quality of life” degradation. “Air Pollution” causes a high rate of death due to different respiratory conditions. These consequences are limited not only to people but also to the ecological plant and animal systems. The radiation of the sun is trapped close to the earth's atmosphere due to “air pollution,” causing a higher surface temperature, resulting in global warming

Air pollution may be traced back to a wide variety of sources, each of which has its own unique set of challenges. Major contributors to environmental pollution include the use of

residential energy for cooking and heating, automobiles, the generation of electricity, the combustion of agricultural produce, and industrial production. It is possible that significant causes of air pollutants may be reduced by implementing more sustainable land use practises, cleaner home mobility options, electrified houses, power generation, industry, and improved management of solid waste policies and investments.

There are several contributors to air pollution, each of which is responsible for its own unique set of problems. The burning of agricultural products, the usage of automobiles, the generation of electricity, and the industrial process are the primary contributors to pollution in the outdoor environment. The use of land in a sustainable manner, the adoption of cleaner energy and transportation methods in the home, the construction of energy-efficient buildings, as well as improvements in the policies and investments surrounding the management of municipal waste, are all ways in which major sources of ambient air pollution could be reduced.

2.2.1 Background

Outside air pollution is a serious public fitness issue that affects people in low-, middle-, and high-earnings countries alike.

In 2016, it became expected that ambient (outside) air pollutants triggered 4.2 million premature deaths worldwide in each city and rural regions; this mortality is due to publicity to excellent particulate rely (PM2.five) with a diameter of 2.5 microns or much less, which reasons cardiovascular and respiratory sickness, in addition to tumours.

People living in nations with low and intermediate incomes have a disproportionate percentage of the burden of dealing with the negative impacts of polluted outdoor air. The 4.2 million premature deaths may be traced back to low- and middle-income nations, with the South-East Asia and Western Pacific areas of the WHO having the greatest burden to bear. The most current estimates of burden demonstrate how significant a link there is between air pollution and cardiovascular disease and mortality. There is a growing body of data linking the presence of air pollutants in the country to an increased risk of cardiovascular disease. These investigations were carried out in very polluted locations. According to the World Health Organization, ischaemic heart diseases accounted for 58 percent of early deaths caused by outdoor air pollution in 2016. The remaining 18 percent

of premature deaths were due to airway obstruction and acute lower respiratory infections, and 6 percent were due to lung cancer. At the same time, it's possible that other factors contributed to the cause of some people's deaths. For example, smoking and polluted air in the environment are both potential contributors to the development of lung cancer. If air quality had been better or if people had smoked less, then maybe some of the fatalities caused by lung cancer might have been avoided.

According to a report published in 2013 by the International Agency for Research on Cancer (IARC), people are more likely to develop cancer if they are exposed to high levels of outdoor air pollution. The IARC found that the particulate matter component of air pollutants was most intently linked with increased cancer occurrence, in specific lung cancer. In addition, there is a correlation between increased levels of pollution in the outside air and an increase in the incidence of malignancies affecting the digestive system and kidney.

To safeguard public fitness, all danger factors for noncommunicable ailments, which include air pollution, ought to be addressed.

The indoor smoke that results from household air pollution poses a significant threat to the health of the 2.6 billion people worldwide who cook and heat their houses with biomass fuels and charcoal in addition to the air pollutants that are found outside. In the year 2016, air pollution in the United States was responsible for the premature deaths of 3.8 million people. the burden has almost exclusively been shouldered by nations with low and moderate incomes. Home air pollutants are a key source of outdoor air pollution, contributing for as much as 50 percent in some components of the sector. This is true in both urban and rural settings.

2.3 Household air pollution

One of the biggest contributors to illness and premature death in developing countries is the air pollution caused by household activities.

Smoke from cooking fires is responsible for 3.8 million deaths annually each year, the vast majority of which take place in countries with low and moderate incomes. When dung, wood, or coal are burnt in inefficient stoves or open hearths, a number of harmful pollutants are created. These pollutants include particulate matter (PM), methane, carbon

monoxide, (PAH), and (VOC). In traditional wick lamps, the burning of kerosene releases a significant number of fine particles as well as various types of pollutants. Particulate matter is a very dangerous kind of environmental contamination. Numerous pieces of research have pointed to a causal relationship between exposure to PM and adverse impacts on one's health. Nanoparticles requires a lower diameter (PM2.5 or less) are much more hazardous than bigger particles, while ultrafine particles (those with a diameter of one micron or less) have the potential to penetrate organs and tissues, posing an even greater risk.

Children and adults alike are susceptible to the adverse health effects that may be brought on by polluted indoor air, which can range from cancer to eyesight impairments to respiratory illnesses. Accidents, burns, poisonings, and injuries to the musculoskeletal system are more likely to occur in households that make use of harmful fuels and equipment. According to the World Health Organization (WHO), this is the case.

2.3.1 Background

Approximately 2 billion people worldwide still use open flames, inefficient stoves, and strong fuels (such as wood, agricultural residues, charcoal, coal, and dung) to prepare their evening meals. Kerosene is also a common fuel used in these methods. The vast majority of these individuals are living in poverty and their countries of residence are classified as either low- or middle-income nations.

These cooking methods are ineffective, and they rely on fuels and new tech that pollute indoor air with a growth of risky polluted air, such as tiny soot particles that permeate deep inside the lungs. In addition, these methods pollute the environment by requiring more resources to produce the pollution. In houses with insufficient ventilation, the levels of indoor smoke might be one hundred times lower than the limits that are considered acceptable for high-quality particles. Particularly at risk are pregnant women, young children, and other members of the family who spend most time around the fireplace.

2.3.2 Impacts on health

Domestic air pollution is caused by the wasteful use of fuel sources and kerosene for cooking, and it is estimated that over 38 million people die prematurely as a consequence of this pollution each year. Among the 38 million people who passed away, 27 percent of

deaths were caused by pneumonia, 18 percent of deaths were caused by stroke, 27 percent of deaths were caused by ischaemic heart disease, 20 percent of deaths were caused by chronic obstructive pulmonary disease (COPD), and 8 percent of deaths were caused by lung cancer.

a) Pneumonia

Pollutants in the air that are found in homes practically increase the risk of paediatric pneumonia, which is responsible for 45 percent of all pneumonia-related deaths in children less than 5 years old. Adults are at risk for acute lower respiratory infections (pneumonia), which are caused by pollutants in the home's air. Pneumonia is responsible for 28 percent of all deaths attributed to the condition.

b) Chronic obstructive pulmonary disease

Exposure to indoor air pollution is the cause of one death from airway obstruction (COPD) for every four people in low- and middle-income countries (COPD). Women who are exposed to high levels of indoor smoke are more than twice as likely to develop COPD compared to women who use purifier fuels and production. This difference in risk is much more than twice times as great. Exposure to contaminants found in the household air almost doubles the risk of COPD in adult males, who already have a greater risk of COPD due to their higher rates of smoking)

c) Stroke

When people cook with solid fuels and kerosene, they are routinely exposed to the air pollutants that are produced in their homes, which is the cause of twelve percent of all stroke-related deaths.

d) Ischaemic heart disease

The presence of air pollution in the house is responsible for around eleven percent of all fatalities related with ischemia coronary heart condition. This results in over one million premature deaths each and every year.

e) Lung cancer

Around 17 percent of lung cancer fatalities in adults are attributable to exposure to cancer-causing compounds in home air pollution caused by cooking with strong fuels such as wood, charcoal, or coal. This pollution is formed when kerosene or other strong fuels are used to cook with. Because they are more likely to be involved in meal education, women are more likely to be affected.

f) other health impacts and risks

The airways and lungs get irritated by the minute particles and other pollutants that are produced by indoor smoking. This reduces the body's capacity to mount an immune response and decreases the amount of oxygen that can be carried by the blood.

In addition to being connected to low birth weight, tuberculosis, conjunctivitis, and oropharyngeal and laryngeal cancers, household air pollution has also been linked to asthma.

Ischemic heart disease and stroke are two of the leading causes of death in the United States. Ischemic heart disease and stroke are both caused by high blood pressure, poor nutrition, lack of physical activity, and smoking. A number of factors may contribute to the development of pneumonia in adolescents, including inadequate breastfeeding, becoming underweight, and being exposed to second-hand smoke. Both active smoking and passive exposure to second-hand smoke are major contributors to the development of lung cancer as well as chronic obstructive pulmonary disease (COPD).

2.3.3 Effects on health disparities, opportunities for growth, and climate change

without sizable coverage modifications, the general range of human beings without get admission to to clean fuels and technology would stay clearly constant with the aid of 2030 (international electricity business enterprise, 2017), making the 2030-time table for Sustainable improvement greater hard to accomplish.

The accumulation of gas raises the risk of musculoskeletal injury, consumes a significant amount of time for both women and children, impedes the performance of other productive tasks (such as the generation of money), and prevents children from attending school. When going to less secure sites to get gasoline, women and children put themselves

at risk of being harmed or assaulted. Black carbon, often known as soot particles, and methane are both significant contributors to climate change and are emitted when a stove burns fuel inefficiently. The technologies and fuels that individuals use in their houses for eating, heating, and lighting may be hazardous to their health in a number of different ways. The ingestion of kerosene is the leading cause of poisoning among children, and the usage of energy inside the house for the purpose of cooking, heating, or lighting is associated to a significant portion of the severe burns and injuries that occur in countries with low to moderate incomes. There are one billion people on the planet who do not have access to electricity; the majority of them light their houses with kerosene lamps, which emit exceptionally high levels of extremely small particulate matter. The use of environmental pollution lighting fuels introduces additional health risks, such as burn injuries, accidents, and poisonings. Additionally, the use of environmental pollution lighting fuels eliminates additional opportunities for healthy development, such as the ability to learn or engage in activities such as slight crafts and deals that require adequate illumination.

2.4 Air pollutants

In a large-scale bureaucracy, air pollution may be caused by a wide variety of toxins. Almost every poisonous substance has the potential to escape into the environment, where it may contaminate the air that humans breathe. The debris known as aerosol, which is defined as "clouds of solid and liquid particles in a gas," and which may be seen floating in the air may also contain pollutants.

Air pollution is the term that is widely used to refer to the many pollutants that lower the quality of the air. The presence of such substances may be ascertained in the air using significant documentation. There is a gaseous form (like gases), and there is also a solid form. One form is like a gas, while the other form is like a solid.

Multiple gas compositions vary in the atmosphere. $N2$, $O2$ and Ar percentages do not change each day. In contrast, 78 percent of $N2$ makes up 21 percent of $O2$ and 9 percent of Ar. Every one-tenth of the total amounts of $CO2$, $N2O$, $CH4$ and $O2$. The concentrations of water vapor vary between 0 and 4%.

Table 2-1 Atmospheric Composition of gases

Chemical Formula	Gaseous form	% Volume
N_2	Nitrogen	78.08
O_2	Oxygen	20.95
H_2O	Water	0 to 4
Ar	Argon	0.93
CO_2	Carbon Dioxide	0.036
Ne	Neon	0.0018
He	Helium	0.0005
CH_4	Methane	0.00017
H_2	Hydrogen	0.00005
N_2O	Nitrous Oxide	0.00003
O_3	Ozone	0.00004

Source: (EPA Gov,2015)

The WHO air transport quality guidelines provide information on thresholds and boundaries for important air pollutants that pose risks to human health and are applicable throughout the globe.

The recommendations are applicable in every region of the world, including both indoor and outdoor settings, and are founded entirely on an expert evaluation of the most recent scientific evidence for factors including the particulate matter count (PM), ozone levels (O3), nitrogen dioxide (NO2), and sulphur dioxide (SO2) (SO2).

In addition, qualitative and accurate practise guidelines for black carbon carbon, ultrafine debris (=1um), and debris resulting from sand and dust storms are included in the proposals.

2.4.1 Particulate matter (PM)

I. Definition and principal sources

It is fairly uncommon for particulate matter to serve as a proxy indication for air pollution. It has a greater influence on the human population than any other pollutant. Sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral soil, and water are the essential components that make up particulate matter (PM). It is made up of a complicated

combination of solid and liquid particles that are composed of organic and inorganic ingredients that are suspended in the air. Far though particles having a diameter of 10 microns or much less, referred to as PM10, are able to penetrate and lodge deep in the lungs, the particles with a diameter of 2.5 microns or much less, referred to as PM2.five, are even more harmful to one's health. The lung barrier may be broken by PM2.5, allowing the particle to enter the circulatory system. A persistent exposure to debris raises the risk of developing cardiovascular and respiratory diseases in addition to the risk of developing lung cancer.

Measurements of air quality are often discussed in terms of daily or yearly mean concentrations of PM10 particles in relation to the volume of air in a cubic metre (m3). Measurements of typical air quality typically indicate PM concentrations in units of micrograms per cubic metre, abbreviated as g/m3. concentrations of first-class particles (PM2.5 or smaller) are also noticeable when sufficiently sensitive testing equipment is available.

II. Health effects

It is possible that there is a tight, quantifiable association between exposure to high concentrations of microscopic particles (PM10 and PM2.5), on a daily basis as well as over the course of time, and increased mortality or morbidity. On the other hand, even if there is a reduction in the concentration of tiny and fine particles, the corresponding mortality rate could actually go in the other direction. This is predicated on the assumption that other parameters will continue to be the same. This makes it possible for policymakers to estimate the improvements in population health that may be anticipated if particle air pollution are decreased.

Even at very low concentrations, small particle pollutants may have an effect on fitness; in fact, there is no threshold that has been identified beyond which there is no risk to one's health. Consequently, the World Health Organization established international guideline limits with the intention of achieving the lowest quantities of PM possible.

2.4.2 WHO Air quality guideline values & properties

1. Particulate matter (PM)
    a. Fine particulate matter ($PM_{2.5}$)

5 µg/m3 annual mean

15 µg/m3 24-hour mean

    b. Coarse particulate matter (PM_{10})

In a manner comparable to that of guideline values, the WHO worldwide air quality guidelines include intervening time targets for concentrations of PM10 and PM2.5. These objectives are designed to encourage a gradual transition from excessive to lower concentrations of the pollutant.

Significant reductions in the risks of acute and long-term fitness outcomes brought on by air pollution may be anticipated if these criteria for the time between targets are met. However, reaching the levels suggested by the rule of thumb should be the ultimate goal.

Even though the exposures in many quickly-growing cities today are frequently a great deal better than in developed cities of comparable size, the outcomes of PM on health take place at levels of publicity which might be presently being experienced by way of a large variety of humans both in urban and rural areas as well as in developed and growing international locations. This is the case despite the fact that exposures in urban areas which might be growing at a faster rate than others are comparable in size.

Exposure to pollution in and around homes, caused by the family combustion of polluting fuels on open fires or traditional stoves for cooking, heating, and lighting, further increases the risk for air pollution-associated diseases in low- and middle-income countries. These diseases include acute lower respiratory infections, cardiovascular disease, chronic obstructive pulmonary disease, and lung cancer.

Exposure to particulate matter (PM), in addition to ozone (O3), nitrogen dioxide (NO2), and sulphur dioxide (SO2), may pose critical health dangers. This isn't just the case when PM is the only pollutant in question (SO2). In the same way as with PM, concentrations are typically at their peak in significant part inside the urban areas of low- and middle-income countries. Ozone is a significant contributor to the morbidity and mortality associated with asthma. Nitrogen dioxide and sulphur dioxide may also have a role in allergic reactions,

bronchial symptoms, lung inflammation, and reduced lung characteristic, but ozone is by far the most important contributor.

