

A STUDY ON SPATIAL AND TEMPORAL VARIATION OF URBAN AIR QUALITY IN CHENNAI

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in Civil Engineering

By

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**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **DINESH. M (Reg.No.39200014)**, **MILTON. J (Reg.No.39200022)** who carried out the project entitled **“A STUDY ON SPATIAL AND TEMPORAL VARIATION OF URBAN AIR QUALITY IN CHENNAI”** under our supervision from January 2023 to April 2023.

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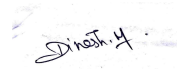
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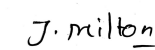
We **DINESH.M (Reg.No.39200014)** and **MILTON. J (Reg.No.39200022)** hereby declare that the Project Report entitled “ **A STUDY ON SPATIAL AND TEMPORAL VARIATION OF URBAN AIR QUALITY IN CHENNAI**” done under the guidance of **Dr.S.PACKIALAKSMI** is submitted in partial fulfilment of the requirements for the award of a Bachelor of Engineering degree in Civil Engineering.

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ABSTRACT

The present study explores the prevailing status of urban air quality in Chennai by collecting and analysing the air quality data from 2015 to 2022. The rapid urbanization and industrialization in Chennai, India have led to increasing concerns about air pollution and its impact on public health. In this study, we used a GIS approach to analyse the spatiotemporal variation of urban air quality in Chennai. Air quality data were collected from Alandur, Arumbakkam, Velachery, Manalai and Kodungayur monitoring stations across the city over a period of one year.. Air quality data were collected from various monitoring stations across the city over a period of one year. Spatial analysis techniques were used to map the spatial distribution of air pollution levels in Chennai and identify areas of high pollution concentration. Temporal analysis was performed to identify seasonal trends and changes in pollution levels. The results showed a significant variation in air quality, which is well evident in the spatial and temporal analyses. The highest pollution levels were observed in industrial areas, busy roads, and densely populated residential areas. The temporal analysis revealed that pollution levels were higher before covid and lower during the covid. The findings of this study could be used to develop strategies for improving air quality in Chennai, such as implementing measures to reduce emissions in high-pollution areas and promoting alternative modes of transportation. The GIS approach used in this study can be applied to other cities for better understanding and managing urban air pollution.

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1. Introduction

1.1 General

Urban air quality is a major environmental concern globally, and the city of Chennai in India is no exception. With a rapidly growing population and increasing urbanization, the air quality in Chennai has deteriorated over the years, leading to various health issues for its citizens. Spatial and temporal variation in air quality is an important aspect that needs to be studied to understand the extent of the problem and devise appropriate strategies for its management.

GIS (Geographic Information System) is a powerful tool that can be used to analyse and visualize spatial data, making it a useful approach for studying the spatial and temporal variation of air quality in Chennai. GIS allows us to integrate data from various sources, such as air quality monitoring stations, traffic volume, land use, and meteorological data, to create spatially explicit models of air pollution.

Using GIS, we can identify hotspots of high air pollution levels and track their temporal variation over time. We can also analyse the impact of various factors, such as traffic congestion, industrial emissions, and weather patterns, on air quality in different parts of the city. By overlaying demographic data, we can identify vulnerable populations that are more susceptible to the effects of air pollution, such as children, the elderly, and those with pre-existing health conditions.

Overall, the use of GIS in studying the spacial and temporal variation of urban air quality in Chennai can provide valuable insights into the nature of the problem and help develop effective strategies for its management.

1.2 History

The history of air pollution in Chennai can be traced back to the industrialization and rapid urbanization of the city. In the 1950s, Chennai was primarily an agricultural-based economy, but over the years, the city has transformed into a major industrial hub, with a growing population and increased vehicular traffic.

The city's air quality began to deteriorate in the 1970s, with the emergence of industrialization, urbanization, and an increase in the number of vehicles on the roads. The burning of fossil fuels and industrial emissions were major contributors to air pollution in the city.

In the 1980s, the government of Tamil Nadu began to take measures to control air pollution, such as implementing emission standards for industries, controlling the use of coal, and introducing the use of compressed natural gas (CNG) for public transport. Despite these efforts, the air quality in Chennai continued to deteriorate, with particulate matter and sulfur dioxide levels exceeding permissible limits.

In the 1990s, the government of Tamil Nadu introduced the Chennai Air Action Plan, which included measures to improve air quality, such as promoting the use of CNG for vehicles, phasing out old vehicles, and encouraging the use of public transportation. However, the implementation of these measures was slow, and air pollution continued to be a major concern.

Today, the air quality in Chennai remains a major environmental concern, with high levels of particulate matter, nitrogen dioxide, and sulfur dioxide, posing significant health risks to the city's residents. The government of Tamil Nadu continues to take measures to control air pollution, such as promoting the use of electric vehicles and improving public transportation infrastructure, but the task remains challenging due to the city's rapid urbanization and industrialization.

1.3 SCOPE OF PRESENT INVESTIGATION

Air quality investigation in Chennai can cover a wide range of factors that contribute to the air quality in the city. Some of the key areas that could be included in such an investigation are:

Air pollution sources: This would involve identifying the major sources of air pollution in Chennai, including vehicular emissions, industrial emissions, construction dust, and burning of waste and biomass.

Air quality monitoring: The investigation would involve monitoring the ambient air quality at various locations in the city using equipment such as air quality monitors. This would help to identify areas with high levels of air pollution and to track changes in air quality over time.

Health impacts: The investigation could also include an assessment of the health impacts of air pollution on the population of Chennai. This would involve analysing data on respiratory illnesses and other health problems that are associated with exposure to polluted air.

Policy and regulation: An investigation of air quality in Chennai would also need to consider the policies and regulations that are in place to control air pollution. This would involve assessing the effectiveness of existing policies and identifying areas where improvements could be made.

Public awareness and engagement: Finally, an investigation of air quality in Chennai would need to involve engaging with the public to raise awareness about the issue of air pollution and to encourage individuals to take action to reduce their own contribution to air pollution. This could involve educational campaigns, public meetings, and other forms of outreach.

1.4 Existing Problem

Chennai, like many other cities, continues to face significant air pollution problems. The following are some of the existing problems on air pollution in Chennai:

1. **Particulate Matter (PM) Pollution:** Particulate matter is a major contributor to air pollution in Chennai. PM10 and PM2.5 levels often exceed the National Ambient Air Quality Standards (NAAQS) in many parts of the city. These tiny particles can cause respiratory and cardiovascular problems, including asthma, bronchitis, and heart disease.
2. **Vehicular Pollution:** Vehicular emissions are a major source of air pollution in Chennai. With an increasing number of vehicles on the road, the level of pollutants emitted by vehicles such as nitrogen oxides, carbon monoxide, and hydrocarbons has increased significantly. This has led to a rise in respiratory and cardiovascular diseases among residents.
3. **Industrial Pollution:** Industrial emissions are another significant source of air pollution in Chennai. The city has a large number of industries, including chemical, pharmaceutical, and textile, which emit toxic gases and particulate matter. The industrial areas are also often located close to residential areas, resulting in significant exposure to toxic pollutants.
4. **Construction Dust:** Dust generated from construction sites is another significant source of air pollution in Chennai. The city has many ongoing construction projects, and the dust generated from these sites can contain harmful pollutants, such as PM10 and PM2.5.
5. **Open Burning:** Open burning of waste, such as plastic and leaves, is a common practice in Chennai, especially during festivals. This practice releases harmful pollutants into the air and contributes to the worsening air quality.

These are just a few of the many problems contributing to air pollution in Chennai, and addressing them will require a concerted effort by the government, industries, and residents of the city

1.5 Objectives

- To study the air quality characteristics with standard norms.
- To assess the prevailing air – quality characteristics for urban Chennai region during Covid- 19 pandemic with respective Pre and Post Covid conditions.
- To map the spatial and temporal variation of air quality characteristics using GIS.
- To recommend the protective measure for preventing air pollution issues.

CHAPTER-2

REVIEW OF LITERATURE

The present chapter explored the earlier studies on air quality to understand the various analysis pattern and the impact of changes in air quality in the national as well global contexts.

Sudipta Sarkar et al (2019) conducted a study on the Impact of Dust Storm (2018) of Air Quality. Meteorological and Atmospheric parameter over the northern parts of India. In this work, the northern part of India, adjoining the Himalaya, is considered as one of the global hot spots of pollution because of various natural and anthropogenic factors. Throughout the year, the region is affected by pollution from various sources like dust, biomass burning, industrial and vehicular pollution, and myriad other anthropogenic emissions. These sources affect the air quality and health of millions of people who live in the Indo-Gangetic Plains. The dust storms that occur during the pre-monsoon months of March–June every year are one of the principal sources of pollution and originate from the source region of Arabian Peninsula and the Thar desert located in north-western India. In the year 2018, month of May, three back-to-back major dust storms occurred that caused massive damage, loss of human lives, and loss to property and had an impact on air quality and human health. In this paper, we combine observations from ground stations, satellites, and radiosonde networks to assess the impact of dust events in the month of May 2018, on meteorological parameters, aerosol properties, and air quality. We observed widespread changes associated with aerosol loadings, humidity, and vertical advection patterns with displacements of major trace and greenhouse gasses. We also notice drastic changes in suspended particulate matter concentrations, all of which can have significant ramifications in terms of human health and changes in weather pattern.

Ramesh P. Singh et al (2020) conducted a study on the Impact of Lockdown on Air Quality in India during COVID 19 Pandemic. In this, First time in India, Total lockdown was announced on 22 March 2020 to stop the spread of COVID-19 and the lockdown was extended for 21 days on 24 March 2020 in the first phase. During the total lockdown, most of the sources for poor air quality were stopped in India. Air Quality Index, and tropospheric NO₂) over India using ground and satellite observations. A pronounced decline in PM_{2.5} and AQI (Air Quality Index) is observed over Delhi, Mumbai, Hyderabad, Kolkata, and Chennai and also a declining trend was observed in tropospheric NO₂ concentration during the lockdown period in 2020 compared with the same period in the year 2019. During the total lockdown period, the air quality has improved significantly which provides an important information to the cities' administration to develop rules and regulations on how they can improve air quality.

Akshansha chauhan et al (2017) conducted a study on Poor air quality and dense hazel smog during 2016 in the Indo – Gangetic plains associated with the crop residue burning and Diwali festival Chau. In this First time in India, total lockdown was announced on 22 March 2020 to stop the spread of COVID-19 and the lockdown was extended for 21 days on 24 March 2020 in the first phase. During the total lockdown, most of the sources for poor air quality were stopped in India. In this paper, we present an analysis of air quality (particulate matter-PM_{2.5}, Air Quality Index, and tropospheric NO₂) over India using ground and satellite observations. A pronounced decline in PM_{2.5} and AQI (Air Quality Index) is observed over Delhi, Mumbai, Hyderabad, Kolkata, and Chennai and also a declining trend was observed in tropospheric NO₂ concentration during the lockdown period in 2020 compared with the same period in the year 2019. During the total lockdown period, the air quality has improved significantly which provides an important information to the cities' administration to develop rules and regulations on how they can improve air quality.

Rajbhandari B et al (2020) conducted a study on Air medical Evacuation of Nepalese citizen during Epidemic of COVID 19 from Wuhan to Nepal. In this Study In December 2019, the world was disrupted by the news of a new strain of virus known as Novel Corona virus, taking lives of many in China. Wuhan, the capital of Central China's Hubei province is said to be the place where the outbreak started. The city went on lockdown as the disease spread rapidly. After the lockdown, most countries like India and Bangladesh airlifted their citizens who were studying in Wuhan. Similarly, Nepal also has many youth studying medicine in Wuhan. Pleas for help from the students reached the government. This was the first encounter of such experience for Nepal government. With the help of Ministry of Health, Ministry of foreign affair, Health Emergency Organizing committee, Epidemiology and Disease Control Division, Nepal Army Hospital, Nepal Police Hospital, Waste Management team, Nepal Ambulance service, Tribhuwan international Airport Authorities and Royal Airlines the government of Nepal planned, organized and successfully brought back all the 175 students on 15 th February 2019 from Wuhan, China. The present article aims to share the experience, the challenges faced and recommendations for future similar cases.

Marimuthu Rajendran et al (2021) conducted a study on Ambient air quality during COVID 19 pandemic in Chennai – An Urban Metro City of India. In this study COVID'19 pandemics has brought a tremendous change in the regular human life style due to the severity of the virus. In addition, a positive impact was observed in the ambient air quality due to complete absence of anthropogenic activities contributing to the air pollutants in the urban sprawl for a short duration because of the lockdown restrictions imposed by the government. In this study, we have discussed the trend of air quality with respect to pre-lockdown, lockdown, and post- lockdown. It was observed that on an average 50%-70% decrease in pollutant concentration measured during lockdown compared to pre-lockdown measurements. However, post-lockdown shown an increasing trend in concentration but are within the permissible

limits due to the restrictions imposed in the post-lockdown. This short analysis presented in this paper highlights the effect of lockdown over air quality improvement observed in a densely populated metro city of Tamil Nadu.