1. Chemical Properties

Particulate matter, or PM for short, may come in many different sizes. PM-10 refers to particles less than 10 micrometres, whereas PM-2.5 refers to particles that are 2.5 micrometres or larger (2.5 micrometres or1less).

Burning fuels are the major contributor to particulate matter in the atmosphere. This includes anything from diesel and gasoline to timber and leaf materials. Other sources of particle count number include construction sites, road construction, manufacturing facilities, and quarries.

2. Toxicity

When individuals are exposed to high amounts of tiny particulate matter, the particulate matter may build in the lung and along the respiratory and become hazardous. The severity of the symptoms increases both with the length of exposure as well as the quantity of particulate matter that is present. Among the consequences we see are: Coughing, difficulty breathing, inflammation of the respiratory tract, difficulty breathing and coughing, lung dysfunctions, chronic bronchitis, and cancer, particularly lung cancer are all potential side effects of smoking.

II. Ozone (O_3)

100 µg/m3, 8-hour daily maximum

60 µg/m3 8-hour mean, peak season

99th percentile, (i.e., 3-4 exceedance days per year)

Top season is described as a mean of each day maximum 8-hour suggest O3 concentration in the six consecutive months with the very best six-month running common O3 attention.

I. Chemical properties

One of the most important components of photochemical smog is ground-level ozone, which should not be confused with the ozone layer that is found inside the upper biosphere.

It is created by using the interaction of pollutants with light (a photochemical reaction), which includes nitrogen oxides (NOx) from automotive and enterprise emissions and volatile organic compounds (VOCs) generated by autos, solvents, and business. As a direct consequence of this, the highest levels of ozone pollution are seen during periods of time when the weather is clear and bright.

II. Toxicity

Ozone levels in the air that are too high might have a significant impact on people's health. It is possible for it to cause breathing difficulties, asthma, a reduction in lung function, and lung diseases.

III. Nitrogen dioxide (NO_2)

10 µg/m3 annual mean

25 µg/m3 24-hour mean

To protect the general population from the negative effects that nitrogen dioxide gas may have on one's health, the World Health Organization has established the current guiding principal value at 10 g/m3 (annual mean).

Nitrogen oxides are everywhere, and this is a consequence of industrial civilisation that is generally considered to be unfavourable. despite the fact that they have a variety of applications that are to their advantage, they may also be major sources of pollution.

1. Chemical properties

NO2 is the primary contributor to the formation of nitrate aerosols, which are a significant component of PM2.5 and, in the presence of UV light, contribute to the formation of ozone. The primary advantages of NO2 emissions caused by human activity are combustion techniques (heating, power era, and engines in automobiles and ships).

Gases known as nitrogen oxides are formed when nitrogen and oxygen combine. It's possible that many of these are man-made and are very hazardous to people's health. Nitric oxide (NO), nitrous oxide (NO), and nitrogen dioxide (NO2) are the most prevalent of these gases (N2O).

The majority of them are odourless and either colourless or brownish when they are at room temperature. They also have a distinctive taste.

2. Toxicity

Epidemiological studies have shown that the progression of bronchitis symptoms in asthmatic children is associated with prolonged exposure to NO2. A decreased lung typical expansion is also associated to NO2 at concentrations that are currently measured (or found) in cities in Europe and the North American United States.

Nitrogen oxides are a major contributor to air pollution and may be produced in a variety of ways, including the combustion of a wide variety of fuels, the use of tobacco products, electroplating, welding, and other similar processes.

Nitrogen oxides contribute to the formation of smog when combined with volatile organic molecules; when combined with sulphur dioxides, they contribute to the formation of acid rain.

Depending on the amount of exposure and how long it lasts, nitrogen oxides can cause serious health problems such as respiratory issues, throat spasms, headaches, fatigue, nausea, dizziness, lung fluid build-up, decreased fertility in women, intellectual confusion, birth defects, and coughing. Nitrogen oxides can also cause birth defects.

3. Uses

Nitrite is used in the bleaching of rayon as well as the transportation of nitric acid. In addition to being utilised in the production of other chemicals, such as rocket fuel and explosives, nitrogen dioxide is also used. On occasion, nitrogen dioxide is used in the bleaching process for flour.

IV. Sulphur dioxide (SO_2)

40 µg/m^3 24-hour mean

According to studies, some people who have asthma have alterations in their pulmonary function as well as symptoms related to their breathing after being exposed to SO2 for extended periods of time. In recent years, it has come to light that the health consequences of SO2 are triggered at far lower concentrations than was previously assumed. It is desired

to have more protection. Despite the fact that the chain of events leading up to the impacts of low SO2 concentrations is still murky, there is a good chance that reducing SO2 concentrations will result in less attention being paid to co-pollutants.

Sulfur oxides are present in every part of our environment. Some of them are clearly occurring naturally (for instance, in volcanic eruptions), and they aren't very dangerous; others, on the other hand, may be the result of industrial processing carried out by humans, and they are quite hazardous.

1. Chemical properties

SO2 is a fuel that is odourless and colourless, and it has a sharp smell. The combustion of fossil fuels (such as coal and oil) and the smelting of mineral ores that contain sulphur are the two primary processes that produce it. The burning of fossil fuels containing sulphur for purposes such as home heating, the production of electricity, and automobile engines is the major source of SO2 produced by human activity.

Sulfur oxides are any one of numerous chemicals that may be generated when sulphur is combined with oxygen. Sulfur dioxide (SO2) and sulphur trioxide are the two that are found most often (SO3). Sulfur dioxide is a completely poisonous fuel that may originate either naturally or as a result of human activity; it is odourless and has the appearance of a simple match that has been struck. In addition to being very hazardous to human health, sulphur trioxide is also extremely reactive and highly corrosive.

2. Toxicity

The irritation of the eyes is caused by SO2, which also has the potential to have an impact on the respiratory system and the structures of the lungs. An infection of the respiratory system may make a person more susceptible to other respiratory tract infections, as well as cause coughing, mucus output, an exacerbation of bronchial asthma, and chronic bronchitis. On days with higher SO2 levels, there is an increase in both the number of people who pass away and the number of people who are admitted to hospitals with cardiac illnesses. When SO2 reacts with water, it produces sulfuric acid, which is the primary component of acid rain, which is a cause of deforestation since it damages forest ecosystems.

The most developed nations produce significant amounts of the pollutant sulphur dioxide via their industrial processing of plants Long-term exposure, exposure to vital levels, exposure in children or in humans with which was before heart and lung conditions such as transient respiratory issues, continual bronchitis, respiratory problems, reduced fertility, and cancer are all examples of situations in which it is possible for it to bring about a variety of serious health problems. Symptoms such as coughing, stomach aches, issues with menstruation, nausea, and an inhibition of thyroid activity include: Discomfort in the Head, Shaking, and Dizziness.

3. Uses

There are several applications for sulphur dioxide to be considered. It is possible to use it as a resource in the process of directing sulfuric acid and sulfites. In addition to those uses, it may be put to work as a disinfectant, a preservative for food, and as a bleach for a variety of different things (flour, grains, fruit, textile fibres, gelatin, etc.).

V. Carbon monoxide

Monoxide is a known pollutant that may be found in almost all cities across the globe on Christmas Day. its mileage that was created in some way by the combustion of gas at some point in time (gasoline, oil, diesel, wood, charcoal and so forth.). This indicates that it may be found in exhaust from automobiles and tobacco smoke, in addition to unventilated areas where petroleum is being burnt.

1. Chemical properties

Carbon monoxide is a colourless, odourless, and tasteless gas that has the chemical formula CO. It is formed when one molecule of carbon and one molecule of oxygen combine to produce carbon monoxide.

2. Toxicity

Depending on how much carbon monoxide you are exposed to, you may experience symptoms of toxicity such as confusion, vision and balance problems, lack of focus, nausea and vomiting, headaches, muscle weakness, fatigue, shortness of breath, memory loss, miscarriage, birth defects, and damage to the nervous system. Other potential side effects include harm to the nervous system and birth defects.

3. Uses

Carbon monoxide is a key component in the manufacturing process for a wide variety of different types of chemical compounds. It is a crucial step in the production of phosgene, methanol, and other chemicals that are used in the colouring of meat and in the extraction of metals from ores in the field of metallurgy. As a neurotransmitter, it is also found in naturally occurring quantities throughout the human body.

VI. Carbon dioxide (CO_2)

Carbon dioxide is a naturally occurring molecule that may be found everywhere on Earth, including the water, the land, and the atmosphere. Because it is able to retain heat while also contributing to the phenomenon of global warming, this property gives it both positive and negative implications for the future of humankind.

1. Chemical properties

Carbon dioxide is a fuel that is odourless and odourless that naturally occurs in volcanic activity, tree felling, spring water, and other natural occurrences, as well as anthropogenically, primarily in the burning of fuels, but also through the various commercial make's uses of carbon dioxide. Carbon dioxide is a gas that has no colour or smell. CO2 is the product of its chemical process.

2. Toxicity

When breathed in by people or made direct touch with, carbon dioxide may be very hazardous to their health, particularly in small settings. Hyperventilation, the vision problems, muscular contractions, breathlessness, cramps, dumbness, dizziness, unconsciousness, damage to the nervous system, memory problems, nausea, confusion, sunburned skin, elevated blood pressure, and birth defects are some of the serious health problems that can be caused by exposure.

3. Uses

Carbon dioxide is put to use in a wide variety of applications. Refrigeration, food processing, metal works, cement manufacture, carbonation of soft drinks, fertilisers, lime

manufacturing, extinguishers, gas extraction, brewing, waste incinerators, and electric generating plant are some of the applications.

VII. Volatile Organic Compounds (VOCs)

Unstable natural chemicals are compounds that include carbon and have a high potential for rapid transformation into vapours or gases. In today's modern lifestyles, the release of these volatile organic compounds (VOCs) can be caused by the use of a wide variety of products or objects, such as the burning of gas or coal, solvents, glues, dry-cleaning products, and so on. These VOCs are a contributor to both air quality and serious health conditions.

1. Chemical properties

organic compounds comprise carbon, and they are the idea of lifestyles. volatile natural compounds are hence called due to the fact they could without difficulty flip from solids into vapours or gases (think of glues or gas, extra specifically of the vapours and poisonous gases they are able to release). they could incorporate fluorine, bromine, sulphur, nitrogen and other factors.

2. Toxicity

Because of the high level of toxicity, volatile organic compounds are much more probable to be present in the environment we breathe anytime the temperature rises, posing a larger threat to human health and well-being. Although not all VOCs are acknowledged to be hazardous, there are a few instances in which there are evident catastrophic outcomes. This is dependent on the component, the period of exposure, and the depth of the exposure. Formaldehyde, diesel fumes, styrene, benzene, and perchloroethylene are all substances that are known to cause cancer or are suspected of causing cancer. Heavy traffic, smoking, and other types of employment exposure may all pose serious threats to one's health. Known adverse effects on health include problems with the respiratory system, complications, exhaustion, dizziness, nausea, damage to the liver and/or kidneys, and problems with the key fearful device.

3. Uses

Unstable natural compounds can be discovered in household products or gadgets typically utilized in current society, from fuel to workplace resources. some of their uses are paint thinners, degreasers, aerosol cans, dry-cleaning merchandise, paints, photographic components, printers and photocopying machines and elements.

VIII. Gaseous Hg

Mercury is thought to be extremely dangerous to human fitness in any shape, a strong neurotoxin which could arise certainly or be released from power plant life and many other resources and unfold across land, soil, air, and water.

1. Chemical properties

Mercury is a heavy metallic that, at room temperature, takes place in liquid shape, however with an already high vapor pressure.

2. Toxicity

Mercury is very hazardous in its gaseous form owing to the fact that it may be breathed, eaten, or deposited on our bodies with much more ease. Despite the fact that mercury is extremely poisonous and that it accumulates in water and soil, its gaseous form poses a far higher threat. Mercury in its gaseous state may have toxic effects, some of which include developmental abnormalities, reproductive issues, thyroid disorders, kidney disorders, and neuropsychological impairments.

3. Uses

There are numerous makes use of for mercury in liquid form; however, there are fantastically few uses when it's miles in gaseous form. Mercury vapours enable strength to produce ultraviolet mild that then produces fluorescent light. some electron tubes, pores and skin tanning lamps, disinfection lamps additionally use gaseous mercury.

IX. Ammonia (NH_3)

Ammonia is a chemical that can be produced artificially in addition to being a naturally occurring substance. In its naturally occurring state, it may be found in decomposing matter, but it can also be covered by water, land, and air. Although it is made, it is most often found

in liquid state and has a variety of applications in both commercial and domestic settings. This caustic substance is almost always offered for sale in liquid form, and it is most frequent.

1. Chemical properties

NH3 is the abbreviation for ammonia in its chemical form. It is a kind of gasoline that is odourless but has a distinct and disagreeable smell. It is necessary for all living things since it provides a source of nitrogen; nevertheless, when consumed in large quantities, it may be highly toxic.

2. Toxicity

When present in high enough concentrations, ammonia may pose a significant threat to human health. harmful effects encompass Eye, skin, and throat irritation, coughing, shortness of breath, headaches, and chest tightness are all potential side effects. a feeling of nausea and sickness, Inflammation of the larynx, discomfort in the chest, allergic reactions, elevated blood pressure, discomfort in the abdomen, accumulation of fluid in the lungs, collapse of the lungs, seizures, and blindness are all potential complications.

3. Uses

Ammonia that has been created may serve a wide variety of purposes. It is used to a variety of uses, including fertiliser, pesticides, and explosives. Cleaning goods, synthetic fibres, fuel cells, industrial stabilisers, coolants, flooring wax, smelling salts, rocket fuel, and leather tanning are some of the items that are manufactured using synthetic fibres.

2.5 Causes of Air Pollution

Pollution of the air is among the most serious threats to the environment that our civilization must contend with in the modern day. Humans activities such as industrial, construction, transportation, economic activity, farming, and smelting are often the causes of kilometres. In contrast to anthropogenic activities, which are pervasive drivers of pollution levels and make a contribution daily to the global pollution of the atmosphere, natural forces such as volcanic activity and forest fires may also be capable of polluting the atmosphere; however, these types of incidents are extremely rare and normally only have a local impact.

According to John Walke, head of the clean Air challenge, which is a component of the climate and smooth strength initiative at the NRDC, "the biggest amount of air pollution comes from the usage of electricity and manufacturing." When fossil fuels are burned, gases and chemicals are released into the atmosphere. And to add insult to injury, pollution now not most effective adds to the problem of climate exchange but is also made worse by means of it, making this a specifically unfavourable feedback loop. According to Walke, the temperature of the planet is increased as a result of air pollution in the form of co2 and methane. "Another kind of air pollution known as smog, which forms when the environment is warmer and there is more UV light, is then made worse by utilising that better heat," The trading of weather will also result in a rise in the production of allergic air pollutants, such as pollen and mould (caused by wet conditions as a consequence of extreme weather and increased flood levels, respectively) (because of an extended pollen season).

"We have achieved progress over the last 50 years in boosting air quality in a few international regions via the simple Air Act," "But weather change will make it more difficult in the future to fulfil pollution criteria, which may be tailored to protect health."

Most of the time, air pollutants are odourless and colourless, making it impossible to detect their presence. On the other hand, this does not indicate that they do not still exist in sufficient amounts to be a threat to people's health! In addition, some gases are linked to the so-called "greenhouse effect," which describes the way in which certain gases retain more heat and, as a result, contribute to the overall warming of the planet. Carbon dioxide is the most frequent example of a greenhouse gas, and it is emitted as a by-product of a number of different industrial activities. Another example of a gas that might explode in a similar manner is methane.