Amid Kumar Mishra et al (2021) conducted a study on Effect of lockdown Amid COVID – 19 on ambient air quality in 16 Indian cities. In this work the COVID-19 pandemic has affected severely the economic structure and health care system, among others, of India and the rest of the world. The magnitude of its aftermath is exceptionally devastating in India, with the first case reported in January 2020, and the number has risen to ~31.3 million as of July 23, 2021. India imposed a complete lockdown on March 25, which severely impacted migrant population, industrial sector, tourism industry, and overall economic growth. Herein, the impacts of lockdown and unlock phases on ambient atmospheric air quality variables have been assessed across 16 major cities of India covering the north-to-south stretch of the country. In general, all assessed air pollutants showed a substantial decrease in AQI values during the lockdown compared with the reference period (2017–2019) for almost all the reported cities across India. On an average, about 30–50% reduction in AQI has been observed for PM_{2.5}, PM₁₀, and CO, and maximum reduction of 40–60% of NO₂ has been observed herein, while the data was average for northern, western, and southern India. SO₂ and O₃ showed an increase over a few cities as well as a decrease over the other cities. Maximum reduction (49%) in PM_{2.5} was observed over north India during the lockdown period. Furthermore, the changes in pollution levels showed a significant reduction in the first three phases of lockdown and a steady increase during subsequent phase of lockdown and unlock period. Our results show the substantial effect of lockdown on reduction in atmospheric loading of key anthropogenic pollutants due to less-to-no impact from industrial activities and vehicular emissions, and relatively clean transport of air masses from the upwind region. These results indicate that by adopting cleaner fuel technology and avoiding poor combustion activities across the urban agglomerations in India could bring down ambient levels of air pollution at least by 30%.

Mohamed Sarmadi et al (2020) conducted a study on Association of COVID – 19 Global distribution and environmental and demographic factors: An three months study. We investigated the association of some environmental and economic factors and the global distribution indicators of the COVID-19 pandemic. Since the number of cases and deaths is higher in high-income countries located in higher latitudes and colder climates, further studies are required to shed light on this matter.

Akshansha Chauhan et al (2020) conducted a study on Decline in PM_{2.5} concentration over major cities around the world associated with COVID – 19. In this work The COVID-19 started from Wuhan city in China, slowly spread across the globe after December 2019. Due to movement of people from one city to other cities, one country to other countries, infection spreads and COVID-19 became a pandemic. Efforts were made at local, regional and national levels to lockdown the movement of people and to keep infected one in quarantine or isolation to stop the spread of COVID-19. The traffic, market and small industries were closed, as a result pronounced decline in the concentrations of particulate matters (PM) were observed. Normally these sources contribute to the high concentrations of particulate matters (PM_{2.5}) which represents air quality of a location. In this short communication, we present analysis of PM_{2.5} of major cities (New York, Los Angeles, Zaragoza, Rome, Dubai, Delhi, Mumbai, Beijing and Shanghai) around the world suffered severely with the COVID-19. Our analysis shows decline in PM_{2.5} concentration due to lockdown, mainly due to less movement of people to keep “social distancing” to control the spread of CORONA-19. The low concentrations of PM_{2.5} reflect the efforts made in the cities to curb the spread of infection, that improve air quality.

Pengfei Wang et al (2020) conducted a study on Severe air pollution events not avoided by reduced Anthropogenic activities during COVID 19 outbreak. In this study Due to the pandemic of coronavirus disease 2019 in China, almost all avoidable

activities in China are prohibited since Wuhan announced lockdown on January 23, 2020. With reduced activities, severe air pollution events still occurred in the North China Plain, causing discussions regarding why severe air pollution was not avoided. The Community Multi-Scale Air Quality model was applied during January 01 to February 12, 2020 to study PM_{2.5} changes under emission reduction scenarios. The estimated emission reduction case (Case 3) better reproduced PM_{2.5}. Compared with the case without emission change (Case 1), Case 3 predicted that PM_{2.5} concentrations decreased by up to 20% with absolute decreases of 5.35, 6.37, 9.23, 10.25, 10.30, 12.14, 12.75, 14.41, 18.00 and 30.79 $\mu\text{g}/\text{m}^3$ in Guangzhou, Shanghai, Beijing, Shijiazhuang, Tianjin, Jinan, Taiyuan, Xi'an, Zhengzhou, Wuhan, respectively. In high-pollution days with PM_{2.5} greater than 75 $\mu\text{g}/\text{m}^3$, the reductions of PM_{2.5} in Case 3 were 7.78, 9.51, 11.38, 13.42, 13.64, 14.15, 14.42, 16.95 and 22.08 $\mu\text{g}/\text{m}^3$ in Shanghai, Jinan, Shijiazhuang, Beijing, Taiyuan, Xi'an, Tianjin, Zhengzhou and Wuhan, respectively. The reductions in emissions of PM_{2.5} precursors were ~2 times of that in concentrations, indicating that meteorology was unfavourable during simulation episode. A further analysis shows that benefits of emission reductions were overwhelmed by adverse meteorology and severe air pollution events were not avoided. This study highlights those large emissions reductions in transportation and slight reduction in industrial would not help avoid severe air pollution in China, especially when meteorology is unfavourable. More efforts should be made to completely avoid severe air pollution.

Nicholas J Long (2020) conducted a study on from social distancing to social containment reimagining socially for coronavirus pandemic. In study This essay develops an anthropological critique of 'social distancing'. While the 2020 coronavirus pandemic requires us to reconfigure established forms of sociality, distancing regimes such as lockdowns can profoundly disrupt the provision of care and support, creating practical difficulties and existential suffering. I advocate instead for strategies of 'social containment', outlining several of the containment arrangements people in England

have developed to reconcile relational obligations with public health imperatives during the pandemic. I end by addressing some of the steps anthropologists must take when translating such ideas into policy.

Brauer, M., et al. (2016). conducted a study on "Ambient air pollution exposure estimation for the Global Burden of Disease 2013." *Environmental Science & Technology*, the authors aimed to estimate the global burden of disease attributable to ambient air pollution exposure, using a model that incorporates satellite-based estimates of PM_{2.5} concentrations and ground-level measurements. They found that in 2013, exposure to ambient PM_{2.5} was responsible for an estimated 4.2 million premature deaths worldwide, with the highest burden observed in low- and middle-income countries. They also found that exposure to other pollutants, such as ozone and household air pollution, contributed to a substantial portion of the overall disease burden. This study provides important insights into the health impacts of air pollution and highlights the need for continued efforts to reduce air pollution exposure globally.

Brook, R. D., et al. (2010). conducted a study on "Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association." The authors provide an update on the evidence linking particulate matter (PM) air pollution to cardiovascular disease. They review epidemiological studies and clinical evidence that support the association between PM exposure and increased risk of cardiovascular morbidity and mortality, including heart attacks, strokes, and arrhythmias. They also discuss the mechanisms by which PM exposure may contribute to cardiovascular disease, including oxidative stress, inflammation, and endothelial dysfunction. The authors conclude that the evidence supports a causal relationship between PM exposure and cardiovascular disease and that reducing exposure to PM air pollution may help prevent cardiovascular events. This study provides important insights into the health impacts of air pollution and highlights the need for continued efforts to reduce air pollution exposure to protect public health.

Cohen, A. J., et al. (2017). conducted a study on "Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: An analysis of data from the Global Burden of Diseases Study 2015." *The Lancet*, In this study, the authors estimated the global burden of disease attributable to ambient air pollution using data from the Global Burden of Diseases Study 2015. They found that in 2015, exposure to ambient PM_{2.5} and ozone was responsible for an estimated 4.2 million premature deaths and 103 million disability-adjusted life years (DALYs) worldwide. They also found that the burden of disease attributable to air pollution had increased substantially since 1990, particularly in low- and middle-income countries. The authors conclude that reducing air pollution exposure is critical for improving public health and that continued efforts are needed to address this global health challenge. This study provides important insights into the global health impacts of air pollution and highlights the urgent need for action to reduce air pollution levels worldwide.

Kelly, F. J (2015). published a article on "Size, source and chemical composition as determinants of toxicity attributable to ambient particulate matter." *Atmospheric Environment*, the authors discuss the factors that determine the toxicity of ambient particulate matter (PM), including size, source, and chemical composition. They review the epidemiological and toxicological evidence that supports the association between exposure to PM and adverse health outcomes, including respiratory and cardiovascular diseases. They also discuss the importance of PM size and composition in determining its toxicity, with smaller particles and those with a higher proportion of toxic components such as metals and organic compounds being more harmful. The authors conclude that reducing exposure to PM air pollution is critical for protecting public health and that efforts to mitigate air pollution should consider the size, source, and chemical composition of particulate matter. This study provides important insights into the complex nature of air pollution toxicity and highlights the need for targeted strategies to reduce exposure to the most harmful components of PM.

CHAPTER-3

STUDY AREA AND DATA ACQUISITION

3.1 MONITORING STATIONS

The urban Chennai city in India is selected for this study. A study on the prevailing and future scenarios of air quality, especially in densely populated and highly urbanised cities, is imperative for providing a protective and livable ecosystem. It is the capital of Tamil Nadu with dense population. It is a well know tourist spot as the city has more than 500 temples and a longest beach in the world. Also, it has numerous and well established educational and research institutes. Since 1990s, the economy of Chennai corporation is largely boomed by the multinational software companies, automobile, and electronic manufacturing industries. The air quality of Chennai city is studied by various research groups around the world through numerous readily available online resources and through field-based monitoring.

The city's population is 7,088,000. The area is 426 km² and is the densely populated area. The climatic conditions of Chennai is dry in summer tropical wet to the months of May to June and the cool in the month of January with occasional rainfall. The rivers that flow in Chennai are Kortalaiyar in the northern part, Cooum rivers and Buckingham canal flows parallel to the coast and the Otteri Nullah that is east - west stream.

In this Article the air quality data is taken from the pollution control board Chennai, the real time monitoring is taken by the State and Central pollution control board Agencies through the National Air Quality Monitoring Program (NAMP). Through this Monitoring program the major pollutants PM_{2.5}, NO, NO₂, NO_X, SO₂ and Other meteorological parameters also to be Considered and Monitoring.



Figure 3.1: Monitoring stations

The above said air pollutants and meteorological parameters data were downloaded for the Chennai metro city for the year 2020 and is investigate through statistical tools to understand the impact of lockdown over the air quality. The regular and complete data for the Chennai region was made available in the CPCB website for five location

1. Alandur
2. Manali
3. Velachery
4. Kodungayur
5. Arumbakkam

1. Alandur

Alandur is one of the zones of Chennai, and an urban node in Guindy division in Chennai district in the state of Tamil Nadu, India. Alandur is the densely populated urban area in Chennai. It is located at the latitude and longitude of 13.03°N 80.21°E. It has an average elevation of 12 meters (39 feet) from mean sea level (MSL). Alandur had a population of 164,430 according to 2011 Census. It has land area of 2 sq.km. This area was so busy with their vehicular movement, and it is one of the congested areas in Chennai.

2. Manali

Manali is covered by industrial and residential part in Chennai. It is the zone in Chennai corporation located in northern part of Chennai in Indian state of Tamilnadu. As per 2011 the Manali have a population of 35,248. Latitude and Longitude is 13.16361°N 80.25856°E.

3. Velachery

Velachery is a commercial and residential area in south Chennai and is the largest commercial centre in south Chennai. It is surrounded by Guindy in the north, IIT Madras in the north-east, Taramani in the east, Perungudi in the south-east.

Latitude and Longitude : 12.9758°N 80.2205°E.

4. Kodungayur

Kodungaiyur is a locality situated in the northern part of Chennai, a city in the state of Tamil Nadu, India. It is primarily a residential area with a mix of commercial establishments. The area is known for its industrial estates, which house several factories and warehouses. Some of the prominent industries in the area include chemical plants, rubber factories, and petroleum refineries. Kodungaiyur is well-connected to other parts of Chennai through public transportation such as buses and trains.

Latitude and Longitude: 13.140961°N 80.248175°E.

5. Arumbakkam

Arumbakkam is a locality situated in the western part of Chennai, a city in the state of Tamil Nadu, India. It is a primarily residential area with a mix of commercial establishments. The area is well-known for its shopping centres and market.

Longitude and Latitude : 13.07354°N 80.20639°E

3.2 Air quality index

The air quality index (AQI) is a measure of air pollution that is used to communicate to the public how polluted the air is in a particular area. The AQI is calculated based on concentrations of pollutants such as particulate matter, ozone, sulfur dioxide, and nitrogen dioxide, and it is reported as a number between 0 and 500. The higher the AQI value, the greater the level of air pollution and the greater the health risk to the population.

The AQI is often used by government agencies and health organizations to issue air quality advisories and warnings, especially during times of high pollution levels. These advisories can be particularly important for vulnerable populations, such as children, the elderly, and people with respiratory or cardiovascular conditions, who are more susceptible to the health effects of air pollution.

In addition to informing the public about current levels of air pollution, the AQI can also be used to track changes in air quality over time and to evaluate the effectiveness of pollution control measures. By monitoring and managing air pollution levels through the use of the AQI, policymakers and public health officials can work to reduce the negative impacts of air pollution on human health and the environment.

Table 3.1: Standard norms for air quality index

API	0-50	51-100	101-150	151-200	201-300	300+
Air pollution Level	Good	Moderate	Unhealthy of sensitive groups	Unhealthy	Very unhealthy	Hazardous
Health Implications	Air quality satisfactory	Air quality acceptable	The general public is not likely to be affected	Serious health effects	Health warning of emergency conditions	More Serious health effects

AQI Basics for Ozone and Particle Pollution			
Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Figure 3.2: Standard norms for AQI

The data for the Air Quality Index (AQI) was collected from the website <https://aqicn.org/city/chennai/> for this study. In this study we are taken a great effort was done to measure the quality from Aug 2019 to May 2020 at the study area of Manali, Chennai, Tamilnadu.

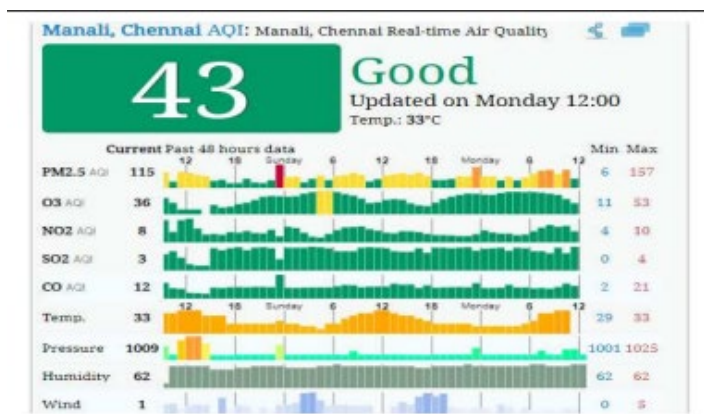


Figure 3.3 : AQI index, Manali, Chennai

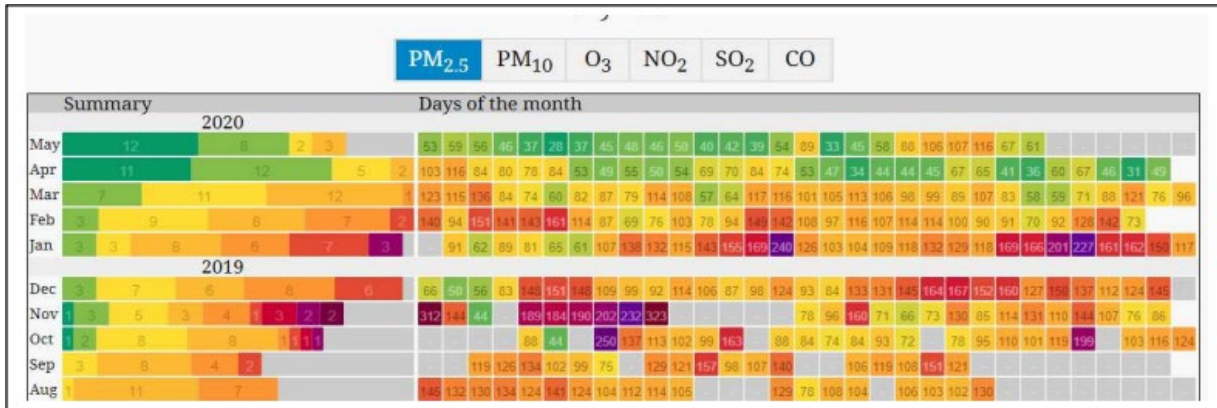


Figure 3.4: PM_{2.5} AQI data from Aug 2019 to May 2020

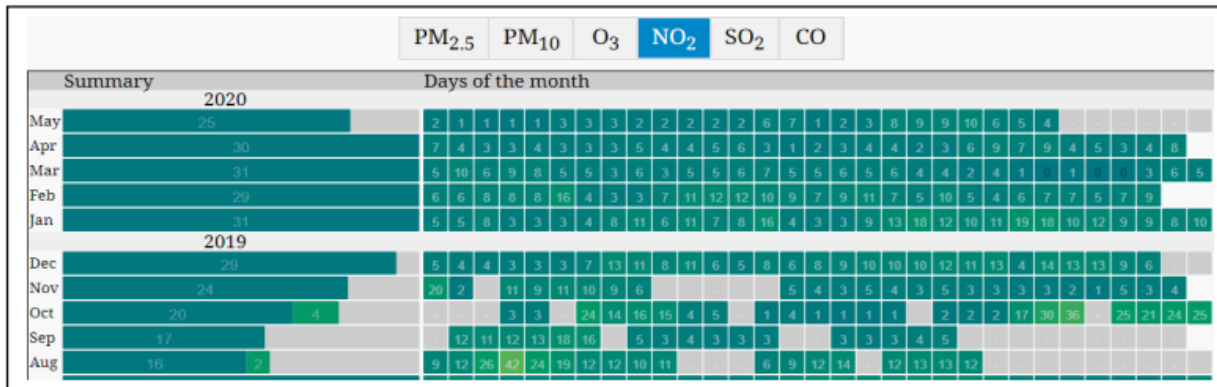


Figure 3.5: NO₂ AQI data from Aug 2019 to May 2020

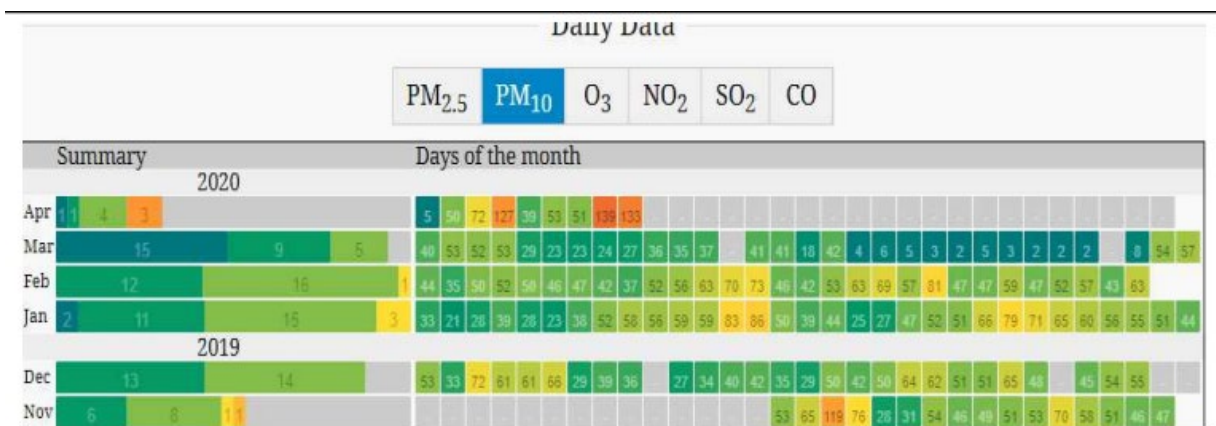


Figure 3.6: PM₁₀ AQI data from Nov 2019 to April 2020

3.3 Ambient air quality

Ambient air quality refers to the quality of the air that surrounds us in the outdoor environment. It is influenced by various factors such as industrial activities, vehicular emissions, agricultural practices, and natural sources such as dust and pollen. The quality of ambient air is determined by measuring the concentration of pollutants such as particulate matter, nitrogen oxides, sulfur dioxide, ozone, and carbon monoxide.

Poor ambient air quality can have adverse effects on human health, including respiratory problems, heart disease, and even cancer. It can also have negative impacts on the environment, such as acid rain and damage to crops and forests.

Air quality monitoring systems are in place in many cities and countries around the world to measure ambient air quality and provide information to the public. This information can be used to inform policies and practices that can improve air quality and protect public health.

Table 3.2: Annual Average data for the year 2019

		ANNUAL AVERAGE DATAS FOR THE YEAR 2019					
STATIONS	LATITUDE	LONGITUDE	PM2.5	PM10	NO	NO2	NOX
ALANDUR	13°00'13"N	80°12'07"E	53.03	40.25	7.06	14.3	20.79
ARUMBAKKAM	13°04'38"N	80°12'26"E	51.57	38.54	7	16.33	22.19
VELACHERY	12°59'15"N	80°13'23"E	44.98	41.53	7.08	14.68	19.38
KODUNGAIYUR	13°06'02"N	80°14'53"E	42.69	33.81	9.12	19.66	25.55
MANALI	13°09'52"N	80°15'45"E	55.37	49.43	8.17	12.67	20.87

Table 3.3: Annual Average data for the year 2020

		ANNUAL AVERAGE DATAS FOR THE YEAR 2020					
STATIONS	LATITUDE	LONGITUDE	PM2.5	PM10	NO	NO2	NOX
ALANDUR	13°00'13"N	80°12'07"E	29.68	32.88	6.14	16.75	16.75
ARUMBAKKAM	13°04'38"N	80°12'26"E	28.41	29.37	6.92	16.72	16.88
VELACHERY	12°59'15"N	80°13'23"E	24.33	29.58	5.57	14.87	12.89
KODUNGAIYUR	13°06'02"N	80°14'53"E	22.95	27.42	5.38	12.68	15.43
MANALI	13°09'52"N	80°15'45"E	22.73	28.55	6.06	15.71	16.95

Table 3.4: Annual Average data for the year 2021

		ANNUAL AVERAGE DATAS FOR THE YEAR 2021					
STATIONS	LATITUDE	LONGITUDE	PM2.5	PM10	NO	NO2	NOX
ALANDUR	13°00'13"N	80°12'07"E	16.88	10.58	4.02	8.65	10.58
ARUMBAKKAM	13°04'38"N	80°12'26"E	16.29	14.55	3.05	9.09	14.29
VELACHERY	12°59'15"N	80°13'23"E	15.82	16.38	5.64	8.24	11.35
KODUNGAIYUR	13°06'02"N	80°14'53"E	16.87	16.28	4.98	7.98	14.54
MANALI	13°09'52"N	80°15'45"E	14.39	11.23	3.49	8.27	10.96

Table 3.5: Annual Average data for the year 2022

		ANNUAL AVERAGE DATAS FOR THE YEAR 2022					
STATIONS	LATITUDE	LONGITUDE	PM2.5	PM10	NO	NO2	NOX
ALANDUR	13°00'13"N	80°12'07"E	58.37	49.66	10.25	17.65	29.98
ARUMBAKKAM	13°04'38"N	80°12'26"E	55.25	49.12	9.16	21.55	27.21
VELACHERY	12°59'15"N	80°13'23"E	51.92	44.62	8.01	19.38	19.54
KODUNGAIYUR	13°06'02"N	80°14'53"E	55.38	48.96	7.96	20.76	20.59
MANALI	13°09'52"N	80°15'45"E	51.73	47.29	8.49	18.61	22.34

Table 3.6: Annual ambient air quality data for the year 2010 – 2022

Prescribed Standards		0-60	0-100	0-80	0-80	0-200
Exceeding Standards		NA	NA	NA	NA	NA
From Date	To Date	PM2.5 (ug/m3)	PM10 (ug/m3)	NO (ug/m3)	NO2 (ug/m3)	NOx (ppb)
01-01-2010 00:00	01-01-2011 00:00	None	None	13.08	31.07	35.97
01-01-2011 00:00	01-01-2012 00:00	None	None	14.49	22.06	21.55
01-01-2012 00:00	01-01-2013 00:00	None	None	27.32	23.53	30.85
01-01-2013 00:00	01-01-2014 00:00	None	None	11.55	None	67.1
01-01-2014 00:00	01-01-2015 00:00	None	None	25.2	54.31	47.61
01-01-2015 00:00	01-01-2016 00:00	132.56	None	15.9	20.47	21.91
01-01-2016 00:00	01-01-2017 00:00	94.54	None	7.16	17.67	15.19
01-01-2017 00:00	01-01-2018 00:00	54.43	None	7.65	15.35	12.9
01-01-2018 00:00	01-01-2019 00:00	59.18	None	12.13	20.44	28.57
01-01-2019 00:00	01-01-2020 00:00	42.74	None	7.61	15.43	21.69
01-01-2020 00:00	01-01-2021 00:00	31.0	135.17	5.62	11.81	16.24
01-01-2021 00:00	01-01-2022 00:00	29.7	55.76	6.42	10.73	16.33
01-01-2022 00:00	31-12-2022 00:00	38.53	65.81	10.33	20.85	30.93
Prescribed Standards		0-400	0-80	0-4	0-180	0-5