Air pollution can be due to numerous processes, both natural or anthropogenic (man-made). a number of them go away glaring strains inside the air; others can pass ignored unless precise tests are carried out - or till you end up unwell from their effects.

Anthropogenic activities, such as fossil fuels, coal, petroleum, oil, and factories and vehicles that emit toxic gases, are significant sources of pollution. The most prevalent gases are $CO2$, CO, $NO2$, $SO2$ and PM. Air pollution became a primary concern during the post-industrial revolution era when more coal-powered trains and infrastructure growth occurred.

There are two main potential air pollution sources: one is vehicular, which emits 80 percent of contaminants into urban areas. The other is a cluster of industries located within or outside the city. There are two primary potential air pollution sources: one is vehicular, which emits 80 percent of contaminants into urban areas. The other is a cluster of industries located within or outside the city.

2.5.1 Natural Causes

There are natural explanations. One is for Volcano sports, in which volcanic eruptions generate a variety of poisonous gases (such as sulphur and chlorine) and particle matter (ash debris), but are often confined to isolated places. Winds and wind patterns may transport pollutants from the ground across vast distances. In addition to particle matter, wildfires emit carbon monoxide into the atmosphere (organic pollutants consisting of PAHs); they may damage large areas, yet, they often have restrictions and are manageable.

This action leads in the spontaneous release of gases, mostly methane gas. Microbial decay processes are processes in which organisms that are prevalent in every ecosystem play a vital part in the decomposition process of living species and environmental contaminants. Radon gas, for example, is emitted from the Earth's crust as a result of radioactive decay processes. This gas has the potential to concentrate in confined places such as basements because of its radioactive nature. Temperature rise is a contributor to an increasing number of pollutants that are released into the atmosphere from polluted soil and water.

Some of the pollutants come from natural sources as well. Huge volcanic eruptions emit sulphur dioxide, and forest fires, which emit volatile organic compounds and release ultrafine dust particles into the atmosphere, affect the earth's atmosphere.

These emissions from natural sources are short-lived, in contrast to emissions from human activities, which almost always result in irreversible changes to the earth's atmosphere.

2.5.2 Anthropogenic Causes

An additional manmade factor has exacerbated global warming. Airborne particulate matter from mining and smelting contains many components that have been attached to them by the crushing and processing of mineral resources. Since mine tailings have a high particle size (due to the crushing and processing of mineral ores), they may scatter metals across a wide area. In addition to the use of furnaces and casting activities, industrial plants emit

both organic and inorganic contaminants via unintended spills and leaks of stored chemical compounds or the handling and storage of chemicals, particularly volatile inorganic chemicals. Internal combustion of various fuels (typically gases consisting of carbon oxides, sulphides, nitrogen oxides, and natural chemicals as PAHs) emits a variety of air pollutants (gases, including carbon monoxide, sulphides, nitrogen oxides and particulate matter) via tailpipe gases, production and demolition activities that pollute the air with numerous production materials that pose a particular risk are all examples of this. When coal is burnt, it releases a variety of gases as well as particulate matter, metals (such as As, Pb, and Hg), and naturally occurring compounds (mainly PAHs), This is because, due to the burning of fossil fuels, a wide range of gases and particles are emitted during home heating as well as during garbage incineration, which is dependent on waste composition. Natural microbial decomposition at the disposal site causes the typical landfill disposal process to produce methane. Insecticides, herbicides, and pesticides, many of which include hazardous, unstable natural compounds, are often used in agriculture, and this pollutes the air. For example, forest and agricultural management may use controlled burning to create gases (as is the case with wildfires) and particles (as is the case with military activities). There are a range of carcinogenic organic and inorganic compounds that are produced by smoking. A ban on the storage and use of household items that contain organic solvents that are emitted into the air has been imposed. Chlorinated solvents (including PCE) and petroleum solvents used by dry cleaners may also be released into the air when clothing is cleaned in this manner and represent a health risk. The garments returned from the dry cleaners may be safely stored in enclosed indoor places.

those pollution sources are due to human activity and are labelled into three primary categories: line, point, region.

These pollution sources are caused by human activity and are classified into three major categories: line, point, and area.

a) Line Sources

Vehicle emissions sources are classified as line sources, and the vehicle composition defines the emission rate in that specific area.

b) Point Sources

Examples of point sources include Chemical facilities, steel plants, oil refining, power plants, and radioactive material incinerators are all examples. 10 kilos are emitted by point sources or 25 tonnes, each year, with both standards' pollution or harmful air pollutants.

c) Area Sources

Area sources shall be listed as sources emitting somewhere around 10 tonnes per year or below 25 tonnes per year of toxic air contaminants or components. This category includes commercial buildings, residential zones, retail zones, and even small bakeries. All primary sources of environmental emissions include open combustion, sewage waste, and wastewater treatment.

2.6 Effects of Air Pollution

The pollutants on the body vary based on the type of pollutant, the duration and intensity of exposure, as well as other factors, such as a person's own personal health risks and the combined influence of several stressors and pollutants.

The effects of exposure to polluted air on human health are devastating. Depending on the amount of contact that is made and the type of pollutant that is breathed in, the effects of this may vary from mild symptoms such as a cough and irritation of the respiratory tract to more serious issues such as asthmatic and chronic lung diseases.

Long-term contact with a variety of air pollutants may irritate the skin and contribute to the progression of cancer bureaucracy. Breathing in contaminants can also contribute to the development of cancer bureaucracy.

Air pollutants that have critical terrible outcomes at the human fitness can be categorized as

a) Toxic
    i. Carcinogenic

    Asbestos, PCE, TCE, VC, benzene, PAHs, EDB, EDC, PCBc, As, Cd, Ni, Cr, some compounds of mercury, arsenic oxide, certain nitrates, and certain pesticides are all known carcinogens.

    ii. Non-Carcinogenic

    lead, carbon monoxide, ammonia, acetone

b) non-toxic

Because these contaminants can still cause asphyxiation due to the oxygen depletion, they are nonetheless hazardous in certain doses and/or situations.

i. Non-explosives:

carbon dioxide

ii. Explosives:

Methane

The outcomes of air pollutants contain a large sort of illnesses, starting with the simple inflammation of eyes, nostril, mouth and throat or diminished strength ranges, headache, and dizziness, but additionally potentially greater extreme situations of which the maximum commonplace are respiration and lung sicknesses which incorporates bronchial asthma assaults, continual Obstructive Pulmonary ailment –COPD, decreased lung function, Pulmonary cancer – as a result of a series of carcinogen chemical substances that enter the frame thru inhalation, Mesothelimo – a specific type of lung most cancers, typically related to publicity to asbestos (it typically happens 20-30 years after the initial publicity) and Pneumonia. It additionally results in Leukemia – a kind of blood cancer commonly associated with exposure to benzene vapours (through inhalation), delivery defects and immune device defects, Cardiovascular issues - coronary heart ailment and stroke (an elevated danger especially due to particulate depend), Neurobehavioral problems - neurological problems and developmental deficits due to air pollutants together with mercury (that's the handiest volatile metallic), Liver and different varieties of most cancers – resulting from breathing carcinogenic volatile chemical substances and premature loss of life

consistent with cornell university have a look at, air pollutants from smoke and diverse chemical substances kills 3 million human beings a year.

2.6.1 Smog and Soot

These are the two most prevalent forms of air pollution that may be found. Pollutants produced by the burning of fossil fuels combine with the sun's rays to create smog, which is sometimes referred to as ground-level ozone. The term "soot" refers to the small particles of chemical compounds, dust, smoke, filth, or allergens that are transported into the air in the form of fuel or solids. Soot is sometimes referred to by its other name, "particulates

count." Both smog and soot are made up of similar components. "Both come from vehicles such as cars and vans, factories and power plants, incinerators and engines, and pretty much anything else that may set fire to fossil fuels such as coal, gas, or natural gas," adds Walke. "Both can also be found in the atmosphere."

People of all ages, but particularly youngsters, the elderly, and those who work or exercise outdoors may experience irritation in their eyes and throats as well as damage to their lungs when exposed to smog.

People who already suffer from asthma or allergies have it much harder since these increased levels of pollution may make their symptoms worse and bring on bronchial asthma episodes. Tiny particles of soot that are carried through the air, whether they are gaseous or solid, are especially hazardous because they may penetrate the lungs and the circulation, so exacerbating bronchitis, triggering heart attacks, or even leading to death. According to a report from the T. H. Chan school of public health at Harvard in 2020, COVID-19 mortality rates were higher in areas with more soot pollution than in regions with even slightly less, demonstrating a link between the virus's deadliness and exposure bracketing to fine particles in the air fascicle and enlightening an environmental justice issue. COVID-19 mortality rates were higher in areas with more soot pollution than in regions with even slightly less.

2.6.2 Hazardous air pollution

a tiny amount Nearly two hundred of them are prohibited by law; mercury, lead, dioxins, and benzene are among the most often encountered ones. According to Walke's research, "These are also often emitted during gasoline or coal burning, incinerating, or, in the case of benzene, seen in fuel." The Environmental Protection Agency (EPA) has identified benzene as a carcinogen, a substance that, in the short term, may cause issues with the eyes, skin, and respiratory system and, in the long term, can cause abnormalities in the blood. Dioxins, which are more usually found in food but may also be found in trace levels in the air, have the potential to cause short-term damage to the liver as well as long-term damage to the immune, neurological, and endocrine systems, as well as processes related to fertility. The central nervous system may be affected by mercury. Even low levels of lead exposure may have an effect on a child's intelligence and ability to learn, while high levels of lead exposure may have a negative impact on the kidneys and brains of youngsters.

Polycyclic aromatic hydrocarbons, sometimes known as PAHs, are a class of dangerous compounds that may be created when vehicle emissions and smoke from wildfires combine. They have been linked to a variety of adverse health effects, including irritation of the lungs and eyes, issues with the blood and liver, and the possibility of cancer at high dosages. One research found that children whose mothers were exposed to PAHs while they were pregnant had slower brain processing speeds and higher indications of ADHD than children whose mothers were not exposed to PAHs.

2.6.3 Greenhouse gases

Because greenhouse gases prevent the heat from the earth from escaping into space, temperatures rise. This phenomenon, known as global warming, is characterised by a rise in sea levels, an increase in the number of people who die from heat-related illnesses, and an increase in the rate at which infectious diseases spread. In the United States in 2018, carbon dioxide was responsible for 81 percent of all greenhouse gas emissions, while methane was responsible for 10 percent of those emissions. According to Walke, "Carbon dioxide is produced when fossil fuels are used, and methane originates from both natural and industrial sources, in addition to the huge volumes that are released during the drilling process for oil and gasoline." Although we release a far greater quantity of carbon dioxide into the atmosphere, the methane that we produce is a much more damaging greenhouse gas. Carbon dioxide isn't the only kind of gas that contributes to global warming; hydrofluorocarbons, sometimes known as HFCs, are several hundred times more potent than carbon dioxide at doing so. Over one hundred forty countries came to an agreement in October 2016 to reduce their use of certain chemicals that are found in air conditioners and refrigerators, and to expand the use of greener alternatives over the course of the following years. "the agreed-upon HFC phasedown will stay away from the equivalent of more than eighty billion tonnes of carbon dioxide over the following 35 years," according to climate and simple power application.”

2.6.4 Pollen and mold

Mold spores and pollen grains from trees, plants, and grasses are also carried in the air. This phenomenon, which is made worse by climate change, poses a potential threat to human health. Even though they are not under human control and are only indirectly related to human activities, it is possible that they may be considered a kind of air pollution. Mold may

grow in places where there has been water damage, such as houses, schools, or businesses, and it has the potential to create allergic airborne contaminants. "Exposure to mould may trigger asthma episodes or allergic reactions, and some moulds can even release toxins that are potentially hazardous for anybody to breathe in," says the Mayo Clinic.

Pollen-induced hypersensitivity responses are becoming more worse as a result of climate change. "Laboratory and field research are displaying that pollen-generating plants, particularly ragweed, develop large and convey more pollen when your growth the amount of carbon dioxide that they develop in," says Knowlton. "This is especially true when your growth the amount of carbon dioxide that they develop in." "Weather change furthermore increases the pollen production season," and "a few research is starting to imply that ragweed pollen itself may be becoming a greater allergen." If this is the case, then more individuals will have symptoms such as runny noses, fevers, itchy eyes, and other ailments.

Pollutants in the air are now the fourth-greatest risk factor for premature mortality throughout the globe. 45 million fatalities were due to exposures to outdoor air pollution in 2019, according to the most recent nation of globe Air report, which compiles the current medical information about air pollution around the sector. Any other 2.2 million deaths had been caused by interior air pollution. "Despite improvements in decreasing global common mortality rates from air pollution, the arena's most populous nations, India and China, continue to endure the very best burdens of disorder," personnel scientist at the NRDC technological know-how Centre said. "[T]he world's most populous nations, India and China, continue to endure the very best burdens of disorder." "This record serves as a sobering warning that the weather catastrophe promises to become worse air pollutants concerns to an appreciable degree if we fail to act to cut carbon pollution."

2.7 Relationship between the built structure and air quality

Air pollution concentration is described by two phenomena, the emission rate and the rate of dispersion. The emission rate is the effect of the pollution source, and the rate of dispersal is determined by natural components such as relative humidity, temperature, and wind speed.

Urban morphology serves as a barrier to these natural components and results in accumulation, venturi, and fugitive air pollution. Cities are becoming highly uninhabitable

(Junyan Yanga, 2020). Unethical construction patterns and unsustainable development are resulting in a lack of ventilation which is hindering the dispersion of pollutants. As a result, it is essential to understanding the pollutant dispersion process in urban areas (Zhengtong Li c, 2021). Air pollution is caused by the source and interaction of the pollutant with the urban structure or form. Thus, understanding air pollution requires more than just environmental engineering; the connection between air quality and urban structures should also be considered (Junyan Yanga, 2020).

While the urban structure and air pollution are not strongly associated, the improved urban form helps to disperse air pollution more effectively. The relation between “urban air pollution” and “urban structure” is the “urban microclimate,” particularly the wind environment. Urban space quality has a significant impact on the health and comfort of individuals. The breeze, which is influenced by the urban microclimate, decides air pollutant dispersion. The urban structure and density are important factors affecting the urban wind environment.

This unique spatial form gives and unique wind environment within the city. For example, the wind would be obstructed from large building volume resulting in poor ventilation conditions. Different zones of airflow would be generated as a result of the urban spatial structure. The urban system can both accelerate and decelerate the wind flow passing by, so the area where the wind is accelerated can be referred to as the "wind velocity zone." The area where the winds are trapped can be referred to as the "wind calm zone." In areas where the wind is calm, the dispersion can take time, and vice versa. The wind clam areas have the most health effects (Junyan Yanga, 2020). The spatial arrangement that does not act as a hindrance creates areas with good ventilation conditions. The pollution will, therefore, not continue for a prolonged duration in these areas. However, pollution will persist for a longer time in highly populated areas (Junyan Yanga, 2020).