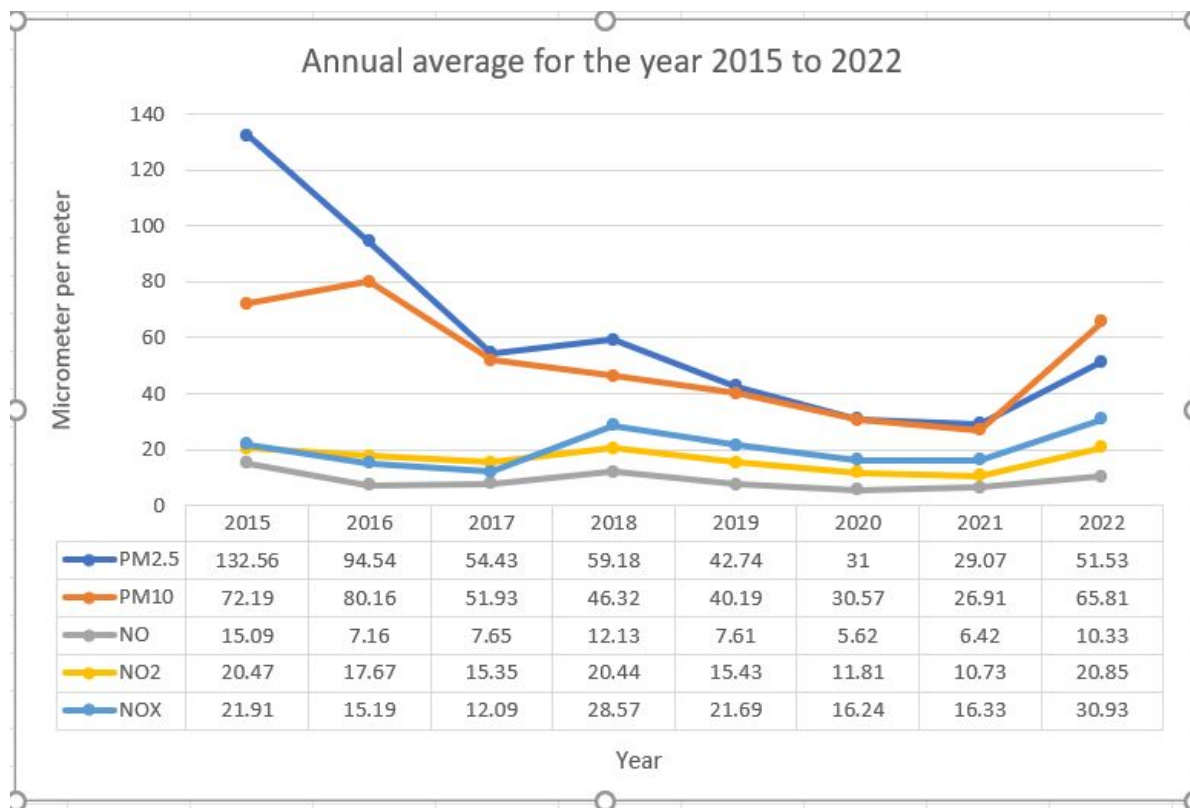


Figure 3.7: Annual variation data for the year 2015 to 2022

3.4 Major air pollutants

The major air pollutants in Chennai, like many other urban areas, include:

1. **Particulate Matter (PM):** PM is a mixture of tiny particles suspended in the air that can penetrate deep into the lungs and cause respiratory problems. PM10 (particles with a diameter of 10 micrometres or less) and PM2.5 (particles with a diameter of 2.5 micrometres or less) are the most common types of PM found in Chennai's air.

2. Nitrogen oxides (NO_x): NO_x is a group of gases, including nitrogen oxide (NO) and nitrogen dioxide (NO₂), that are emitted mainly by vehicles and industrial sources. These gases can cause respiratory problems and contribute to the formation of ground-level ozone.
3. Sulphur dioxide (SO₂): SO₂ is a gas emitted primarily by burning fossil fuels, particularly coal. Exposure to high levels of SO₂ can cause respiratory problems and aggravate existing heart and lung conditions.
4. Carbon monoxide (CO): CO is a colourless and odourless gas emitted by vehicles and other sources that burn fossil fuels. Exposure to high levels of CO can cause headaches, dizziness, and nausea and can be lethal at very high concentrations.
5. Nitrogen dioxide (NO₂) is a reddish-brown toxic gas with a pungent odour. It is a highly reactive compound that forms when nitrogen oxide (NO) reacts with oxygen in the air. NO₂ is a major air pollutant and is emitted from sources such as cars, trucks, buses, and power plants.

These pollutants can have adverse effects on human health, particularly for those with pre-existing respiratory conditions. It is important to monitor the levels of these pollutants and take necessary measures to reduce their emissions and exposure to them.

3.5 Methodology

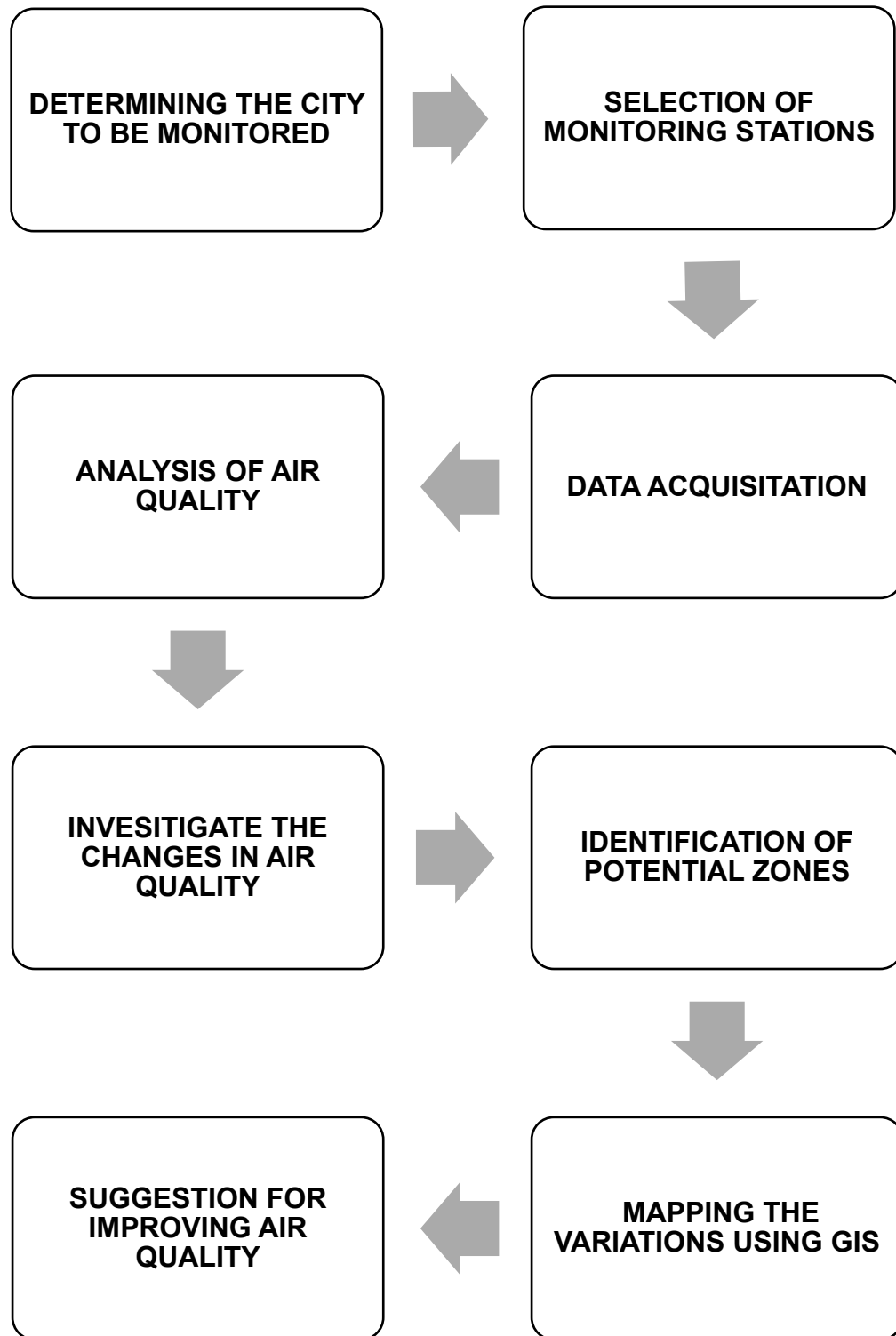


Figure 3.8 Methodology

CHAPTER-4

ANALYSIS AND RESULTS

The air quality in Chennai, like many other Indian cities, has been a cause for concern due to high levels of air pollution.

According to the National Air Quality Index (AQI), which is an index for measuring air quality, Chennai's air quality was categorized as 'Poor' on many days throughout the year, especially during the winter months. This means that the air quality is likely to cause respiratory problems, especially for sensitive groups such as children, the elderly, and those with respiratory conditions.

The major sources of air pollution in Chennai are industrial emissions, vehicular traffic, and construction and demolition activities. The construction of the Chennai Metro Rail and other infrastructure projects has also contributed to the dust pollution in the city.

The main pollutants in Chennai's air include particulate matter (PM10 and PM2.5), nitrogen oxides (NOx), sulfur dioxide (SO2), and carbon monoxide (CO). The levels of these pollutants have been consistently higher than the national and international standards for air quality, posing a threat to public health.

To address this problem, the government of Tamil Nadu has taken several measures such as the installation of air quality monitoring stations, imposing restrictions on industrial emissions and traffic congestion, and promoting the use of public transportation and electric vehicles. However, the effectiveness of these measures is yet to be seen in improving the overall air quality in the city.

In conclusion, the air quality in Chennai, like many other cities in India, is a cause for concern due to high levels of air pollution. It is important to monitor the levels of air

pollutants and take necessary measures to reduce their emissions and exposure to them to protect public health.

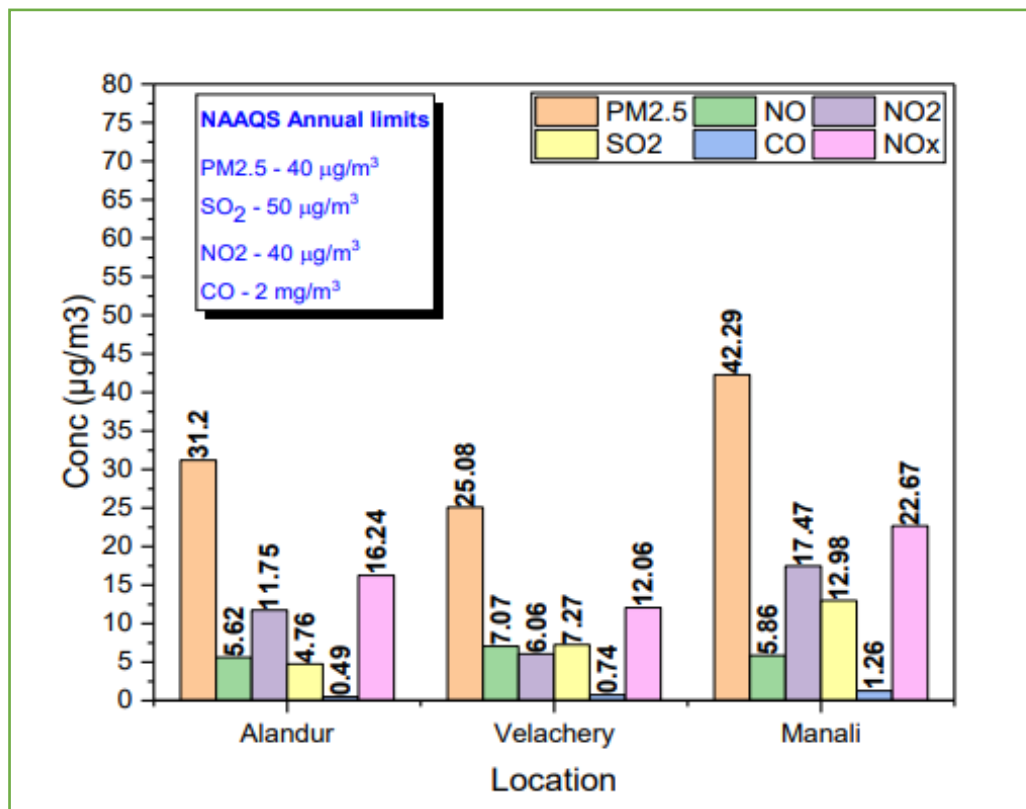


Figure 4.1: Annual mean concentrations of three monitoring locations considered in this study

Shows the monthly air pollutant trend of six criteria pollutants and the graph is bifurcated mentioning the lockdown scenarios. Irrespective of the pollutant, the concentration trend shows drastic variations with respect to the lockdown period. All six pollutants observed a maximum fall in concentration during the lockdown period compared to pre and post lockdown periods. This signifies the contribution of anthropogenic activities to the urban air quality. During pre-lockdown, Alandur measured the maximum PM2.5 compared to other two locations. The reason could be that the site proximate to the busy traffic routes and elevated roundabout connecting the four parts of Chennai city. The routes are always busy round the

clock occupied with dense traffic movement mostly with queues due to signalised junctions. The least was observed for Velachery location, as it is a residential zone. Though the road in this location provides the major traffic route to the MNCs located in the southern region, the busy traffic movement happens during morning and evening for a shorter time span. Hence, we find no higher concentrations of PM_{2.5} in this location.

In post-lockdown, the pollutant trend found to increase further however, the concentrations were low compared to pre-lockdown observations as the post-lockdown period was summer followed by monsoon. Summer are the climatic periods generally observing good atmospheric environment suitable to easily disperse the pollutant plumes. This further reduces the risk of COVID-19 contaminant stagnation in the air. Whereas in the monsoon, the pollutants get precipitated thus observing low concentration. The sudden increase of all pollutants in three locations after lockdown, clearly specifies the impact of traffic emissions and other industrial sources. But these concentrations levels are well below the previous decades which has given us a favourable air quality improvement in the pandemic situation.

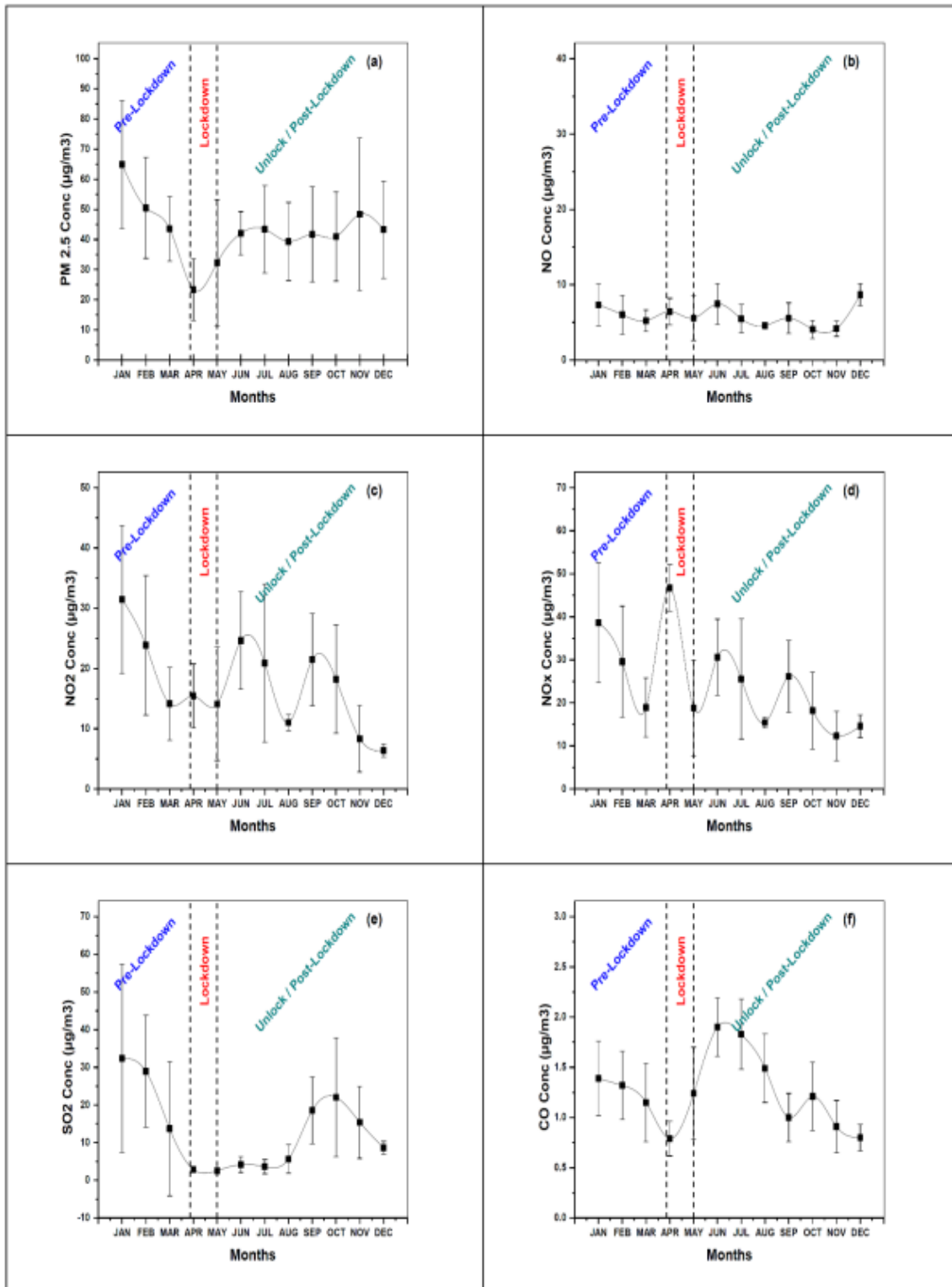


Figure 4.2: Monthly pollutant variation of the Alandur sampling location for the year 2020

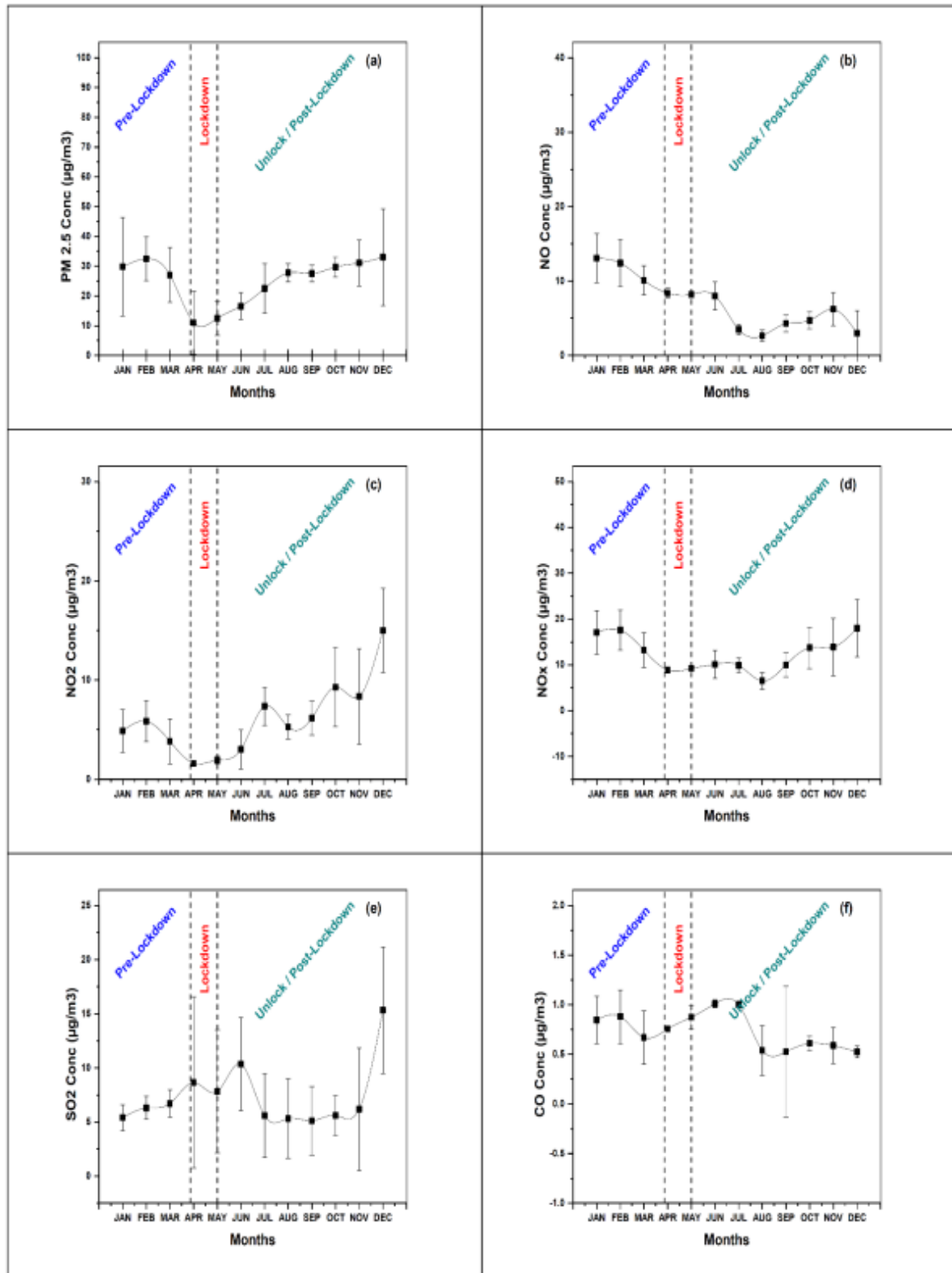


Figure 4.3: Monthly pollutant variation of the Velachery sampling location for the year 2020

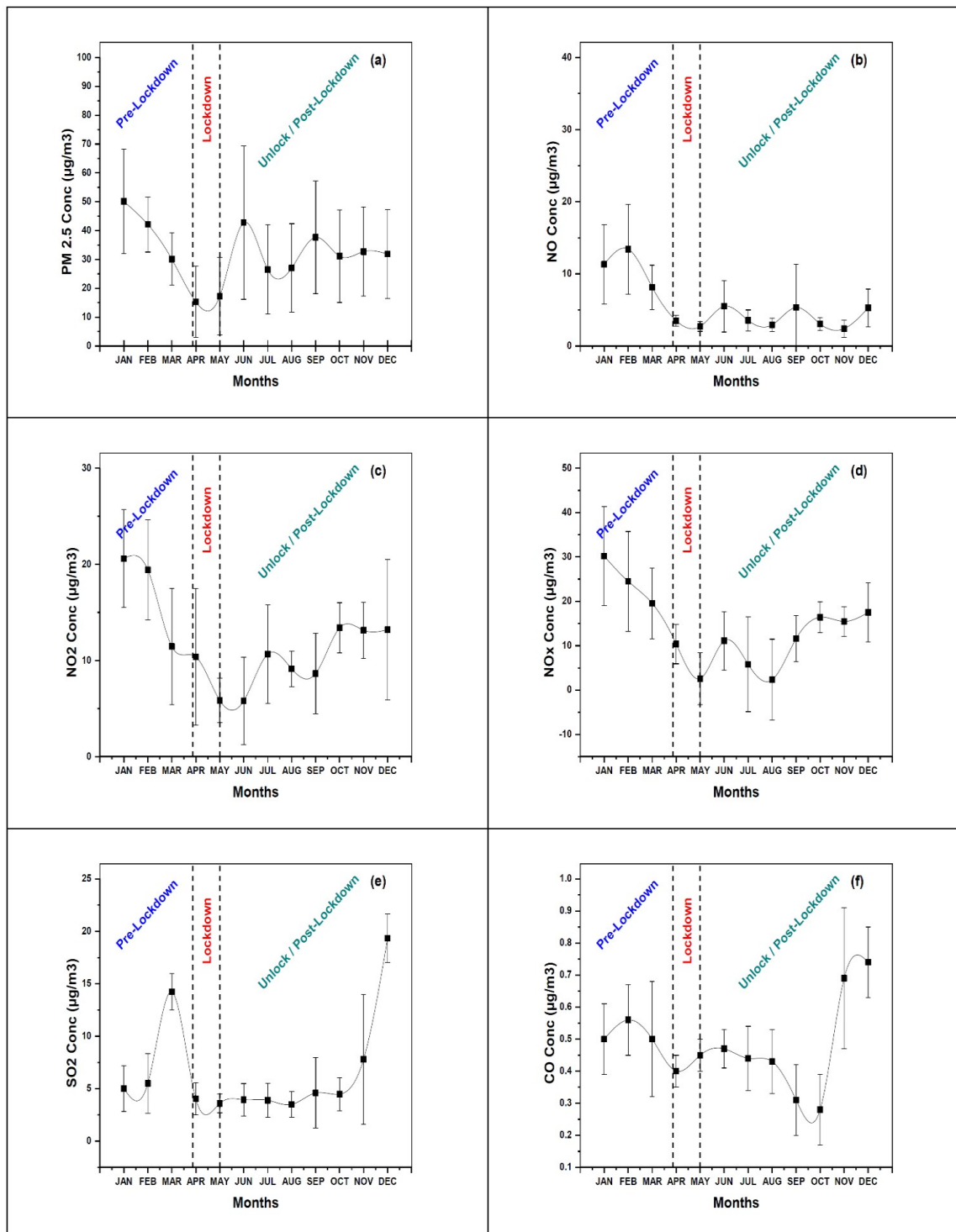


Figure 4.4: Monthly pollutant variation of the Manali sampling location for the year 2020

The comparative concentration variations in terms of percentage with respect lockdown implications are given in table

Table 4.1: Percentage variation in pollutants during the lockdown scenario

Location	Percentage change in concentration									
	Pre-Lockdown to Lockdown					Lockdown to Post-lock down				
	PM _{2.5}	NO	NO ₂	SO ₂	CO	PM _{2.5}	NO	NO ₂	SO ₂	CO
<u>Alandur</u>	- 60%	- 72%	- 53%	- 54%	- 18%	102%	29%	30%	78%	13%
Velachery	- 61%	- 30%	- 63%	- 34%	2%	128%	- 44%	337%	34%	- 17%
Manali	- 47%	- 3%	- 36%	- 89%	- 21%	54%	8%	7%	311%	29%

Percentage values were computed from the monthly mean values for the specific duration. Minus indicates decrease.