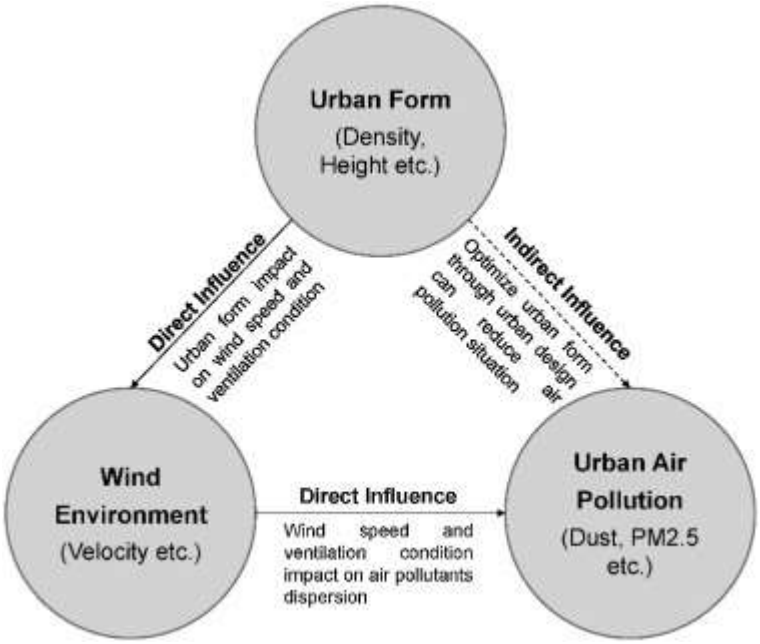


Figure 2-1The link between air quality, built form, and wind system

Source: (Junyan Yanga, 2020)

The fig shows how air quality, urban structure, and wind climate relate to each other. Wind and air emissions are closely connected. Wind speeds and directions are determined by the urban spatial structure in the wind system. The wind can be regarded as an essential element in the relationship between “air quality” and “urban morphology.

2D and 3D variables determine the association between urban morphology and air quality. The 2D elements are low-resolution urban tissue as we deal with factors such as urban fragmentation, compactness, forest area ratio, etc., where it indicates that the rise in travel time due to urban sprawl responsible for air quality deterioration, "vehicle miles travelled (VMT)." In contrast, the city's compactness helps minimize air pollution to a certain level by increasing traffic congestion (Jung Eun Kang, 2019) (Lee, 2019). 2D considerations also deal with land use land cover and provide us with information on sparseness, vegetative coverage, the ratio of the built area to the natural environment, and an essential consideration in air quality (Fan Li a, 2020). However, all these definitions speak about the state level, but the local level is still lacking

On the other hand, 3D factors are mainly associated with the dispersion and concentrations of air pollutants. Wind movement in the city is mainly driven by 3D urban geometry and building structure. That explains that elements such as site coverage and degree of

enclosure negatively impact wind dispersion. They all prevent the air from passing through them, allowing contaminants to collect within. While the building's average height indicates a positive correlation in air dispersion, there is a relative rise in wind velocity as its height increases (Junyan Yang*, 2020). The 3D factors are the high-resolution urban tissues that speak about building clusters or structures. Thus, all of the reviews and reports reviewed here indicate that both 2D and 3D variables are essential in deciding the effect of urban structure on air quality. Still, these studies should be carried out on a local scale rather than on a regional scale (P. Edussuriya a, 2011) (Lee, 2019). Thus, focusing on urban form to combat air pollution concerns directly approaches environmental issues with an optimistic view for a flexible, zone-based strategy, allowing quantification of urban spatial structure, which further promotes particular areas for countermeasures and design.

According to different kinds of literature, urban form metrics explore the concept of urban form by presenting measurable details in urban size, shape, fragmentation, sprawl, etc. Where these quantified values are correlated further with current levels of pollution. Here within, the polluted local zones are identified based on responsible urban features. These are understood and modelled to give out spatial mitigation strategies (Fan, 2019).

CHAPTER 3. STUDY AREA

3.1 Introduction

The city's expansion is crucial to the region's overall development because it's been and remains to be a canter of economic activity. As a result of urbanisation, a rising number of people are moving to the town. This group engages in activities like as working, receiving an education, participating in recreational activities, maintaining their healthcare, and so on in order to increase their socioeconomic well-being, and one of their derived needs is to travel. As a result, having enough transportation infrastructure is critical to the city's growth. More transportation activity, on the other hand, may result in more pollutants, traffic, and accidents in the city. As a result, effective planning is necessary to encourage safe access and mobility for people of all socioeconomic levels while simultaneously safeguarding the health of the environment.

3.2 Delineation of planning area

The research area is the Greater Vizag Municipal Corporation (GVMC) is a 534-square-kilometer urban agglomeration zone in the city of Visakhapatnam. Hills, trees, the port, and industry cover large areas of the city. Except for these locations, the city's urban built area is centred in 166km2 of the overall city area of 534km2. The figure illustrates the Map, which shows the GVMC boundaries, road system, and built-up region.

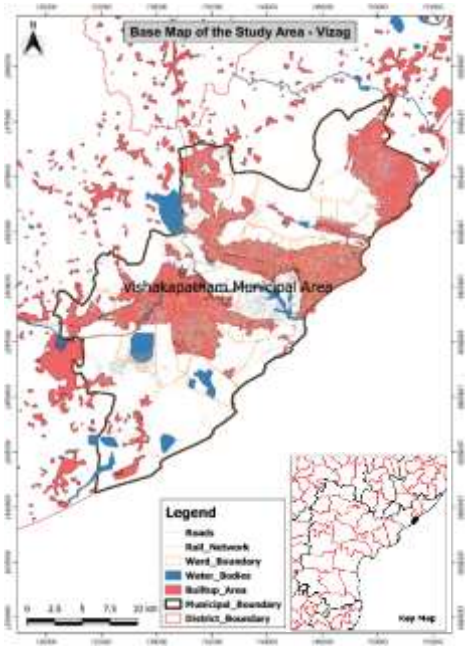


Figure 3-1Planning area of the GVMC

3.3 City profile

From 1858, From the formation of its 'Municipal Association' until 2012, For citizens of northeast Andhra and southern Odisha, the city has evolved into a major economical, intellectual, health, and tourism hub. The metropolis's National Highway (NH-5) is well linked both regionally and domestically. Railways, an airport, and a harbour are all nearby. The city is also a regional centre for education, health, and tourism, attracting a daily influx of people seeking these services.

With 68 percent of people under the age of 40, the city's demographic information displays a comparatively young population. The city's 1.73 million population is made up of 875,000 men and 855,000 females, for a ratio of 977 females to 1000 males. (2011 Census)

3.4 City structure

In 2005, the old VMC, Gajuwaka Municipal Council, and 32 minor towns make up Visakhapatnam Municipal Corporation (VMC). combined to become the greater Visakhapatnam Municipal Corporation (GVMC). The elements that are seen characterise the modern-day city form.

3.4.1 Patterns underlying land use

The present land use pattern of the city is depicted in Table 1. As previously stated, just 166km2 of the city's 534km2 are now developed, with the remainder covered by hills, woods, and water bodies. The built-up area's usage pattern is seen below. Industries are noted to occupy 57% of the locality, a representing a prominent land use category. Housing is the most prevalent land use among others, with commercial and public areas accounting for less than 1% each. In comparison to residential areas, this is abnormally low. Even these business districts are all centred in the inner-city region, encouraging long-distance excursions from residents on the city's periphery. In all city outgrowths, the need to encourage sustainable land usage and expand commercial areas.

Table 3-1 Patterns of land use in Visakhapatnam

The kind of land usage	Built up area	Percentage of Area occupied
Industrial	95-kilometre 2	57 percent
Residential	38-kilometre 2	23 percent

Commercial	2-kilometre 2	1 percent
Public spaces	1 kilometre 2	1 percent
Roads	17-kilometre 2	10 percent
Railways + airport + bus terminals	11-kilometre 2	6 percent
Other	2-kilometre 2	1 percent
Total	166-kilometre 2	100 percent

Source: VMRDA, Revised Master Plan for Visakhapatnam Metropolitan Region – (2021)

3.4.2 Regional Integration

This region, which is positioned roughly in the middle, has been essential in the development of contemporary Andhra Pradesh, which stretches all the way from Chennai in the southern (762 kilometres) to Kolkata in the northern (879 kilometres). The Bay of Bengal borders the region to the east, the Srikakulam district to the north, and the Godavari region of Andhra to the southeast. The rest of Vizag district is located on the region's western side, and it is bounded in the extreme west by the state of Orissa. Vizag, The Visakhapatnam district includes Gajuwaka, Anakapalli, and Bheemunipatnam , whereas the Vizianagaram district includes Vizianagaram. Visakhapatnam is the main city in this area. Hyderabad, Vizag is 637 kilometres away from Hyderabad, the historical capital of the state, which is well connected by roadway, railway, and aviation. (VMRDA's The Visakhapatnam Metropolitan Region 2021 Revised Master Plan)

3.4.3 Population density

The city has a density of population of 3,300 people per square kilometre and a surrounding area of 530km2. Considering the city's population density, the built-up area is 166km2. The 50km2 major city zone has a density of population of 27,000 persons per square kilometre and houses around 50% of the city's residents. In the city's core, population density might exceed 60,000 per sq.km. In addition, population density is minimal beyond the central city.

CHAPTER 4. DATA ANALYSIS

4.1 Travel behavior of the city

4.1.1 City trips

The daily travel rate in the city is 1.66 trips per person, with men making 1.81 more trips per day than females, who only make 1.52 excursions per day. As a consequence, the 1.73 million people who utilise various modes of transportation in the city make a complete of 2.88 million travels per day. These journeys are classified into two types: trip intention and gender. It has been observed that educational excursions are attended by an equal number of men and women. However, the proportion of female business trips is extremely low, owing to female's cheaper labour participation rates.

Table 4-1 Trips purpose inside city

Trip Purpose	Males	Females	Proportion of trips
Work	33 percent	39 percent	39 percent
Education	16 percent	32 percent	32 percent
Recreational	4 percent	27 percent	27 percent
Others	2 percent	2 percent	2 percent

Figure 4-1 Trips purpose in the city

4.1.2 Mode share

According to the average mode share for a number of different journeys, non-motorized modes of transportation such as walking and bicycling account for up to 55 percent among all journeys. About 2 percent of all journeys taken inside the city are completed by private automobiles. The most common kind of motorised transportation is the bus, followed by the two-wheeled variety and then the auto-rickshaw. There is a significant disparity between the mean shares of males and females. It is estimated that women commute on foot up to seventy percent of the time, with the buses and auto-rickshaw accounting for around twenty-three percent of their trips combined. The other forms of transportation only make up a negligible part of total journeys. However, males make up a considerable chunk of the mode-share, and two-wheelers are responsible for 22 percent of all travels taken by men.

Mode	Male	Female	Total
Walk	37%	69%	52%
Car	2%	1%	2%
2-Wheeler	22%	6%	15%
Bus	22%	14%	18%
Auto-Rickshaw	10%	9%	9%
Cycle	5%	1%	3%
Others	1%	0%	1%

Table 4-2 Mode shares in the city

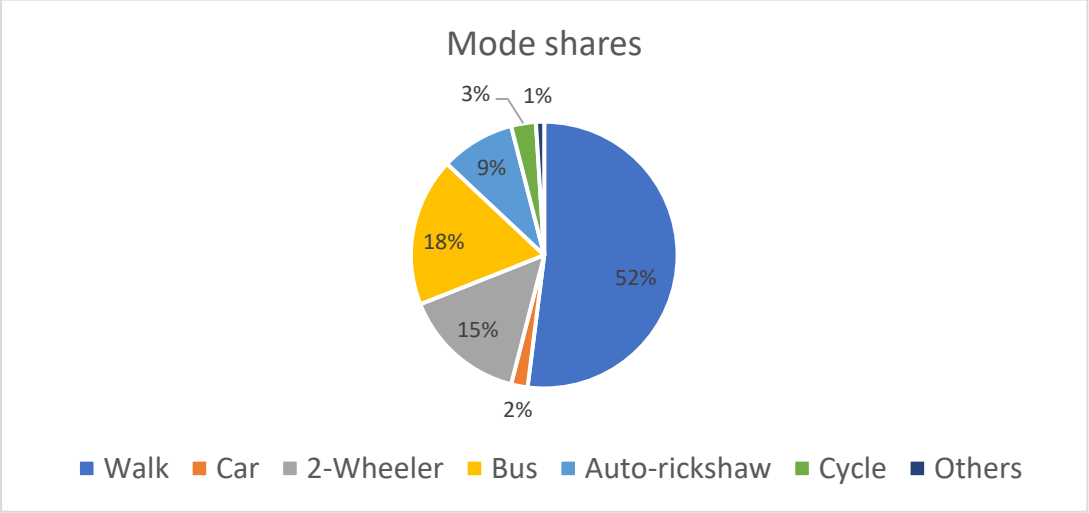


Figure 4-2 Mode shares in the city

4.1.3 Trip mode shares based on purpose

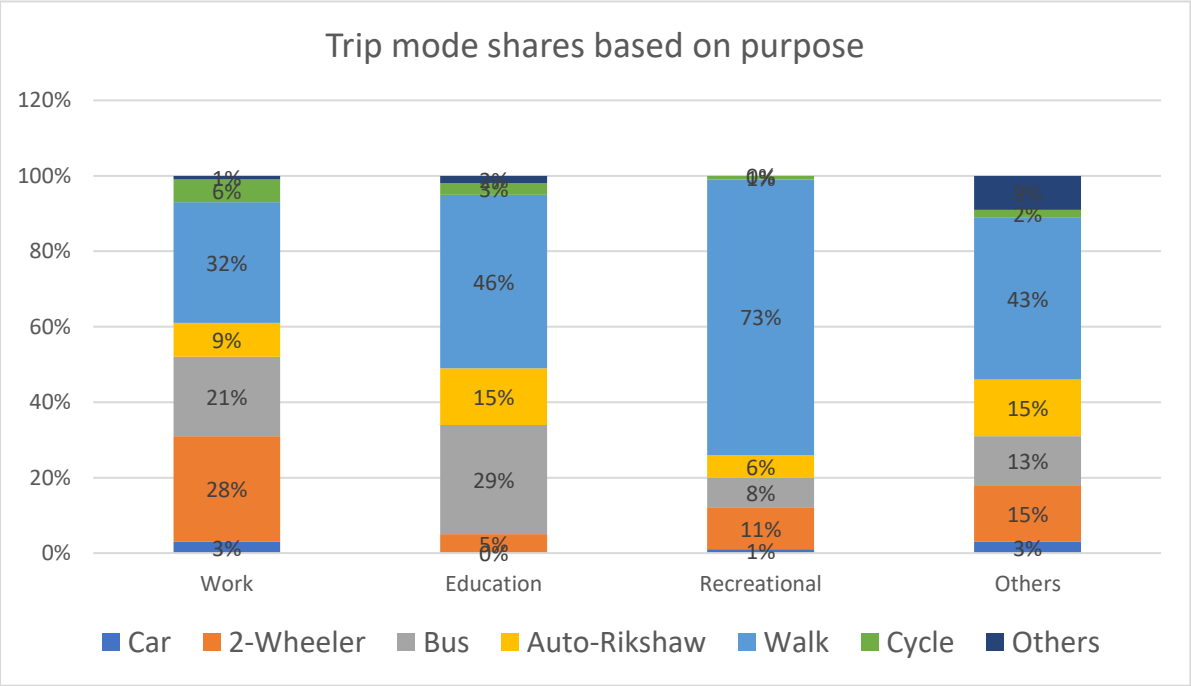


Figure 4-3 Trip purpose-wise mode shares

These modal shares differ based on the reason for the trip, the person's level of income, and the duration of the trip. Walking remains the most preferred mode of transportation for all sorts of journeys. For business trips, two-wheelers are the most prevalent method of transportation, whereas busses and auto-rickshaws are most common vehicles of road transport for educational trips. It is also important to highlight that the frequency of bicycle use during business travels is much higher than that seen during educational excursions. This demonstrates that cyclists are restricted to riding since they are unable to pay the costs associated in utilising buses or an auto-rickshaw. Consequently, they are forced to ride.