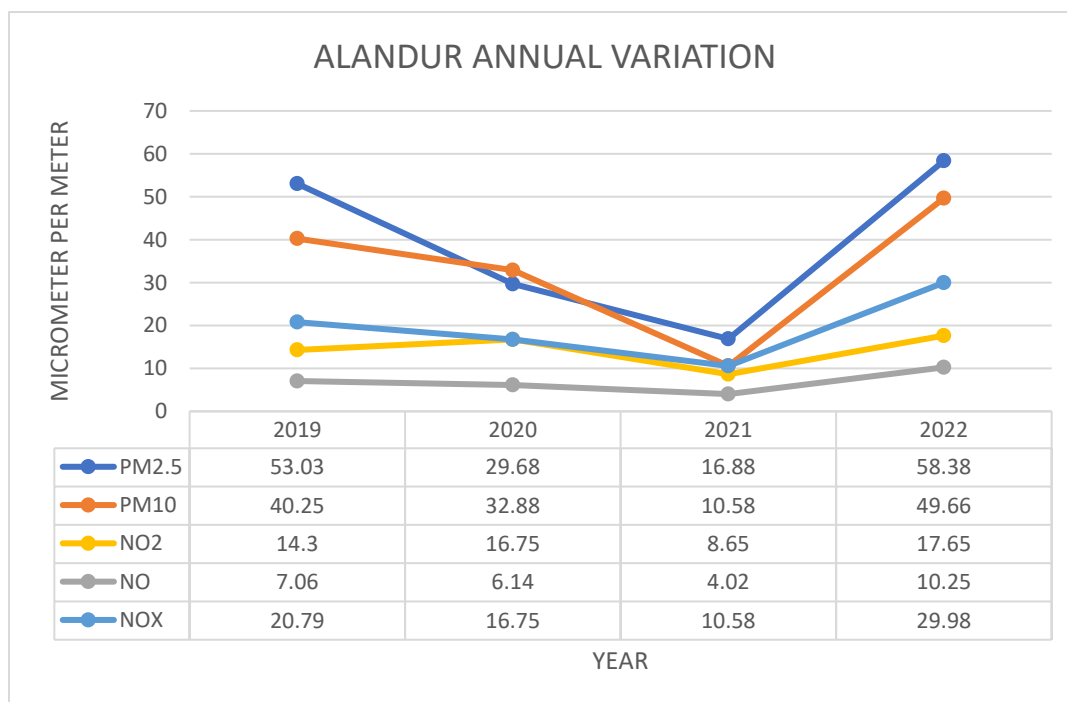


Figure 4.5: Annual variation for ALANDUR monitoring station

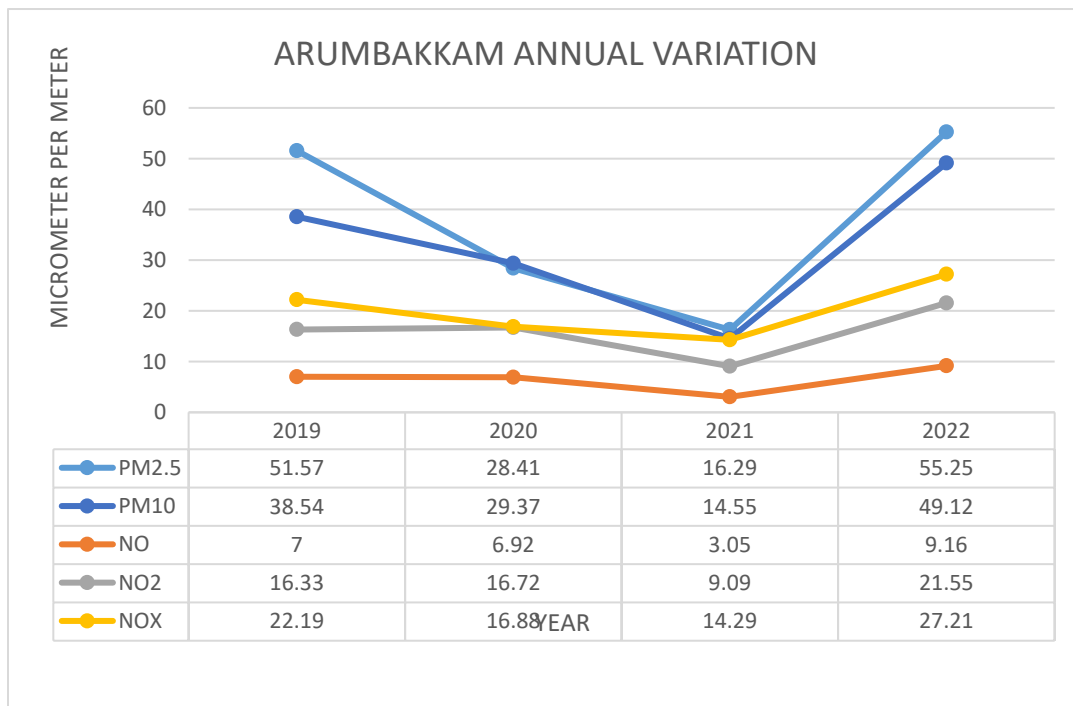


Figure 4.6: Annual variation for ARUMBAKKAM monitoring station

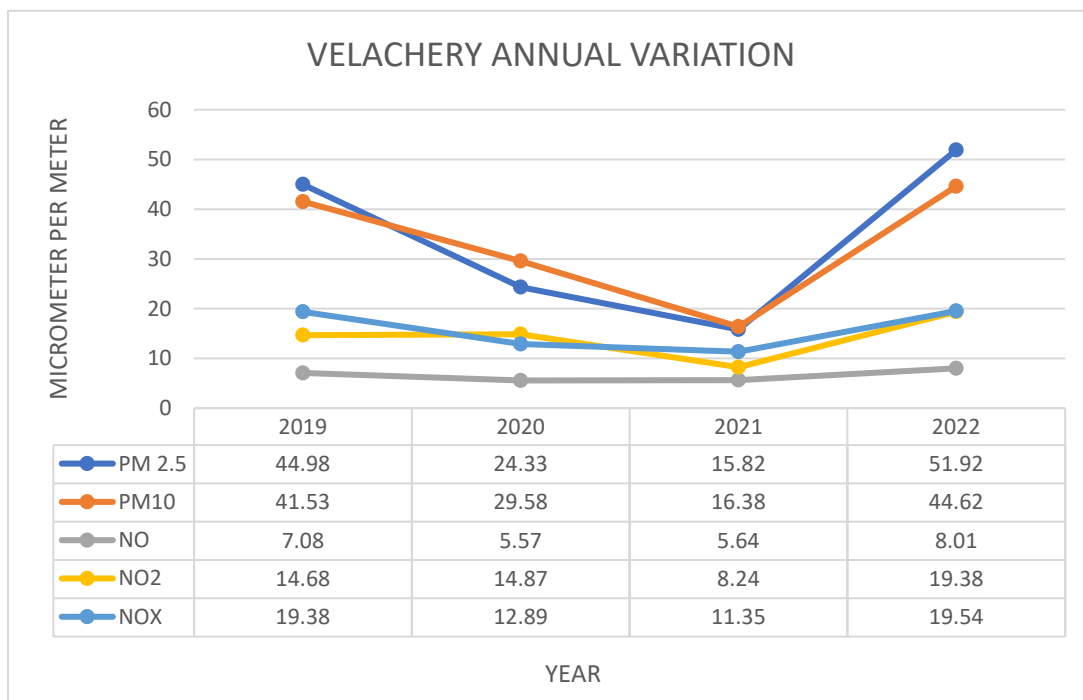


Figure 4.7: Annual variation for VELACHERY monitoring station

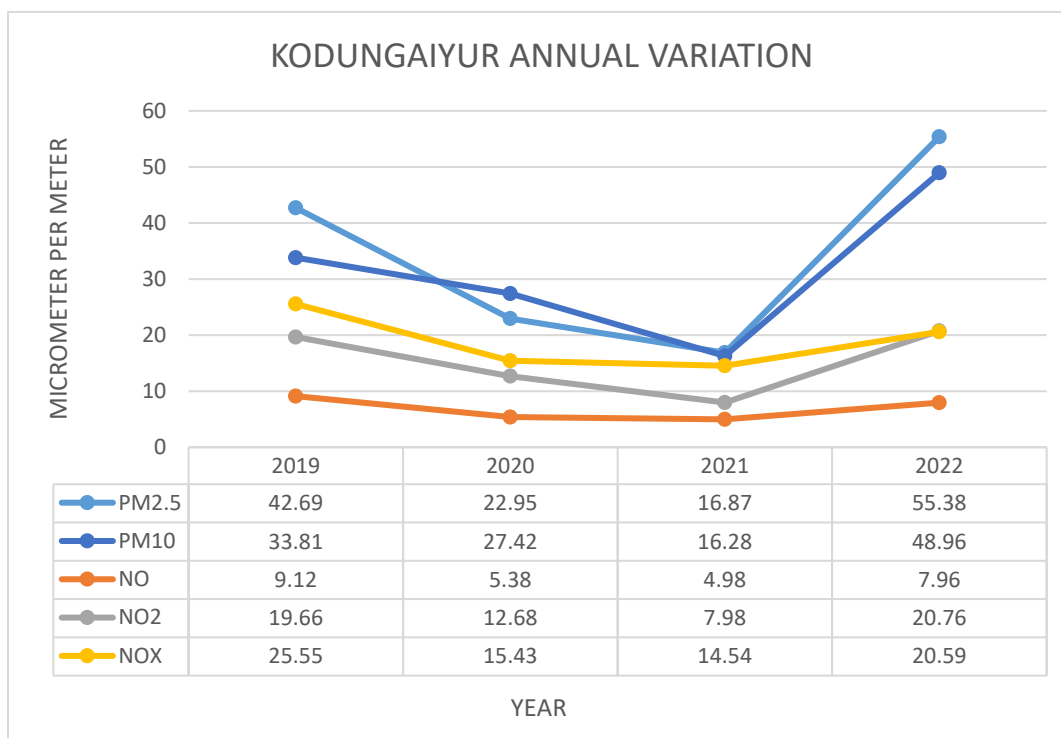


Figure 4.8: Annual variation for KODUNGAIYUR monitoring station

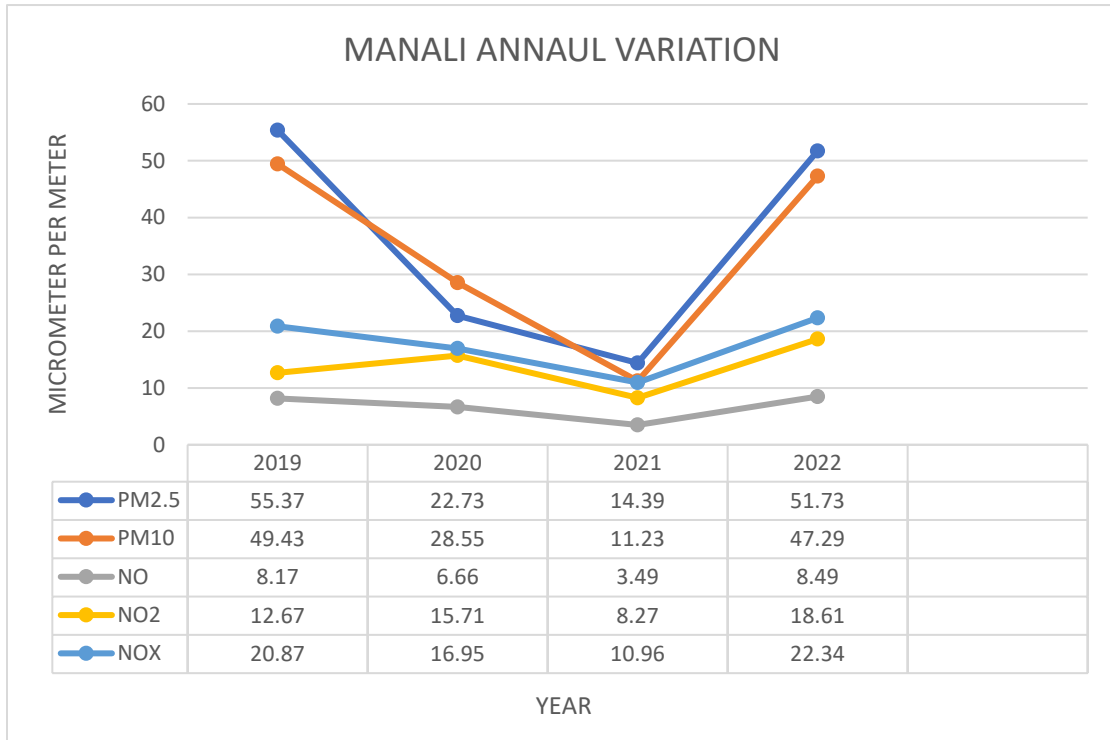


Figure 4.9: Annual variation for MANALI monitoring station

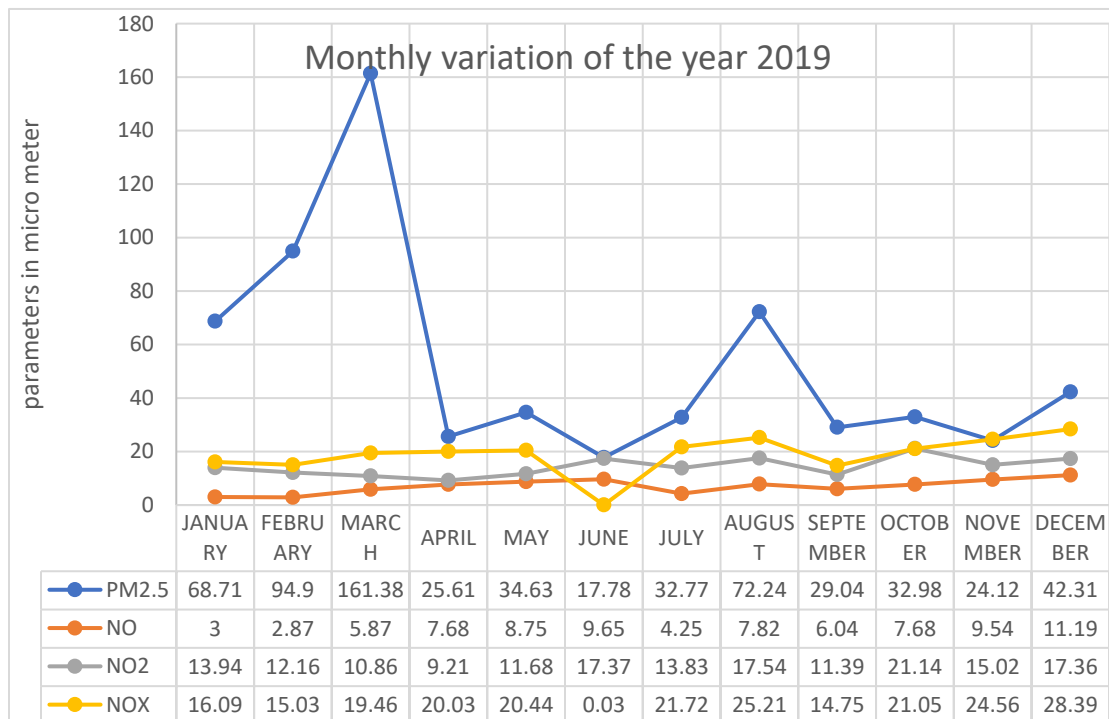


Figure 4.10: Monthly variation of the year 2019

4.1 GIS MAPPING

GIS mapping can be a powerful tool for visualizing and analyzing air pollution in Chennai GCC. To create a GIS map of air pollution in Chennai GCC, you will need to gather data on various air pollutants such as particulate matter (PM2.5, PM10), nitrogen oxides (NO_x), nitrogen monoxide (NO), Nitrogen Dioxide (NO₂), sulfur dioxide (SO₂), and ozone (O₃) concentrations in different locations.

There are several sources for this data, including government agencies, research organizations, and private companies. Once you have gathered the data, you can use GIS software to create a map that displays the concentration of each pollutant at different locations in Chennai GCC.

You can also overlay other data sets such as population density, traffic patterns, and industrial zones to gain a better understanding of how these factors contribute to air pollution. This can help policymakers and researchers to identify areas that are most affected by air pollution and to develop targeted interventions to reduce emissions.

In addition to creating a static map, you can also use GIS software to create interactive maps that allow users to explore the data in more detail. For example, you could create a map that allows users to compare air pollution levels across different time periods or to explore the relationship between air pollution and other factors such as temperature and humidity.

Overall, GIS mapping can be a valuable tool for understanding and addressing air pollution in Chennai GCC. By visualizing the data in a spatial context, policymakers and researchers can gain insights into the causes and impacts of air pollution and develop effective strategies for reducing emissions and improving air quality.

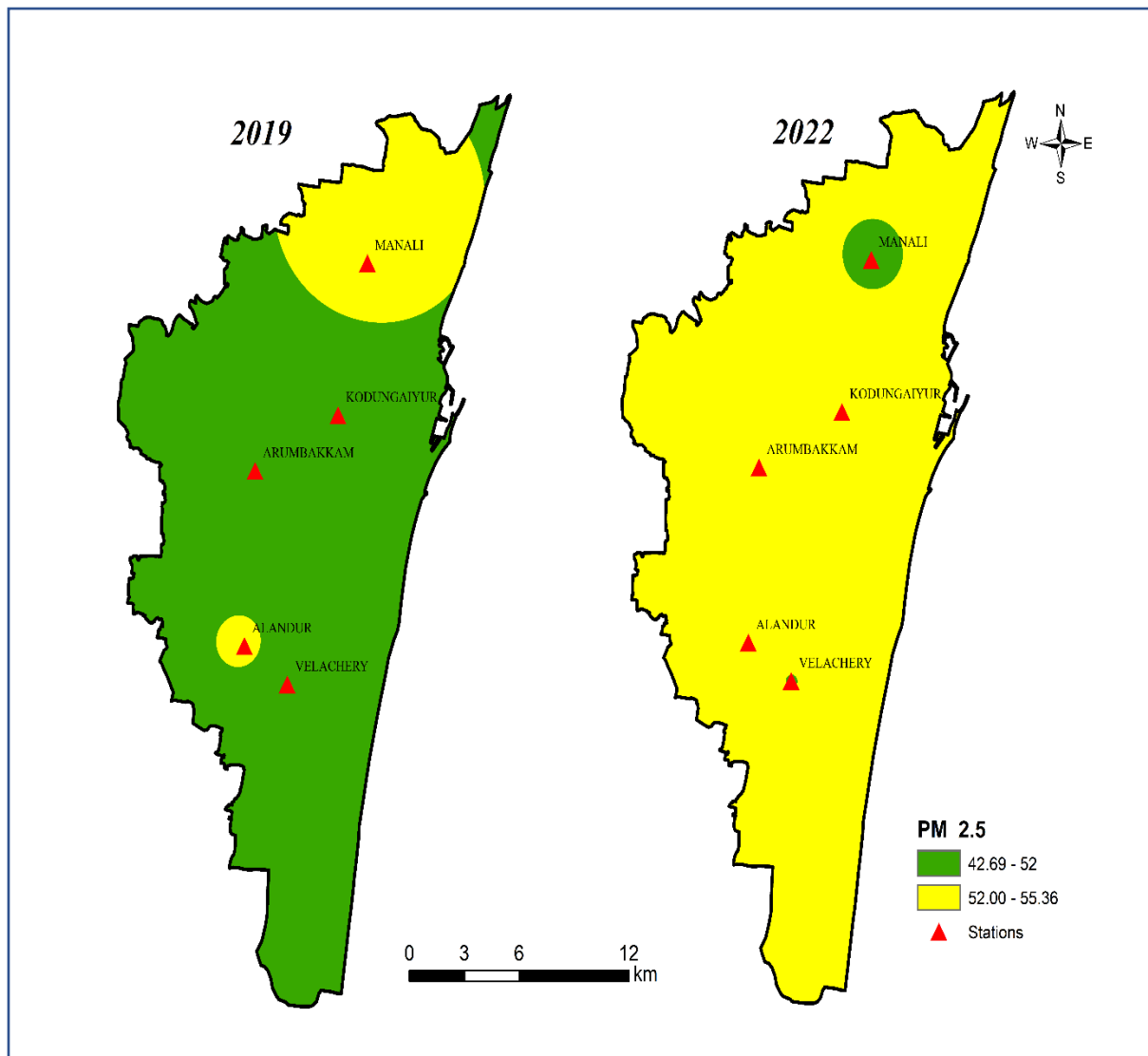


Figure 4.11: Spatial variation of PM_{2.5}

Chennai, a major urban center in India, is prone to high levels of PM_{2.5} pollution due to its industrial activity and heavy traffic. During the COVID-19 pandemic, lockdown measures led to a reduction in PM_{2.5} levels in Chennai, particularly in industrial areas. However, as the lockdown was lifted, pollution levels began to increase again, and by December 2020, had returned to pre-pandemic levels. Sustained efforts are needed to address the underlying sources of pollution and improve air quality in Chennai.

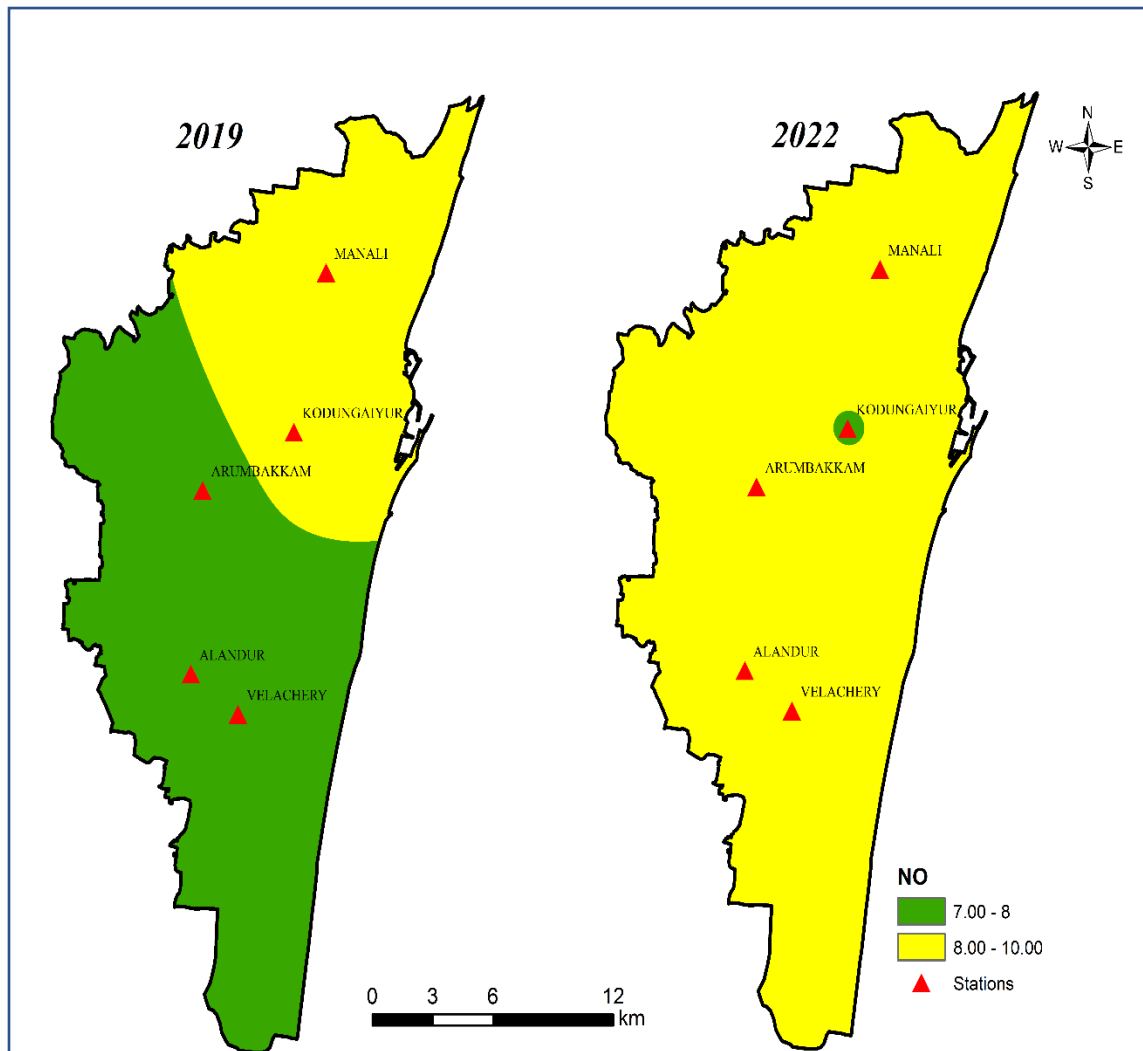


Figure 4.12: Spatial variation of NO

NO, a harmful air pollutant emitted primarily from transportation and industrial activity, is a major source of air pollution in Chennai, a major urban center in India. Before the COVID-19 pandemic, areas with high traffic density, such as Anna Salai and Jawaharlal Nehru Road, were particularly prone to high levels of NO pollution, often exceeding national standards. During the pandemic, there was a temporary reduction in NO levels in Chennai, particularly in areas with high traffic density, due to lockdown measures. However, NO levels began to increase again as the lockdown was lifted, and by December 2020, had returned to pre-pandemic levels. Sustained efforts are needed to address the sources of NO pollution in Chennai and improve air quality in the region.