4.1.4 Trips lengths

Seventy-one % of all excursions in the city are less than 3 kilometres long, this explains the large percentage of journeys taken by foot around the city. The typical journey within the region is around 4.1 kilometres in length.

Table 4-3 The distribution of trip lengths within the city

Trip lengths	percent of trips
Less then 1 Km	54 percent
1-3 Km	17 percent

3-5 Km	9 percent
5-10 Km	10 percent
More then 10 Km	9 percent

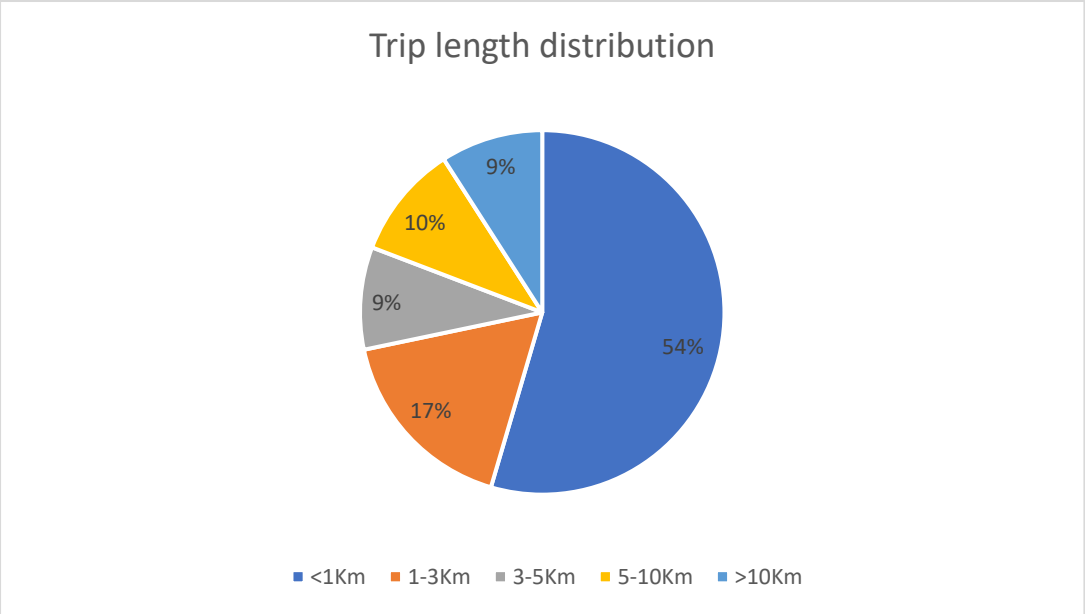


Figure 4-4 Trip length distribution in the city

4.1.5 Mode wise average Trips length

The patterns of trip duration reveal a striking discrepancy between the uses of various modes. the typical travel times of the different forms of transportation The length of the journey is the most important factor in deciding which mode to choose, so each mode refers to a different category of trip duration. It is standard practise to travel shorter distances using non-motorized forms of transportation, such as walking or riding a bicycle. The fact that the city's average travel distance is just 4.1 kilometres despite its huge size demonstrates that people prefer to live near to their destinations in spite of the city's massive size.

Table 4-4 Mode-wise average trip length

Modes	Average trip length
Car	9.3 Kilometre
Two-Wheeler	5.8 Kilometre
Bus	11.7 Kilometre
Auto-rickshaw	5.9 Kilometre

Walk	0.7 Kilometre
Cycle	3.2 Kilometre

After obtaining these average route durations, the data is next disaggregated in order to investigate the distribution of trip lengths in each mode of transportation. Pedestrian trips, the most popular means of transportation, are noted to be 87% within 1km, demonstrating the city's current integrated land use pattern of development. Furthermore, contrary to common belief, the urban buses and auto-rickshaw really aren't competitors. They cater to public transportation excursions of varied lengths, Auto-rickshaws, which have a set fare and a limited passenger capacity, are used to transport passengers for shorter trip lengths, whereas buses, which have a higher passenger capacity but lower frequency, transport passengers for longer journeys.

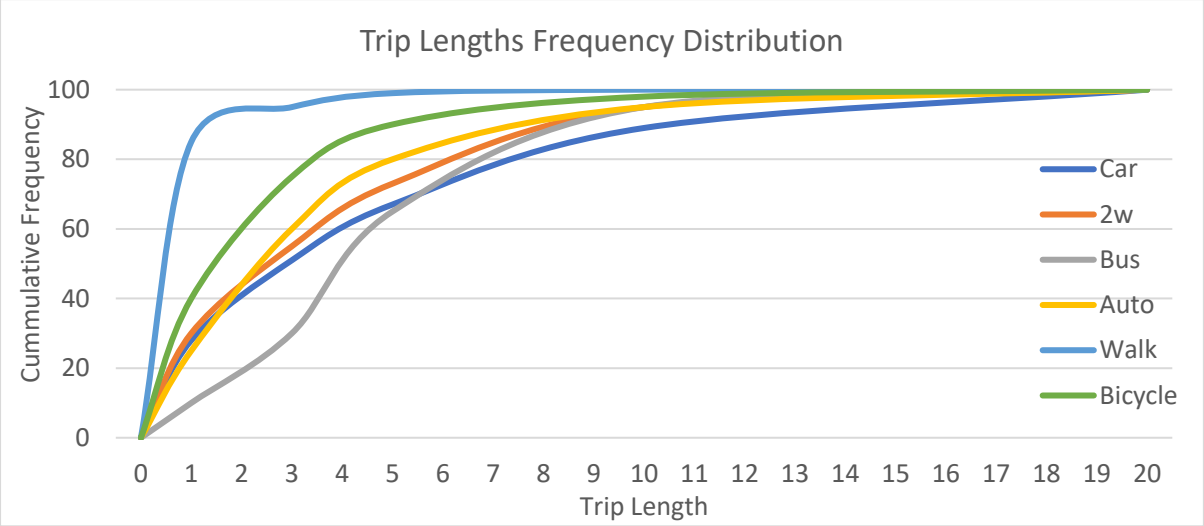


Figure 4-5 Mode-wise trip length distribution (in km)

4.1.6 Quality of footpath infrastructure

It has been discovered that fifty percent of the region's paths are in disarray due to a variety of problems like the existence of utility lines and plants on the sidewalk, entrance to dwellings all along the road, and gaps in walks at crossings and on-street parking. Twenty percent of the walkways have been taken up by parking, while shop owners along the road are expanding their businesses onto the sidewalks. Only thirty percent of the trails are completely devoid of obstacles. However, even these pathways are not totally accessible since the majority of them are constructed out of concrete blocks that operate as a covering

for the walkways that are comprised of sewage pipes that are located underneath them. They are between 180 and 200 micrometres above the roadways and have regular gaps between the concrete blocks, both of which are uncomfortable for drivers and passengers.

Table 4-5 Quality of footpath infrastructure

The standard of the pathways	percentage of pedestrian walkways
No intrusions	30 percent
Irregular	50 percent
Mostly unusable	20 percent
Total	100 percent

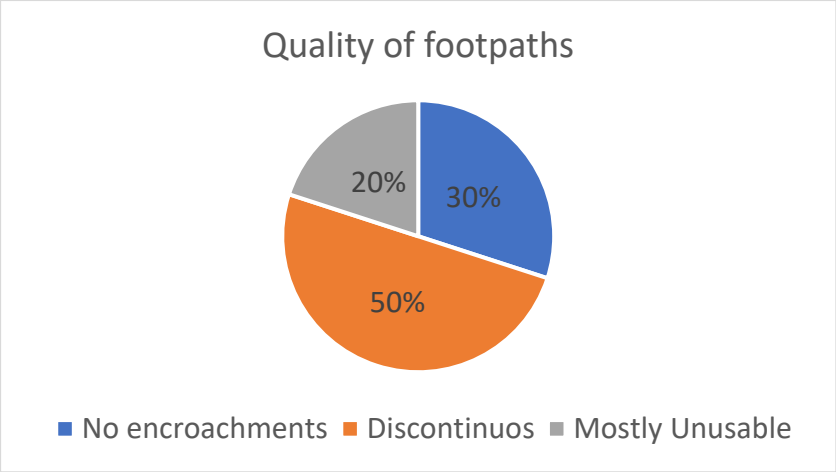


Figure 4-6 Quality of footpath infrastructure

4.2 City level pollution

Finding correct equation to find out the emission from vehicle with SIM-air Model

Equation 1

Emissions (tons/year) = Number of Vehicles * Vehicle km traveled (km/year) * Emission factor (gm/km) * 10-6 (tons/gm)

Equation 2

Emissions (tons/year) = Fuel Consumption per mode (litres/year) * Fuel Efficiency (km/litre) * Emission factor (gm/km) * 10-6 (tons/gm)

Equation 3

Emissions (tons/year) = Passenger trips per mode (trips/year) / Passengers per km * Emission Factor (gm/km) * 10-6 (tons/gm)

Equation 4

Emissions (tons/year) = Concentration (µg/m3) * Vehicular Contribution (%) * City Cross Sectional Area (m2) * Average Wind Speed (m/sec) * 60*60*24*365 (sec/year) * 10-12 (tons/µg)

In which 1st equation is selected to find out the pollution of the city and we need three kinds of data for that equation like Number of vehicles, Vehicles km travelled and emission factor

Table 4-6 Data to for the equation

Vehicle mode	No of vehicles	Vehicle travelled	%Petrol	%Diesel
2W	378,090	8,383	100%	-
3W	25,862	18,656	100%	-
Cars	85,286	13,107	50%	50%
Buses	1,286	72,285	-	100%
LDVs	2,510	30,590	-	100%
HDVs	11,384	20,775	-	100%
Total	5,04,382			

4.2.1 PM10

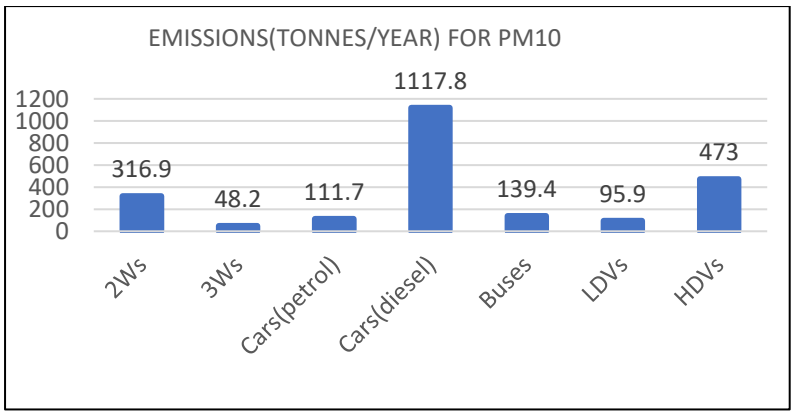


Figure 4-7 Emission level of PM10 in the city

The above graph shows the PM10 air pollution levels of the city of different mode of transport as we can see that the diesel car emits way too more PM10 pollution than any other mode of transport followed by HDVs vehicles, two wheelers and the least pollution emitting mode of transport is three wheelers.so the outcome is private vehicles causes more pollution than other vehicles.

4.2.2 PM2.5

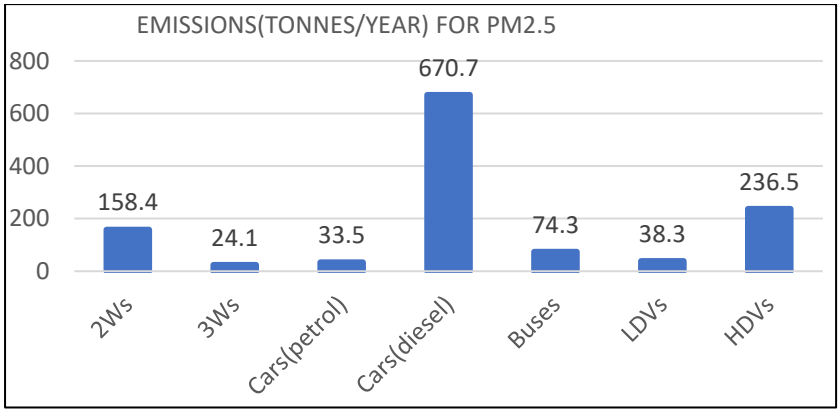


Figure 4-8 Emission level of PM2.5 in the city

The above graph shows the PM2.5 air pollution levels of the city of different mode of transport as we can see that the diesel car emits more PM2.5 pollution than any other mode of transport followed by HDVs vehicles, two wheelers and the least pollution emitting mode of transport is three wheelers followed by petrol cars & LDVs vehicles .so the outcome is private vehicles causes more pollution than other vehicles.

4.2.3 SO

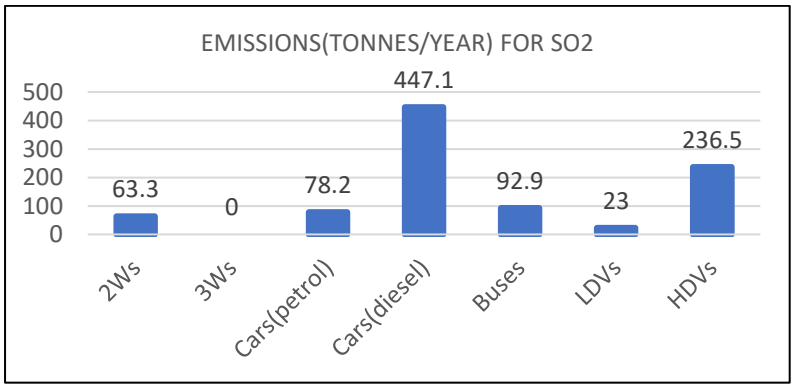


Figure 4-9 Emission level of SO in the city

The above graph shows the SO2 air pollution levels of the city of different mode of transport as we can see that the diesel car emits more SO2 pollution than any other mode of

transport followed by HDVs vehicles and the three wheelers does not emit the SO2 pollution and the least pollution emitting mode of transport is LDVs vehicles followed by two wheelers, petrol cars .so the outcome is private vehicles causes more pollution followed by HDVs.

4.2.4 NO

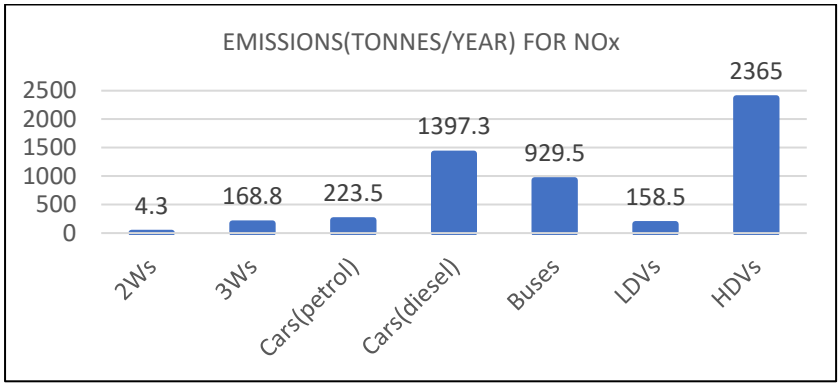


Figure 4-10 Emission level of NO in the city

The above graph shows the PM10 air pollution levels of the city of different mode of transport as we can see that the diesel car emits more PM10 pollution than any other mode of transport followed by HDVs vehicles, two wheelers and the least pollution emitting mode of transport is three wheelers.so the outcome is private vehicles causes more pollution than other vehicles.

4.2.5 CO

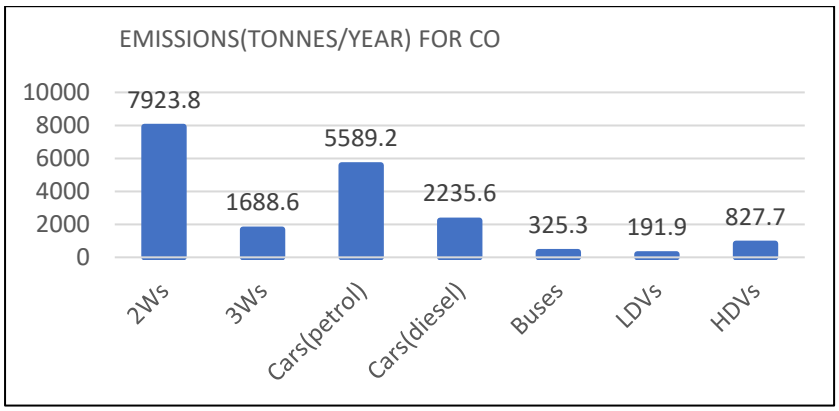


Figure 4-11 Emission level of CO in the city

The above graph shows the CO air pollution levels of the city of different mode of transport as we can see that the two-wheeler emits more CO pollution than any other mode of transport followed by petrol cars, diesel cars and the least pollution emitting mode of

transport is LDVs vehicle followed by Buses .so the outcome is private vehicles causes more pollution than other vehicles.

4.2.6 CO2

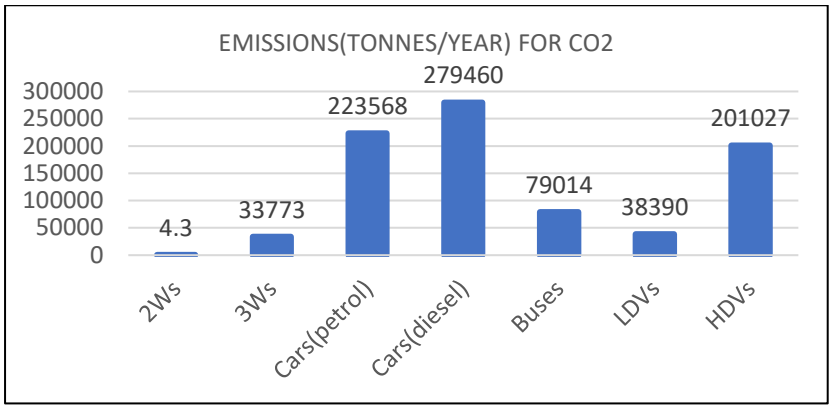


Figure 4-12 Emission level of CO2 in the city

The above graph shows the CO2 air pollution levels of the city of different mode of transport as we can see that the diesel car emits more CO2 pollution than any other pollutants followed by petrol cars, HDVs vehicles and the least pollution emitting mode of transport is two wheelers which is too low .so the outcome is cars and HDVs vehicles causes more pollution than other vehicles.

4.2.7 HC

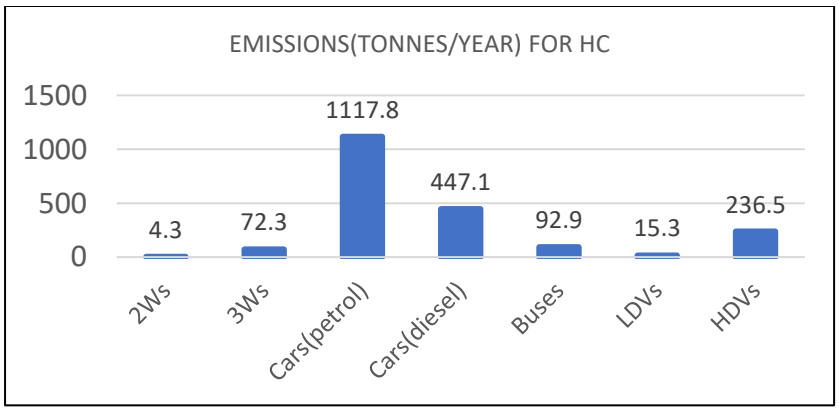


Figure 4-13 Emission level of HC in the city

The above graph shows the HC air pollution levels of the city of different mode of transport as we can see that the petrol car emits more HC pollution than any other mode of transport followed by diesel cars and the least pollution emitting mode of transport is two wheelers

followed by LDVs vehicles, three wheelers, Buses .so the outcome is cars causes more pollution than other vehicles.

4.3 site level pollution

Twelve locations within the area have been selected for the purpose of analysing the level of air pollution; these locations reflect the city's key intersections as well as imaginary screen lines that separate the traffic patterns in the area from northwards, eastwards, between two major areas, and so on. As can be seen in the following image, which illustrates where the chosen connection points are located on the map, these 12 locations are spread out in a somewhat even manner around the city.

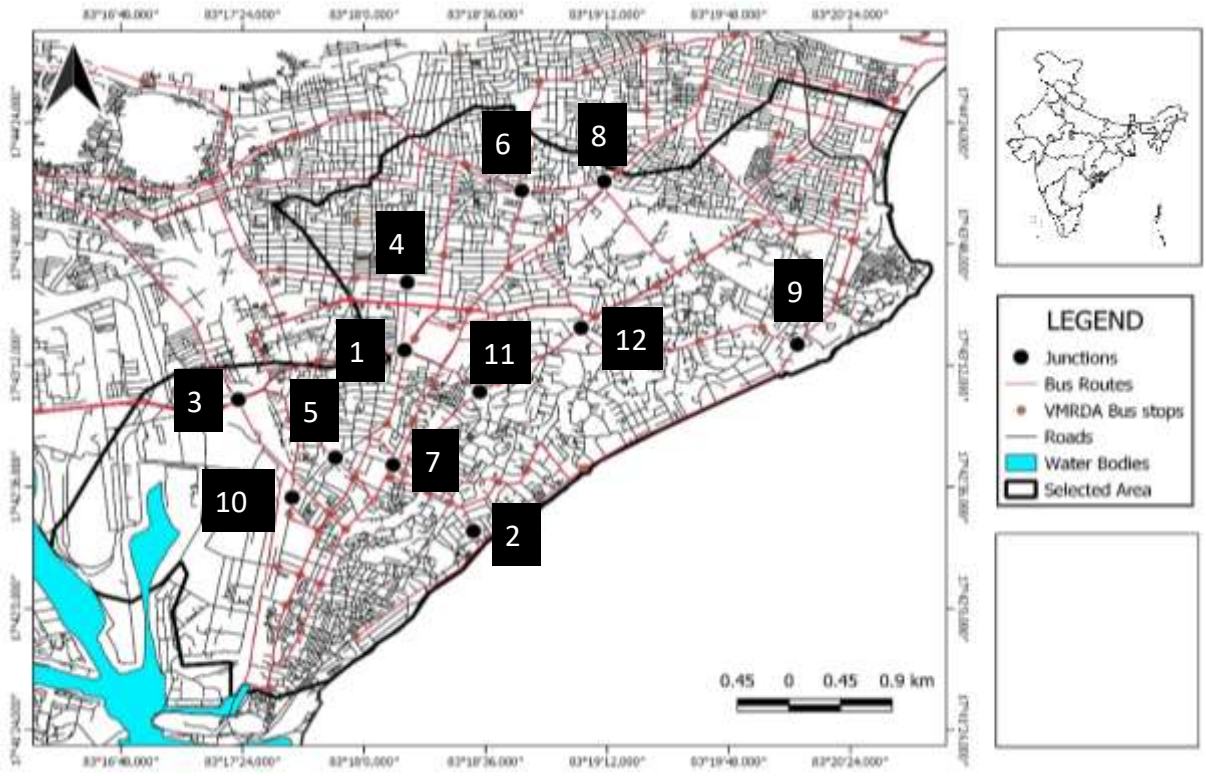


Figure 4-14 Study area map showing twelve selected junctions

Table 4-7 List of selected junctions

		Type of intersection
1	AMBEDKAR'S JUNCTION	5
2	COLLECTOR'S OFFICE	4
3	CONVENT JUNCTION	5
4	DIAMOND PARK	4

5	DOLPHIN HOTEL	4
6	GURUDWARA	4
7	JAGADAMBA	4
8	MADDILAPALEM	4
9	PALM BEACH	3
10	PURNA MARKET	3
11	SEVEN HILLS	3
12	SIRIPURAM	4

There are five intersections in two locations, Ambedkar and convent junctions followed by four intersections in seven locations, Diamond Park, collector office, dolphin hotel, gurudwara, jagadamba, maddilipalem, siripuram junctions and rest are having three intersections.

Table 4-8 emission of the pollutants in twelve selected junctions

ID	Name	PM10	PM2_5	SO2	NO	CO	CO2
1	AMBEDKAR'S JUNCTION	2529.9	1254.24	835.97	4809.5	39499.5	1077710
2	COLLECTOR'S OFFICE	3412.35	1657.355	961.895	4994.825	67450	1414075
3	CONVENT JUNCTION	4670	2267.9	1462.43	8636.5	76152.5	1980290
4	DIAMOND PARK	5984.75	2927.315	1830.945	10039.03	99544	2507015
5	DOLPHIN HOTEL	6669.6	3207.59	1875.16	10166.05	121261.5	2761940
6	GURUDWARA	10752.05	5413.275	3906.165	24661.33	143129.5	4689385
7	JAGADAMBA	15917.6	7528.99	4691.95	28180.05	256179.5	6694760
8	MADDILAPALEM	19143.35	9183.375	6325.495	43458.53	281689	8324915
9	PALM BEACH	25375.95	12852.5	8476.505	40621.63	316504.5	10522565
10	PURNA MARKET	23423.55	11362.35	9050.765	75511.78	296839	10813625
11	SEVEN HILLS	25063.45	12373.02	7500.785	34284.83	377359.5	10237645
12	SIRIPURAM	27959	14009.68	8851.27	40510.8	392141	11492720

4.3.1 PM10

The below map shows the PM10 air pollution levels in the selected junction points of the city it is observed that at siripuram junction the pollution level is high followed by palm beach junction, Purna market, seven hills and the junction having least pollution are Collector office junction followed by Ambedkar junction, Convent junction, Diamond Park and Dolphin hotel.

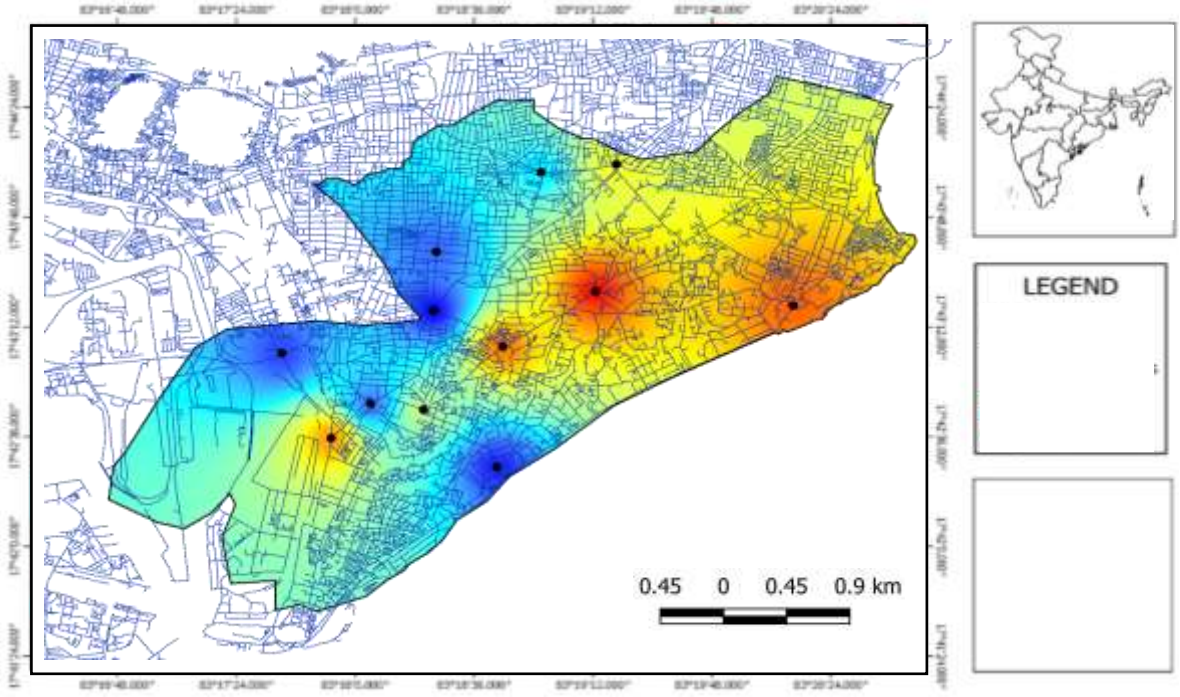


Figure 4-15 Emission of PM10 in 12 Selected junctions

4.3.2 PM2.5

The below map shows the PM2.5 air pollution levels in the selected junction points of the city it is observed that at siripuram junction the pollution level is high followed by palm beach junction, Purna market, seven hills and the junction having least pollution are Collector office junction followed by Ambedkar junction, Convent junction, Diamond Park and Dolphin hotel.

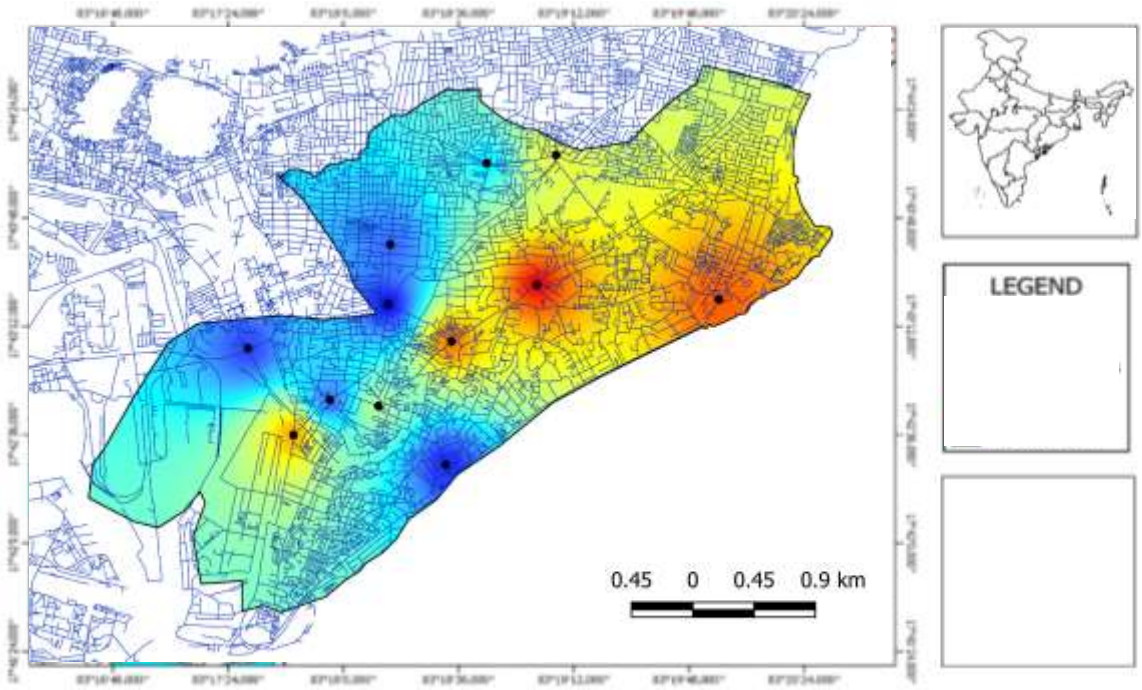


Figure 4-16 Emission of PM2.5 in 12 Selected junctions

4.3.3 SO2

The below map shows the SO2 air pollution levels in the selected junction points of the city it is observed that at siripuram junction the pollution level is high followed by palm beach junction, Purna market, seven hills and the junction having least pollution are Collector office junction followed by Ambedkar junction, Convent junction, Diamond Park and Dolphin hotel.