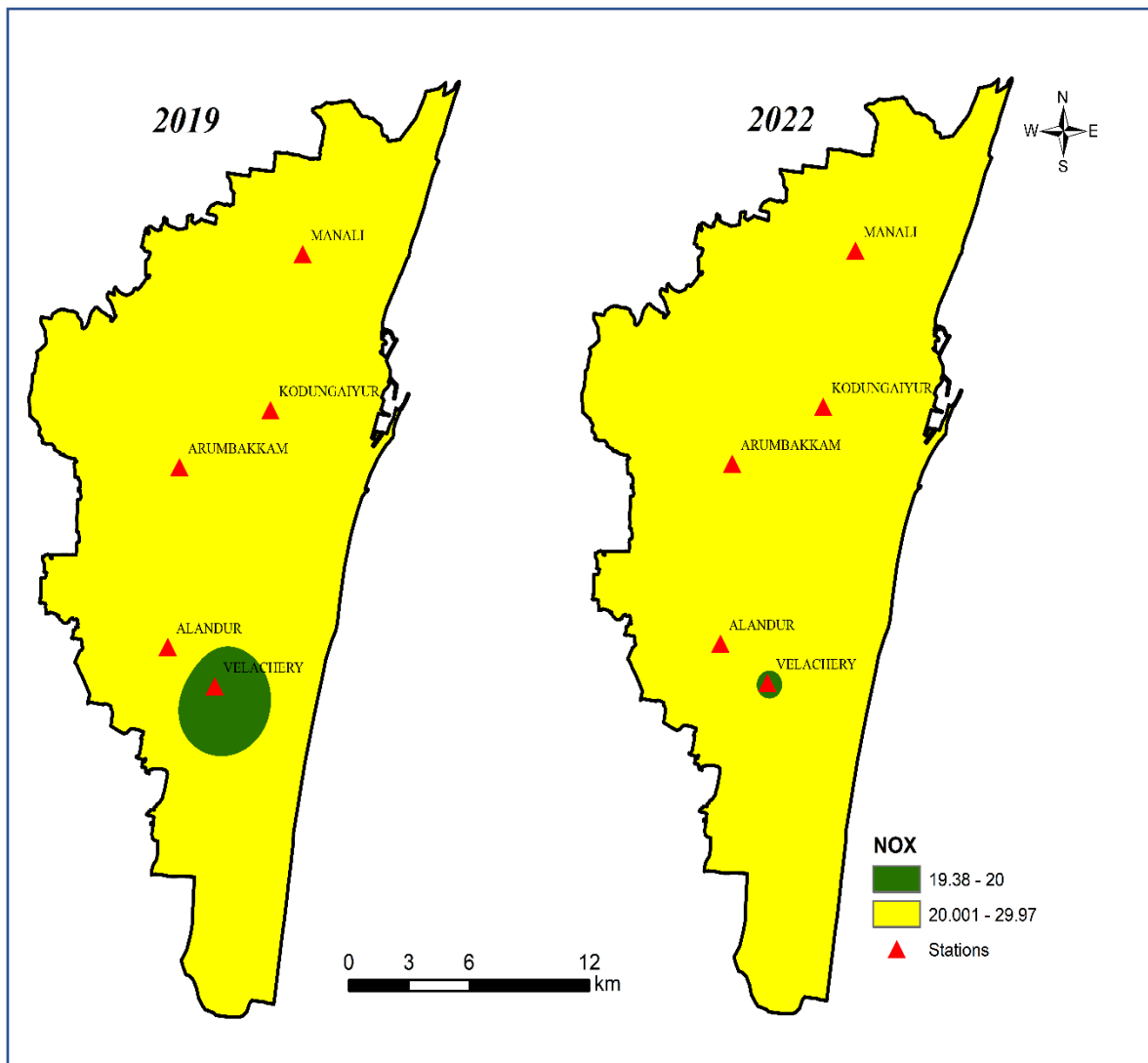


Figure 4.13: Spatial variation of NOx

NOx, a group of harmful air pollutants that include NO and NO₂, is emitted primarily from transportation and industrial activity and is a major source of air pollution in Chennai, a major urban center in India. Before the COVID-19 pandemic, areas with high traffic density, such as Anna Salai and Jawaharlal Nehru Road, were particularly prone to high levels of NOx pollution, often exceeding national standards. During the pandemic, there was a temporary reduction in NOx levels in Chennai, particularly in areas with high traffic density, due to lockdown measures. However, NOx levels began to increase again as the lockdown was lifted, and by December 2020, had returned to pre-pandemic levels. Sustained efforts are needed to address the sources of NOx pollution in Chennai and improve air quality in the region.

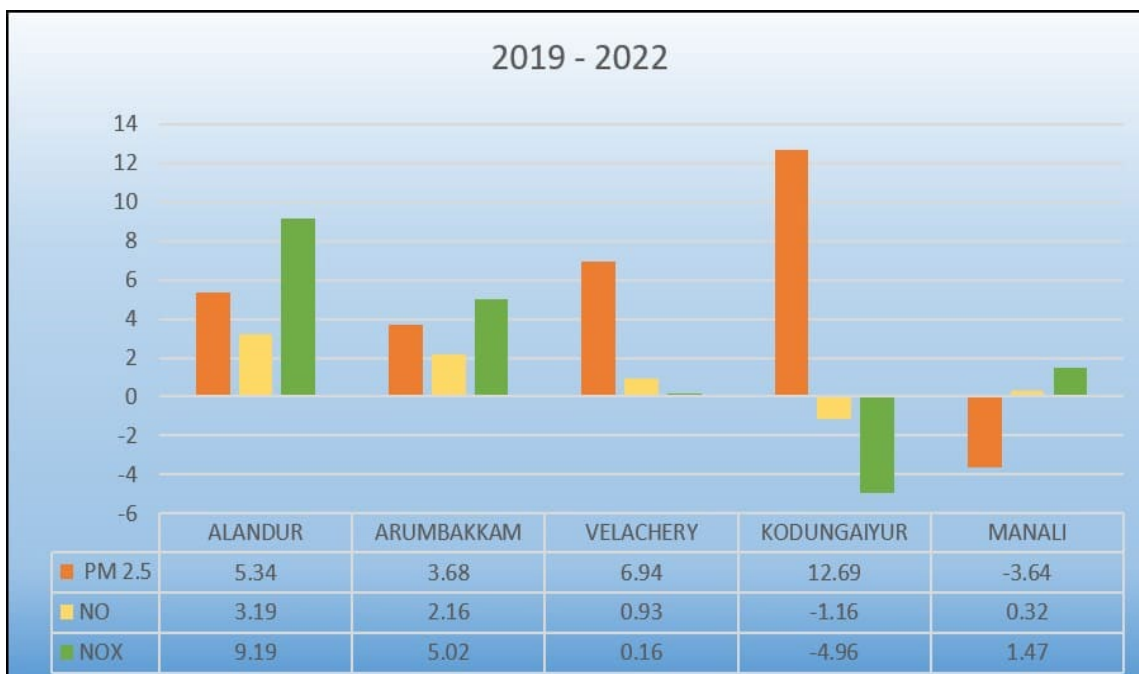


Figure 4.14: Temporal variation of PM_{2.5}, NO, NO_x

Chennai, a major urban center in India, experiences high levels of air pollution due to industrial activity, heavy traffic, and other sources. Here are some points on the temporal variation of PM_{2.5}, NO, and NO_x before and after the COVID-19 pandemic in Chennai:

Before the COVID-19 pandemic:

- PM_{2.5} levels in Chennai were typically highest during the winter months (November to February), when weather patterns and increased industrial activity led to stagnant air and higher levels of pollution.
- NO and NO_x levels in Chennai were highest during the summer months (March to June), when temperatures and sunlight facilitated the formation of these pollutants.
- Overall, pollution levels in Chennai remained consistently high throughout the year, with occasional spikes during festivals and other events.

During the COVID-19 pandemic:

- Lockdown measures implemented in Chennai led to a significant reduction in PM 2.5 levels, particularly in industrial areas, due to reduced industrial activity and traffic.
- NO and NOx levels also saw a temporary reduction during the early months of the pandemic, particularly in areas with high traffic density.
- However, as the lockdown was lifted and economic activity resumed, pollution levels began to increase again and by December 2020, had returned to pre-pandemic levels.

Overall, while the COVID-19 pandemic led to a temporary reduction in pollution levels in Chennai, sustained efforts are needed to address the underlying sources of pollution and improve air quality in the region.

4.2 RESULT

It is to observe from the results discussed in this paper that impose of lockdown has brought a tremendous improvement in the urban air quality in a short span of time. This brings a though provoking note to the researchers, scientific communities and regulators to think about how this reduced or improved ambient concentration can be further prolonged in the forthcoming days. Our findings conclude that reduction of pollutant concentration from pre-lockdown to lockdown is seemingly higher compared to the increasing rate from lockdown to post-lockdown measurements except for PM2.5 (table 2). In case of PM2.5, post-lock down concentration increased by twice in comparison to the decrease in concentration observed during lockdown in Alandur and Velachery. This could be due to movement of traffic as the unlock was announced. However, the scenario was quite found an equivalent increase in post-lockdown with respect to decrease in lockdown for PM2.5 concentrations at Manali. This observation can be related to the reduced less traffic movement and functioning of the industries on a regulated timing imposed by the government

CHAPTER-5

SUMMARY AND CONCLUSION

5.1 SUMMARY

Spatial variation:

- Air quality in different areas of Chennai varies due to differences in local sources of pollution and meteorological conditions.
- Areas with high traffic density and industrial activity tend to have poorer air quality than residential areas.

Temporal variation:

- Air quality in Chennai varies by season, time of day, and weather conditions.
- Chennai experiences high levels of pollution during the winter months due to the influence of the northeast monsoon winds.
- Air quality is generally better during the summer months, but it can still be affected by factors such as temperature, humidity, wind speed, and rainfall.

Efforts to improve air quality:

- Efforts to improve air quality in Chennai include reducing traffic congestion, promoting public transport and cycling, and increasing green spaces.
- High levels of particulate matter and other pollutants in the air have been contributing to a range of health problems in the city.

5.2 CONCLUSION

Improving air quality in Chennai is a complex and multifaceted issue that requires a comprehensive approach. Here are some suggestions that could be implemented to improve air quality in Chennai:

1. Reducing vehicle emissions: Encouraging the use of public transport, promoting the use of electric and hybrid vehicles, and improving vehicle emission standards can help reduce the amount of pollutants released into the air.
2. Promoting sustainable transport: Promoting walking, cycling, and the use of public transport can help reduce traffic congestion, which in turn can reduce air pollution.
3. Improving industrial practices: Enforcing strict regulations on industries to reduce their pollution emissions, encouraging the use of cleaner technologies, and increasing monitoring of pollution levels can help reduce the amount of pollutants released into the air.
4. Promoting green spaces: Increasing the number of trees and green spaces in the city can help absorb pollutants and release oxygen, which can help improve air quality.
5. Controlling open burning: Implementing strict laws to control open burning of waste and agricultural residues can help reduce the amount of pollutants released into the air.

These suggestions require a coordinated effort from government bodies, industries, and individuals to achieve significant improvements in air quality.

3. Reference

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