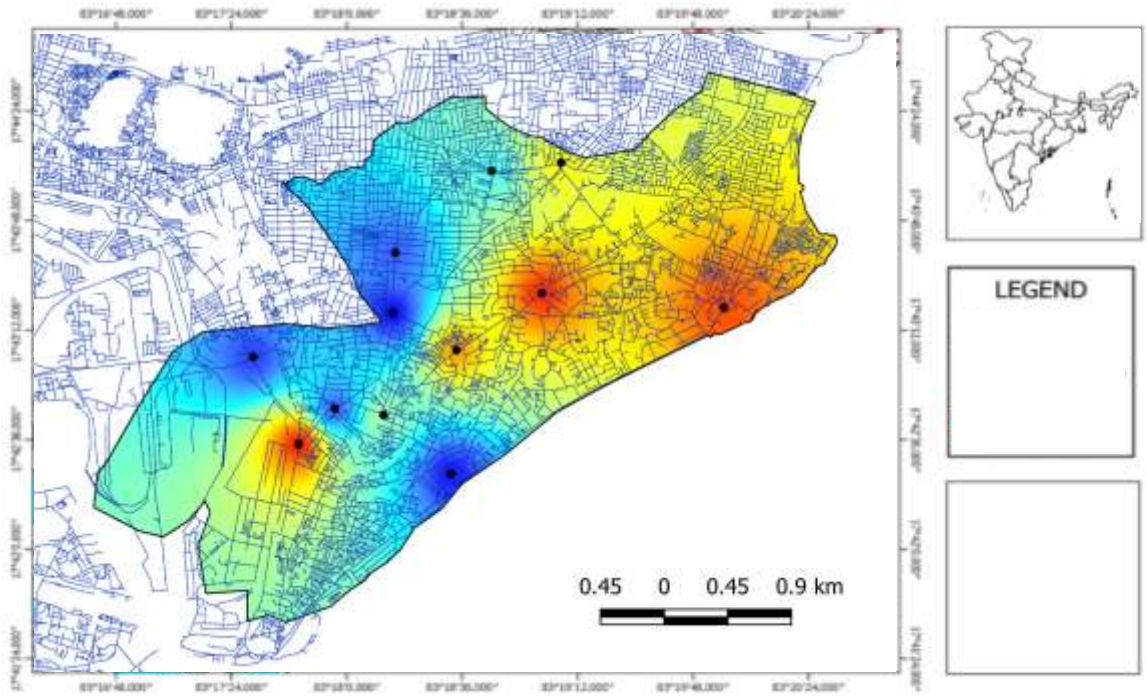


Figure 4-17 Emission of SO2 in 12 Selected junctions

4.3.4 NO

The below map shows the NO air pollution levels in the selected junction points of the city it is observed that at Jagadamba junction the pollution level is high and the junction having least pollution are Collector office junction followed by Ambedkar junction, Convent junction, Diamond Park and Dolphin hotel.

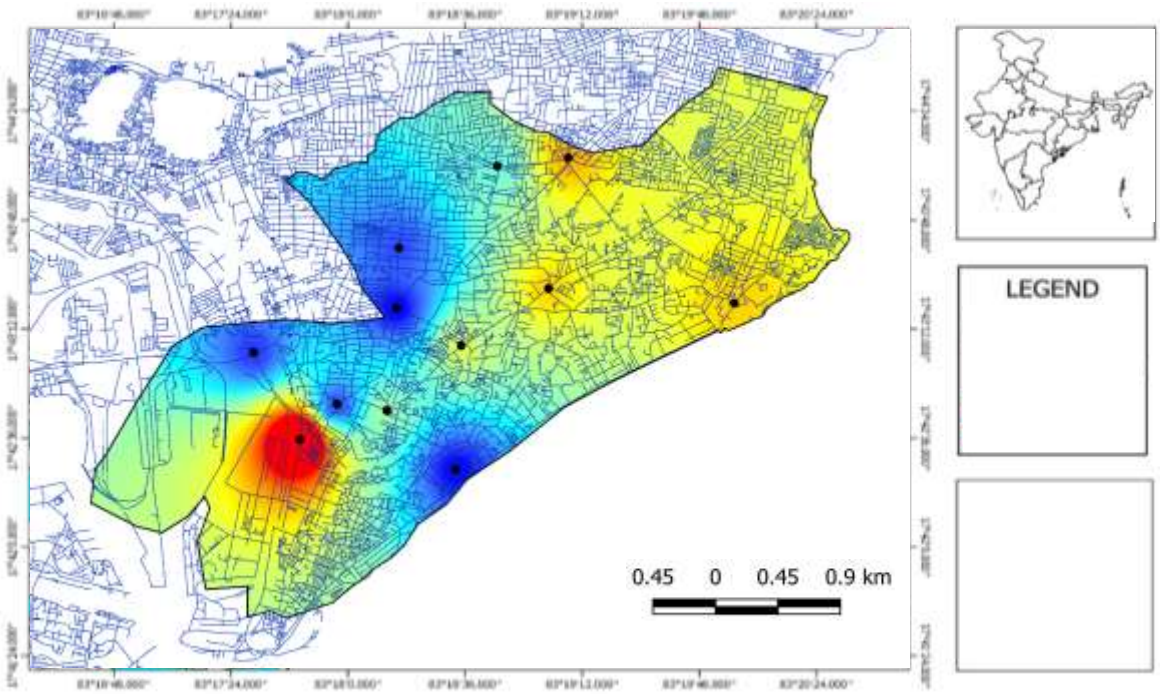
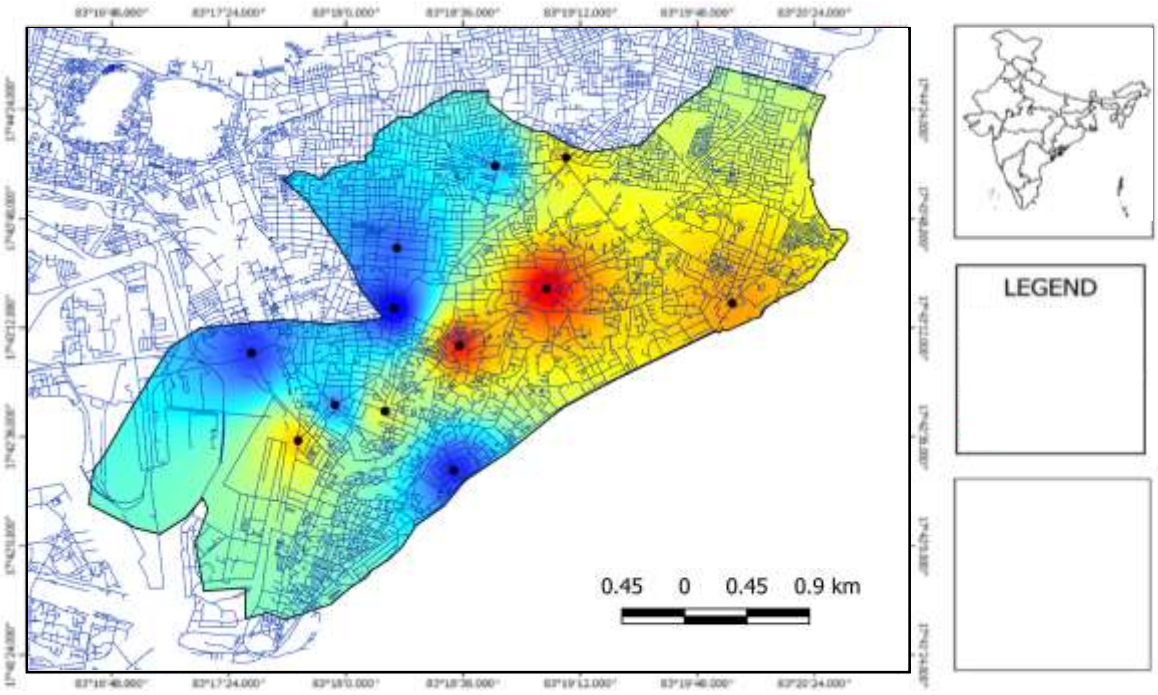


Figure 4-18 Emission of NO in 12 Selected junctions

4.3.5 CO

The below map shows the CO air pollution levels in the selected junction points of the city it is observed that at siripuram & seven hills junction the pollution level is high followed by palm beach junction, Purna market and the junction having least pollution are Collector office junction followed by Ambedkar junction, Convent junction, Diamond Park and Dolphin hotel.



4.3.6 CO2

The below map shows the CO air pollution levels in the selected junction points of the city it is observed that at siripuram the pollution level is high followed by palm beach junction, seven hills junction, Purna market and the junction having least pollution are Collector office junction followed by Ambedkar junction, Convent junction, Diamond Park and Dolphin

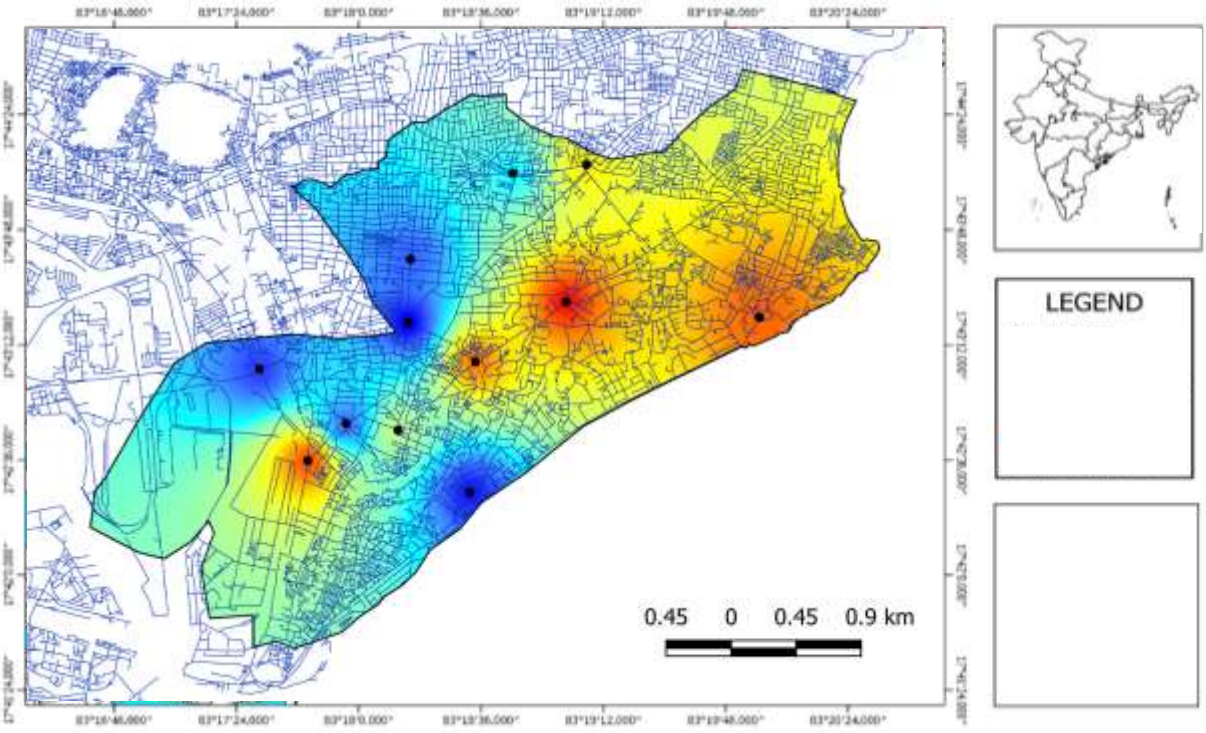


Figure 4-20 Emission of CO2 in 12 Selected junctions

AQI Calculation

Pollutant concentration in µg/m3 = Total emission/$\pi r^2 H$

Where Total emission= emission*24, R=500 m, H= 100 to 150 m

AQI Equation

$AQI = (I_{Hi} - I_{Lo} / BP_{Hi} - BP_{Lo}) * (C_P - BP_{Lo}) + I_{Lo}$

Where: Ip = the index for pollutant P

Cp = the rounded concentration of pollutant P

BPK = the breakpoint that is greater than or equal to Cp

BPLo = the breakpoint that is less than or equal to Cp

IHi = the AQI value corresponding to BPHi

ILO = the AQI value corresponding to BPLo

4.3.7 AQI

The below map shows the AQI levels in the selected junction points of the city it is observed that at Purna market junction pollution level is high followed by palm beach junction, seven hills and siripuram junction. Then the junction having least pollution are Collector office junction followed by Ambedkar junction, Convent junction, Diamond Park and Dolphin

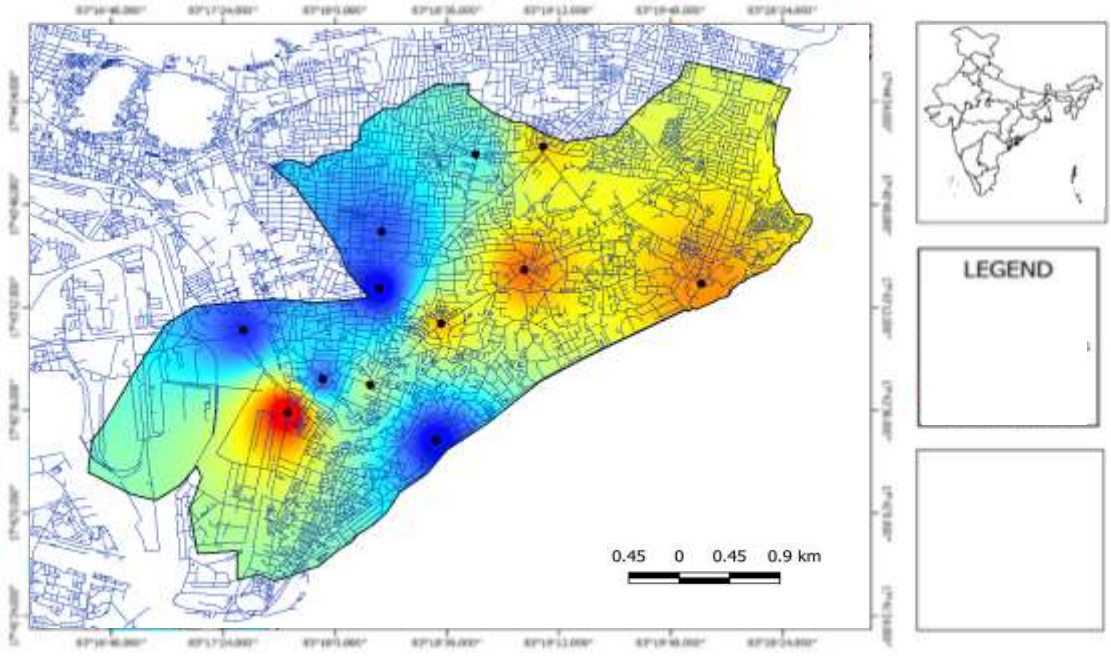


Figure 4-21 AQI of the study area in 12 Selected junctions

CHAPTER 5. RECOMMENDATIONS & PROPOSALS

5.1 At city level

Because of rising urbanisation, public transportation in Indian cities is characterised by high reliance and poor availability. It also has significant shortcomings in terms of transport production as well as operating efficiency. Given the policy limitations in Indian cities, the following actions are suggested to minimise traffic congestion in Vizag. These suggestions are in additional to those on congestion charges and other fees that may be imposed in order to limit personal car traffic.

5.1.1 Recommendation and Policy Guidelines

I. Andhra Pradesh EV policy 2018

- Attract approximately 30,000 crores of Indian rupees combined investments over the next 5 years in the e - mobility ecological system, with a potential workforce of 60,000 people.
- Bring in production sites of growing power storage with a total capacity of at least 10GVVh to service the both global markets within the next five years.
- By 2029, convert all of APSRTC's almost 11,000 buses into electric buses (BEVs/FCEVs), with the first step of switchover in the top four cities finished by 2024.
- By 2024, all commercial fleets that run on fossil fuels and logistical trucks within the top four cities will be phased out, and by 2030, in all cities.
- By 2024, government vehicles of all kinds, such as those used by government enterprises, boards, electric automobiles will replace buses, taxis, and ambulances.
- By the year 2024, there will be EVs number in the tens of thousands across the global vehicle segments.
- There would be 100,000 fast and slow charging stations by 2024.
- The GoAP (Global Open Access Program) focuses on EV manufacture and design and manufacturing, charging points, water splitting and refueling infrastructures, EV demand development, and research & innovation to achieve its goals.
- major Capital Subsidized of 25% of charging station value for first 100 sites up to the maximum cost of INR for the use of DC chargers over IOOV.

- For DC adapters below IOOV, a material subsidy of 25% of the charging station value is available for first 300 charging points, up to a specified subsidy of Rupees 30,000.
- Major financial subsidy of 25percent of Permanent Capital Investment for the first 50 stations, up to the maximum subsidy of ten lakhs.
- The state received a 100 percent net SGST as compensation for purchase of fast charger (DC chargers of capacity IOOV and above).
- The state received 100 percent net SGST as payment for the acquisition of battery technologies for BEV switching stations.
- A grant funding of 500 crore rupees will be awarded to the most cutting-edge modes of transportation. Lands and office spaces will also be granted to publicly or privately research laboratories, incubators, and entrepreneurs working on solutions and products in the electric transportation arena.
- The government will contribute financially to Quality certifications for patents. The financial assistance will be limited to 75% of the cost, with a maximum of 25 lakhs given for applications and 50% among all expenditures paid, with a maximum of 5 lakhs paid for certification.

II. Integrated transport policies are required to solve urban transportation and infrastructure development issues through an organized institutional framework. In India, for example, to generate such strategies, a National Transportation Policy Committee was constituted. In addition, the committee suggests that Institutional frameworks that work be developed at the national/ state as well as municipal levels.

III. In Indian cities, dedicated lanes for public transportation are required. For example, In Delhi, the amount of land available for transport systems is limited. In this context,

a comprehensive approach towards land use is critical for various kinds of transportation.

A different way to clean up pollutants from Vehicles might deploy gadgets that remove contaminants from the environment right away. Several companies, for example, are developing photocatalysts treatments that remove toxins from the air when exposed to sunlight. Roof tiles, roofing felt, as well as the road surface can all benefit from these treatments. In a recent study published by the Environmental Industry Sectors Commission, one of the most cost-effective solutions to decrease PM and NOx pollution is to apply photocatalytic treatment to roads; nevertheless, further research is required to fully appreciate the potential of this method. However, according to a recent Defra review, there is "no strong evidence" that implementing these solutions will reduce NOx emissions much.

IV. The move toward automated driving, sometimes referred to as "self-driving cars," is one of the megatrends that can be found in the automotive sector. This might have a big impact on how autos use the road system, perhaps reducing the stop-and-go nature of traffic (which is partly caused by the way that we people drive automobiles) and making it possible for "vehicle platooning" on freeways. According to the findings of a number of studies, the fuel economy of autonomous vehicles may be improved by 15–40 percent, leading to a reduction in emissions of both toxic and greenhouse gases. This is in addition to the potential benefits in the areas of protection and traffic congestion. The 2016 budget featured a number of efforts to encourage the use of electric and automated cars, and Volvo has announced plans to conduct autonomous vehicle tests around London by the year 2017.

V. Another method for lowering emissions is to use additives to improve the efficiency of the internal combustion stroke in the vehicles that are currently on the road. The ezero1technology, which was created by a company in the United Kingdom called CGON, does this by introducing minute volumes of hydrogen into the air intake of the car, which results in a more effective burn. Independent tests have shown that this increases fuel efficiency while also reducing emissions of carbon monoxide, nitrogen oxides, particulate matter, and hydrocarbons. Even though it has been only sold in limited quantities up to this point, the innovation may be installed into

gasoline or diesel-powered vehicles and vans that are currently on the market. It is also commercially available.

VI. One option to cut down on the pollution caused by diesel vehicles is to switch to other fuels. Although electrical and LPG fuel systems are completely different from one another, there are other technologies that have the ability to clean up old diesels. Shell, for example, has created a new synthetic "gas to liquid" (GTL) fuel generated from natural gas that may be used in place of diesel (i.e., the engine requires no modification). Testing has indicated that using GTL in big heavy vehicles like trucks, buses, and ships may cut NOx emissions by 5-37 percent and PM emissions by 10-38 percent, based on the vehicle generation. GTL fuel is already manufactured in substantial amounts across the world and is commercially accessible in the Netherlands, although its usage is currently quite limited in the UK. Similarly, natural gas may be turned into dimethyl ether (DME), which is another possible diesel substitute. DME is anticipated to lower NOx emissions by roughly 25% (when compared to regular diesel) and nearly eliminate PM emissions. DME is more difficult to execute than GTL since it involves engine modifications, although manufacturers like as Ford and Volvo are supposedly researching the possibility of bringing DME-powered cars to market.

5.2 At Site level

5.1.1 Recommendation and Policy Guidelines

I. According to recent research from Ohia State University, planting trees and plants to landscapes near industries and other air pollutants like as junction sites might cut pollution levels by an estimate of 27 percent. We can see that such facilities, rather than technology, There are potentially more cost-effective techniques to clean the air near a wide range of industrial facilities, motorways, power plants, corporate radiators, and petroleum & energy pumping sites.

II. Smog in metropolitan areas has grown increasingly important, noticeable, and deadly. In answer to this pressing issue, a Dutch design firm created a Smog free tower, which draws dirty air while unloading clean, pure air. The collected pollutants are then transformed into jewellery. The first tower, built in Rotterdam, is said to clear 3.5 million cubic metres of air every day.

III. The artificial tree is another fantastic modern creation. Every day, these "supertrees" suck in 200,000 cubic metres of contaminated air and emit only clean oxygen. This is accomplished by the inventive and imaginative application of a water filtering technology. Despite the fact that they now cost more than $100,000, the Peruvian prototype has yielded promising results. If these findings are reproduced, these one will be a benefit to cities and communities all around the world.

IV. Megacities require a stringent parking regulation and standardised parking costs at the national level for urban transit. Also, there is a need to raise parking fees since it affects parking demand. In megacities, it's also vital to link parking costs to the economic viability of parking structures.

5.3 At Junction level

Figure 5-1 Selected locations

From AQI pollution levels in the selected junction points of the city it is observed that at Purna market junction pollution level is too high followed by palm beach junction, seven hills and siripuram junction.

Poorna Bazaar, one of the city's oldest and most famous destinations, begs for improvement but receives none. There are unclean roads, litter, a mound of vegetable trash on the road,

and traffic in the region. The market merchants were asked not to sell their wares on the roadways since it was causing traffic congestion in the region. Due to a paucity of parking spaces, visitors are compelled to park their cars further away from the business. All the roads in Purna Market are lined with illegal lanes. The sidewalk towards the main road is the last. The courtyard is also inaccessible to pedestrians. It is noteworthy that the market is occupied by businesses on the road with baskets in the parking lot. two-wheeler motorists are facing difficulties in finding a place for parking and many similar problems are being faced by the people in the entire market. Businesses should not be conducted on the main road at Poorna Market. Then the traders inside the market were getting embarrassed and traffic problems were arising as businesses were occupying the road outside the market.

Figure 5-2 Purna market Junction

The main issue in purna market junction for high pollution is Congestion due to narrow roads, heavy vehicles and pedestrians. Vehicle users get stuck in traffic jams within seconds of entering the road, when vehicles from jagadamba to join the road.

HCV can be banned to enter the market area and only allowing LCV, E-trucks and Carbo bikes

So, the congestion due to HCV will decrease in the narrow road.

Constructing of foot over and foot under bride in the area for pedestrians. Which foot over is a kind of bridge which connects from one side to another side of road So the people can move freely without causing the congestion and the foot under bridge is another kind of bridge for pedestrians which we can move from one side to another and it helps to create underground real estate.

5.4 Policy based Recommendation

It has been recommended that a number of the urban transport-related policies that have been released on a national scale by the Ministry of Urban Development (MoUD) should also be implemented in Visakhapatnam. The pertinent policy papers provide an explanation of the details of how it will be carried out.

I. The establishment of the Visakhapatnam United Metropolitan Transportation Body (UMTA), which will function as the city's definitive authority for all matters pertaining to urban transportation. The UMTA, which will be based under the Vizag Urban Development Authority, will consist of all of the essential stakeholders, similar to the UMTA that is located in Hyderabad (VUDA).

II. Creating an Urban Transport Fund (UTF) for the city, which will act as the city's primary financial reserve for investing in environmentally friendly transportation initiatives. The fund accumulates revenue from a variety of sources, such as parking, the value of land captured, ecological deductions on fuel, and so on, which may subsequently be used toward financing programmes for public transit and non-motorized transportation alternatives.

III. Creating a municipality parking policy that recognises land as an utility service and charges for car parks in such a manner that the real worth of the land is represented in the parking fee Creating a municipal parking strategy that identifies property as a public utility In order to do this, various pricing tiers need to be devised for commercial and residential neighbourhoods, the central business area, the city's outskirts, and so on.

IV. Non-motorized transport (NMT) is the process of transforming street facilities such as walkability walks, having crossed facilities, cycleways, bicycle parking, bus terminals, and other street amenities such as street lamps, landscaping, and so on.

Non-motorized transport is required to receive five percent of its annual transportation budget.

V. Doing away with the restrictions now placed on the number of auto-rickshaws that may be awarded permits by the city

Other national policy documents, such as the National Urban Transportation Policy (NUTP), the 12th 5 Plan – Urban Transportation suggestions, the National Transport Development Policy Committee (NTDPC), the notification from the High-Powered Expert Committee (HPEC), the National Mission for Sustainable Habitat (NMSH), and the National Action Plan for Climate Change, must be accepted by the city (NAPCC).

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Annexure-: Survey Formats

Household Survey Part I: (Revealed Preference Survey)

1. Reference

Date:	Surveyor name:	
Area:	Ward No:	Address/ Door No.:
Contact number of respondent (Landline and mobile):	Email id:	
Settlement Code: _____ (**1.** Apartment **2.** RCC Ordinary Building **3.** Masonry Terraced Building **4.** Masonry Tiled Building **5.** Ordinary Tiled Building **6.** Hut)		

2. Household Information (Socio-economic)

S. No. (Tick Respondent)	Name	Relation with head	Sex (M/F)	Age	Education	Main Activity	Subsidiary activity
	1	2	3	4	5	6	7
1 Head		1					
2							
3							
4							
5							
6							
7							
8							

3. Household Assets

Household Assets owned		
	Y/N (Yes / No)	Number
Mobile phone		
Fridge		
LPG Stove/Cylinder		
Cooler		
A.C.		
T.V.		
Desktop/Laptop Computer		

4. Housing and Living Conditions

1	What is the type of the house?		Kutcha		Semi-Pucca		Pucca
2.	What is your total Household's Income?						
3	What is the tenure arrangement of the house you live in?				Rented		Shared
4	If it is Rented, What is the rent you pay for it?		Rs. _____ /Month				
5	Tick and write the appropriate spaces in the house		Rooms _____ (no.)		Separate Kitchen Y/N		Floors ____ (no.)
6	What is the area of the house?		Area _____		_____ (unit)		
7	What is your property tax? (Tick and Write the appropriate value)		Rs. _____		No		
8	How long have you been staying in this house?		_____ Years				
9	Where were you living before?						
	Household Tap	(Y/N)	Piped Sewerage	(Y/N)	H/h Toilets	(Y/N)	No.

5. Vehicle Ownership in the household

	Present				Before 2 year		
	Type	Age/ Year	Fuel	Mileage	Type	Fuel	Mileage
1							
2							
3							
4							
5							

6. Accessibility to important destination

Utility	Distance (km)	Walking minutes
Grocery Store		
Milk booth		
Vegetables		
Dhobi		
Doctor		
e-Seva		

Type: Car, Two-Wheeler, Bicycle, Auto-rickshaw, Cycle Rickshaw		Others (specify)		

7. Travel Diary of each Individual (Separate Access and In vehicle trips for Bus and Auto)

HH member no						Day of Trip:	Mon/Tue/Wed/Thur/Frid			
Seg	Purpose[17]	Mode[18]	Start Location	Waiting Time	Start time	End Location	Travel time (min)	Distance (km)	Fare/Parking cost	Trip Frequency
1										
2										
3										
4										
5										
6										

HH member no						Day of Trip:	Mon/Tue/Wed/Thur/Frid			
Seg	Purpose	Mode	Start Location	Waiting Time	Start time	End Location	Travel time (min)	Distance (km)	Fare/Parking cost	Trip Frequency
1										
2										
3										
4										
5										
6										

HH member no						Day of Trip:	Mon/Tue/Wed/Thur/Frid			
Seg	Purpose	Mode	Start Location	Waiting Time	Start time	End Location	Travel time (min)	Distance (km)	Fare/Parking cost	Trip Frequency
1										
2										
3										
4										

Household Survey Part II: (Stated Preference Survey)

Scenario 1 Choices			
Member	Work trip	Daily needs	School/College
1			
2			
3			
4			
5			
6			
7			

Scenario 2 Choices			
Mem no	Work trip	Daily needs	School/College
1			
2			
3			
4			
5			
6			
7			

Scenario 3 Choices			
Mem no	Work trip	Daily needs	School/College
1			
2			
3			
4			
5			

State the second preferred mode if 1st mode is not available							
Member	Walk	Bicycle	Bus	MTW	Car	Auto	**Reason**
1							
2							
3							
4							
5							
6							

Reasons for Not using the 2nd Mode					
i	Inaccessible		iv	Not socially acceptable	
ii	Unaffordable		v	Unavailable	
iii	Fear of accident		vi	Others (specify)	